Measurement & Verification Load Impact Study for Northern California Power Agency Senate Bill 5X Programs

Study ID: NCP0001.01

FINAL REPORT

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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 a portfolio of sixty-three (63) energy efficiency and renewable energy peak electricity demand reduction and load control (i.e., emergency based) programs. The programs were implemented by seventeen California public utilities with funding from SB5X and administered by NCPA under the auspices of the CEC. The M&V study adhered to the International Performance Measurement and Verification Protocols. Program budgets, ex ante savings, and M&V savings for each program are provided in **Table 1.1**. Each program was grouped into one of ten categories: Commercial and Industrial (C&I) Lighting, C&I HVAC, C&I Refrigeration, C&I Custom, LED Traffic Signals, Residential HVAC, Residential CFL, Refrigerator Recycling, Load Control, and Miscellaneous Programs (**Table 1.1** and **2.1**). Provided under separate cover are M&V reports for each of the ten program categories. Program tracking data are provided in the Microsoft™ Access NCPA Tracking Database. The total NCPA program budget was $8,700,000. The programs provided incentives for 281,390 measures. The ex ante savings are 43,410,097 kWh per year and 18,877 kW. The M&V net ex post savings are 37,346,290 ± 546,362 kWh per year and 15,886 ± 204 kW. The net ex post lifecycle savings are 541,241,505 ± 6,822,445 kWh per year with an average effective useful lifetime of 14.5 years. The net realization rates are 0.860 ± 0.013 for kWh and 0.842 ± 0.011 for kW. The net ex post cost effectiveness is 547.66 ± 7.03 dollars per kW.

Table 1.1 Expenditures and Energy Savings for NCPA SB5X Programs

Utility	Program	Budget $	Qty. Units	Ex Ante kWh Savings	Ex Ante kW Savings	M&V Net Ex Post Savings kWh	M&V Net Ex Post Savings kW	M&V Category
Alameda	Com Lighting	$221,425	6,091	1,127,255	368.0	954,938	286.7	C&I Lighting
	Admin Audits	$50,807		0	0.0	0	0.0	-
	Subtotal	**$272,232**		**1,127,255**	**368.0**	**954,938**	**286.7**	
Biggs	CFL	$7,600	1,407	94,329	38.7	56,315	19.3	Residential CFL
	Refrig. Recycle	$400	2	2,106	0.4	3,061	0.7	Refrig. Recycling
	Subtotal	**$8,000**		**96,435**	**39.1**	**59,376**	**20.0**	
Gridley	Residential CFL	$6,032	1,117	126,126	52.0	47,433	20.0	Residential CFL
	Com. HVAC	$9,144	2	3,995	4.4	972	1.1	C&I HVAC
	Refrig. Recycling	$15,598	42	64,663	12.5	38,854	10.2	Refrig. Recycling
	Com Lighting	14,876	74	38,468	17.0	31,870	14.1	C&I Lighting
	Administration	$27,590		0	0.0	0	0.0	-
	Subtotal	**$73,240**		**233,252**	**85.9**	**119,129**	**45.4**	
Healdsburg	CFL	$16,388	3,024	190,512	136.1	111,133	26.0	Residential CFL
	C&I Lighting	$8,390	110	20,434	4.9	17,310	3.8	C&I Lighting
	Administration	$59,723		0	0.0	0	0.0	-
	Subtotal	**$84,500**		**210,946**	**141.0**	**128,443**	**29.8**	
Lassen	Comm Lighting	$114,000	994	183,964	80.4	155,842	62.7	C&I Lighting
	Subtotal	**$114,000**		**183,964**	**80.4**	**155,842**	**62.7**	
Lodi	C&I Refrig.	$380,000	1	1,194,000	765.0	821,708	889.0	C&I Refrigeration
	Comm Lighting	$6,864	24	4,500	1.0	3,812	0.8	C&I Lighting
	Comm Win. Film	$2,050	9	900	0.6	610	0.2	Miscellaneous
	Comm HVAC	$5,928	6	1,200	1.3	3,860	4.4	C&I HVAC
	Refrig. Recycle	$51,000	541	861,813	97.4	627,874	148.8	Refrig. Recycling
	Administration	$158		0	0.0	0	0.0	-
	Subtotal	**$446,000**		**2,062,413**	**865.3**	**1,457,864**	**1043.3**	
Lompoc	Refrig. Recycle	$42,224	77	121,121	13.9	79,004	22.0	Refrig. Recycling

Table 1.1 Expenditures and Energy Savings for NCPA SB5X Programs

Utility	Program	Budget $	Qty. Units	Ex Ante kWh Savings	Ex Ante kW Savings	M&V Net Ex Post Savings kWh	M&V Net Ex Post Savings kW	M&V Category
	Exit Signs	$2,348	50	15,768	1.8	15,768	1.8	C&I Lighting
	PV Buydown	$24,000	2	4,680	2.6	4,680	2.6	C&I Custom
	LED Traffic	$71,313	1,074	546,568	62.4	432,369	49.4	LED Traffic Signl
	Res Matress Pad	$25	1	900	0.3	216	0.1	Miscellaneous
	Res Conserv. Kit	$7,995	500	36,850	13.0	26,800	9.2	Miscellaneous
	Administration	$22,095		0	0.0	0	0.0	-
	Subtotal	**$170,000**		**725,887**	**94.0**	**558,837**	**85.1**	
MID	AC Load Control	$1,030,740	3,234	0	3,000.0	0	3,095.0	Load Control
	Res WH Fan	$1,947	24	6,600	12.0	3,216	3.2	Miscellaneous
	Res Sun Screens	$6,360	5881	12,938	23.5	4,517	2.0	Miscellaneous
	Res ES Windows	$48,526	44872	98,718	179.5	64,167	87.5	Miscellaneous
	Residential AC	$146,533	316	110,645	201.2	115,513	135.8	Resid. HVAC
	Com Sun Screens	$18,837	16243	51,978	65.0	42,102	23.4	Miscellaneous
	Com Lighting	$156,239	11,230	847,226	207.2	709,272	159.5	C&I Lighting
	Com AC	$31,020	79	46,479	52.8	38,918	44.5	C&I HVAC
	Com AC Custom	$103,100	9	1,582,858	789.0	1,603,623	920.7	C&I HVAC
	Energy Star Ref.	$131,202	704	371,893	80.4	37,171	7.9	Miscellaneous
	LED Traffic	$63,270	2,109	923,114	105.4	729,360	83.3	LED Traffic Signl
	Administration	$22,227		0	0.0	0	0.0	-
	Subtotal	**$1,760,000**		**4,052,449**	**4,716.0**	**3,347,857**	**4562.7**	
Oakland	EMS	$66,000	1	250,000	60.0	250,000	60.0	C&I HVAC
	Subtotal	**$66,000**		**250,000**	**60.0**	**250,000**	**60.0**	
Palo Alto	Com HVAC	$460,130	3	2,776,800	960.0	1,456,957	805.9	C&I HVAC
	Com Lighting	$219,870	8,822	1,128,674	285.7	1,010,682	253.5	C&I Lighting
	Load Curtail	$70,000	101	0	115.0	0	108.0	Load Control
	Subtotal	**$750,000**		**3,905,474**	**1,360.7**	**2,467,638**	**1167.5**	
PSREC	Residential CFL	$8,814	1,469	104,299	83.7	102,469	26.7	Residential CFL
	Refrig. Recycle	$30,000	200	191,600	75.0	208,568	57.2	Refrig. Recycling
	Res GSHP	$82,000	82	1,312,082	324.7	62,864	144.6	Resid. HVAC
	Com GSHP	$16,000	16	256,016	63.4	80,396	21.5	C&I HVAC
	Subtotal	**$136,814**		**1,863,997**	**546.9**	**454,296**	**250.1**	
Redding	Res. AC/GSHP	$479,975	704	469,104	536.3	327,658	413.2	Resid. HVAC
	Com HVAC	$23,763	33	38,101	42.5	19,141	21.9	C&I HVAC
	Residential CFL	$211,263	65,610	1,367,968	1,640.2	3,168,498	964.5	Residential CFL
	Subtotal	**$715,000**		**1,875,173**	**2,219.1**	**3,515,296**	**1399.7**	
Roseville	Res HVAC	$299,950	134	347,616	347.6	67,011	91.2	Resid. HVAC
	Com HVAC	$150,613	93	203,288	205.3	79,681	67.0	C&I HVAC
	Com Light	$314,462	6,718	1,651,041	385.0	1,139,394	372.4	C&I Lighting
	Vender Miser	$18,975	115	212,900	19.3	171,562	11.0	Miscellaneous
	AC Tune-up ≤5T	$34,983	250	130,000	130.0	70,875	42.9	C&I HVAC
	AC Tune-up >5T	$6,017	43	44,720	44.7	24,949	13.5	C&I HVAC
	Subtotal	**$825,000**		**2,589,565**	**1,131.9**	**1,553,471**	**598.1**	
SVP	LED Traffic	$316,114	1,741	1,230,672	140.5	964,477	110.1	LED Traffic Signl
	Com Lighting	$914,011	87,913	15,612,124	3,436.3	15,844,468	3,106.0	C&I Lighting
	Plug Sensors	$9,450	315	122,850	28.1	32,501	35.1	Miscellaneous
	Refrig Recycle	$205,425	747	1,189,971	135.8	766,437	205.5	Refrig. Recycling
	Subtotal	**$1,445,000**		**18,155,617**	**3,740.6**	**17,607,883**	**3456.7**	
TDPUD	Com Lighting	$127,998	3,940	394,545	156.4	418,162	152.9	C&I Lighting
	High Eff. Chiller	$10,000	1	229,166	87.0	290,347	110.2	C&I HVAC
	Solar PV	$2,002	1	329	0.1	329	0.1	C&I Custom
	Subtotal	**$140,000**		**624,040**	**243.5**	**708,838**	**263.1**	
TID	C&I Custom	$286,953	235	4,877,817	1,148.3	3,733,869	814.0	C&I Custom
	C&I Win Film	$1,152	34	5,376	5.60	4,335	2.04	Miscellaneous
	Residential AC	$336,345	656	472,845	483.2	228,313	268.4	Resid. HVAC
	Com HVAC	$25,550	50	29,177	29.8	18,538	21.3	C&I HVAC
	AC Load Control	$500,000	1,502	0	1,500.0	0	1,437.0	Load Control
	Subtotal	**$1,150,000**		**5,385,214**	**3,166.9**	**3,985,055**	**2542.7**	

Table 1.1 Expenditures and Energy Savings for NCPA SB5X Programs

Utility	Program	Budget $	Qty. Units	Ex Ante kWh Savings	Ex Ante kW Savings	M&V Net Ex Post Savings kWh	M&V Net Ex Post Savings kW	M&V Category
Ukiah	Photovoltaics	$57,595	1	15,160	5.0	15,160	5.0	C&I Custom
	Com HVAC	$46,501	11	53,255	12.2	6,367	7.3	C&I HVAC
	Subtotal	**$104,096**	6,091	**68,415**	**17.2**	**21,527**	**12.3**	
Utility Total		**$8,259,882**	**281,390**	**43,410,097**	**18,876.5**	**37,346,290**	**15885.7**	
EM&V		$388,091						
NCPA		$52,027						
Total		**$8,700,000**						

The M&V participant surveys generally found high satisfaction with the programs and no negative comments. The NCPA SB5X M&V study focused on load impacts and free riders (i.e., net-to-gross ratios), and did not include a process or market evaluation. The NCPA utilities have not previously conducted independent third-party M&V studies of their programs. Future programs should set aside at least 5 percent of the total budget for ongoing load impact and process evaluation studies. The most important lessons learned are for the utilities to implement third-party EM&V studies and consistent program tracking databases in order to document program accomplishments and improve load impact realization rates. The NCPA utilities should also develop ex ante savings from existing M&V studies and reports available from the California Measurement Advisory Council (www.calmac.org). Studies worthy of consideration include the *2004 California Statewide Residential Appliance Saturation Survey* (RASS, available online at: http://websafe.kemainc.com/RASSWEB) and the *Database for Energy Efficiency Resources* (DEER).[1]

Section 2 presents an overview of the M&V plan and approach, decision-maker surveys, net-to-gross ratio analysis, tracking database, sampling methods, statistical analysis, on-site M&V, engineering analysis, and reporting. **Sections 3** through **12** provide detailed M&V results for each utility and program category. **Appendix A** provides the decision-maker survey for C&I lighting, C&I HVAC, C&I refrigeration, C&I custom, LED traffic signals, residential HVAC, and miscellaneous programs. **Appendix B** provides the decision-maker survey for residential CFLs, and **Appendix C** provides the decision-maker survey for refrigerator recycling. **Appendix D** provides a description of the NCPA Tracking Database.

2. M&V Plan and Approach

M&V plans for each program were based on 63 programs implemented by NCPA utilities. The programs were organized into ten (10) program categories as shown in **Table 2.1**. The M&V reports are based on these program categories. More effort was spent on program categories with the greatest share of budget and savings as shown in **Table 2.2**. For example, the M&V plan focused more effort on C&I lighting, C&I HVAC, C&I custom, residential HVAC, and load control programs. Within program categories the M&V plan focused more effort on sites with

[1] *California Statewide Residential Appliance Saturation Survey*. Prepared by KEMA-Xenergy, Inc. Prepared for the California Energy Commission. P300-00-004. June 2004. *2001 DEER Update Study*, prepared by XENERGY, Inc., prepared for the CEC, Contract 300-99-008, Aug. 2001.

the largest share of savings. Provided under separate cover are M&V reports for each of the ten program categories. This report provides a summary of M&V findings from each of the reports.

Table 2.1 NCPA SB5X Program Categories, Budget, and Savings

#	NCPA Program Category	Budget $	Ex Ante MWh/yr	Ex Ante MW	Ex Ante Lifecycle GWh	M&V Ex Post MWh/yr	M&V Ex Post MW	M&V Ex Post Lifecycle GWh
1	C&I Lighting	$2,100,482	21,024	4.94	336.38	20,302	4.41	324.82
2	C&I HVAC	$988,748	5,645	2.48	83.72	3,945	2.14	58.50
3	C&I Refrigeration	$380,000	1,194	0.77	23.88	822	0.89	16.43
4	C&I Custom	$370,550	4,898	1.16	73.86	3,754	0.82	56.61
5	LED Traffic Signals	$450,697	2,700	0.31	43.21	2,126	0.24	34.02
6	Residential HVAC	$1,344,803	2,712	1.89	40.68	801	1.05	12.02
7	Residential CFL	$250,096	1,883	1.95	12.66	3,486	1.06	23.42
8	Refrigerator Recycling	$344,647	2,431	0.33	14.59	1,724	0.44	10.34
9	Miscellaneous Programs	$246,519	922	0.43	12.06	387	0.18	5.06
10	Load Control	$1,600,740	0	4.62	0.00	0	4.64	0.00
	Total	**$8,077,282**	**43,410**	**18.88**	**641.03**	**37,346**	**15.89**	**541.24**

Table 2.2 M&V Sample Sizes by NCPA SB5X Program Category

#	NCPA Program Category	Budget %	Lifecycle kWh %	kW %	Units	Program Quantity	M&V Sample
1	C&I Lighting	26.0%	60.0%	27.8%	Fixtures	125,966	23,875
2	C&I HVAC	12.2%	10.8%	13.5%	Tons	12,489	9,620
3	C&I Refrigeration	4.7%	3.0%	5.6%	Tons	560	560
4	C&I Custom	4.6%	10.5%	5.2%	hp	239	10
5	LED Traffic Signals	5.6%	6.3%	1.5%	Signals	4,924	890
6	Residential HVAC	16.6%	2.2%	6.6%	Tons	1,892	60
7	Residential CFL	3.1%	4.3%	6.7%	Units	72,627	60
8	Refrigerator Recycling	4.3%	1.9%	2.8%	Units	1,609	107
9	Miscellaneous Programs	3.1%	0.9%	1.1%	Measures	68,698	50
10	Load Control	19.8%	0.0%	29.2%	Units	4,837	3,237
	Total	**100%**	**10.%**	**100%**		**293,841**	**38,469**

The M&V plan for each NCPA utility program adhered to the *International Performance Measurement & Verification Protocols* and IPMVP Options defined in **Table 2.3**.[2] Each M&V plan determined energy or peak demand savings by comparing measured kW and kWh use before and after implementation of programs or projects according to **Equation 2.1**.

Eq. 2.1 Energy Savings = Base Year Energy Use - Post-Retrofit Energy Use ± Adjustments

The "Adjustments" term in **Equation 2.1** brings energy use in the two time periods to the same set of conditions. Conditions commonly affecting energy use are weather, occupancy, production, and equipment operations. Adjustments may be positive or negative. Adjustments were used to normalize for weather variations, or when a second shift or occupants were added or for abnormal increased or decreased electrical equipment usage.

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

Table 2.3 IPMVP M&V Options

M&V Option	How Savings Are Calculated	Typical Applications
Option A. Partial Measured Retrofit Isolation Savings are determined by short-term or continuous field measurements of energy use of ECM, separate from facility energy use. Partial measurement means that some parameters may be stipulated. Careful review of ECM design and installation ensures that stipulated values fairly represent probable actual value.	Engineering calculations using short term or continuous post-retrofit measurements and stipulations.	Lighting retrofit where power draw is measured periodically. Operating hours of the lights are measured with light loggers, based on interviews with personnel, or assumed to be one half hour per day longer than store open hours.
Option B. Retrofit Isolation Savings are determined by short-term or continuous measurements of energy use of ECM, separate from the energy use of the rest of the facility.	Engineering calculations using short term or continuous measurements	Variable speed controls used on a constant speed fan. Electricity use is measured with a kW and kWh meter on fan motor with and without the VS.
Option C. Whole Facility Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period.	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.	Energy management program affecting many systems in a building. Energy use is measured with utility meters for pre- and post-retrofit periods.
Option D. Calibrated Simulation Savings are determined through simulation of components or whole facility. Simulation routines model actual energy performance measured in the facility.	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end-use metering.	Program affecting many systems in a building but base year data are unavailable. Savings are determined by simulations calibrated with pre- or post-retrofit utility data.

M&V plans were closely linked with the NCPA project or program designs. The M&V plan and approach is summarized below.

Step 1. NCPA Tracking Database

The tracking database provided a framework for the M&V study – from sample design to reporting net ex post savings. The NCPA tracking database is described in **Section 2.2** and **Appendix D**.

Step 2. Sample Design

A statistical sample design was be used to select a sample of customers or projects from each program population. Samples were selected to obtain a reasonable level of precision and accuracy at the 80 to 90 percent confidence level. Samples were selected across NCPA utility service areas for similar programs. Statistical sampling methods are described in **Section 2.3**.

Step 3. Decision-Maker Survey

Decision-maker surveys were used to assess net savings for rebate programs (i.e., to discount gross savings for free riders). Decision-maker surveys were also used with engineering estimates to assess savings for residential CFL programs. Decision-maker surveys were completed using a combination of telephone and on-site interviews of program participants. Decision-maker surveys were not used for NCPA programs where the decision-maker is the utility (i.e., load control programs). Decision-maker surveys and net-to-gross ratios are discussed in **Section 2.1**. The decision-maker surveys are provided in **Appendices A**, **B**, and **C**.

Step 4. Prepare Site-Specific M&V Plan
Site-specific M&V Plans were developed for large lighting projects and custom commercial & industrial projects.

Step 5. On-Site M&V and Engineering Analyses
On-site M&V and engineering analyses were used to gather information regarding the pre-installation and as-built equipment in order to evaluate kW and kWh savings. Sites with significant savings received more effort in terms of spot, short-term, or continuous measurements to monitor hours of use (e.g., light loggers) or electrical use (e.g., data loggers). For sites with HVAC, EMS, or process measures the M&V efforts included gathering enough information to develop calibrated simulations or spreadsheets to assess kW and kWh savings. Sites with large HVAC savings were evaluated using DOE-2.2 simulations (or eQuest) calibrated to utility billing data. On-site M&V and engineering analyses are described in **Section 2.3** and relevant sections of the report.

Step 6. Statistical Analyses of Program Savings
Statistical analyses were used to extrapolate kW and kWh savings at the sample level to the program level. This step included an assessment of the relative precision and error bounds of program-level kW and kWh savings. The statistical analysis is described in **Section 2.3** and relevant sections of the report.

Step 7. Report Gross and Net Savings for Sites, Projects and Programs
Reporting of savings for sites, projects, and programs was performed on a bi-annual basis. The NCPA tracking database contains detailed records for all participants. Provided under separate cover are M&V reports for each of the ten program categories.

These steps were repeated for each program category. Savings were deemed to be statistically valid if the M&V results for the sample and program were within the 80 to 90 percent confidence interval.

2.1 Decision-Maker Surveys and Net-to-Gross Ratios

Decision-Maker Surveys (DMS) were used to estimate the net-to-gross ratio (NTGR) used to calculate net kWh and peak kW savings. **Appendix A** provides the Decision-Maker Survey for C&I lighting, C&I HVAC, C&I refrigeration, C&I custom, LED traffic signals, residential HVAC, and miscellaneous programs. **Appendix B** provides the Decision-Maker Survey for residential CFLs, and **Appendix C** provides the Decision-Maker Survey for refrigerator recycling. The NTGR is used to estimate the fraction of free riders who would have otherwise implemented improvements in the absence of the program. Ten participant survey questions were used to assess net-to-gross ratios as shown in **Table 2.4**. The NTGR score for each completed participant survey is the average score based on answers to questions 2 through 10. No score is assigned to responses of “don’t know”, “refused to answer,” or “other.”

Table 2.4 Net-to-Gross Ratio Participant Survey Questions and Scoring

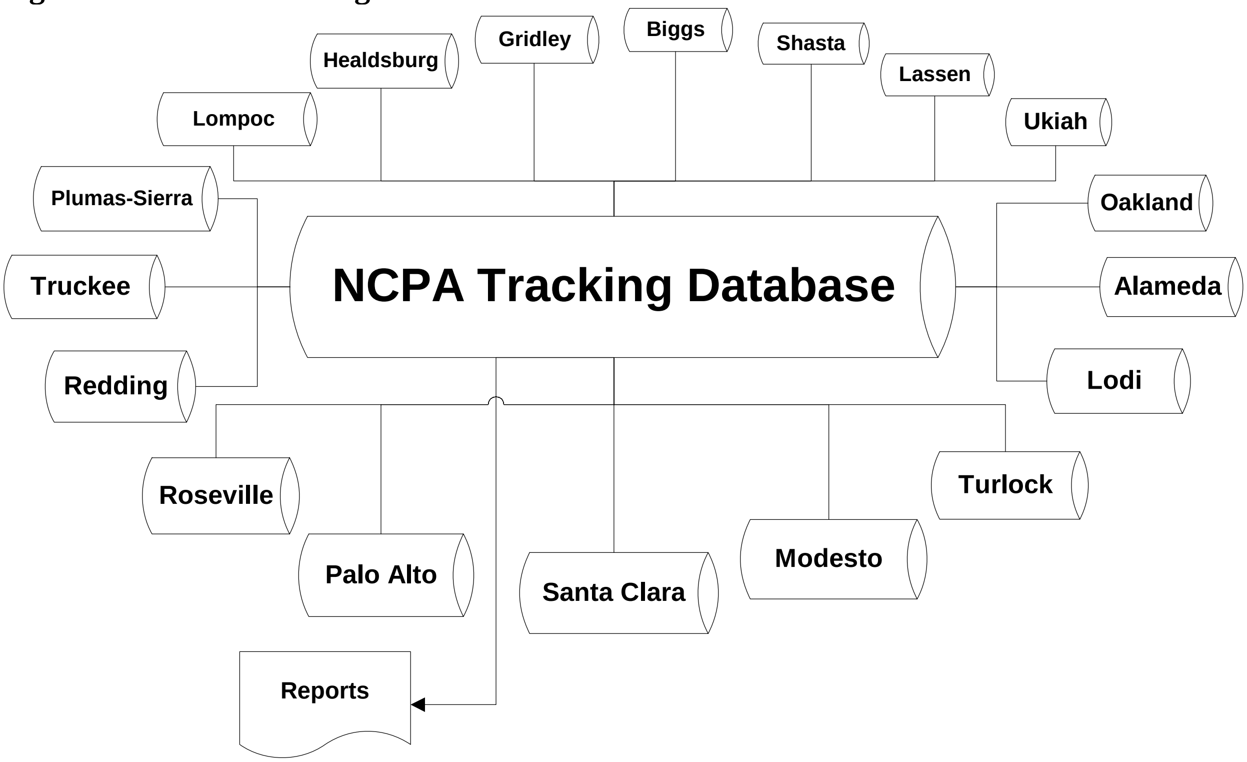
#	Question	Answer	Score
2	Did you understand the value of the program BEFORE or AFTER you installed the efficiency upgrades?	Before	1
		After	0
3	Did you install the lighting efficiency upgrade BEFORE or AFTER you heard about the Rebate Program?	Before	0
		After	1
4	On a scale from 0 to 10, with 0 being 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
5	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
6	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
7	The Utility Program was nice but it was unnecessary to get the efficiency upgrades installed.	0 to 10	0=1, 10=0
8	The Utility Program was a critical factor in installing the efficiency upgrades.	0 to 10	0=0, 10=1
9	We would not have installed the efficiency upgrades without the Utility Program.	0 to 10	0=0, 10=1
10	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

Decision-Maker Surveys were conducted for all programs except AC load control program since this project would not have been implemented by customers without utility funding. For programs using on-site surveys as part of the M&V plan, the decision-maker surveys were conducted with the site contact. If the site contact was not the correct decision-maker, a follow-up telephone survey was conducted. Telephone surveys were conducted using qualified engineers and surveyors.

2.2 NCPA Tracking Database

The NCPA Tracking Database was used to archive program tracking information and M&V data for the NCPA member utilities. The database includes: program name, incentive amount, customer information, quantity and type of energy efficiency measures, make and model number, account number (if available), and M&V results. The database has separate records for each energy efficiency measure to capture pre- and post-retrofit information, kW savings, kWh savings, paid incentives, and M&V information. The NCPA Tracking Database consists of a “Master” database that stores records from all utilities and separate Access “Satellite” databases or pre-formatted Excel spreadsheets used by each utility to enter tracking data for M&V purposes. The architecture for all the databases is similar, except that the Master database has additional modules to combine records and produce reports about data for all utilities. The database was updated with program activity sent electronically by utility staff. **Figure 2.1** presents an overview of the NCPA Tracking Database.

Figure 2.1 NCPA Tracking Database



The NCPA Tracking Database is a Microsoft™ Access database application. Microsoft™ Access is part of the Microsoft™ Office Professional suite of productivity software. Microsoft™ Office includes the Excel spreadsheet application, which the NCPA Tracking Database uses as a file structure for import and export functions. Microsoft™ Word, another part of the Office suite, is also used for conversion of the database reports to a file format that can be easily attached to Email and opened from most Windows desktops.

As a complete relational database system, Access is designed for adding, deleting, and editing records (such as program and customer information). Relational databases help manage the one-to-many relationships between data (such as one customer participating in multiple programs, and each program being comprised of multiple energy efficiency measures). A relational database system has built-in mechanisms to insure data accuracy and referential integrity. It also provides SQL (Structured Query Language) for asking various questions about data stored in multiple tables.

In addition to its relational database functions, Microsoft™ Access provides an application development environment for creating user-friendly programs. The user interface supports the common screens and controls (text boxes, push buttons, and menus) that Windows users are familiar with. All the application software in the NCPA Tracking Database is written using VBA (Visual Basic for Applications), the most common Windows programming language. VBA is a powerful structured language that supports the common Windows APIs (Application Program Interfaces), allowing ease of integration with other Windows software (such as Word and Excel).

Each "satellite" database has file-server architecture, with a "front-end" user interface that resides on each client PC, and a "back-end" data file that is stored on a server. The server may be one of the Windows PCs in a peer-to-peer network, or a dedicated file server in the more traditional sense (Novell, UNIX, NT, etc.). If the database is housed on a single machine, both the front-end and back-end files reside on the same PC. This design has four advantages:

1. Multiple users have access to shared data over the network.
2. Performance is enhanced by minimizing network traffic to data, with all forms and reports being loaded from a local hard disk.
3. Data is stored on a centralized server for regular backup.
4. Off-site modifications to the front-end user interface can be made while the back-end data tables continue to be in use. Upgrades to the front-end can be installed without risk of overwriting recently changed data.

The back-end data file contains the database "tables" that store all the information records. Each table has multiple "fields" (for example, customer name, address, or phone), which hold different types of data for each record. Table indexes and relationships are established in the back-end data file to maintain accuracy and prevent redundancy.

All the primary record operations (add, delete, modify, and select) are performed through the user interface to simplify the user's experience. Records are added through the program interface by typing data into text entry boxes, by selecting options from dropdown menus, or imported using pre-formatted Excel spreadsheets (the most common method). The display of records on the screen and in reports is controlled by SQL queries, which filter and sort records to match the user's needs.

2.2.1 Database Management and Reporting

RMA maintained the NCPA Tracking Database and provided copies of the database to NCPA as needed. The database was updated with program data supplied by NCPA utilities. Data collected specifically for M&V was entered into the database as it was collected. For most programs final tracking data was collected by the fourth quarter of 2004 or first quarter of 2005.

RMA provided summaries of program activity on a bi-annual basis after the receiving data from NCPA utilities. Annual summary reports were generated from the database and exported in Excel and Word formats. Database reporting functions include kW and kWh savings for all NCPA utilities, individual utilities, and individual programs. The user can select various reporting options and then view the report, send selected pages to the printer, or export the report into Word. A more detailed presentation of the NCPA Database interface and file structure is provided in **Appendix D**.

2.3 Sampling Methods 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.[3] 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. For C&I lighting, C&I HVAC, C&I refrigeration, and C&I custom programs the savings per site were normalized on a per unit basis in the statistical analyses (e.g., kW/fixture, kW/ton, kW/bin, and kW/hp).[4] Normalizing the savings on a per unit basis allows clearer interpretation of the savings data in the statistical analysis. As noted above in **Section 2**, the M&V plan was based on ten program categories. Considering each NCPA utility program within a program category as a stratum, the sample mean within a program was calculated using **Equation 2.2**.

Eq. 2.2 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."

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 2.3**.

Eq. 2.3 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 2.4**.

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[3] 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.

[4] For C&I lighting the savings units are fixtures (i.e., hard-wired), for C&I HVAC the savings units are cooling tons (i.e., 1 ton = 12,000 Btu/hr), for C&I refrigeration the savings units are industrial bins of fruit per degrees Fahrenheit delta T (i.e., 32 ft^3 accommodating 835 pounds of apricots or 1,010 pounds of peaches), and for C&I custom the savings units are horsepower (i.e., 745.7 watts or 33,000 foot-pounds per minute).

Eq. 2.4 $$s_h^2 = \frac{\sum_{k=1}^{n}\left(y_k - \bar{y}_h\right)^2}{N_h - 1}$$

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 2.5**.

Eq. 2.5 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 2.6**.

Eq. 2.6 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.[5]

Eq. 2.7 FPC Sample Size = $n_{FPC\,h} = \frac{n_h}{1 + \left(n_h - 1\right)/N_h}$

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 2.8**.

Eq. 2.8 Stratum Error Bound $= Eb\left(\bar{y}_h\right) = t_o \frac{s_h}{\sqrt{n_h}}$

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.

[5] 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.

An unbiased estimate of the program category variance was calculated using **Equation 2.9**.

Eq. 2.9 $$s_p^2 = \sum_{h=1}^{L} \frac{W_h^2 s_h^2}{n_h} - \sum_{h=1}^{L} \frac{W_h s_h^2}{N_p}$$

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 2.10**.

Eq. 2.10 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. For LED traffic signals residential HVAC, residential CFLs, residential refrigerator recycling, miscellaneous, and load control programs with discrete measures, the program category savings estimate was calculated as the sum of the number of measures for the utility program stratum times the M&V sample mean savings estimate as shown in **Equation 2.11**.

Eq. 2.11 $\hat{Y}_p =$ M&V Gross Ex Post Program Category Savings $= \sum_{h=1}^{L} \left[N_h \times \bar{y}_h \right]$

Where,

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

Savings for the M&V samples or sites were summed and compared to ex ante savings to develop M&V Average Gross Realization Rates (AGRR) for kW and kWh savings. The AGRR for kW and kWh savings were calculated using **Equation 2.12**.

Eq. 2.12 $$AGRR_h = \frac{\sum_{k=1}^{n} \text{M \& V Sample Savings}_k}{\sum_{k=1}^{n} \text{Ex Ante Sample Savings}_k}$$

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).

For C&I lighting, C&I HVAC, and C&I custom programs with multiple measures at sites, the 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 2.13**.

Eq. 2.13 $\hat{Y}_p =$ M&V gross ex post program category savings $= \sum_{h=1}^{L} \left[\hat{X}_h \times AGRR_h \right]$

Where,

$\hat{X}_h =$ Ex ante program stratum "h" savings (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 2.14**.[6]

Eq. 2.14 $\hat{E}b(\bar{y}_p) = \sqrt{\sum_{h=1}^{L} \left[Eb(\bar{y}_h) \right]^2}$

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 2.15**.

Eq. 2.15 $NRR_h = NTGR_h \times AGRR_h$

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 (see **Section 2.1**).

Some statistics were calculated using other equations.[7]

2.3.1 M&V Sample Sizes and Relative Precision

The M&V sample sizes were designed to focus more effort on programs with the greatest share of budget and savings. **Table 2.5** shows the M&V decision maker survey (DMS) sample sizes, coefficient of variation (Cv), and relative precision for each of the ten NCPA program categories. The M&V plan called for a total DMS sample of 251 with Cv values ranging from 0.3 to 0.6 and relative precision ranging from ±10 to 20 percent. The total DMS sample was 388 with Cv values ranging from zero to 0.46 and relative precision ranging from ±0 to 7.4 percent.

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[6] 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.

[7] 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.

Table 2.5 M&V Savings, Sample Sizes and Relative Precision for Decision-Maker Surveys

NCPA Program	M&V Net Ex Post Savings GWh	M&V Net Ex Post Savings MW	Participants or Units	M&V DMS Sample	M&V DMS C_v	DMS Relative Precision
Commercial & Industrial Lighting	20.30	4.41	626	75	0.18	3.4%
Commercial & Industrial HVAC	3.94	2.14	526	41	0.09	2.3%
Commercial & Industrial Refrigeration	0.82	0.89	1	1	0.00	0.0%
Commercial & Industrial Custom	3.75	0.82	64	12	0.17	8.1%
LED Traffic Signals	2.13	0.24	165	3	0.00	0.0%
Residential HVAC	0.80	1.05	1,871	60	0.14	3.0%
Residential CFL	3.49	1.06	34,984	62	0.29	6.1%
Residential Refrigerator Recycling	1.72	0.44	1,568	110	0.46	7.2%
Miscellaneous Programs or Projects	0.39	0.18	1,726	24	0.22	7.4%
Load Control	0.00	4.64	4,739	n/a	n/a	n/a
Total	**37.35**	**15.89**	**46,270**	**388**		

Table 2.6 shows the M&V load impact sample sizes, Cv, relative precision, and error bounds at the 90 percent confidence interval for each of the ten NCPA program categories.

Table 2.6 M&V Net Savings, Sample Sizes and Relative Precision for Load Impacts

NCPA Program	M&V Net Ex Post Savings GWh	M&V Net Ex Post Savings MW	Total Units	M&V Sample	C_v MW	C_v GWh	Relative Precision MW	Relative Precision GWh	Error Bound MW	Error Bound GWh
Comm. & Ind. Lighting	20.30	4.41	125,966	23,875	0.40	0.55	1.0%	1.1%	0.05	0.21
Comm. & Ind. HVAC	3.94	2.14	12,489	9,620	0.42	0.47	7.3%	5.7%	0.16	0.23
Comm. & Ind. Refrig.	0.82	0.89	560	560	0.04	0.39	4.4%	14.2%	0.04	0.12
Comm. & Ind. Custom	3.75	0.82	239	10	0.52	0.59	4.1%	4.7%	0.03	0.18
LED Traffic Signals	2.13	0.24	4,924	890	0.04	0.21	1.2%	0.9%	0.00	0.02
Residential HVAC	0.80	1.05	1,892	60	0.24	0.11	6.7%	18.2%	0.07	0.15
Residential CFL	3.49	1.06	72,627	60	0.26	0.47	5.7%	10.3%	0.06	0.36
Res. Refrig. Recycling	1.72	0.44	1,609	107	0.40	0.46	3.8%	4.3%	0.02	0.07
Miscellaneous	0.39	0.18	68,698	50	0.07	0.03	11.2%	5.0%	0.02	0.02
Load Control	0.00	4.64	4,837	3,237	0.32	n/a	1.3%	n/a	0.06	0.00
Total	**37.35**	**15.89**	**293,841**	**38,469**			**1.3%**	**1.5%**	**0.20**	**0.55**

The M&V plan called for total relative precision of ±6.9 percent for MW and ±7.4 percent for GWh. The M&V samples were chosen to improve the relative precision for each program and reduce the error bounds across all programs. The overall relative precision associated with total MW and GWh savings is the square root of the sum of the squared error bounds for each of the programs. **Table 2.6** shows estimated demand savings were measured with an error bound of ±0.20 MW and total relative precision of ±1.3%. Similarly, the energy savings were measured with an error bound of ±0.55 GWh and relative precision of ±1.5%. The decision-maker and on-site sample sizes were designed to provide an estimate of savings for the entire NCPA portfolio of programs within the 90 percent confidence level.

2.4 On-Site M&V and Engineering Analyses

On-site measurements and engineering analyses were used to evaluate load impacts for lighting, HVAC, process, refrigeration, custom, LED signals, refrigerator recycling, miscellaneous, and load control programs. On-site measurements and engineering were compared to ex-ante savings estimates from the tracking system. Measured data and engineering were used to develop estimates of gross savings using either spreadsheet analysis for commercial lighting sites and custom measures or DOE-2 (or eQuest) models for commercial HVAC measures. Net savings for each program were based on net-to-gross ratio analysis from decision-maker survey data. The gross and net results were expanded to the population using statistical methods.

A systematic process was used to verify lighting and equipment inventories, install data loggers, and collect and analyze data. During site visits, decision-maker surveys were conducted and survey data was used to develop net-to-gross ratios and estimates of free riders. The on-site surveyors made the site visits as unobtrusive to customers as possible. This was accomplished by being well prepared for each site and by being attentive to the customer's needs regarding scheduling and site access RMA recognized the importance of each individual utilities' relationship with their customers and paid close attention to each site visit with respect to duration of conversations with customers and appropriate content to discuss with each customer.

A comprehensive M&V plan was completed prior to visiting the large lighting, HVAC, and custom measure sites. The site-specific M&V plan included verification of all as-built energy efficiency measures. Surveyors obtained 12 to 36 months of historical utility billing data for each site. Spot, short-term, or continuous temperature and electrical measurements were taken during on-site visits. Measurements and utility billing data improved the accuracy of the M&V effort and allowed for calibration of engineering algorithms and computer simulations.

Field measurements of the Energy Efficiency Ratio (EER) were made to determine in-situ efficiency for packaged and split-system residential and commercial air conditioners with and without proper refrigerant charge and airflow.[8] Field measurements, measurement equipment, and measurement tolerances are provided in **Table 2.7**.

[8] EER is the cooling capacity in thousand British Thermal Units per hour (kBtuh) divided by total air conditioner electric power (kW) including indoor fan, outdoor condensing fan, compressor, and controls. The Btu is the energy required to raise one pound of water one degree Fahrenheit. EER values are typically measured under laboratory conditions of 95°F condenser entering air and 80°F drybulb and 67°F wetbulb evaporator entering air.

Table 2.7 Field Measurements, Measurement Equipment, and Tolerances

Field Measurement	Measurement Equipment	Measurement Tolerances
Temperature in degrees Fahrenheit (°F) of return and supply wetbulb and drybulb and outdoor condenser entering air	4-channel temperature data loggers with 10K thermisters. Calibration of wetbulb and drybulb temperatures were checked using sling psychrometers	Data logger: ± 0.1°F Thermisters: ± 0.2°F Sling psychrometer: ± 0.2°F (wetbulb and drybulb)
Pressure in pounds per square inch (psi) of vapor and suction line	Compound pressure gauge for R22 and R410a	Refrigerant pressure: ± 2 % for R22 and ± 3 percent for R410a
Temperature (°F) of vapor and suction lines	Digital thermometer with clamp-on insulated type K thermocouples	Digital thermometer: ± 0.1°F Type K thermocouple: ± 0.1% °F
Temperature (°F) of actual and required superheat and subcooling	Digital thermometer with clamp-on insulated type K thermocouples	Digital thermometer: ± 0.1°F Type K thermocouple: ± 0.1% °F
Airflow in cubic feet per minute (cfm) across air conditioner evaporator coil	Digital pressure gauge and fan-powered flow hood, flow meter pitot tube array, and electronic balometer	Fan-powered flowhood: ± 3% Flow meter pitot tube array: ± 7% Electronic balometer: ± 4%
Ounces (oz.) of refrigerant charge added or removed	Digital electronic charging scales	Electronic scale: ± 0.5 ounces or ± 0.1% whichever is greater
Total power in kilowatts (kW) of air conditioner compressor and fans	True RMS 4-channel power data loggers and 4-channel power analyzer	Data loggers, CTs, PTs: ± 1% Power analyzer: ± 1%

Return and supply temperatures were measured inside the return and supply plenums. Temperature and power were measured at one minute intervals. Airflow was measured before and after making any changes to the supply/return ducts, opening vents, or installing new air filters that would affect airflow. Return and supply enthalpies were derived from the temperature measurements using standard psychrometric algorithms.[9] EER was derived from the combination of enthalpy, airflow, and power measurements. Measurements were made to evaluate the relative change in efficiency not the absolute efficiency. All measurements of air conditioner performance were made within minutes of any efficiency improvements, but at least 15 minutes after any refrigerant charge adjustments. Measurement tolerances are less important than the relative performance change. New and old systems were examined with labeled Seasonal Energy Efficiency Ratios (SEER) or EER ranging from 6 to 15.5.[10] Billing data for most sites was collected for a three year period from January 2001 through December 2003. These data were used to develop annual energy savings.

Time-of-use loggers or spot-measurements were used to determine the connected load and power factor of installed measures. A minimum of a few hours of data up to a maximum of several months of data were gathered for short-term metering. Additionally, wattage measurements were performed on lighting and HVAC measure installations to calibrate estimates and engineering calculations of electrical demand. In order to ensure a high level of accuracy, all kW and kWh savings estimates were compared to spot-measurements, short-term measurements, continuous measurements, utility data, and manufacturers' data.

[9] Kelsey, J. 2004. Get Psyched™ Psychrometric Software for MS Excel, Available online: www.kw-engineering.com. Oakland, Calif. kW Engineering.

[10] SEER is an adjusted rating based on steady-state EER measured at standard conditions of 82°F outdoor and 80°F drybulb/67°F wetbulb indoor temperature multiplied by the Part Load Factor with a default of 0.875 (ARI 2003).

2.5 Reporting

The NCPA Tracking Database was updated on a bi-annual basis and utility program data and M&V data was summarized on an annual basis. Annual reporting of the tracking data provided summary information of program activity including estimated total kW and kWh savings for each NCPA program. Reports provided ex-ante kW and kWh savings for each program as well as utility spending by program. As M&V efforts were completed the reports showed both ex-ante and M&V gross and net savings. Semi-annual and annual reports provided up-to-date information regarding the M&V efforts and gross and net savings. The first annual report summarized program activity and database savings through August 2002. This report summarized database savings and included verified gross and net savings based on results from completed projects. The final report presents gross and net results, as well as process evaluation findings that assessed the effectiveness of the programs.

In addition to the bi-annual and annual reports, written status reports were submitted to the NCPA Project Manager along with invoices. The reports included a summary of previous activities, future activities, and necessary revisions or changes to the schedule and budget.

3. Commercial & Industrial Lighting Programs

Commercial and Industrial (C&I) Lighting Programs were implemented by Alameda, Gridley, Healdsburg, Lassen Municipal Utility District (LMUD), Lodi, Lompoc, Modesto Irrigation District (MID), Palo Alto, Roseville, Santa Clara (Silicon Valley Power), and Truckee Donner Public Utility District (TDPUD). The programs realized peak kW and kWh savings by paying incentives to consumers for the installation of high efficiency lighting systems, lamp removal (i.e., delamping), or controls. The lighting measures have an effective useful life of 16 years.[11] Approximately 626 projects and 125,966 lighting fixtures were installed from 2001 through 2003 under programs sponsored by 11 utilities with $2,100,482 of SB5X funds administered by NCPA.

The M&V results for C&I lighting are summarized in **Table 3.1**. The ex ante savings are 21,023,999 kWh/yr and 4,944 kW. The M&V gross ex post program savings are 24,067,909 kWh/yr ± 255,650 kWh/yr and 5,203 kW ± 54 kW at the 90 percent confidence level. The M&V net ex post program savings are 20,301,517 kWh/yr ± 213,512 kWh/yr and 4,414 kW ± 46 kW at the 90 percent confidence level. The M&V net ex post lifecycle savings are 324,824,278 ± 3,416,193 kWh based on a 16-year effective useful life. The net realization rates are 0.97 for kWh and 0.89 for kW savings. The ex post savings are based on engineering analyses and on-site audits for a random sample of 44 sites. The on-site audits included verification of all installed measures that received incentives as well as true RMS power measurements of pre- and post-installation fixtures and light logger measurements or interviews to obtain hours of operation. The net-to-gross ratios are calculated based on decision maker surveys completed for 75

[11] The SB5X lighting programs provided incentives for hard-wired fixtures with an effective useful lifetime of 16 years. See *Energy Efficiency Policy Manual*, Chapter 4, page 21-22, prepared by the California Public Utilities Commission, 2001.

participants. The weighted average net-to-gross ratio is 85 percent meaning that roughly 15 percent of customers would have made the lighting improvements without the program.[12]

Table 3.1 Summary of M&V Results for NCPA SB5X C&I Lighting Programs

NCPA Utility	Measures	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Gross Ex Post Savings kWh/yr	M&V Gross Ex Post Savings kW	Net-to-Gross Ratio	M&V Net Ex Post Savings MWh/yr	M&V Net Ex Post Savings kW	Net Realization Rate Relative to Planning kWh/yr	Net Realization Rate Relative to Planning kW
Alameda	6,091	1,127,255	368.00	1,123,456	337.27	0.85	954,938	286.68	0.85	0.78
Gridley	74	38,468	16.99	37,940	16.74	0.84	31,870	14.06	0.83	0.83
Healdsburg	110	20,434	4.90	20,365	4.49	0.85	17,310	3.81	0.85	0.78
LMUD	994	183,964	80.44	183,344	73.72	0.85	155,842	62.67	0.85	0.78
Lodi	24	4,500	1.01	4,485	0.92	0.85	3,812	0.78	0.85	0.78
Lompoc	50	15,768	1.81	15,768	1.81	1.00	15,768	1.81	1.00	1.00
MID	11,230	847,226	207.20	844,371	189.89	0.84	709,272	159.51	0.84	0.77
Palo Alto	8,822	1,128,674	285.71	1,031,308	258.72	0.98	1,010,682	253.55	0.90	0.89
Roseville	6,718	1,651,041	384.96	1,294,766	423.13	0.88	1,139,394	372.36	0.69	0.97
SVP	87,913	15,612,124	3,436.29	19,089,720	3,742.14	0.83	15,844,468	3,105.98	1.01	0.90
TDPUD	3,940	394,545	156.40	422,386	154.40	0.99	418,162	152.86	1.06	0.98
Total	125,966	21,023,999	4,943.70	24,067,909	5,203.25	0.85	20,301,517	4,414.07	0.97	0.89

Note: Net-to-gross ratios for Alameda, Healdsburg, LMUD, and Lodi are weighted average values for all surveys.

A separate report titled, *Measurement & Verification Report for NCPA SB5X Commercial and Industrial Lighting Programs,* provides detailed M&V reports for the 44 on-site audits performed in Gridley, Lompoc, Palo Alto, Roseville, Santa Clara, and Truckee Donner PUD. M&V site work was performed at customer sites from September 2001 through December 2002. **Appendix A** provides the Decision-Maker Survey.

3.1 M&V Approach for C&I Lighting

The measurement and verification of energy and demand impacts of Commercial & Industrial Lighting programs are based on 44 detailed on-site surveys and 75 participant surveys. The ex post energy and peak demand savings were determined using IPMVP Option A (i.e., partially measured retrofit isolation) and IPMVP Option B (i.e., retrofit isolation). Data were collected during the on-site surveys to support the engineering analyses. Make, model numbers, fixture types, wattages, and quantities of rebated equipment were verified (i.e., lamps and electronic ballasts). Representative lighting fixtures were measured for wattage using true RMS digital meters. Groups of like fixtures were measured at the light switch with the digital clamp meter to determine true wattage. Lighting logger data were used to develop accurate estimates of lighting system time-of-use. Lighting loggers were installed for a period of 1-2 weeks to record on and off times. The use of monitored data provided a better estimate of kW and kWh savings. Savings were estimated for a statistically representative sample, and expanded to the population using statistical methods.

Gross M&V program evaluation savings (i.e., kWh/yr and kW) are based on the average gross realization rates from the detailed M&V on-site audits. Gross M&V savings for each site in the

[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.

audit are based on the difference between pre- and post-retrofit equipment power and hours of operation. 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. M&V net program savings are based on the participant decision-maker survey results that were analyzed to develop net-to-gross ratios for kWh and kW savings.

3.2 M&V Sample Design and Precision

The sample design for the M&V on-site audits and participant surveys achieved a minimum precision of plus or minus 10% at the 90% confidence level. Load impacts were evaluated with a random M&V sample of 44 program participants who accounted for 29 percent of the total program savings. The M&V sample coefficient of variation is 0.55 for kWh/fixture and 0.40 for kW/fixture based on the gross realization rates from the M&V results. The M&V on-site audit sample size included 23,875 fixtures at 44 participant sites. The participant survey coefficient of variation was 0.18. The M&V participant survey sample size is 75.[13] These sample sizes exceed the 90/10 confidence level.

Statistical methods were used to analyze data and extrapolate M&V savings estimates from the sample to the population of program participants and to evaluate the statistical precision of the results.[14] The M&V on-site survey sample of 44 participants provided relative precision of ±1% for MW and GWh. The survey sample of 75 participants yielded relative precision of ±3.4%.

3.3 Baseline

The baseline kWh and kW values are based on measured fixture wattages or reference fixture wattages. The baselines for new construction were Title-24 lighting power densities. Measurements were made to verify pre-retrofit equipment power and hours of operation to develop the M&V baseline of energy and peak demand (i.e., kWh/yr and kW). Data were collected for representative lighting fixtures using true RMS digital power meters, data loggers, light loggers, interviews, and telephone surveys (i.e., decision maker survey). Groups of like fixtures were measured at the light switch or electrical panel to determine true RMS wattage per fixture. Measured values were compared to reference values to ensure accurate engineering analysis of energy and peak demand savings.

3.4 M&V Findings for C&I Lighting

Findings of the random M&V on-site audits are provided in the **Tables 3.2** through **3.7** for customer sites in the Gridley, Lompoc, Palo Alto, Roseville, Santa Clara, and TDPUD utility service areas.

[13] M&V audit sites were randomly selected in each utility service area based on a first come first served basis (i.e., available customer information from the utility program tracking databases and customers willing to participate).

[14] 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.

Table 3.2 Findings of Random M&V On-Site Audits in Gridley

Site	Ex Ante Savings kWh/yr	Ex Ante kW	M&V Savings kWh/yr	M&V Savings kW	Gross Realization Rate kWh	Gross Realization Rate kW	Fixture Qty.	Fixture Retrofit Type	Floor Area	Lighting Retrofit Cost	Incentive	M&V Measurement
#1	28,545	12.75	28,019	12.5	0.98	0.98	42	T5-6	n/a	$28,000	$10,000	True RMS Power
#2	9,923	4.24	9,922	4.24	1.00	1.00	32	T-8	7,200	$6,138	$4,876	True RMS Power
Total	**38,468**	**16.99**	**37,940**	**16.74**	**0.99**	**0.99**	**74**		**7,200**	**$34,138**	**$14,876**	

Table 3.3 Findings of Random M&V On-Site Audits in Lompoc

Site	Ex Ante Savings kWh/yr	Ex Ante kW	M&V Savings kWh/yr	M&V Savings kW	Gross Realization Rate kWh	Gross Realization Rate kW	Fixture Qty.	Fixture Retrofit Type	Floor Area	Lighting Retrofit Cost	Incentive	M&V Measurement
#1	**3,469**	**0.4**	**3,469**	**0.4**	**1.00**	**1.00**	**11**	**LED Exit**	**12,000**	**$550**	**$195**	True RMS Power

Table 3.4 Findings of Random M&V On-Site Audits in Palo Alto

Site	Ex Ante Savings kWh/yr	Ex Ante kW	M&V Savings kWh/yr	M&V Savings kW	Gross Realization Rate kWh	Gross Realization Rate kW	Fixture Qty.	Fixture Retrofit Type	Floor Area	Lighting Retrofit Cost	Incentive	M&V Measurement
#1	308,148	55.3	262,059	42.8	0.85	0.77	1,827	T-8, CFL, LED Exit	357,800	$88,252	$45,178	True RMS Power
#2	310,463	100.6	273,882	89.3	0.88	0.89	1,954	T-8, CFL, LED Exit	212,485	$124,621	$63,794	True RMS Power
#3	26,122	9.5	43,288	17.1	1.66	1.80	350	T-8, CFL, LED Exit	30,309	$16,663	$8,530	True RMS Power
#4	36,209	9.6	20,413	6.7	0.56	0.70	311	T-8, CFL, LED Exit	15,247	$14,408	$7,375	True RMS Power
#5	54,189	16.9	43,383	14.1	0.80	0.83	580	T-8, CFL, LED Exit	22,679	$27,642	$14,150	True RMS Power
#6	74,921	22.7	62,240	19.5	0.83	0.86	800	T-8, CFL, LED Exit	30,302	$32,689	$16,733	True RMS Power
#7	31,624	8	26,580	6.9	0.84	0.87	274	T-8, CFL, LED Exit	12,284	$19,234	$9,846	True RMS Power
#8	200,732	35.2	215,949	31.7	1.08	0.90	801	T-8, CFL, LED Exit	n/a	$59,908	$30,667	True RMS Power
#9	44,750	12.3	33,507	8.1	0.66	0.75	391	T-8, CFL, LED Exit	26,313	$26,120	$13,371	True RMS Power
#10	41,515	15.7	50,007	22.5	0.66	0.75	377	T-8, CFL, LED Exit	29,869	$19,983	$10,229	True RMS Power
Total	**1,128,674**	**285.8**	**1,031,308**	**258.8**	**0.91**	**0.91**	**7,665**		**737,288**	**$429,518**	**$219,870**	

Table 3.5 Findings of Random M&V On-Site Audits in Roseville

Site	Ex Ante Savings kWh/yr	Ex Ante kW	M&V Savings kWh/yr	M&V Savings kW	Gross Realization Rate kWh	Gross Realization Rate kW	Fixture Qty.	Fixture Retrofit Type	Floor Area	Lighting Retrofit Cost	Incentive	M&V Measurement
#1	6,479	1.5	3,450	1.2	0.53	0.80	69	T-8	9,300	$1,990	$1,820	True RMS Power
#2	5,714	1.3	4,239	1.3	0.74	1.00	54	T-8	8,900	$1,708	$1,608	True RMS Power
#3	3,936	1.0	6,163	1.3	1.57	1.30	34	T-8	4,000	$1,320	$1,230	True RMS Power
#4	6,123	1.4	4,083	1.4	0.67	1.00	43	T-8	3,000	$2,580	$1,720	True RMS Power
#5	43,866	9.8	28,094	11.71	0.64	1.19	266	T-8, CFL, LED Exit, Delamp	25,000	$7,025	$5,125	True RMS Power
#6	22,106	4.7	19,293	4.7	0.87	1.00	92	T-8, CFL, LED Exit	5,700	$2,976	$1,595	True RMS Power
#7	4,922	1.1	8,272	1.1	1.68	1.00	37	T-8	3,700	$1,420	$1,335	True RMS Power
#8	4,877	1.0	2,980	1.1	0.61	1.10	44	T-8	1,500	$1,539	$1,372	True RMS Power
#9	6,098	1.4	3,794	1.6	0.62	1.14	43	T-8, Delamp, Occ. Sensors	4,500	$3,502	$1,182	True RMS Power
#10	4,416	1.1	4,748	1.3	1.08	1.18	35	T-8	3,000	$1,730	$1,380	True RMS Power
Total	**108,537**	**24.3**	**85,116**	**26.71**	**0.78**	**1.10**	**717**		**68,600**	**$25,790**	**$18,367**	

Table 3.6 Findings of Random M&V On-Site Audits in Santa Clara

Site	Ex Ante Savings kWh/yr	Ex Ante kW	M&V Savings kWh/yr	M&V Savings kW	Gross Realization Rate kWh	Gross Realization Rate kW	Fixture Qty.	Fixture Retrofit Type	Floor Area	Lighting Retrofit Cost	Incentive	M&V Measurement
#1	90,696	23.5	106,012	28.0	1.17	1.19	730	T-8, CFL, LED Exit, Delamp	47,000	$57,836	$13,293	True RMS Power
#2	81,613	19.1	199,942	51.1	2.45	2.68	629	T-8	36,022	$10,141	$9,563	True RMS Power
#3	243,338	82.8	294,776	84.7	1.21	1.02	2,266	T-8, CFL, LED Exit, Occ. Sensors	31,600	$374,525	$62,535	Lite Loggers, True RMS Power
#4	41,678	16.0	57,729	19.0	1.39	1.19	254	T-8	25,125	$6,273	$6,273	True RMS Power
#5	196,560	22.5	273,403	23.1	1.39	1.03	331	T-8, Occ. Sensors	32,000	$48,350	$6,450	Lite Loggers, True RMS Power
#6	2,187,787	342.5	2,670,777	364.0	1.22	1.06	3,345	T-8, CFL, LED Exit, Delamp, Occ. Sensors	814,000	$381,728	$130,352	Lite Loggers, True RMS Power

Table 3.6 Findings of Random M&V On-Site Audits in Santa Clara (continued)

Site	Ex Ante Savings kWh/yr	Ex Ante kW	M&V Savings kWh/yr	M&V Savings kW	Gross Realization Rate kWh	Gross Realization Rate kW	Fixture Qty.	Fixture Retrofit Type	Floor Area	Lighting Retrofit Cost	Incentive	M&V Measurement
#7	141,523	32.4	159,909	37.3	1.13	1.15	401	T-8	30,000	$31,563	$8,708	True RMS Power
#8	194,401	43.8	205,310	44.1	1.06	1.01	372	T-8, CFL, LED Exit	32,150	$28,462	$7,699	True RMS Power
#9	225,228	58.9	321,743	70.9	1.43	1.20	1,871	T-8, CFL, Delamp, LED Exit, Occ. Sensors	125,482	$112,555	$34,997	True RMS Power
#10	69,568	29.7	120,763	35.9	1.74	1.21	454	T-8	80,210	$13,472	$7,939	True RMS Power
#11	341,687	78.2	253,300	58.0	0.74	0.74	1,595	T-8, CFL, Halogen	53,000	$18,386	$18,386	True RMS Power
Total	**3,814,079**	**749.4**	**4,663,664**	**816.1**	**1.22**	**1.09**	**12,248**		**1,306,589**	**$1,083,291**	**$306,195**	

Table 3.7 Findings of Random M&V On-Site Audits in Truckee Donner PUD

Site	Ex Ante Savings kWh/yr	Ex Ante kW	M&V Savings kWh/yr	M&V Savings kW	Gross Realization Rate kWh	Gross Realization Rate kW	Fixture Qty.	Fixture Retrofit Type	Floor Area	Lighting Retrofit Cost	Incentive	M&V Measurement
#1	66,171	34	72,827	37.2	1.10	1.10	66,171	T-8, CFL, MH, LED Exit	62,745	$65,036	$21,677	True RMS Power
#2	65,319	31	64,940	30.5	0.99	0.98	65,319	T-8, CFL, Delamp, Sensors	56,585	$60,787	$20,262	True RMS Power
#3	4,007	2	6,692	3.4	1.67	2.13	4,007	T-8, CFL, LED Exit	9,252	$3,948	$1,316	True RMS Power
#4	97,181	28	109,500	33	1.13	1.18	97,181	T-8, CFL, LED Exit, Halogen	n/a	$24,502	$15,000	True RMS Power
#5 - #9 5 sites	33,425	5.9	16,890	6.6	0.51	1.12	33,425	T-8, CFL, Halogen	n/a	$18,159	$6,053	True RMS Power
#10	55,802	18	106,824	28.7	1.91	1.59	55,802	T-8, CFL, LED Exit, Sensors	40,000	$52,308	$52,308	Lite Loggers, True RMS Power
Total	**321,905**	**118.5**	**377,673**	**139.4**	**1.17**	**1.18**	**3,170**		**168,582**	**$224,740**	**$116,616**	

Note: TDPUD Site #1 and #2 received additional measures after the M&V audit was completed.

3.5 Participant Survey Findings

Participant surveys were completed for 75 participants in seven NCPA utility service areas. The net-to-gross ratios for Alameda, Healdsburg, LMUD, and Lodi are the weighted average value. The NTGR is used to estimate the fraction of free riders who would have otherwise implemented lighting improvements in the absence of the program. Participant Survey Findings for each program are presented in **Table 3.8**. The weighted average net-to-gross ratio is 0.85 based on average participant survey results multiplied times savings for each program divided by total savings for all programs.[15]

Table 3.8 Findings of NCPA SB5X C&I Lighting Program Participant Surveys

NCPA Utility	Projects	Completed Surveys	Gross Ex Post Savings kWh/yr	Gross Ex Post Savings kW	Weighting Factor kWh/yr	Weighting Factor kW	Net-to-Gross Ratio
Alameda	41	n/a	1,123,456	337.3	0.046679	0.064820	0.85
Gridley	4	1	37,940	16.7	0.001576	0.003217	0.84
Healdsburg	2	n/a	20,365	4.5	0.000846	0.000862	0.85
Lassen MUD	5	n/a	183,344	73.7	0.007618	0.014169	0.85
Lodi	3	n/a	4,485	0.9	0.000186	0.000177	0.85
Lompoc	2	1	15,768	1.8	0.000655	0.000349	1
MID	12	3	844,371	189.9	0.035083	0.036495	0.84
Palo Alto	10	39	1,031,308	258.7	0.042850	0.049723	0.98
Roseville	338	9	1,294,766	423.1	0.053796	0.081321	0.88
Santa Clara	201	7	19,089,720	3742.1	0.793161	0.719193	0.83
TDPUD	8	15	422,386	154.4	0.017550	0.029674	0.99
Total	626	75	24,067,909	5203.2	1	1	0.85

Note: Net-to-gross ratios for Alameda, Healdsburg, LMUD, and Lodi are weighted average values for all surveys.

3.6 Gross Realization Rates for C&I Lighting Programs

Gross M&V program evaluation savings (i.e., kWh/yr and kW) are based on the Average Gross Realization Rates (AGRR) from the M&V on-site audits. The weighted average gross realization rates for the 44 M&V sites are 1.145 for kWh and 1.053 for kW as shown in **Table 3.9**. Gross ex post savings and realization rates for all utilities in the C&I lighting program category are provided in **Table 3.10**.

Table 3.9 Average Gross Realization Rates for M&V Sites

NCPA Utility	Qty.	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Ex Post Savings kWh/yr	M&V Ex Post Savings kW	AGRR kWh/yr	AGRR kW
Gridley	74	38,468	16.99	37,942	16.74	0.986	0.985
Lompoc	11	3,469	0.40	3,469	0.40	1.000	1.000
Palo Alto	7,665	1,128,674	286	1,031,308	259	0.914	0.906
Roseville	717	108,537	24	85,116	27	0.784	1.099
SVP	12,248	3,814,079	749	4,663,664	816	1.223	1.089
TDPUD	3,170	321,905	119	377,673	139	1.173	1.176
M&V Total	23,885	5,415,132	1,195	6,199,172	1,258	1.145	1.053

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

Table 3.10 Gross Ex Post Savings and Realization Rates for C&I Lighting Programs

NCPA Utility	Qty.	Ex Ante Program Savings kWh/yr	Ex Ante Program Savings kW	M&V Gross Ex Post Savings kWh/yr	M&V Gross Ex Post Savings kW	AGRR kWh/yr	AGRR kW
Alameda	6,091	1,127,255	368.00	1,123,456	337.27	0.997	0.917
Gridley	74	38,468	16.99	37,942	16.74	0.986	0.985
Healdsburg	110	20,434	4.90	20,365	4.49	0.997	0.917
LMUD	994	183,964	80.44	183,344	73.72	0.997	0.917
Lodi	24	4,500	1.01	4,485	0.92	0.997	0.917
Lompoc	50	15,768	1.81	15,768	1.81	1.000	1.000
MID	11,230	847,226	207.20	844,371	189.89	0.997	0.917
Palo Alto	8,822	1,128,674	285.71	1,031,308	258.72	0.914	0.906
Roseville	6,718	1,651,041	384.96	1,294,766	423.13	0.784	1.099
SVP	87,913	15,612,124	3,436.29	19,089,720	3,742.14	1.223	1.089
TDPUD	3,940	394,545	156.40	422,386	154.40	1.173	1.176
Total	125,966	21,023,999	4,943.70	24,067,911	5,203.25	1.145	1.053

4. Commercial & Industrial HVAC Programs

Commercial and Industrial (C&I) Heating, Ventilating, and Air Conditioning (HVAC) Incentive Programs were implemented by Gridley, Lodi, Modesto Irrigation District (MID), Palo Alto, Port of Oakland, Plumas Sierra Electric Cooperative (PSREC), Redding, Roseville Electric, Truckee-Donner Public Utility District (TDPUD), Turlock Irrigation District (TID), and Ukiah. The programs realized peak kW and kWh savings by paying incentives to C&I customers for installing high efficiency air conditioning measures. The programs provided incentives for 590 projects from 2001 through 2003 with $988,748 of SB5X funds administered by NCPA.

Ex ante program savings are summarized in **Table 4.1**, and ex post savings are summarized in **Table 4.2**. The total ex ante program savings are 5,645,055 kWh/yr and 2,482 kW. The total M&V gross ex post savings are 4,095,475 ± 231,669 kWh/yr and 2,236 ± 159 kW. The total M&V net ex post savings for the program are 3,944,622 ± 225,177 kWh/yr and 2,142 ± 156 kW. The M&V net ex post lifecycle savings are 58,498,564 ± 3,370,974 kWh as shown in **Table 4.3**. Ex post savings are based on billing data, engineering analysis, and computer simulations consistent with the *International Performance Measurement & Verification Protocols*. Ex post energy savings for six custom air conditioning projects in MID, Palo Alto, and TDPUD are based on billing data, engineering analysis, measured data, and DOE-2.2 simulations. The six large custom air conditioning projects accounted for 79 percent of total kWh and 71 percent of total kW savings for the C&I Air Conditioner Programs. Ex post energy savings for the Gridley, Lodi, MID, Redding, Roseville, TID, and Ukiah small commercial air conditioning rebate programs and the PSREC Ground Source Heat Pump (GSHP) rebate program are based on billing regression analyses and engineering analyses for 54 sites using the PRInceton Scorekeeping Method (PRISM).[16] Ex post energy and peak demand savings for the Roseville commercial HVAC tune-up program are based on billing regression and engineering analyses for 11 sites with 20 air conditioners. Ex post peak kW savings are based on field measurements of peak kW for 19 packaged air conditioners, 16 GSHP units, and 6 large custom air conditioning projects. The net-to-gross ratio is calculated based on decision maker surveys regarding whether or not the unit would have been installed without rebates from the programs. The average net-to-

[16] Fels, M., Kissock, K., Marean, M., Reynolds, C. 1995. *PRISM Advanced Version 1.0 User's Guide*. Princeton, New Jersey. Princeton University, Center for Energy and Environmental Studies.

gross ratio is 96 percent indicating approximately 4 percent of C&I high air conditioning measures would have been purchased anyway without the program.[17] The realization rates are 0.70 for kWh savings and 0.86 for kW savings. The M&V savings and net realization rates are lower than anticipated primarily due to lower baseline usage, unrealized or lower ex post savings, and lower net-to-gross ratios.

Table 4.1 Ex Ante Savings for NCPA SB5X C&I HVAC Incentive Programs

NCPA Utility	Qty.	Ex Ante Savings kWh/yr	Ex Ante Savings kW	Ex Ante Net-to-Gross Ratio kWh/y	Ex Ante Net-to-Gross Ratio kW	Ex Ante Savings kWh/y	Ex Ante Savings kW
Gridley	2	3,995	4.4	1	1	3,995	4.4
Lodi	6	1,200	1.3	1	1	1,200	1.3
MID	79	46,479	52.8	1	1	46,479	52.8
MID-Custom	4	1,582,858	789.0	1	1	1,582,858	789.0
Palo Alto-Custom	1	2,776,800	960.0	1	1	2,776,800	960.0
Port of Oakland-Custom	1	250,000	60.0	1	1	250,000	60.0
PSREC-GSHP	16	256,016	63.4	1	1	256,016	63.4
Redding	33	38,101	42.5	1	1	38,101	42.5
Roseville	93	203,288	205.3	1	1	203,288	205.3
Roseville AC Tune-up ≤5 ton	250	130,000	130.0	1	1	130,000	130.0
Roseville AC Tune-up >5 ton	43	44,720	44.7	1	1	44,720	44.7
TDPUD-Custom	1	229,166	87.0	1	1	229,166	87.0
TID	50	29,177	29.8	1	1	29,177	29.8
Ukiah	11	53,255	12.2	1	1	53,255	12.2
Total	**590**	**5,645,055**	**2,482.4**	**1.00**	**1.00**	**5,645,055**	**2,482**

Table 4.2 M&V Ex Post Savings for NCPA SB5X C&I HVAC Incentive Programs

NCPA Utility	Qty.	M&V Gross Ex Post Savings kWh/y	M&V Gross Ex Post Savings kW	Net-to-Gross Ratio kWh/y	Net-to-Gross Ratio kW	M&V Net Ex Post Savings kWh/y	M&V Net Ex Post Savings kW	Net Realization Rate kWh/y	Net Realization Rate kW
Gridley	2	1,005	1.2	0.97	0.97	972	1.1	0.24	0.25
Lodi	6	4,021	4.6	0.96	0.96	3,860	4.4	3.22	3.41
MID	79	50,542	57.8	0.77	0.77	38,918	44.5	0.84	0.84
MID-Custom	4	1,673,760	961.0	0.96	0.96	1,603,623	920.7	1.01	1.17
Palo Alto-Custom	1	1,473,327	815.0	0.99	0.99	1,456,957	805.9	0.52	0.84
Port of Oakland-Custom	1	250,000	60.0	1.00	1.00	250,000	60.0	1.00	1.00
PSREC-GSHP	16	91,881	24.6	0.88	0.88	80,396	21.5	0.31	0.34
Redding	33	19,939	22.9	0.96	0.96	19,141	21.9	0.50	0.52
Roseville	93	95,731	80.5	0.83	0.83	79,681	67.0	0.39	0.33
Roseville AC Tune-up <5 ton	250	73,828	44.7	0.96	0.96	70,875	42.9	0.55	0.33
Roseville AC Tune-up >5 ton	43	25,988	14.0	0.96	0.96	24,949	13.5	0.56	0.30
TDPUD-Custom	1	305,628	116.0	0.95	0.95	290,347	110.2	1.27	1.27
TID	50	23,457	26.9	0.79	0.79	18,538	21.3	0.64	0.71
Ukiah	11	6,367	7.3	1.00	1.00	6,367	7.3	0.12	0.60
Total	**590**	**4,095,475**	**2,236.46**	**0.96**	**0.96**	**3,944,622**	**2,142.35**	**0.70**	**0.86**

[17] The net-to-gross ratios reflect what customers would have done in the absence of the program (see Section 3).

Table 4.3 Ex Post Lifecycle Savings for NCPA SB5X C&I HVAC Programs

NCPA Utility	Qty.	M&V Net Ex Post Annual Savings kWh/yr	Effective Useful Lifetime	M&V Net Ex Post Lifecycle Savings kWh	90% CI kWh
Gridley	2	972	15	14,577	4,361
Lodi	6	3,860	15	57,906	17,324
MID	79	38,918	15	583,766	174,651
MID-Custom	4	1,603,623	15	24,054,340	1,554,968
Palo Alto-Custom	1	1,456,957	15	21,854,351	2,635,563
Port of Oakland-Custom	1	250,000	15	3,750,000	375,000
PSREC-GSHP	16	80,396	15	1,205,935	290,858
Redding	33	19,141	15	287,114	85,899
Roseville	93	79,681	15	1,195,214	395,294
Roseville AC Tune-up <5 ton	250	70,875	8	567,003	118,245
Roseville AC Tune-up >5 ton	43	24,949	8	199,590	62,735
TDPUD-Custom	1	290,347	15	4,355,199	1,246,600
TID	50	18,538	15	278,066	83,192
Ukiah	11	6,367	15	95,505	28,573
Total	**590**	**3,944,622**	**15**	**58,498,564**	**3,370,974**

Note: The total 90% confidence interval (CI) kWh is the square root of the sum of the squares of the 90% CI for each program.

The M&V gross savings are based on in-situ 15-minute true RMS power measurements. Each unit included in the random sample was measured for several weeks in order to obtain 15-minute average kW measurements during the 2 PM to 6 PM time frame. The peak kW for each unit was taken as the maximum kW that occurs during the 2 PM to 6 PM weekday time frame from the 15-minute data. Participant telephone surveys were used to evaluate program performance criteria and net-to-gross ratios.

A separate report titled, *Measurement & Verification Report for NCPA SB5X Commercial and Industrial HVAC Incentive Programs*, provides detailed M&V reports for the six custom air conditioning projects in MID, Palo Alto, and TDPUD. M&V site work was performed at customer sites from September 2001 through December 2003. **Appendix A** provides the Decision-Maker Survey.

4.1 M&V Approach for C&I HVAC

The measurement and verification of energy and demand impacts of the Commercial & Industrial HVAC programs are based on billing data, engineering analysis, calibrated DOE-2.2/eQuest computer simulations, and billing regression analyses using the PRInceton Scorekeeping Method (PRISM).[18] The M&V approach is consistent with IPMVP Option B (i.e., retrofit isolation), Option C (whole facility billing regression analysis), and Option D (calibrated simulations). Billing regression analyses was used to baseline annual kWh energy use for packaged units. DOE-2.2 simulations calibrated to billing data were used to estimate gross kWh/yr savings for custom sites. Field measurements were used to estimate gross kW savings.

[18] Fels, M., Kissock, K., Marean, M., Reynolds, C. 1995. *PRISM Advanced Version 1.0 User's Guide*. Princeton, New Jersey. Princeton University, Center for Energy and Environmental Studies.

Field measurements of kW and Energy Efficiency Ratios (EER) were made to evaluate in-situ efficiency for a sample of 34 small commercial air conditioners and 16 GSHP units.[19]

Gross ex post kWh savings are based on billing data analysis of 76 packaged air conditioners and 6 custom sites accounting for 84 percent of the total savings. Gross ex post peak kW savings are based on field measurements of peak kW of 19 packaged air conditioners, 16 GSHP units, and 6 large custom air conditioning projects. Gross savings for the sampled units were compared to ARI ratings and other sources. Net savings are based on decision maker surveys regarding whether or not efficient units would have been installed without rebates from the programs. Participant decision-maker survey results were analyzed to develop net-to-gross ratios for kWh and kW savings.

4.2 Sample Design and Precision

The sample design for the M&V on-site audits and participant surveys achieved a minimum precision of plus or minus 10% at the 90% confidence level. Load impacts were evaluated with a random M&V sample of 67 program participants who accounted for 91 percent of the total program savings. The M&V participant survey sample size is 41. These sample sizes exceed the 90/10 confidence level. The weighted sample coefficient of variation for kWh savings is 0.47, the weighted Cv for kW savings is 0.42, and the weighted participant survey coefficient of variation is 0.09. The Cv values are relatively small because 84 percent of program savings are from 6 custom sites where the savings are based on monthly billing data, detailed site audits, 15-minute kW measurement data, and calibrated DOE-2.2 simulations. The kWh and kW billing and metered data sample included 45 packaged AC units, 16 GSHP units, and 6 custom sites. All results in this report are presented at the 90/10 confidence level.

Sampling methods were used to analyze the data and extrapolate M&V savings estimates from the sample to the population of all program participants and to evaluate the statistical precision of the results. The M&V on-site survey sample of 67 participants provided relative precision of ±7.3% for MW and ±5.7% for GWh. The DMS sample of 41 participants yielded relative precision of ±2.3% for the survey results.

4.3 Baseline

The baseline kWh values are based on billing data and PRISM analyses. For custom HVAC measures the baseline was taken from monthly billing data normalized using DOE-2.2 analyses. The baseline kW values are based on metering results for a random sample of new high efficiency air conditioners, chillers and custom measures (monthly kW from billing data), and old standard air conditioners or the appropriate baseline prior to retrofit of the custom measures. The sample mean baseline full-year unit energy consumption for the standard efficiency commercial packaged air conditioners was 4,366 ± 440 kWh/yr at the 90 percent confidence

[19] EER is the cooling capacity in thousand British Thermal Units per hour (kBtuh) divided by total air conditioner electric power (kW) including indoor fan, outdoor condensing fan, compressor, and controls. The Btu is the energy required to raise one pound of water one degree Fahrenheit. EER values are typically measured under laboratory conditions of 95°F condenser entering air and 80°F drybulb and 67°F wetbulb evaporator entering air.

level. The sample mean baseline full-year unit energy consumption for the Roseville HVAC Tune-up program was 4,881 ± 1,287 kWh/yr at the 90 percent confidence level. The sample mean baseline kW varied from 3.01 ± 0.3 kW for 2 ton standard air conditioner to 6.4 ± 0.6 kW for 5-ton standard units. The baseline efficiency level for each measure was within the requirements of the Energy Policy Act of 1992 (EPACT). EPACT mandated minimum energy efficiency levels of cooling equipment manufactured for sale in the US. EPACT required states adopt codes at least as strict as ASHRAE /IES Standard 90.1-1989. These standards govern the minimum efficiency of packaged and split-system central air conditioners, packaged terminal air conditioners, and water and air-cooled chillers. Recent revisions to these standards and 2001 California Title 24 building codes were used to establish the baseline for each measure and/or site.

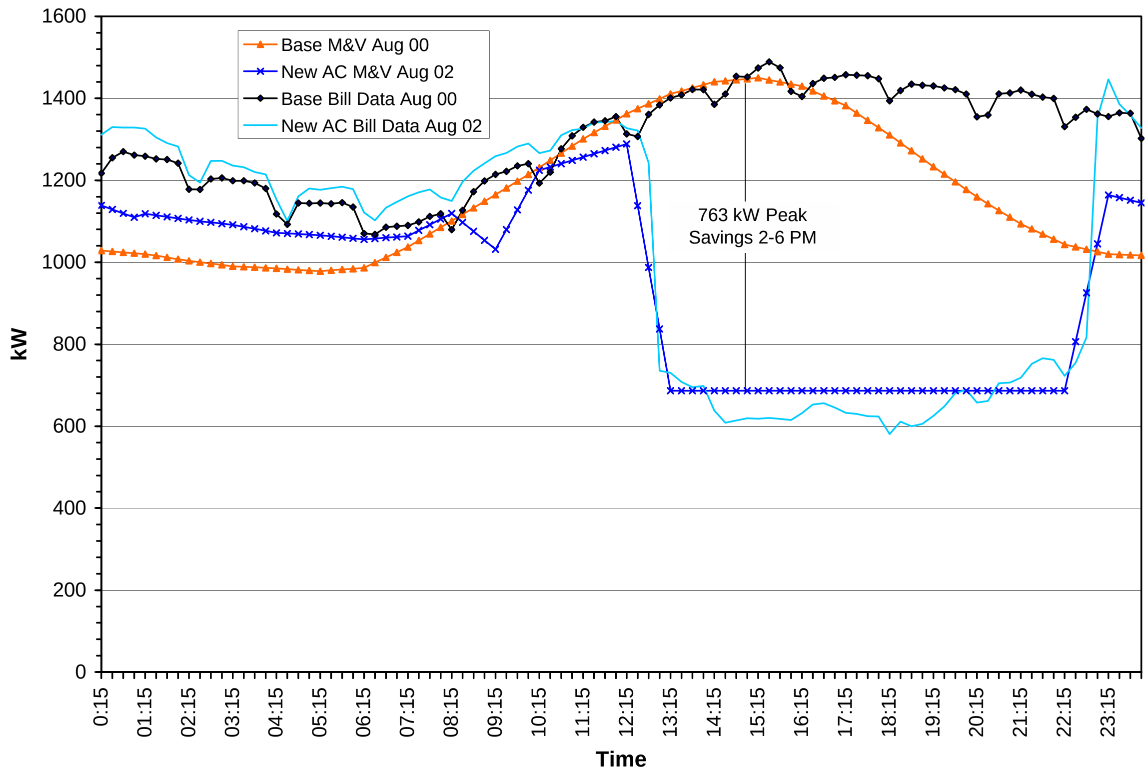
4.4 M&V Findings for C&I HVAC

Field measurements were made to determine in-situ energy and peak demand savings. Multiple data loggers were installed at six large custom sites and more than 20 small commercial sites to measure peak demand and energy use for standard and high efficiency air conditioners or GSHP units and chillers. The measurement sample included chillers, cooling towers, controls, large packaged units (greater than 15 tons), small packaged units (less or equal to 15 tons), and GSHP units (from in the 1.5 to 5.5 tons).

4.4.1 Findings for C&I Custom HVAC Projects

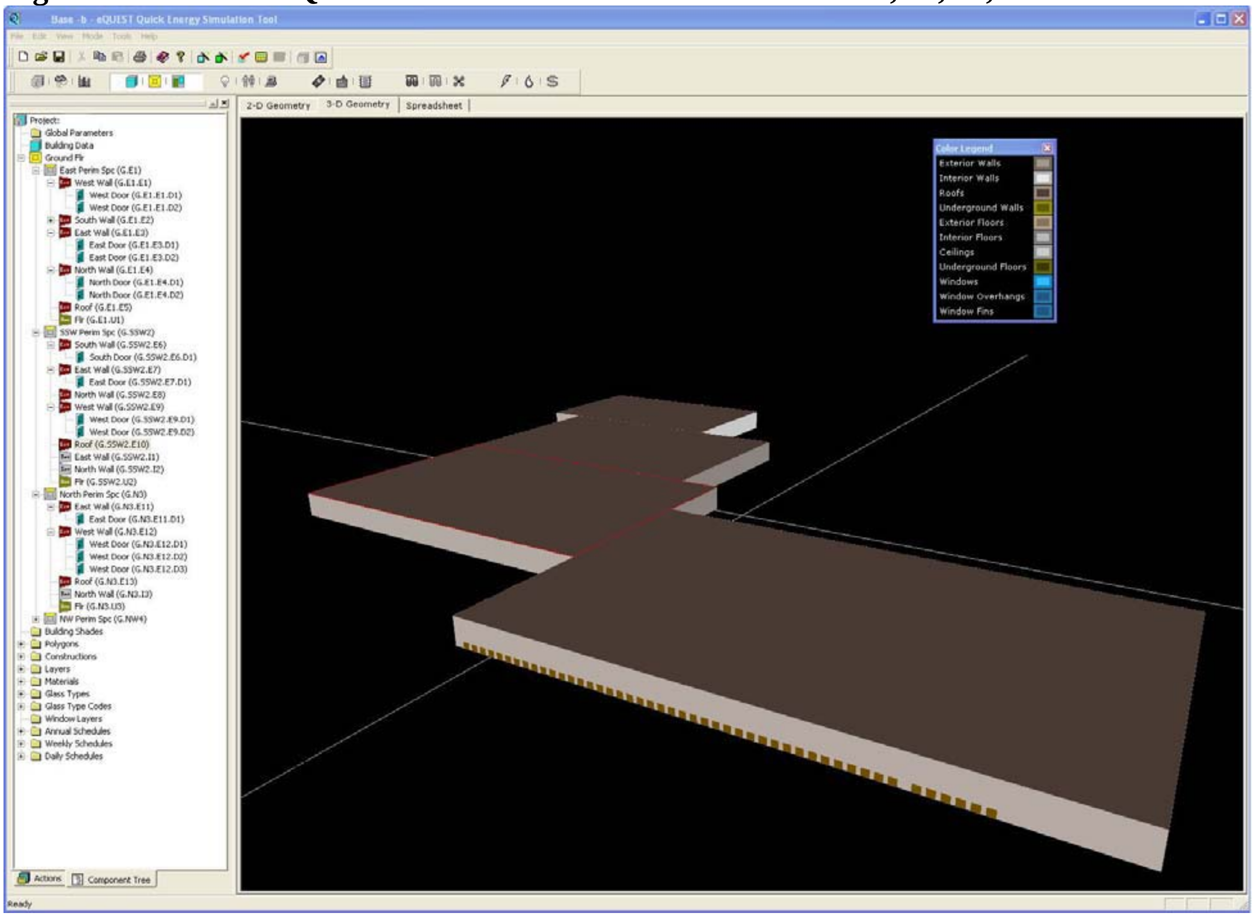
Seven large custom projects accounted for 84 percent of total ex ante kWh savings and 75 percent of peak demand savings for the SB5X C&I Air Conditioner Rebate Programs. This study evaluated 6 out of 7 of the large custom projects. Data loggers were installed at these sites to measure peak demand and energy use for chillers, cooling towers, controls, and 24 large packaged units (greater than 15 tons). Peak kW savings are based on 15-minute kW measurements of pre- and post-retrofit conditions as shown in **Figure 4.1** for the thermal storage project at Site #2. This site provided 33 percent of the total M&V savings.

Figure 4.1 Measurements of Thermal Storage Peak kW Savings for Custom Site #2



The kWh savings for custom sites are based on DOE-2.2 simulations calibrated using utility meter data, average monthly kW profiles, monthly kWh usage, and short-term measurements. The DOE-2,2/eQuest 3-D model for site #2 is shown in **Figure 4.2**.

Figure 4.2 DOE-2.2/eQuest 3-D Model for Site #2 Warehouses #1, #2, #3, and #4



Baseline cooling and M&V savings values for MID custom projects are summarized in **Table 4.4** Baseline cooling and M&V savings for custom projects in Palo Alto and TDPUD are summarized in **Tables 4.5** and **4.6**. The measure effective useful life (EUL) is 15 years for high efficiency chillers, evaporative pre-coolers, thermal storage, and chiller tower optimization.[20]

Table 4.4 MID Baseline Cooling and M&V Savings for C&I Custom HVAC Projects

Site	Base Cooling (kWh/yr)	Tons	Rebated Measure	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option or Report
1	21,278,898	425	Evaporative Pre-cooler	531,250	130	453,792	60	B, C, D
2	4,035,000	1,000	Thermal Storage	730,276	514	747,600	763	B, C, D
3	18,524,071	1,900	CTO Optimization	221,037	90	201,453	51	B, C, D
4	16,075,501	2,400	CTO Optimization	100,295	55	270,915	87	B, C, D
Total	**59,913,470**			**1,582,858**	**789**	**1,673,760**	**961**	
90% CI						108,198	75.98	

[20] See *Energy Efficiency Policy Manual*, Chapter 4, page 21-22, prepared by the California Public Utilities Commission, 2001.

Table 4.5 Palo Alto Baseline Cooling and M&V Savings for C&I Custom HVAC Project

Site	Base Cooling (kWh/yr)	Tons	Rebated Measure	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option or Report
56	5,345,061	3,200	High Eff. VFD Chillers	2,776,800	960	1,473,327	815	B, C, D
90% CI						177,678	137.56	

Table 4.6 TDPUD Baseline Cooling and M&V Savings for C&I Custom HVAC Project

Site	Base Cooling (kWh/yr)	Tons	Rebated Measure	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option or Report
57	3,188,738	370	High Eff. VFD Chiller	229,166	87	305,628	116	B, C, D
90% CI						87,481	2.62	

The Port of Oakland installed an energy efficient cooling tower and energy management system (EMS) at the Oakland Airport involving seven buildings and 430,000 square feet. An on-site inspection was conducted in October 2002 to verify the installed equipment and review the ex ante energy and peak demand savings developed by a third-party engineering consulting firm. The M&V evaluation verified the Port of Oakland ex ante savings of 250,000 kWh/yr and 60 kW, and these values were accepted as the ex post savings.

4.4.2 Findings for C&I High Efficiency Air Conditioners

The 290 C&I high efficiency air conditioner measures accounted for 13 percent of total ex ante kWh savings and 18 percent of total ex ante peak demand savings for the SB5X C&I HVAC Incentive Programs. Data loggers were installed at 20 sites on 19 packaged units and 16 GSHP units to measure peak demand and energy use for standard and high efficiency air conditioners. Measured kW values for packaged air conditioners are shown in **Table 4.7**.

Table 4.7 Measured kW Values for Packaged Air Conditioners

Site	Cooling Capacity Tons	SEER or EER	Baseline kW	Average Measured kW	kW Savings	Indoor Dry/Wetbulb & Outdoor Temperature °F
16	2	15.5 GSHP	2.8	1.77	1.03	80/67/95
35	2	12	2.82	2.26	0.56	80/67/95
36	2	12	2.82	2.14	0.68	80/67/95
15	2.5	15.5 GSHP	3.5	2.21	1.29	80/67/95
40	3	13	4.14	3.21	0.93	80/67/95
17	3	15.5 GSHP	4.1	2.67	1.43	80/67/95
37	4	11	5.4	5.14	0.26	80/67/95
54	4	12	5.4	4.96	0.44	80/67/95
55	4	13	5.4	4.25	1.15	80/67/95
21	4	15.5 GSHP	5.38	3.72	1.66	80/67/95
38	5	11	6.82	6.2	0.62	80/67/95
39	5	12	6.82	5.885	0.935	80/67/95
33	5	12	7.26	6.47	0.79	80/67/103
34	5	12	6.673	5.785	0.888	80/67/92
33	5	13	6.82	5.76	1.06	80/67/95
34	5	13	6.8	5.69	1.11	80/67/95
35	5	13	6.82	5.55	1.27	80/67/95
36	5	13	6.82	5.538	1.282	80/67/95

Table 4.7 Measured kW Values for Packaged Air Conditioners

Site	Cooling Capacity Tons	SEER or EER	Baseline kW	Average Measured kW	kW Savings	Indoor Dry/Wetbulb & Outdoor Temperature °F
37	5	13	6.82	5.571	1.249	80/67/95
27	5	15.5 GSHP	6.8	4.74	2.06	80/67/95
32	7	10.3	8.90	8.02	0.87607	80/67/95
32	10	10.3	13	11.68	1.32	80/67/95
32	10	10.3	13	11.779	1.221	80/67/95
31	10	10.3	13	11.44	1.56	80/67/95
32	15	9.7	20.4	18.67	1.73	80/67/95
47	15	9.7	20.4	18.89	1.51	80/67/95
72	5	10	6.33	5.93	Non-part.	80/67/85
72	5	10	6.655	6.335	Non-part.	80/67/92
73	10	8.9	13	14.57	Non-part.	80/67/103
73	10	8.9	13.3	15.132	Non-part.	80/67/105

Average measured versus calculated kW savings from manufacturer data are shown in **Table 4.8**. Savings range from 0.32 kW for a 2 ton 11-SEER unit to 1.26 kW for a 5 ton 15-SEER conventional unit with maximum savings of 2.1 kW for GSHP units.

Table 4.8 Measured versus Calculated kW Savings for Packaged Units ≤ 5 tons

	Measured kW Baselines and Savings					Calculated kW from Manufacturer Data				
Tons	Baseline 10 SEER kW	11 SEER ΔkW	12 SEER ΔkW	13 SEER ΔkW	GSHP 15.5 EER ΔkW	Baseline 10 SEER kW	11 SEER ΔkW	12 SEER ΔkW	13 SEER ΔkW	GSHP 15.5 EER ΔkW
2	2.8		0.62		1.03	2.82	0.32	0.61	0.79	1.03
2.5	3.8				1.29	3.32	0.25	0.48	0.7	1.29
3	4.1			0.92	1.43	4.14	0.33	0.64	0.93	1.55
3.5	n/a					4.77	0.38	0.74	1.04	1.61
4	5.1	0.26	0.44	1.12	1.66	5.4	0.23	0.45	1.15	1.66
5	6.8	0.62	0.87	1.23	2.06	6.82	0.44	0.85	1.26	2.1

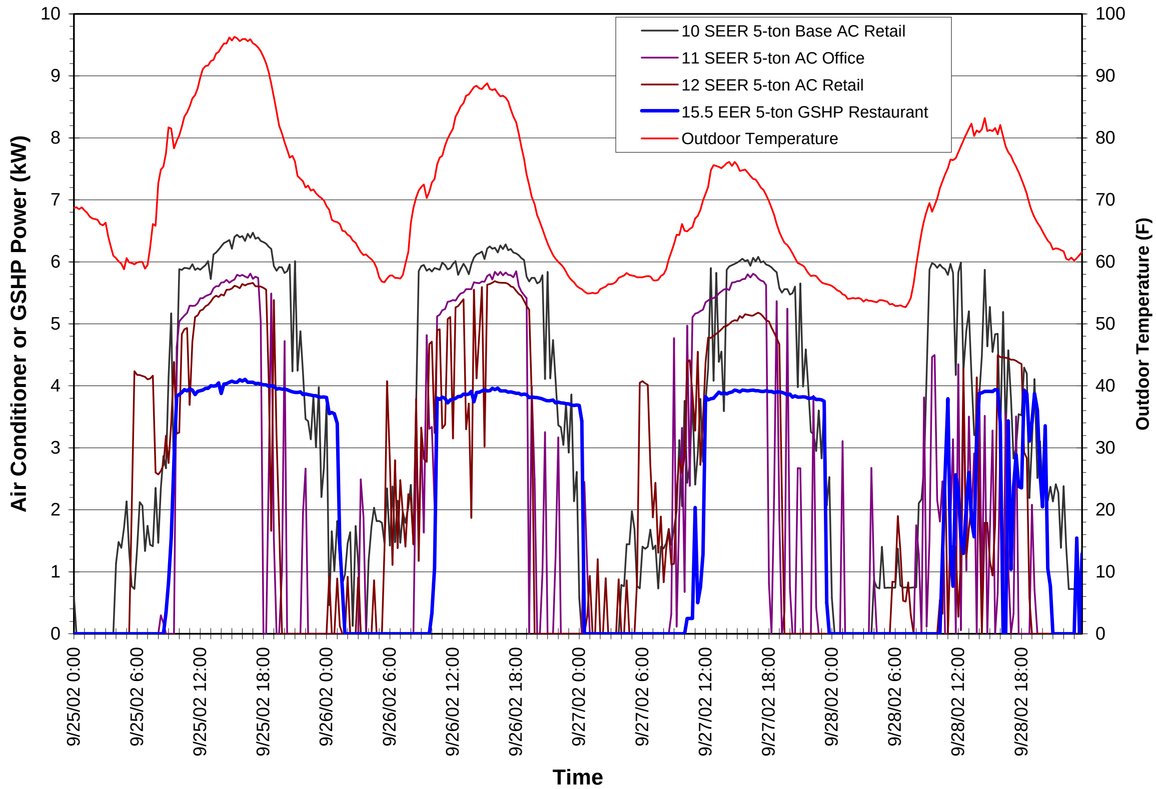
Average estimated peak kW savings for 7, 10, and 15 ton properly installed packaged AC units are shown in **Table 4.9**. Savings range from 0.88 kW for a 7 ton 10.3 EER unit to 4.34 kW for a 15 ton 10.8 EER unit.

Table 4.9 Measured versus Calculated kW Savings for Packaged Units >5 tons

	Measured kW Baselines and Savings			Calculated kW from Manufacturer Data		
Tons	Baseline 8.9 EER kW	10.3 EER ΔkW	11.0 EER ΔkW	Baseline 8.9 EER kW	10.3 EER ΔkW	11.0 EER ΔkW
7	8.65	0.88		8.7	1.26	1.73
10	13	1.37		3.32	1.77	2.09
Tons	Baseline 8.5 EER kW	9.7 EER ΔkW	10.8 EER ΔkW	Baseline 8.5 EER kW	9.7 EER ΔkW	10.8 EER ΔkW
15	20.4	1.62		20.7	2.52	4.34

Average measured savings are based on short-term measurements of standard and energy efficient air conditioners and GSHP units as shown in **Figure 4.3**. These measurements were made on units with proper refrigerant charge and airflow within manufacturers' specifications.

Figure 4.3 Measurements of 5-ton Packaged AC and Ground Source Heat Pump Units



Billing data were collected from 54 sites in MID, PSREC, Roseville, Palo Alto, and TDPUD. These data were used as inputs for the PRInceton Scorekeeping Method (PRISM) or for calibration with DOE-2.2 to develop base cooling values. The cooling savings for packaged units are based on the average SEER or EER improvement with respect to the baselines. Peak kW savings are based on 15-minute data collected for 19 packaged units. Baseline cooling and M&V savings values for MID are summarized in **Table 4.10**. Baseline cooling and M&V savings for GSHP units in PSREC are summarized in **Table 4.11**. Baseline cooling and M&V savings values for Roseville are summarized in **Table 4.12**. The ex ante effective useful life for high efficiency packaged air conditioners is 15 years.[21]

[21] See *Energy Efficiency Policy Manual*, Chapter 4, page 21-22, prepared by the California Public Utilities Commission, 2001.

Table 4.10 MID Baseline Cooling and M&V Savings for Packaged HVAC Units

Site	Base Cooling (kWh/yr)	Tons	Rebated Measure	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option
5	1,620	2.5	12 SEER Pkg. AC	348	0.4	336	0.48	B, C, D
6	2,571	5	13 SEER Pkg. AC	1071	1.22	593	1.26	B, C, D
7	1,493	3	12 SEER Pkg. AC	418	0.47	249	0.64	B, C, D
98	2,684	2	12 SEER Pkg. AC	278	0.32	447	0.61	B, C, D
9	2,617	5	12 SEER Pkg. AC	696	0.79	436	0.85	B, C, D
10	4,212	5	12 SEER Pkg. AC	676	0.79	702	0.85	B, C, D
11	4,774	3	12 SEER Pkg. AC	418	0.47	796	0.64	B, C, D
12	7,264	5	12.5 SEER Pkg. AC	891	1.01	1,453	0.85	B, C, D
13	3,218	4	12 SEER Pkg. AC	557	0.63	536	0.45	B, C, D
14	3,977	2.5	12 SEER Pkg. AC	348	0.4	663	0.48	B, C, D
Average	**3,443**			**570**	**0.65**	**621**	**0.71**	
90% CI	940			143	0.16	185	0.14	

Table 4.11 PSREC Baseline Cooling and M&V Savings for GSHP Units

Site	Base Cooling (kWh/yr)	Tons	Rebated Measure	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option
15	15,260	2.5	15.5 SEER GSHP	16,001	3.96	6,012	1.29	B, C, D
16	12,208	2	15.5 SEER GSHP	16,001	3.96	4,809	1.03	B, C, D
17	18,312	3	15.5 SEER GSHP	16,001	3.96	7,214	1.55	B, C, D
18	9,156	1.5	15.5 SEER GSHP	16,001	3.96	3,607	0.77	B, C, D
19	9,156	1.5	15.5 SEER GSHP	16,001	3.96	3,607	0.77	B, C, D
20	18,312	3	15.5 SEER GSHP	16,001	3.96	7,214	1.55	B, C, D
21	24,416	4	15.5 SEER GSHP	16,001	3.96	9,618	1.66	B, C, D
22	18,312	3	15.5 SEER GSHP	16,001	3.96	7,214	1.55	B, C, D
23	18,312	3	15.5 SEER GSHP	16,001	3.96	7,214	1.55	B, C, D
24	24,416	4	15.5 SEER GSHP	16,001	3.96	9,618	1.66	B, C, D
25	18,312	3	15.5 SEER GSHP	16,001	3.96	7,214	1.55	B, C, D
26	11,191	1.83	15.5 SEER GSHP	16,001	3.96	4,408	0.95	B, C, D
27	29,503	5	15.5 SEER GSHP	16,001	3.96	11,622	2.10	B, C, D
28	2,236	5.5	15.5 SEER GSHP	16,001	3.96	881	2.31	B, C, D
29	1,898	4.67	15.5 SEER GSHP	16,001	3.96	748	1.95	B, C, D
30	2,236	5.5	15.5 SEER GSHP	16,001	3.96	881	2.31	B, C, D
Average	**14,577**			**16,001**	**3.96**	**5,743**	**1.53**	
90% CI	3,516					1,385	0.21	

Table 4.12 Roseville Baseline Cooling and M&V Savings for Packaged AC Units

Site	Base Cooling (kWh/yr)	Tons	Rebated Measure	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option
31	95,864	10	10.3 EER Pkg. AC	3,970	3.97	3,284	0.47	B, C, D
32	20,496	10	10.3 EER Pkg. AC	4,339	3.34	1,254	0.47	B, C, D
33	17,050	5	13 SEER Pkg. AC	2,698	3.36	1,616	0.61	B, C, D
34	19,837	3	13 SEER Pkg. AC	2,698	3.36	763	0.93	B, C, D
35	2,805	2	12 SEER Pkg. AC	1,060	1.06	468	0.93	B, C, D
36	2,805	2	12 SEER Pkg. AC	1,060	1.06	468	0.93	B, C, D
37	3,726	5	11 SEER Pkg. AC	2,650	2.65	339	0.93	B, C, D
38	2,981	4	11 SEER Pkg. AC	2,650	2.12	271	0.93	B, C, D
39	20,906	5	12 SEER Pkg. AC	2,128	2.65	3,484	0.64	B, C, D
40	3,737	3	13 SEER Pkg. AC	1,950	1.63	652	0.23	B, C, D
41	4,983	4	13 SEER Pkg. AC	2,600	2.17	869	1.15	B, C, D
42	6,229	5	13 SEER Pkg. AC	3,250	2.71	1,086	0.45	B, C, D
43	6,229	5	13 SEER Pkg. AC	3,250	2.71	1,086	1.26	B, C, D
44	6,229	5	13 SEER Pkg. AC	3,250	2.71	1,086	0.44	B, C, D
45	6,229	5	13 SEER Pkg. AC	3,250	2.71	1,086	0.85	B, C, D
46	18,686	15	9.7 EER Pkg. AC	9,749	8.14	3,259	1.26	B, C, D
47	18,686	15	9.7 EER Pkg. AC	9,749	8.14	3,259	1.26	B, C, D
48	2,317	3	13 SEER Pkg. AC	740	0.74	535	1.26	B, C, D
49	26,153	3	13 SEER Pkg. AC	2,020	2.02	6,035	1.26	B, C, D
50	4,146	3	13 SEER Pkg. AC	1,480	1.48	957	1.26	B, C, D
51	1,221	2	12 SEER Pkg. AC	838	0.70	203	1.77	B, C, D
52	2,944	3	12 SEER Pkg. AC	1,590	1.59	491	1.77	B, C, D
53	6,667	5	13 SEER Pkg. AC	3,360	3.36	1,539	2.52	B, C, D
54	5,526	4	12 SEER Pkg. AC	4,024	2.12	921	2.52	B, C, D
Average	**12,769**			**3,098**	**2.77**	**1,459**	**1.09**	
90% CI	6,610			784	0.64	482	0.20	

4.4.3 Findings for Commercial HVAC Tune-ups

The 293 commercial HVAC tune-up measures accounted for 3 percent of the total ex ante kWh savings and 7 percent of the total ex ante peak demand savings for the SB5X C&I Air Conditioner Rebate Programs. Billing data were obtained for 20 participating sites, but pre- and post-retrofit billing data were only available for 11 sites with 22 participating HVAC tune-ups. These data were used as inputs for PRISM to develop pre- and post-retrofit Normalized Annual Consumption (NAC) and Normalized Annual Cooling Consumption (NACC). The average NAC savings are negative as shown in **Table 4.13**. According to IPMVP Option C, the estimated annual energy savings must be greater than or equal to 10 percent of the total building annual consumption to be separated from the noise. Only site 70 met this requirement. Therefore, a combination of billing analyses, field measurements, and engineering analyses were used to evaluate energy savings for HVAC tune-ups.

Table 4.13 NAC and Ex Ante Savings for 11 Sites with HVAC Tune-up Measures

Site	Pre NAC kWh/yr	Post NAC kWh/yr	NAC Savings kWh/yr	Ex Ante Savings kWh/yr	Savings as % of Base NAC	Savings >10% of NAC per IPMVP Option C?
61	305,703	323,116	-17,413	2,080	0.7%	No
62	76,469	81,062	-4,594	2,600	3.4%	No
63	15,537	14,255	1,282	1,040	6.7%	No
64	22,668	19,447	3,221	520	2.3%	No
65	10,071	10,051	20	520	5.2%	
66	648,545	693,052	-44,507	5,200	0.8%	No
67	35,913	35,787	126	520	1.4%	No
68	57,818	59,443	-1,625	1,560	2.7%	No
69	12,666	16,119	-3,452	520	4.1%	No
70	3,884	3,610	274	520	13.4%	
71	32,065	30,806	1,260	1,040	3.2%	No
Ave.	**186,910**	**196,278**	**-9,367**	**1,473**	**0.8%**	**No**

An engineering estimate of the percentage savings for 22 HVAC tune-up measures at 11 sites are provided in **Table 4.14**. The estimated savings for refrigerant charge adjustments are based on the ratio of the absolute value of the refrigerant charge adjustment in ounces divided by the factory charge in ounces according to the following equation.

Eq. 4.1 $$\%_{\text{Charge Savings}} = \frac{\text{ABS}[\Delta\ \text{Oz.}]}{\text{Factory Oz.}}$$

The estimated ex ante savings for airflow adjustments were assumed to be 5%, if the airflow adjustment was recorded and zero if no airflow adjustment was recorded in the tracking database.[22] The HVAC tune-up savings per unit were calculated using the following equation.

Eq. 4.2 $$\%_{\text{Tune-up Savings}} = 1 - \{(1 - \%_{\text{Charge Savings}}) \times (1 - \%_{\text{Airflow Savings}})\}$$

These values were multiplied times the normalized annual cooling consumption at each site to develop ex post kWh savings for the sample according to the following equation.

Eq. 4.3 $$\text{kWh Savings}_{unit} = \text{NACC} \times \frac{\text{CAP}_i}{\sum_{i=1}^{n} \text{CAP}_i} \times \%_{\text{Tune-up Savings}_i}$$

Where,

i = i^{th} air conditioning unit at the site
N = Number of air conditioning units at the site
NACC = Normalized annual cooling consumption for the site
CAP_i = Cooling capacity of each air conditioning unit at the site.

[22] The 5% savings for airflow adjustments is based on multiplicative difference of the ex ante savings per measure of 17% minus the ex ante savings of 12.5% for refrigerant charge adjustments. Note that the airflow adjustments are less likely to deliver persistent savings due to filters getting dirty and registers being adjusted or closed. Ex post savings of 5% are assumed for any reported airflow adjustment in the database in spite of these potential problems.

Table 4.14 Engineering Estimate of Percentage Savings for HVAC Tune-up Measures

Site #	Capacity (tons)	Refrigerant Charge Adjustment Oz.	Airflow Adjustment	Refrigerant Charge Savings	Airflow Savings	HVAC Tune-up Savings
61	4	0		0.0%		0.0%
61	5	-9		5.9%		5.9%
61	10	-36		13.5%		13.5%
62	AC < 5T	-6	Open registers	5.9%	5.0%	10.6%
62	6	-18	Open registers	11.3%	5.0%	15.7%
62	6	2		1.3%		1.3%
63	6.25	12	Open registers	8.3%	5.0%	12.9%
64	5	-7	Open Registers, clean filter	4.0%	5.0%	8.8%
65	2.5	-2	Increase blower	2.5%	5.0%	7.4%
66	7.5	3	Open Registers	3.1%	5.0%	8.0%
66	10	-3		1.1%	5.0%	6.0%
66	7.5	-2		2.1%		2.1%
66	7.5	10		10.4%		10.4%
66	10	-10		4.3%		4.3%
67	5	-8	Increase blower, no filter	8.0%	5.0%	12.6%
68	AC < 5T	-6		6.3%		6.3%
68	AC < 5T	6		6.3%		6.3%
68	AC < 5T	0		0.0%		0.0%
69	3	-10		13.9%		13.9%
70	2.5	-16		26.7%		26.7%
71	2	2	Open Registers	2.3%	5.0%	7.2%
71	3.5	-10	Open Registers	10.0%	5.0%	14.5%
Ave.				**6.7%**		**8.8%**

Peak cooling savings estimates were calculated based on the minimum of the following two equations.

1) Peak demand-to-energy ratio (i.e., PDER) times the estimated kWh savings.[23]
2) Average peak demand for the air conditioner times a coincident diversity factor (i.e., CDF) times the refrigerant charge savings.[24]

Eq. 4.4

$$\text{kW Savings}_{unit} = \text{MIN}\left| \begin{array}{l} \dfrac{0.000647\ \text{kW}}{\text{kWh}} \times \text{kWh Savings}_{\text{unit}} \\ \\ \dfrac{\text{CAP}_\text{i}}{1{,}000 \times \text{EER}_\text{i}} \times \text{CDF} \times \%_{\text{Charge Savings}_i} \end{array} \right.$$

Where,

$PDER_i$ = Peak demand-to-energy ratio assumed to be 0.000647 kW/kWh for this study.
CDF_i = Coincident Diversity Factor assumed to be 0.85 for this study.
EER_i = Energy Efficiency Ratio at 95°F outdoor air temperature and 80°F return drybulb and 67°F return wetbulb temperature for each air conditioning unit.

[23] SCE Energy-Efficiency Potential Study, prepared by XENERGY, Inc., Oakland, CA, prepared for Southern California Edison Company, 1992.

[24] The field measurements generally found airflow adjustments improved capacity and EER and reduced run time (see Section 2.2.3.2). Airflow adjustments were not found to reduce peak kW unless low airflow caused icy evaporator coils. Therefore, only refrigerant charge savings were used to estimate peak kW savings.

Baseline cooling and savings values are summarized in **Table 4.15**. Ex ante energy and peak demand savings are based on the average estimated efficiency improvement times the baseline values.[25] The ex post efficiency improvement was verified by conducting detailed on-site inspections at ten sites. The average ex ante unit savings are 0.52 kW and 520 kWh/yr for air conditioners less than or equal to 5 tons, and 1.04 kW and 1,040 kWh/yr for air conditioners greater than 5 tons. The average M&V ex post unit engineering estimate of savings are 277 ± 79 kWh/yr and 0.17 ± 0.04 kW for air conditioners less than or equal to 5 tons, and 588 ± 194 kWh/yr and 0.32 ± 0.13 kW for units greater than 5 tons.

Table 4.15 NACC, Ex Ante, and M&V Savings for Roseville HVAC Tune-up Sites

Site	Base NACC kWh/yr	≤ 5 tons	> 5 tons	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option
61	7,966	1	1	1,560	1.56	690	0.45	B, C, D
62	17,100	1	2	2,600	2.6	1,523	0.99	B, C, D
63	2,905		1	1,040	1.04	375	0.24	B, C, D
64	6,071	1		520	0.52	534	0.35	B, C, D
65	1,584	1		520	0.52	117	0.08	B, C, D
66	52,579		5	5,200	5.2	3,176	2.06	B, C, D
67	3,797	1		520	0.52	478	0.31	B, C, D
68	8,278	2		1,040	1.04	348	0.22	B, C, D
69	2,578	1		520	0.52	358	0.23	B, C, D
70	1,297	1		520	0.52	346	0.22	B, C, D
71	3,223	2		1,040	1.04	384	0.25	B, C, D
≤ 5 tons	**2,609**	**11**		**520**	**0.52**	**277**	**0.17**	
90% CI	617					79	0.04	
> 5 tons	**8,162**		**9**	**1,040**	**1.04**	**588**	**0.32**	
90% CI	1905					194	0.13	

Note: Average savings for ≤ 5 tons excludes two units with zero savings at sites #61 and #68 (i.e., no adjustments).

4.4.3.1 Evaluation of Commercial HVAC Tune-up Program Database

The commercial HVAC tune-up program database was evaluated to: 1) determine how many refrigerant charge and airflow tune-up adjustments were made, and 2) verify the cooling capacity and factory refrigerant charge from manufacturers' data.[26] The findings of the program database evaluation are provided in **Tables 4.16** and **4.17**. The program reported 250 tune-ups on air conditioners less than or equal to 5 tons (or 60,000 Btu/hr of cooling capacity), and 43 tune-ups greater than 5 tons. The database contained 225 documented tune-ups where an adjustment was reported for either refrigerant charge, airflow, or both (i.e., 197 tune-ups ≤ 5 tons and 28 tune-ups > 5 tons). An engineering estimate of percentage savings for each of these types of adjustments were evaluated using equations provided above.

[25] The Roseville HVAC Tune-up program assumed a 17 percent average ex ante efficiency improvement based on Neme, C., Nadel, S., and Proctor, J. 1998. *National Energy Savings Potential from Addressing HVAC Installation Problems*, Vermont Energy Investment Corporation, prepared for US Environmental Protection Agency.

[26] Based on reported model numbers versus manufacturer model numbers for units greater than 5 tons, the factory charge was incorrectly reported for 18 units and the capacity was misreported for 16 units where 8 units were actually less than or equal to 5 tons.

Table 4.16 Evaluation of HVAC Tune-ups for Air Conditioners ≤ 5 tons

Description	Qty.	% Savings	Tons	Factory Charge Oz.	Charge Adjustment Oz.
Total Reported in Database	**250**	17.0%			
No Adjustments Reported in Database	61	0.0%	4.3	81.0	0.0
Refrigerant Charge Adjustment Only	48	9.2%	4.1	103.2	8.8
Air Flow Adjustment Only	35	5.0%	4.3	107.3	0.0
Refrigerant Charge and Airflow Adj.	114	14.8%	4.3	111.7	10.9
Total Adjusted Units	**197**	**11.7 ± 0.9%**	**4.2**	**108.9**	**10.2**

Table 4.17 Evaluation of HVAC Tune-ups for Air Conditioners > 5 tons

Description	Qty.	% Savings	Tons	Factory Charge Oz.	Charge Adjustment Oz.
Total Reported in Database	**43**	17.0%			
No Adjustments Reported in Database	7	0.0%	9.3	313.3	0.0
Refrigerant Charge Adjustment Only	13	4.6%	8.2	217.2	9.5
Air Flow Adjustment Only	3	5.0%	9.7	290.3	0.0
Refrigerant Charge and Airflow Adj.	12	9.6%	7.7	215.0	8.6
Total Adjusted Units	**28**	**6.8 ± 1.4%**	**8.1**	**224.1**	**9.0**

The average percent savings for units less than 5 tons is 11.7 ± 0.9%, and the average percentage savings for units greater than 5 tons is 6.8 ± 1.4%. The average annual cooling consumption for units less than or equal to 5 tons is 2,609 ± 617 kWh/yr and the average unit energy consumption for units greater than 5 tons was 8,162 ± 1,905 kWh/yr. These values can be used to develop another estimate of average unit energy savings using the following equation.

Eq. 4.5 $$\text{kWh Savings}_{unit} = \text{NACC}_{\text{average}} \times \%_{\text{Tune-up Savings}_{\text{average}}}$$

Where,
$\text{NACC}_{\text{average}}$= Average normalized annual cooling consumption

Using **Equation 4.5**, the average unit energy savings are 287 ± 68 kWh/yr for units less than or equal to 5 tons, and 555 ± 42 kWh/yr for units greater than 5 tons. These values are within 3 to 6 percent of the ex post unit savings shown in **Table 4.15** (i.e., of 277 ± 79 kWh/yr for units less than or equal to 5 tons, and 588 ± 194 kWh/yr for units greater than 5 tons. The savings values from **Table 4.15** are normalized on a per unit basis (e.g., kWh/ton or kW/ton) to allow clearer interpretation of the data and develop ex post program savings. Normalized ex ante and M&V ex post cooling savings are summarized in **Table 4.18**.

Table 4.18 Normalized Ex Ante and M&V Savings for Roseville HVAC Tune-ups

Site	Base NACC kWh/yr-ton	≤ 5 tons	> 5 tons	Ex Ante Savings kWh/yr-ton	Ex Ante Savings kW/ton	M&V Savings kWh/yr-ton	M&V Savings kW/ton	IPMVP Option
61	531.1	5.0	10.0	104.0	0.104	46.0	0.030	B, C, D
62	830.8	4.0	16.6	126.3	0.126	74.0	0.048	B, C, D
63	464.8		6.3	166.4	0.166	60.0	0.038	B, C, D
64	1,214.2	5.0		104.0	0.104	106.8	0.070	B, C, D
65	633.6	2.5		208.0	0.208	46.8	0.032	B, C, D
66	1,237.2		42.5	122.4	0.122	74.7	0.048	B, C, D
67	759.4	5.0		104.0	0.104	95.6	0.062	B, C, D
68	1,034.8	8.0		130.0	0.130	43.5	0.028	B, C, D
69	859.3	3.0		173.3	0.173	119.3	0.077	B, C, D
70	518.8	2.5		208.0	0.208	138.4	0.088	B, C, D
71	586.0	5.5		189.1	0.189	69.8	0.045	B, C, D
≤ 5 tons	**809.95**	**3.7**		**141.2**	**0.141**	**80.2**	**0.049**	
90% CI	116.77					16.7	0.011	
> 5 tons	**989.93**		**8.4**	**124.2**	**0.124**	**72.2**	**0.039**	
90% CI	177.94					22.7	0.015	

The average gross realization rates for the HVAC tune-up sites are shown in **Table 4.19**, and the M&V gross ex post savings are shown in **Table 4.20**.

Table 4.19 Average Gross Realization Rates for HVAC Tune-up Sites

NCPA Utility	Qty. tons	Ex Ante kWh/yr-ton	Ex Ante kW/ton	M&V kWh/yr-ton	M&V kW/ton	AGRR kWh/yr-ton	AGRR kW/ton
Roseville AC Tune-up ≤5 tons	40.5	141.23	0.141	80.21	0.049	0.567911	0.344005
Roseville AC Tune-up >5 tons	75.35	124.22	0.124	72.19	0.039	0.581133	0.313942

Table 4.20 M&V Gross Ex Post Savings for Roseville HVAC Tune-up Sites

NCPA Utility	Qty.	Ex Ante Savings kWh/y	Ex Ante Savings kW	AGRR kWh/yr-ton	AGRR kW/ton	M&V Gross Ex Post Savings kWh/y	M&V Gross Ex Post Savings kW
Roseville AC Tune-up <5 ton	1,096.1	130,000	130.0	0.567911	0.344005	73,828	44.7
Roseville AC Tune-up >5 ton	292.6	44,720	44.7	0.581133	0.313942	25,988	14.0
Total	**1,388.7**	**174,720**	**174.7**	**0.571291**	**0.336005**	**99,816**	**58.7**

The M&V ex post program savings are 99,816 ± 22,623 kWh/yr and 58.7 ± 14.7 kW. The ex ante program savings are 174,720 kWh/yr and 174.7 kW and the average gross realization rates for the program are 0.57 ± 0.13 for kWh savings and 0.33 ± 0.08 for kW savings. The effective useful life for HVAC tune-ups is assumed to be 8 years. Therefore, the lifecycle savings are 766,593 ± 180,980 kWh. The gross realization rates are lower than expected due to 23 percent of sites not requiring tune-up adjustments, lower baseline usage, and smaller refrigerant charge and airflow adjustments than assumed in ex ante program plans. Another reason for lower savings is due to under-reporting refrigerant charge adjustments in the tracking database. The database reported an average refrigerant charge adjustment of 6.7 percent for the 22 M&V sites (see **Table 4.14**). The pre- and post-tune-up refrigerant pressures and temperatures were independently analyzed for these sites. It was determined that the average refrigerant charge adjustment should have been 12.2 percent or 182 percent greater than what was reported in the database. Correcting for this would have yielded greater realization rates.

4.4.3.2 Evaluation of Efficiency Improvement for Commercial HVAC Tune-ups

The Roseville commercial HVAC tune-up program assumed an average efficiency improvement of 17 percent based previous studies.[27] This assumption was evaluated using billing analysis, refrigerant charge and airflow adjustments in program tracking database, and detailed on-site inspections at ten sites. Several studies indicate approximately 50 to 67 percent of air conditioners have improper refrigerant charge and airflow (RCA), and found this reduces efficiency by roughly 10 to 20 percent.[28] Finding from the on-site inspections found 80 percent of units had improper RCA consistent with the program database showing 77 percent of units required an adjustment (i.e., 225 out of 293 units). Measurements of refrigerant charge and airflow, kW, capacity, and EER were made on ten packaged units to evaluate HVAC tune-ups. The relative efficiency gains due to proper refrigerant charge and airflow for a random sample of ten packaged air conditioners are shown in **Table 4.21**. Sites labeled "n/c" were not checked due to insufficient time or customer refusal. Site #33 had an efficiency gain of 90.7% due to 7.1 percent overcharge and dirty/icy evaporator coil. Including this site yields an average efficiency gain of 18.7 percent. Excluding this site, yields an average efficiency gain of 8.6 ± 3.5 percent for the sample. This is consistent with the average ex post efficiency improvement of 8.8 ± 2.2 percent shown in **Table 4.14**.

Measurements of EER were made at non-standard temperature conditions (i.e., not at 95°F outdoor temperature or 80°F dry-bulb/67°F wet-bulb inlet conditions). The absolute EER measurements are not directly comparable to laboratory measurements of EER at standard conditions where airflow, return air temperatures, and condenser entering air temperatures are carefully controlled. The relative efficiency gains shown in **Table 4.21** are applicable to normal operating conditions since laboratory studies indicate the change in EER (as a function of airflow and charge) is independent of operating conditions.

Table 4.21 EER Measurements and Efficiency Gain for Packaged Air Conditioners

Site	Tons	Factory Charge oz.	Charge Adjust +Add -Remove	Rated SEER/ EER	Pre-EER	Post-EER	Relative Efficiency Gain	Average Outdoor Temp °F	Airflow cfm/ton	Notes
32	10	323	Okay	11	10.4	n/a	n/a	74	280	New Unit
33	10	200	-7.1%	10.3	5.4	10.3	90.7%	83	383	New Iced Coil
34	5	192	13.8%	13	9	10.1	12.2%	98	296	New Unit
37	2	85	-3.5%	12	9.1	9.4	3.3%	95	409	New Unit
44	5	156	3.8%	13	10.7	11	2.8%	70	366	New Unit
45	5	156	4.9%	13	10.6	11	3.8%	70	327	New Unit
47	15	n/a	Okay	10.8	n/a	n/a	n/a	70	n/a	New Unit
55	4	166	-9.4%	11	8.6	9.3	8.1%	70	255	New Unit
59	5	126	13.7%	n/a	6.2	7	12.9%	72	289	Old Unit
60	10	250	13.8%	n/a	5.6	6.5	16.1%	72	366	Old Unit
Ave	**7.1**	**184**	**8.8%**	**11.8**	**8.4**	**9.3**	**8.6%**	**77.4**	**330**	Excl. Site 33

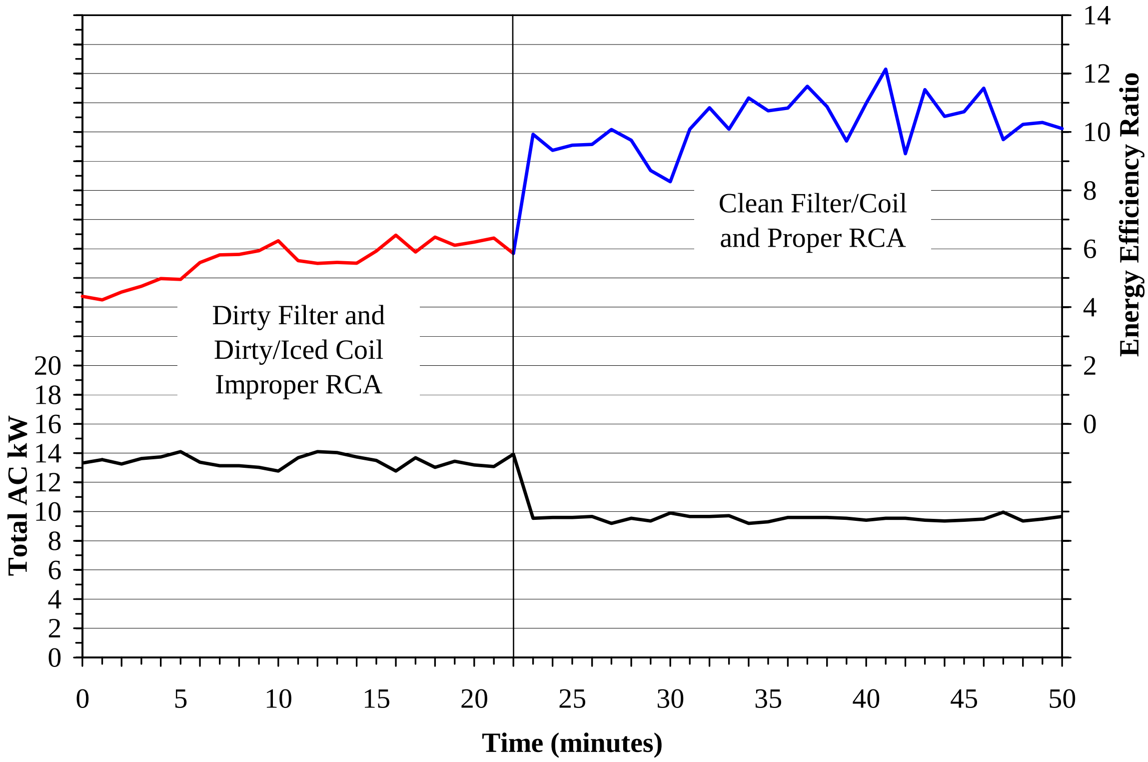
[27] Ibid.

[28] Downey, T., Proctor, J. 2002. "What Can 13,000 Air Conditioners Tell Us?" In the *Proceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings.* 1:53-67. Washington, D.C.: American Council for an Energy-Efficient Economy. Rodriguez, A. 1995. *The Effect of Refrigerant Charge, Duct Leakage, and Evaporator Air Flow on the High Temperature Performance of Air Conditioners and Heat Pumps*, Palo Alto, Calif.: Electric Power Research Institute.

The uncertainty associated with field measurements of capacity and EER was evaluated using the propagation of error technique including the following factors: sensor accuracy; recording system accuracy; data display or recording resolution; and sampling error.[29] The uncertainty associated with instrument error is ± 3.7 percent, and the measurement error is ± 4.6 percent. Therefore, the total uncertainty error is ± 5.9 percent and this is close to uncertainty errors reported in laboratory studies.[30]

Measurements of a 10-ton packaged rooftop air conditioner at site #33 are shown in **Figure 4.4** before and after an HVAC tune-up. The 10-ton unit had a dirty/icy evaporator coil and dirty air filters and was overcharged by 14.2 ounces or 7.1 percent of the factory charge of 200 ounces. The evaporator coil was cleaned/de-iced and new air filters were installed. Prior to performing the HVAC tune-up, the average efficiency was 5.7 EER, and average power usage was 13 kW. After performing the HVAC tune-up the efficiency improved to 10.3 EER, and the average power usage was reduced to 9.5 kW. This is consistent with the ARI rating of 10.3 EER.

Figure 4.4 Measurements of 10-ton Packaged Rooftop Air Conditioner at Site #33



[29] American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE). 2002. *ASHRAE Guideline 14-2002 – Measurement of Energy and Demand Savings*. Atlanta, Ga.: American Society of Heating Refrigerating and Air-Conditioning Engineers. 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*, Appendix to Chapter 7: 191-195. Uncertainty Calculation. San Francisco, Calif.: California Public Utilities Commission.
[30] Ibid.

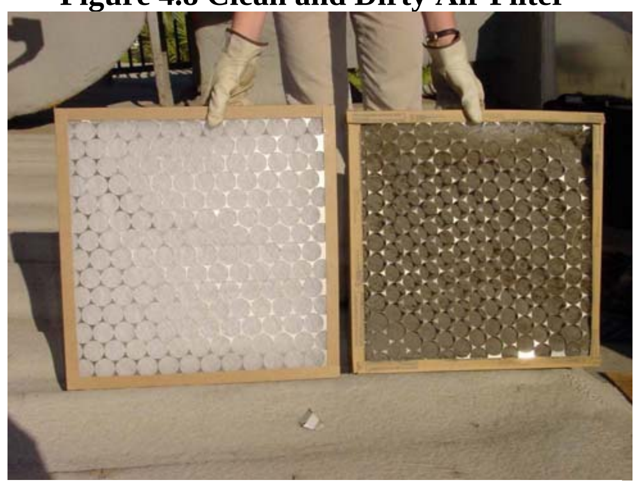
Figure 4.5 shows the technician measuring airflow and **Figure 4.6** shows the technician measuring temperature across the coil, kW, and EER. **Figure 4.7** shows the clean and dirty evaporator coil, and **Figure 4.8** shows the clean and dirty air filters.

Figure 4.5 Measuring Airflow

Figure 4.6 Measuring EER

Figure 4.7 Clean and Dirty Evaporator Coil

Figure 4.8 Clean and Dirty Air Filter



4.5 Participant Survey Findings

Participant surveys were completed for 27 participants in nine NCPA utility service areas. This sample size exceeded the M&V plan of 20 sites, and included all of the custom sites accounting for more than 91 percent of the total M&V savings. Participant Survey Findings for each program are presented in **Table 4.22**. The weighted average net-to-gross ratio is 0.96 based on average participant survey results multiplied times savings for each program divided by total savings for all programs. The average net to gross ratio of 0.96 is consistent with the statewide nonresidential Express Efficiency program that offers rebates for high efficiency air conditioners for commercial and industrial customers.[31]

[31] See *Energy Efficiency Policy Manual*, Chapter 4, page 23, prepared by the California Public Utilities Commission, 2001.

Table 4.22 Findings of Participant Surveys

NCPA Utility	Ex Post Measure Qty.	Completed Surveys	Gross Ex Post Savings kW	Weighting Factor	Actual Net-to-Gross Ratio	Coefficient of Variation Cv	Required Sample to Meet 90/10 Criteria	Weighted Net-to-Gross Ratio
Gridley	2	2 (Census)	1.15	0.000516	0.97	n/a	n/a	0.000500
Lodi	6		4.61	0.002062				0.000000
MID	79	5	57.76	0.025824	0.77	0.17	7	0.019885
MID-Custom	4	4 (Census)	961.00	0.429697	0.96	n/a	n/a	0.412509
Palo Alto	1	1 (Census)	815.00	0.364415	0.99	n/a	n/a	0.360771
Port of Oakland	1	1 (Census)	60.00	0.026828	1	n/a	n/a	0.026828
PSREC-GSHP	16	2 (Census)	24.58	0.010988	0.88	n/a	n/a	0.009670
Redding	33		22.86	0.010221	0.96			0.009812
Roseville	93	14	80.55	0.036017	0.83	0.18	8	0.029894
Roseville HVAC Tune-up ≤5 ton	250		44.72	0.019996	0.96			0.019196
Roseville HVAC Tune-up >5 ton	43		14.03	0.006275	0.96			0.006024
TDPUD	1	1 (Census)	116.00	0.051868	0.95	n/a	n/a	0.049274
TID	50	10	26.90	0.012029	0.79	0.24	11	0.009503
Ukiah	11	1 (Census)	7.30	0.003265	1	n/a	n/a	0.003265
Total	**590**	**41**	**2,236**	**1**				**0.96**

A census was performed for Gridley, MID (Custom), Palo Alto, Port of Oakland, PSREC, TDPUD, and Ukiah. A random participant sample was selected for the other C&I HVAC programs. The coefficient of variation was used to measure the sample size required to satisfy the 90 percent confidence level criteria for estimating mean net-to-gross ratios for the population (see Equations 9, 10, and 11, Section 4, below). For MID a survey sample of 5 yielded a 0.77 ± 0.09 NTGR with a Cv of 0.17 indicating a finite population corrected (FPC) sample of 7 to achieve 90% confidence and 10% relative precision (i.e., 90/10 criteria). For Roseville a survey sample of 14 yielded a 0.83 ± 0.07 NTGR with a Cv of 0.18 indicating a FPC sample of 8 to achieve 90/10 criteria. For TID a survey sample of 10 yielded a 0.79 ± 0.10 NTGR with a Cv of 0.24 indicating a FPC sample of 11 to achieve 90/10 criteria. The sample size for Roseville exceeded the 90/10 criteria, and the sample size for MID and TID exceeded the 85/15 criteria.

4.6 Gross Realization Rates for C&I HVAC Programs

Gross M&V program evaluation savings (i.e., kWh/yr and kW) are based on the Average Gross Realization Rates (AGRR) from the M&V on-site audits. The weighted average gross realization rates for M&V custom, packaged AC, and GSHP and Tune-up sites are provided in **Tables 4.23**, **4.24**, and **4.25**.

Table 4.23 Average Gross Realization Rates for M&V Custom Sites

NCPA Utility	Qty. tons	Ex Ante kWh/yr-ton	Ex Ante kW/ton	M&V kWh/yr-ton	M&V kW/ton	AGRR kWh/yr-ton	AGRR kW/ton
MID Custom #1	425	1,250.00	0.306	1,067.75	0.141	0.854197	0.461538
MID Custom #2	1,000	730.28	0.514	747.60	0.763	1.023723	1.484436
MID Custom #3	1,900	116.34	0.047	106.03	0.027	0.911399	0.566667
MID Custom #4	2,400	41.79	0.023	112.88	0.036	2.701182	1.581818
Palo Alto Custom #56	2000	1,388.40	0.480	736.66	0.408	0.530584	0.848958
TDPUD Custom #57	370	619.37	0.235	826.02	0.314	1.333653	1.333333

Table 4.24 Average Gross Realization Rates for M&V Packaged HVAC Sites

NCPA Utility	Qty. tons	Ex Ante kWh/yr-ton	Ex Ante kW/ton	M&V kWh/yr-ton	M&V kW/ton	AGRR kWh/yr-ton	AGRR kW/ton
MID Packaged AC	37	154.08	0.176	167.55	0.192	1.087426	1.093846
Roseville Packaged AC	128	580.87	0.520	273.54	0.204	0.470913	0.392352

Table 4.25 Average Gross Realization Rates for GSHP and HVAC Tune-up Sites

NCPA Utility	Qty. tons	Ex Ante kWh/yr-ton	Ex Ante kW/ton	M&V kWh/yr-ton	M&V kW/ton	AGRR kWh/yr-ton	AGRR kW/ton
PSREC GSHP	53	4,830.49	1.195	1,733.60	0.463	0.358887	0.387622
Roseville AC Tune-up ≤5 tons	40.5	141.23	0.141	80.21	0.049	0.567911	0.344005
Roseville AC Tune-up >5 tons	75.35	124.22	0.124	72.19	0.039	0.581133	0.313942

The MID savings per ton were used to develop engineering estimates of AGRR values for packaged HVAC incentive programs implemented by Gridley, Lodi, Redding, TID and Ukiah since these utilities are located in similar climate zones to MID (see **Table 4.26**).

Table 4.26 Average Gross Realization Rates for Other Packaged HVAC Programs

NCPA Utility	Qty. tons	Ex Ante kWh/yr-ton	Ex Ante kW/ton	M&V kWh/yr-ton	M&V kW/ton	AGRR kWh/yr-ton	AGRR kW/ton
Gridley	6	665.8	0.733	167.6	0.192	0.251642	0.262039
Lodi	24	50.0	0.054	167.6	0.192	3.351035	3.547609
Redding	119	320.2	0.357	167.6	0.192	0.523307	0.537838
TID	140	208.4	0.213	167.6	0.192	0.803964	0.902775
Ukiah	38	1,401.4	0.321	167.6	0.192	0.119556	0.598538

M&V gross ex post savings and realization rates for all utilities in the C&I HVAC program category are provided in **Table 4.27**.

Table 4.27 M&V Gross Savings and Realization Rates for C&I HVAC Programs

NCPA Utility	Qty. tons	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Gross Ex Post Savings kWh/yr	M&V Gross Ex Post Savings kW	AGRR kWh/yr	AGRR kW
Gridley	6	3,995	4.4	1,005	1.2	0.251642	0.262039
Lodi	24	1,200	1.3	4,021	4.6	3.351035	3.547609
MID	342	46,479	52.8	50,542	57.8	1.087426	1.093846
MID-Custom	5,725	1,582,858	789	1,673,760	961.0	1.057429	1.217997
Palo Alto-Custom	3,200	2,776,800	960	1,473,327	815.0	0.530584	0.848958
Port of Oakland-Custom	600	250,000	60	250,000	60.0	1.000000	1.000000
PSREC-GSHP	80	256,016	63.4	91,881	24.6	0.358887	0.387622
Redding	119	38,101	42.5	19,939	22.9	0.523307	0.537838
Roseville	456	203,288	205.3	95,731	80.5	0.470913	0.392352
Roseville AC Tune-up ≤5 tons	1,096	130,000	130	73,828	44.7	0.567911	0.344005
Roseville AC Tune-up >5 tons	293	44,720	44.7	25,988	14.0	0.581133	0.313942
TDPUD-Custom	370	229,166	87	305,628	116.0	1.333653	1.333333
TID	140	29,177	29.8	23,457	26.9	0.803964	0.902775
Ukiah	38	53,255	12.2	6,367	7.3	0.119556	0.598538
Total	12,488	5,645,055	2,482.40	4,095,475	2,236.46	0.725498	0.900927

5. Commercial & Industrial Refrigeration Program

The Commercial and Industrial (C&I) Refrigeration Incentive Program was implemented by City of Lodi. The program realized peak kW and kWh savings by paying incentives for energy efficient refrigeration projects. This custom program provided incentives for multiple measures in 2001 with $380,000 of SB5X funds administered by NCPA.

Ex ante program savings are summarized in **Table 5.1**, and ex post savings are summarized in **Table 5.2**. The ex ante program savings are 1,194,000 kWh/yr and 765 kW. The M&V gross ex post program savings are 838,477 ± 118,943 kWh/yr and 907 ± 40 kW. The M&V net ex post program savings are 821,708 ± 116,564 kWh/yr and 889 ± 39.2 kW. The effective useful life for the refrigeration process overhaul is 20 years.[32] Therefore, the M&V net ex post lifecycle savings are 16,434,160 ± 2,331,275 kWh. Ex post kWh and kW savings are based on billing data, production, and engineering analyses for 2000 and 2001. The net-to-gross ratio is calculated based on decision maker surveys regarding whether or not the unit would have been installed without rebates from the programs. The net-to-gross ratio is 98 percent indicating approximately 2 percent of the high efficiency refrigeration measures would have been purchased without the program.[33] The realization rates are 0.69 for kWh savings and 1.16 for kW savings.

Table 5.1 Ex Ante Savings for NCPA SB5X C&I Refrigeration Rebate Program

NCPA Utility	Qty.	Ex Ante Savings kWh/yr	Ex Ante Savings kW	Ex Ante Net-to-Gross Ratio kWh/y	Ex Ante Net-to-Gross Ratio kW	Ex Ante Savings kWh/y	Ex Ante Savings kW
Lodi	1	1,194,000	765	1.0	1.0	1,194,000	765

Table 5.2 Ex Post Savings for NCPA SB5X C&I Refrigeration Rebate Program

NCPA Utility	Qty.	M&V Gross Ex Post Savings kWh/y	M&V Gross Ex Post Savings kW	Net-to-Gross Ratio kWh/y	Net-to-Gross Ratio kW	M&V Net Ex Post Savings kWh/y	M&V Net Ex Post Savings kW	Net Realization Rate kWh/y	Net Realization Rate kW
Lodi	1	838,477	907	0.98	0.98	821,708	889	0.69	1.16

The M&V gross savings are based on billing data, engineering analyses, and true RMS power measurements. The peak kW for each unit was taken as the maximum kW that occurs during the 2 PM to 6 PM weekday time frame from the billing data and engineering analyses. A participant telephone survey was used to evaluate program performance criteria and net-to-gross ratios. A separate report titled, *Measurement & Verification Report for NCPA SB5X Commercial and Industrial Refrigeration Incentive Programs,* provides more detailed information. **Appendix A** provides the Decision-Maker Survey.

5.1 M&V Approach for C&I Refrigeration

The measurement and verification of energy and demand impacts of the Commercial & Industrial Refrigeration program are based on billing data and engineering analysis. The M&V

[32] See *Energy Efficiency Policy Manual*, Chapter 4, pages 21-22, prepared by the California Public Utilities Commission, 2001.
[33] The net-to-gross ratios reflect what customers would have done in the absence of the program (see Section 3).

approach is consistent with IPMVP Option B (i.e., retrofit isolation) and Option C (whole facility billing analysis). Whole facility billing data was used to develop baseline kWh energy use. Billing and engineering analyses were used to estimate gross kWh/yr savings. Field measurements were made to verify in-situ power usage on a sample of energy efficient refrigeration equipment (i.e., VFD fans, chillers, cooling tower).

Gross ex post kWh savings are based on billing data analysis. Gross ex post peak kW savings are based on field measurements of peak kW. Gross savings for the sampled units were compared to ARI ratings and other sources. 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.

5.2 M&V Sample Design and Precision

There was only one site in this program so no sample design was required.

5.3 Baseline

There are no standards governing the efficiency of custom refrigeration equipment so the baseline was the pre-installation equipment. The baseline kWh values are based on billing data analyses. The baseline kW values are based on metering results (monthly kW from billing data), and the appropriate baseline prior to retrofit of custom measures.

5.4 M&V Findings for C&I Refrigeration

Site #1 was the only site and accounted for 100 percent of total ex ante savings for the SB5X C&I Refrigeration Incentives Programs. Data loggers were installed at the site to measure peak demand and energy use. Peak kW savings are based on billing data and kW measurements as shown in **Figure 5.1** for a variable frequency drive (VFD) fan at Site #1.

Figure 5.1 Power Measurements of a VFD Fan at Site #1

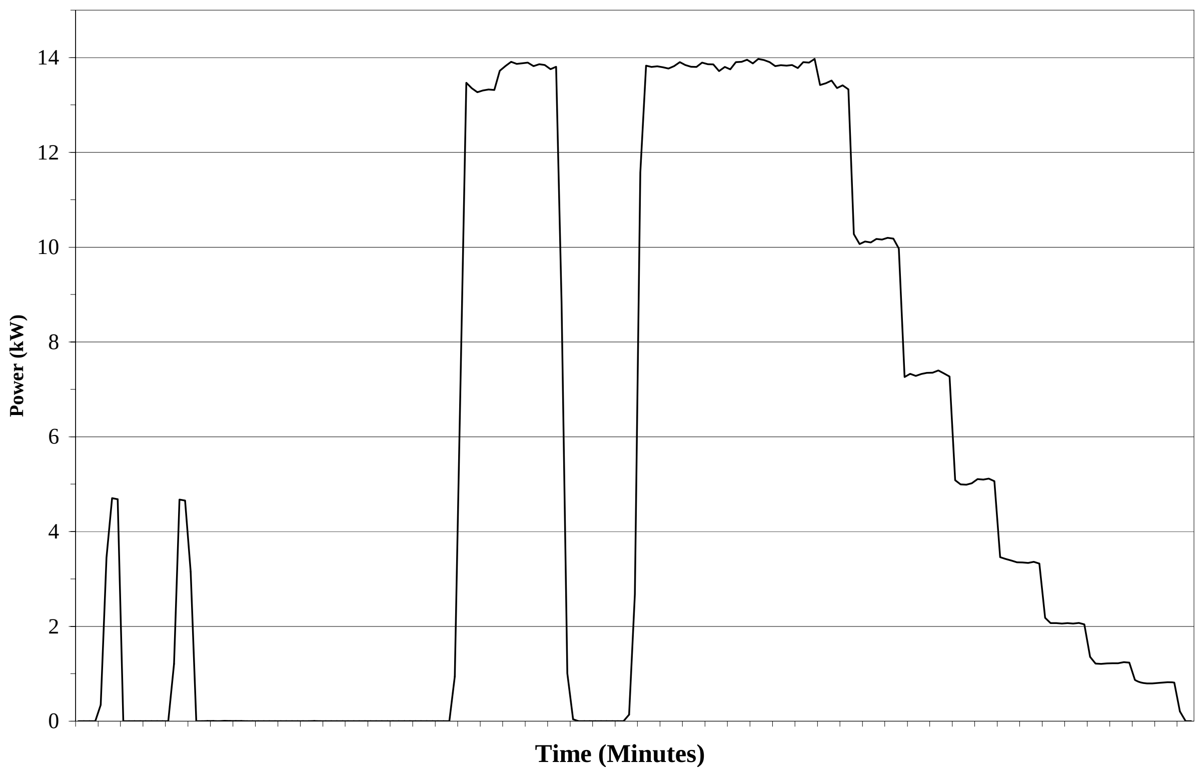


Figure 5.2 shows the old hydro-cooling refrigeration system at site #1. The old system involved pouring chilled water over the top of bins of fruit that traveled slowly down a conveyor. These bins were then taken inside the cold storage building and stored until processing. **Figure 5.3** shows the new internal air-cooling system. With computer control, variable-frequency and two-speed drives, and air versus water cooling, the new air-cooling system was designed to save 56 percent on peak electric demand and 67 percent on electrical usage

Figure 5.2 Old Hydro-Cooling Refrigeration

Figure 5.3 New Internal Air-Cooling System

Data loggers were installed at the site to measure peak demand and energy use. Billing data were collected and these data were used along with short-term kW metering data and engineering analyses to develop baseline values. The kWh savings for the site are based on billing data and engineering analyses. Peak demand (kW) savings are based on the difference between the pre-retrofit and post-retrofit kW demand. Savings were verified with monthly utility demand data.

In 2000, Site #1 processed 19,263 bins of fruit and electrical consumption for the pre-installation hydro-cooling fruit storage system was 325,539 kWh and 563 kW (see **Table 5.3**, 2000 actual).

Table 5.3 Historical Billing Data in 2000/2001 and Estimated Savings in 2001[34]

			A	B	C	D	A - C	B – D
Month	**2000 Actual kW**	**2000 Actual kWh/yr**	**2001 M&V Baseline kW**	**2001 M&V Baseline kWh/yr**	**2001 Actual As-Built kW**	**2001 Actual As-Built kWh/yr**	**2001 M&V Savings kW**	**2001 M&V Savings kWh/yr**
Jan								
Feb								
Mar								
Apr								
May								
Jun	163	50,019	1,533	258,941	691	127,440	842	131,501
Jul	400	126,560	1,652	350,131	745	172,320	907	177,811
Aug	563	126,560	1,557	553,967	702	272,640	855	281,327
Sep	319	22,400	565	75,585	255	37,200	310	38,385
Oct								
Nov								
Dec								
Total	563	325,539	1,652	1,238,624	745	609,600	**907**	**629,024**

In 2001, Site #1 processed 56,865 bins of fruit using the new internal air-cooling process. If Site #1 would have used the existing hydro-cooling system to chill 56,865 bins to the same temperature (58 DF) as the new forced-air system, then the equivalent electrical consumption would have been 1,238,624 kWh and 1,652 kW (see **Table 5.3**, 2001 M&V baseline). With the new internal air-cooling system the 2001 actual as-built electrical consumption was 609,600 kWh and 745 kW, and the 2001 M&V savings are 629,024 kWh and 907 kW (see **Table 5.3**).

The new internal air-cooling system is designed to handle 75,800 bins of fruit per season. Full production was not met in 2001 due to harvest shortfall of 11% or 24,860 bins. With full production of 75,800 bins of fruit in 2002, the M&V baseline would have been 1,651,063 kWh and 1,652 kW based on increasing the existing hydro-cooling system from 70 bins per hour to 207 bins per hour and also increasing product quality cooling requirements from 45 to 58 degrees Fahrenheit delta T (DF). The M&V as-built electricity use was 812,586 kWh and 745 kW. Therefore, the gross M&V savings are 838,477 ± 92,233 kWh/yr and 907 ± 81 kW for the new internal air-cooling system (see **Table 5.4** and **Appendix B**).

[34] Historical electricity use and estimated savings are based on actual 2000 and 2001 billing and production data. Billing data for 2001 has been adjusted for the new 240 current transformer (CT) multiplier (i.e., 1,200 to 5) from the pre-2001 CT multiplier of 160 (i.e., 800 to 5). The new CT multiplier is from Rod Brown, Power Quality Technician, City of Lodi Electric Utility 11-29-01.

Table 5.4 M&V Estimate of Electrical Use and Savings in 2002

	A	B	C	D	A - C	B - D
Month	2002 M&V Baseline kW	2002 M&V Baseline kWh/yr	2002 M&V As-Built kW	2002 M&V As-Built kWh/yr	2002 M&V Savings kW	2002 M&V Savings kWh/yr
Jan						
Feb						
Mar						
Apr						
May						
Jun	1,533	345,163	691	169,875	842	175,288
Jul	1,652	466,718	745	229,699	907	237,019
Aug	1,557	738,428	702	363,424	855	375,004
Sep	565	100,754	255	49,587	310	51,167
Oct						
Nov						
Dec						
Total	**1,652**	**1,651,063**	**745**	**812,586**	**907**	**838,477**

Baseline and savings values for each measure at Site #1 are summarized in **Table 5.5**. The gross ex post savings are 838,477 ± 118,943 kWh/yr and 907 ± 40 kW.

Table 5.5 Site #1 Baseline and Savings for C&I Energy Efficient Refrigeration

Site	Baseline (kWh/yr)	Base kW	Rebated Measure	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Gross Ex Post Savings kWh/yr	M&V Gross Ex Post Savings kW	IPMVP Option or Report
1	1,084,385	1,085	Chillers	817,502	524	574,084	621	B, C
1	20,988	21	Tower	-23,696	-15	-16,640	-18	B, C
1	537,695	538	VFD Fans	397,561	254	279,184	302	B, C
1	7,995	8	Lighting	2,633	2	1,849	2	B, C
Total	**1,651,063**	**1,652**		**1,194,000**	**765**	**838,477**	**907**	
90% CI						118,943	40.0	

5.5 Participant Survey Findings

A decision-maker survey was completed for the project to measure the net-to-gross ratio. The NTGR was applied to the gross savings estimate to develop net kW and kWh savings. Findings of the participant survey are presented in **Table 5.6**. The net-to-gross ratio is 0.98 based on participant survey results.

Table 5.6 Findings of Participant Surveys

NCPA Utility	Rebates	Completed Surveys	M&V Gross Ex Post Savings kWh/yr	M&V Gross Ex Post Savings kW	Weighting Factor	Actual Net-to-Gross Ratio	Weighted Net-to-Gross Ratio
Lodi	1	1	838,477	907	1.00	.98	.98
Total	**1**	**1**	**838,477**	**907**	**1.00**	**.98**	**.98**

6. Commercial & Industrial Custom Programs

Commercial and Industrial (C&I) Custom Incentive Programs were implemented by Turlock Irrigation District (TID), Ukiah, Lompoc, and Truckee Donner Public Utility District (TDPUD). The programs realized peak kW and kWh savings by paying incentives to C&I customers for installing custom high efficiency measures such as air compressors, variable speed controllers, computer monitors, vacuum pumps, motors, solar sunscreens, and photovoltaic systems. The programs provided incentives for 64 projects from 2001 through 2003 with $370,550 of SB5X funds administered by NCPA.

Ex ante program savings are summarized in **Table 6.1**, and ex post savings are summarized in **Table 6.2**. The ex ante program savings are 4,897,986 kWh/yr and 1,156 kW. The total M&V gross ex post savings are 4,465,251 ± 210,158 kWh/yr and 977 ± 41 kW. The M&V net ex post savings are 3,754,038 ± 176,534 kWh/yr and 821.7 ± 34 kW. The net ex post lifecycle savings are 56,613,105 ± 2,648,085 kWh as shown in **Table 6.3**. Ex post kWh savings are based on billing data and engineering analysis of 10 custom sites accounting for 31 percent of the total kWh savings and 25 percent of total kW savings. The M&V sample included high efficiency air compressors, variable frequency drives, vacuum pumps, and motors affecting 419 horsepower out of a total of 2,808 horsepower in the program. The net-to-gross ratio is calculated based on decision maker surveys regarding whether or not the unit would have been installed without rebates from the programs. The average net-to-gross ratio is 84 percent indicating approximately 16 percent of high efficiency custom measures would have been purchased anyway without the program.[35] The realization rates are 0.77 for kWh savings and 0.71 for kW savings. The M&V savings and net realization rates are lower than anticipated due to lower baseline usage and lower net-to-gross ratios.

Table 6.1 Ex Ante Savings for NCPA SB5X C&I Custom Programs

NCPA Utility	Qty.	Ex Ante Savings kWh/yr	Ex Ante Savings kW	Ex Ante Net-to-Gross Ratio kWh/y	Ex Ante Net-to-Gross Ratio kW	Ex Ante Savings kWh/y	Ex Ante Savings kW
TID	60	4,877,817	1148.3	1	1	4,877,817	1148.3
Ukiah	1	15,160	5.0	1	1	15,160	5.0
Lompoc	2	4,680	2.6	1	1	4,680	2.6
TDPUD	1	329	0.1	1	1	329	0.1
Total	**64**	**4,897,986**	**1,156**	**1.00**	**1.00**	**4,897,986**	**1,156**

Table 6.2 M&V Ex Post Savings for NCPA SB5X C&I Custom Programs

NCPA Utility	Qty.	M&V Gross Ex Post Savings kWh/y	M&V Gross Ex Post Savings kW	Net-to-Gross Ratio kWh/y	Net-to-Gross Ratio kW	M&V Net Ex Post Savings kWh/y	M&V Net Ex Post Savings kW	Net Realization Rate kWh/y	Net Realization Rate kW
TID	60	4,445,082	969.0	0.84	0.84	3,733,869	814.0	0.77	0.71
Ukiah	1	15,160	5.0	1.00	1.00	15,160	5.0	1.00	1.00
Lompoc	2	4,680	2.6	1.00	1.00	4,680	2.6	1.00	1.00
TDPUD	1	329	0.1	1.00	1.00	329	0.1	0.07	0.03
Total	**64**	**4,465,251**	**976.7**	**0.84**	**0.84**	**3,754,038**	**821.7**	**0.77**	**0.71**

[35] The net-to-gross ratios reflect what customers would have done in the absence of the program (see Section 3).

Table 6.3 M&V Ex Post Lifecycle Savings for NCPA SB5X C&I Custom Programs

NCPA Utility	Qty.	M&V Net Ex Post Annual Savings kWh/yr	Effective Useful Lifetime	M&V Net Ex Post Lifecycle Savings kWh	90% CI kWh/yr
TID	60	3,733,869	15	56,008,035	2,647,978
Ukiah	1	15,160	30	454,800	22,740
Lompoc	2	4,680	30	140,400	7,020
Truckee	1	329	30	9,870	494
Total	**64**	**3,754,038**		**56,613,105**	**2,648,085**

The M&V gross savings are based on in-situ true RMS power measurements. The peak kW for each unit was taken as the maximum kW that occurs during the 2 PM to 6 PM weekday time frame. Participant telephone surveys were used to evaluate program performance criteria and net-to-gross ratios. A separate report titled, *Measurement & Verification Report for NCPA SB5X Commercial and Industrial Custom Incentive Programs,* provides more detailed information. M&V on-site work was performed in 2002. **Appendix A** provides the Decision-Maker Survey.

6.1 M&V Approach for C&I Custom

The measurement and verification of energy and demand impacts of Commercial & Industrial Custom programs are based on 10 detailed on-site surveys and 10 participant surveys. The ex post energy and peak demand savings were determined using IPMVP Option B (i.e., retrofit isolation), and Option C (whole facility billing analysis). Whole facility monthly billing data was used to develop baseline kWh energy use. Billing and engineering analyses were used to estimate gross kWh savings. Billing data for most sites was collected for a three year period from January 2001 through December 2003. These data were used to develop annual energy savings. Field measurements were used to estimate gross peak kW savings.

Gross M&V program evaluation savings (i.e., kWh/yr and kW) are based on the Average Gross Realization Rates (AGRR) from the M&V on-site audits. Gross ex post kWh and kW savings are based on billing data, engineering analyses, and field measurements of 10 custom sites accounting for 31 percent of the total kWh savings and 25 percent of total kW savings. The M&V sample included high efficiency air compressors, variable frequency drives, vacuum pumps, and motors affecting 419 horsepower out of a total of 2,808 horsepower in the program. 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.

6.2 M&V Sample Design and Precision

The sample design for metering and participant surveys was designed to achieve a minimum precision of plus or minus 10% at the 90% confidence level. Sampling methods were used to analyze the data and extrapolate mean savings estimates from the sample measurements to the population of all program participants and to evaluate the statistical precision of the results. Load impacts were evaluated with a random M&V sample of 10 program participants who accounted for 31% percent of the total program savings. The M&V participant survey sample size is 12. The weighted sample coefficient of variation (Cv) for kWh savings was 0.52, the weighted Cv for kW savings was 0.59, and the weighted participant survey coefficient of variation was 0.17.

Sampling methods were used to analyze the data and extrapolate M&V savings estimates from the sample to the population of all program participants and to evaluate the statistical precision of the results. The M&V on-site survey sample of 10 participants provided relative precision of ±4.1% for MW and ±4.7% for GWh. The DMS sample of 12 participants yielded relative precision of ±8.1% for the survey results.

6.3 Baseline

The baseline kWh values are based on billing data analyses. The baseline kW values are based on metering results for a random sample of high efficiency custom measures (monthly kW from billing data), and the appropriate baseline prior to retrofit of custom measures.

6.4 M&V Findings for C&I Custom

Field measurements were made to determine in-situ energy and peak demand savings for TID projects. Multiple data loggers were installed at 10 custom sites to measure peak demand and energy use for standard and high efficiency custom measures. The measurement sample included air compressors, variable speed drives, vacuum pumps, and controls. Insufficient data were available to fully evaluate savings for Solar Photovoltaic projects implemented by Ukiah, Lompoc, and TDPUD. The ex ante savings for PV projects were based on engineering analyses and they were accepted as reasonable ex post savings.

6.4.1 Findings for C&I Custom Projects

The custom projects accounted for 99 percent of total ex ante savings for the SB5X C&I Custom Incentives Programs. Data loggers were installed at 10 of the custom sites to measure peak demand and energy use. Peak kW savings are based on kW measurements as shown in **Figure 6.1** for the vacuum pump with variable frequency drive (VFD) at Site #1.

Figure 6.1 Power Measurements of Vacuum Pump with VFD at Site #1

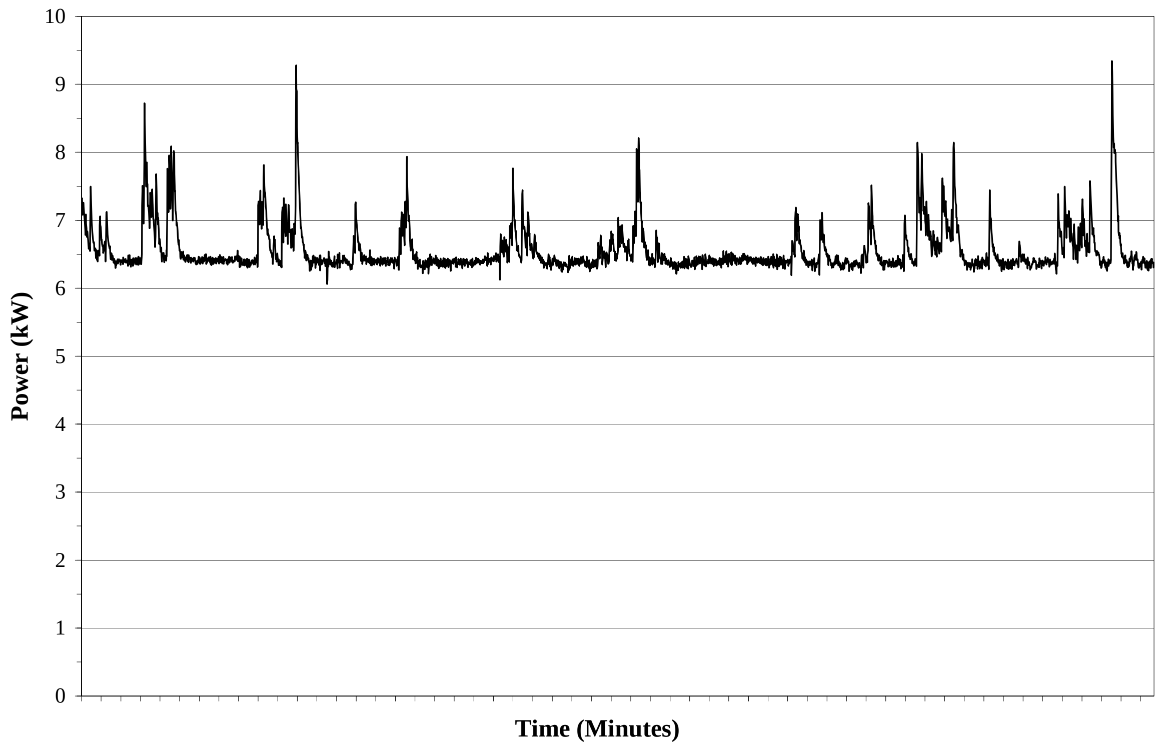


Figure 6.2 shows the old vacuum dairy pump with constant speed drive at site #1, and **Figure 6.3** shows the new vacuum dairy pump with VFD.

Figure 6.2 Old Vacuum Pump at Site #1

Figure 6.3 New Pump w/VFD at Site #1

Power measurements for the variable speed drive (VSD) air compressor at site #4 are shown in **Figure 6.4**, and measurements for the VSD air compressor at site #6 are shown in **Figure 6.5**.

Figure 6.4 Power Measurements of VSD Air Compressor at Site #4

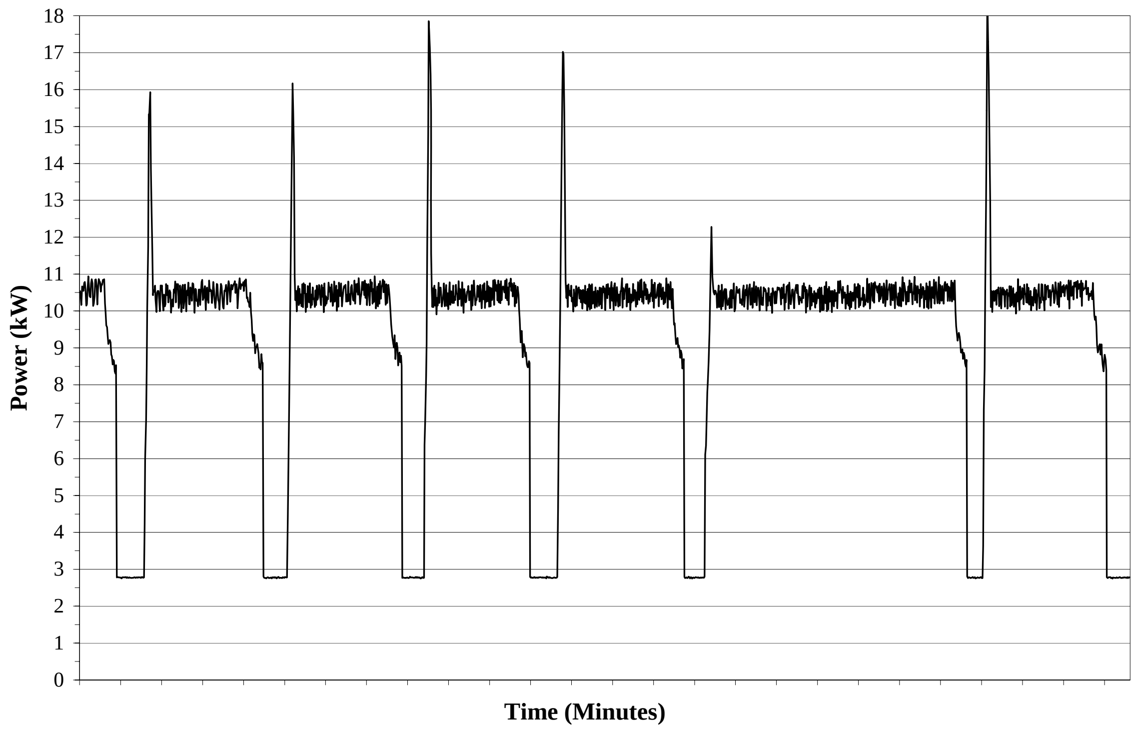


Figure 6.5 Power Measurements of VSD Air Compressor at Site #6

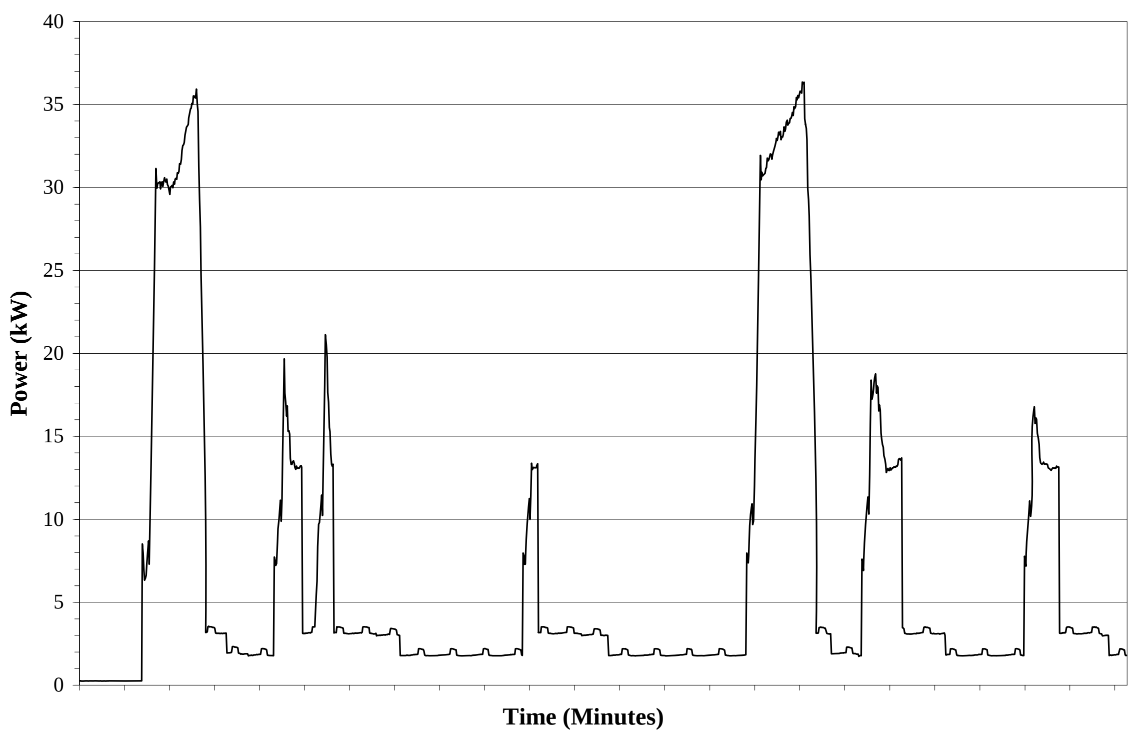


Figure 6.6 shows the VSD air compressor at Site #4, and **Figure 6.7** shows VSD air compressor at Site #6.

Figure 6.6 VSD Air Compressor at Site #4

Figure 6.7 VSD Air Compressor at Site #6

Three years of pre-retrofit and post-retrofit monthly utility billing data were collected for the 10 custom sites in TID from 2000 through 2002. Monthly utility billing data including both kWh and kW, sub-metered kW data, and engineering analyses were used to develop the kWh and kW baselines and savings for each site. Baseline kWh and kW values and ex ante and M&V ex post normalized savings per horsepower are summarized in **Table 6.4**. The ex ante mean savings for the ten sites are 3,814 kWh/hp-yr and 0.72 kW/hp. The gross M&V ex post mean savings for the ten sites are 3,476 ± 164.3 kWh/yr and 0.61 ± 0.03 kW/hp. The average gross realization rates (AGRR) are 0.9113 for kWh and 0.8439 for kW. The AGRR values are multiplied by the TID ex ante values of 4,877,817 kWh and 1,156 kW to calculate the gross M&V ex post savings of 4,445,082 ± 210,157 kWh/yr and 969 ± 40.5 kW. The net-to-gross ratio (NTGR) for TID is 0.84. Multiplying the NTGR times the M&V gross savings yields the net M&V savings for TID of 3,733,869 ± 176,532 kWh/yr and 814 ± 34 kW. The M&V sample included high efficiency air compressors, variable frequency drives, vacuum pumps, and motors affecting 419 horsepower out of a total of 2,808 horsepower in the program. Custom measures included air compressors, variable speed drives, vacuum pumps, motors, and controls. The effective useful lifetime for these custom measures is 15 years.[36]

[36] The net-to-gross ratio and effective useful lifetime (EUL) are taken from the *Energy Efficiency Policy Manual*, Chapter 4, page 22, prepared by the California Public Utilities Commission, 2001.

Table 6.4 TID Baseline and Savings for C&I Custom Projects

Site	Baseline (kWh/yr)	Base kW	Rebated Measure	hp	Ex Ante Savings kWh/hp-yr	Ex Ante Savings kW/hp	Ex Post Savings kWh/hp-yr	Ex Post Savings kW/hp	IPMVP Option
1	363,000	93	VFD Vacuum Pump	20	2,735.8	0.47	2,929.2	0.45	B, C
2	306,480	63	VFD Vacuum Pump	15	3,426.1	0.59	1,982.5	0.35	B, C
3	252,160	52	VFD Vacuum Pump	20	2,730.2	0.47	4,144.0	0.47	B, C
4	228,320	177	VSD Air Compressor	67	1,296.0	0.30	1,190.0	0.28	B, C
5	2,133,379	759	VSD Air Compressor	40	3,396.6	0.94	1,926.0	0.54	B, C
6	152,448	74	VSD Air Compressor	40	5,504.2	1.89	4,109.9	1.41	B, C
7	605,440	260	VSD Air Compressor	75	2,594.6	0.46	2,169.7	0.38	B, C
8	152,587	47	Eff. Air Compressor	15	2,148.5	0.75	2,378.9	0.83	B, C
9	4,270,578	843	Eff. Air Compressor	117	6,446.5	0.74	6,449.5	0.74	B, C
10	328,080	70	VSD Air Compressor	10	1,347.7	0.93	1,096.7	0.76	B, C
Mean					**3,814**	**0.72**	**3,476**	**0.61**	
90% CI							**164.3**	**0.03**	
Cv							0.59	0.52	
AGRR							**0.9113**	**0.8439**	

6.4.2 Findings for Solar Photovoltaic Systems

Insufficient data were available to fully evaluate savings for Solar Photovoltaic systems. The ex ante savings were based on engineering analyses and were accepted as reasonable. Ex ante and ex post savings for Ukiah, Lompoc, and Truckee are summarized in **Tables 2.4**, **2.5**, and **2.6**. The effective useful lifetime for photovoltaic systems is 30 years.[37] The relative precision for PV savings is 5% based on manufacturer's data.[38]

Table 6.5 Ukiah Baseline and M&V Savings for C&I Custom Project

Site	Baseline (kWh/yr)	kW	Rebated Measure	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option or Report
11	n/a	n/a	Solar Photovoltaic System	15,160	5	15,160	5	n/a

Table 6.6 Lompoc Baseline and M&V Savings for C&I Custom Project

Site	Baselne (kWh/yr)	kW	Rebated Measure	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option or Report
12	n/a	n/a	Solar Photovoltaic System	4,680	2.6	4,658	2.6	n/a

Table 6.7 TDPUD Baseline and M&V Savings for C&I Custom Project

Site	Baseline (kWh/yr)	kW	Rebated Measure	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option or Report
13	n/a	n/a	Solar Photovoltaic System	329	0.08	329	0.08	n/a

[37] According to the Solar Electric Light Fund, photovoltaic modules from crystalline cells have a lifetime of over twenty years. Available Online: http://www.self.org/shs_tech.asp. According to PV-WEB photovoltaic modules can be expected to operate for over 30 years with minimal maintenance. Available Online: http://www.pv-uk.org.uk/technology/whypv.html.

[38] According to manufacturer's specifications, minimum Photovoltaic system power is within 10 percent of rated power for most systems (see http://www.aetsolar.com/Solar_Products_Services/solar_components.htm).

6.5 Participant Survey Findings

Participant surveys were completed for 12 participants in three NCPA utility service areas. This sample size exceeded the M&V plan of 10 sites, and included all of the custom sites accounting for more than 3 percent of the total M&V savings. Participant Survey Findings for each program are presented in **Table 6.8**. The weighted average net-to-gross ratio is 0.841 based on average participant survey results multiplied times ex post savings for each program divided by total savings for all programs.[39]

Table 6.8 Findings of Participant Surveys

NCPA Utility	Rebates	Completed Surveys	Gross Ex Post Program Savings kWh/yr	Gross Ex Post Program Savings kW	Weighting Factor	Actual Net-to-Gross Ratio	Weighted Net-to-Gross Ratio
TID	60	10	4,445,082	969.0	0.992	0.840	0.833
Ukiah	1	1	15,160	5.0	0.005	1.000	0.005
Lompoc	2	1	4,680	2.6	0.003	1.000	0.003
Truckee	1		329	0.1	0.000	1.000	0.000
Total	**64**	**12**	**4,465,251**	**977**	**1.000**		**0.841**

7. LED Traffic Signals Programs

Light Emitting Diode (LED) Traffic Signals Programs were implemented by Lompoc, Modesto Irrigation District (MID), and Santa Clara. The programs realized peak kW and kWh savings by paying incentives to local city or county jurisdictions for the installation of high efficiency LED traffic signals. The three programs provided incentives totaling $450,697 for 4,924 LED traffic signals installed from 2001 through 2003 with SB5X funds administered by NCPA.

The M&V results are summarized in **Table 7.1**. The ex ante program savings are 2,700,354 kWh/yr and 308 kW. Total gross M&V program savings are 2,419,003 ± 22,919 kWh/yr and 276 ± 3.3 kW. Total M&V net program savings are 2,126,207 ± 20,102 kWh/yr and 242.8 kW ± 3 kW at the 90 percent confidence level. The effective useful life for LED traffic signals is 16 years.[40] Therefore, the net ex post lifecycle savings are 34,019,304 ± 321,629 kWh. The net realization rates are 0.79 for kWh and kW savings.

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

[40] See *Energy Efficiency Policy Manual,* Chapter 4, pages 21-22, prepared by the California Public Utilities Commission, 2001.

Table 7.1 Summary of M&V Results for NCPA SB5X LED Traffic Signals

NCPA Utility	Qty.	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Gross Ex Post Savings kWh/yr	M&V Gross Ex Post Savings kW	Net-to-Gross Ratio	M&V Net Ex Post Savings kWh/yr	M&V Net Ex Post Savings kW	Net Realization Rate Relative to Planning kWh/yr	Net Realization Rate Relative to Planning kW
Lompoc	1,074	546,568	62.4	496,976	56.7	0.87	432,369	49.4	0.79	0.79
MID	2,109	923,114	105.4	838,345	95.7	0.87	729,360	83.3	0.79	0.79
Santa Clara	1,741	1,230,672	140.5	1,083,682	123.7	0.89	964,477	110.1	0.78	0.78
Total	4,924	2,700,354	308.3	2,419,003	276	0.88	2,126,207	243	0.79	0.79

The M&V savings are based on detailed on-site engineering analyses for a random sample of 18 traffic signal intersections encompassing roughly 1,074 traffic signal measurements. Pre- and post-retrofit billing data was available for 17 intersections and 890 signals and this data along with the on-site measurements were used to develop M&V savings. The on-site audits included verification of all installed measures that received incentives as well as true RMS power measurements of pre- and post-installation fixtures. Respective traffic engineering departments provided operational hour data from their traffic signal controllers and this data was verified with power measurements. The net-to-gross ratios are based on decision maker surveys.

A separate report titled, *Measurement & Verification Report for NCPA SB5X LED Traffic Signals Programs,* provides more detailed information. M&V on-site work was performed in 2002. **Appendix A** provides the Decision-Maker Survey.

7.1 M&V Approach for LED Traffic Signals

The measurement and verification of energy and demand impacts of LED Traffic Signals programs are based on metering data for 42 signals, billing data for 890 traffic signals. A census was conducted for the DMS surveys. The ex post energy and peak demand savings were determined using IPMVP Option A (i.e., partially measured retrofit isolation), Option B (i.e., retrofit isolation), and IPMVP Option C (whole site billing regression analysis). Billing data, sub-metered data, engineering analyses, and previously published M&V studies were used to develop baseline energy use and gross energy and peak demand savings. A random sample of 42 signals where selected from the program tracking database for metering. True RMS electric power measurements were performed for a representative sample of incandescent and LED traffic signal lamps. Respective traffic engineering departments provided operational hour data from their traffic signal controllers. Billing data was collected for a three year period from January 2001 through December 2003. These data were used to develop annual energy savings. Field measurements were used to estimate gross peak kW savings.

Gross M&V program evaluation savings (i.e., kWh/yr and kW) are based on the average gross realization rates from the metered data and billing data. Gross M&V savings for each site in the audit are based on the difference between pre- and post-retrofit equipment power and billing data. 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.

7.2 M&V Sample Design and Precision

The sample design for the M&V on-site audits and participant surveys was designed to achieve a minimum precision of plus or minus 10% at the 90% confidence level. Sampling methods were used to analyze the data and extrapolate mean savings estimates from the sample measurements to the population of all program participants and to evaluate the statistical precision of the results. Load impacts were evaluated with a random M&V sample of 890 traffic signals accounting for 14.7 percent of the total program savings. The weighted sample coefficient of variation (Cv) for kWh savings is 0.21, the weighted Cv for kW savings is 0.04. Pre- and post-retrofit lamp power consumption, traffic signal intersection power use, and billing data were used to develop M&V savings. This data was used to develop accurate hours of operation verified from the traffic signal computer controls and CalTrans data. Therefore, the minimum 90/10 sample size for the M&V site visits was less than 12. The M&V on-site audit sample size included 18 signal intersections encompassing roughly 1,074 traffic signal measurements. Pre- and post-retrofit billing data was available for 17 intersections and 890 signals and this data along with the on-site measurements were used to develop M&V savings. The participant survey sample size was a census of 3.[41] These sample sizes exceed the 90/10 confidence level.

Sampling methods were used to analyze the data and extrapolate M&V savings estimates from the sample to the population of all program participants and to evaluate the statistical precision of the results. The M&V on-site survey sample of 890 traffic signals provided relative precision of ±1.2% for MW and ±0.9% for GWh. A census was conducted for the DMS surveys with zero free riders and zero relative precision.

7.3 Baseline

The baseline kWh and kW values are based on measured fixture Wattages or reference fixture Wattages. Measurements were made to verify pre-retrofit incandescent traffic signal power and hours of operation to develop the M&V baseline of energy and peak demand (i.e., kWh/yr and kW). Data were collected for representative incandescent traffic signal fixtures using true RMS digital power meters, data loggers, light loggers, interviews, and telephone surveys (i.e., decision maker survey). Groups of like fixtures were measured at the traffic signal intersection control panel to determine true RMS wattage per fixture. Measured values were compared to reference values to ensure accurate engineering analysis of energy and peak demand savings.

7.4 M&V Algorithms for LED Traffic Signals

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 fixture wattages and hours of operation (obtained from Caltrans or traffic engineering personnel). Traffic signal

[41] M&V audit sites of traffic signal intersections were randomly selected in the utility service areas of Lompoc and Santa Clara. MID signal intersections were verified and power measurements were made of pre-retrofit lamps. MID post retrofit LED lamp power measurements were based on M&V measurements of the same products from LED manufacturers for the other programs.

hours of operation from CalTrans are shown in **Table 7.2**.[42] Power measurements of incandescent and LED traffic signals are shown in **Table 7.3**.

Table 7.2 CalTrans Traffic Signal Estimated Operational Hours

Signal Type	Hours/yr
12" LED Red	4746
8" LED Red	4746
12" LED Red Arrow	7771
12" LED Green	3751
8" LED Green	3751
12" LED Green Arrow	726
12" LED Yellow	263
8" LED Yellow	263
12" LED Yellow Arrow	263
Pedestrian Hand/Walking Person Combo	8642

Table 7.3 Power Measurements of Incandescent and LED Traffic Signals

#	Incandescent Baseline Description	Rated Power (Watts)	Measured Power (Watts)	LED Measure	Rated Power (Watts)	Measured Power (Watts)
1	12" Ball Incandescent Rated 169W	169	149	12" LED Red	11	11
		169	149	12" LED Green	12	12
		169	149	12" LED Yellow	10	10
2a	8" Ball Incandescent Rated 116W	116	107	8" LED Red	8	8
		116	107	8" LED Green	10	10
		116	107	8" LED Yellow	13	13
2b	8" Ball Incandescent Rated 69W	69	64	8" LED Red	8	8
		69	64	8" LED Green	10	10
		69	64	8" LED Yellow	13	13
3a	12" Arrow Incandescent Rated 169W	169	149	12" LED Red Arrow	7.5	7.5
		169	149	12" LED Green Anrow	10	10
		169	149	12" LED Yellow Arrow	10	10
3b	12" Arrow Incandescent Rated 116W	116	107	12" LED Red Arrow	7.5	7.5
		116	107	12" LED Green Arrow	10	10
		116	107	12" LED Yellow Arrow	10	10
4	Pedestrian Incandescent 169W	167	149	LED Ped/Combo	9	9
4	Pedestrian Incandescent 116W	116	107	LED Ped/Combo	9	9

The M&V kW and kWh savings for each site are calculated using **Equations** 7.**1** and 7.**2**.

Eq. 7.1 $$\text{kW Savings}_k = \sum_{k=1}^{n} \text{Quantity}_k \times \left[\text{kW}_{pre} - \text{kW}_{post}\right]_k$$

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. 7.2 $$\text{kWh Savings}_k = \sum_{j=1}^{m} \text{Quantity} \times \left[\text{kW}_{pre} - \text{kW}_{post}\right] \times \text{hours/year}$$

[42] CalTrans traffic signal operational hours are based on intersection metering data by Electra-test, Inc. (ETI) and verified by Schiller Associates for the PG&E Power Saving Partners. ET1 monitored 160 signals over 29 intersections. *Review of CalTrans-Traflic Signal Duty Cycle Monitoring Results*, Schiller Associates, prepared for PG&E Power Saving Partners Program, lD#95PSP 105 CalTrans - Traffic Signal Retrofit, November 1999.

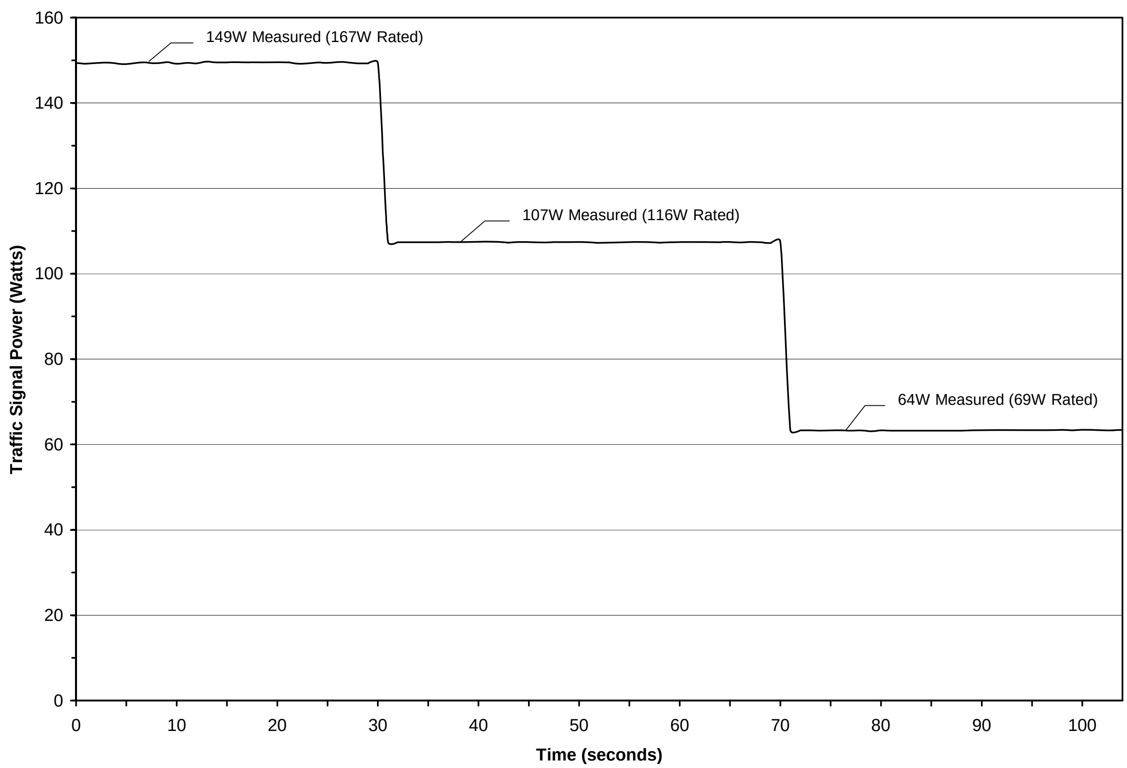
Where,

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

hours/year = Hours of operation per year per fixture based on traffic engineering or CalTrans traffic signal operational hours (see **Table 7.3**).

The measured power of incandescent traffic signal lamps is 7 to 11 percent less than the rated power (see **Table 7.2** and **Figure 7.1**). The measured power of LED signals is equivalent to the rated power as shown in **Figure 7.2** for an LED signal intersection in Lompoc where 32 signals are on at any given time (i.e., 315W / 32 = 9.84 W/LED signal).[43] Measurements of a Santa Clara intersection with all LED signals except incandescent amber signals shows roughly the same power usage (i.e., 315W) when the red, green, and pedestrian LED signals are operating without the amber signals (see **Figure 7.3**). The power use is two to four times greater for this intersection, when the incandescent amber signals are operating.

Figure 7.1 Incandescent Traffic Signal Power Measurements



[43] For the Lompoc intersection with all LED signals there are eight 12" red signals (8 x 11W = 88W) plus eight 12" red arrow signals (8 x 7.5 = 60W) plus eight 12" Green signals (8 x 12W = 96W) plus eight pedestrian/combo signals (8 x 9W = 72W) for a total of 316W and this is within 0.4% of the average measured power of 315W.

Figure 7.2 Lompoc Intersection with All LED Traffic Signals

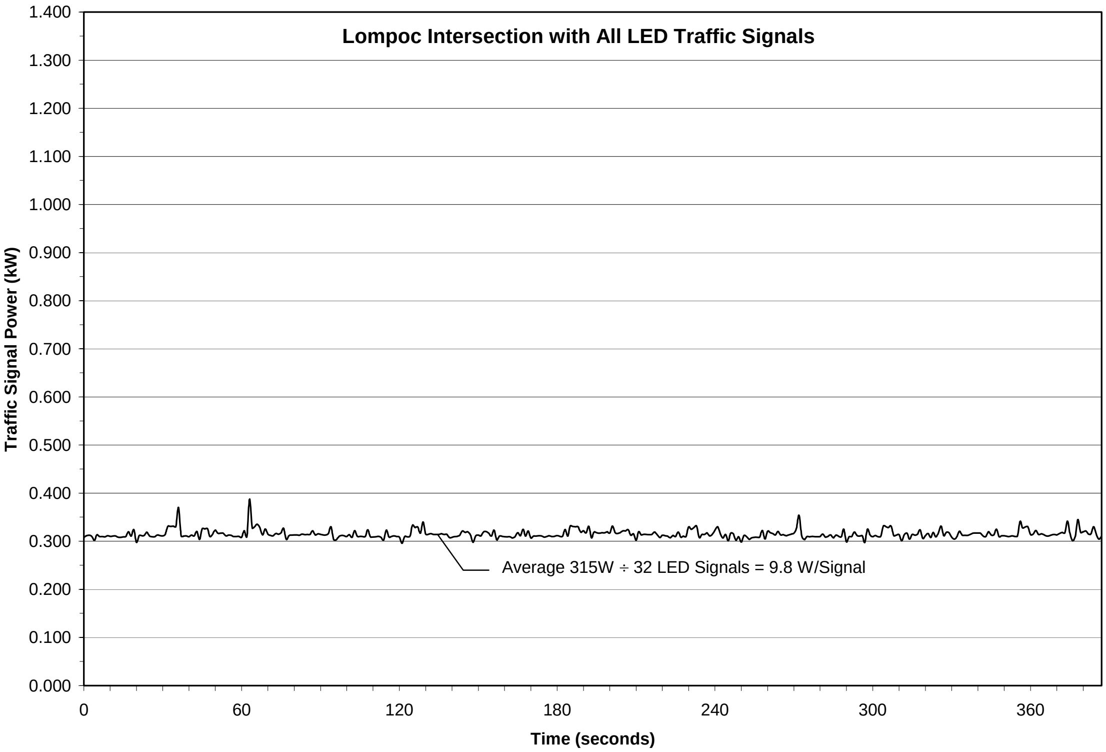
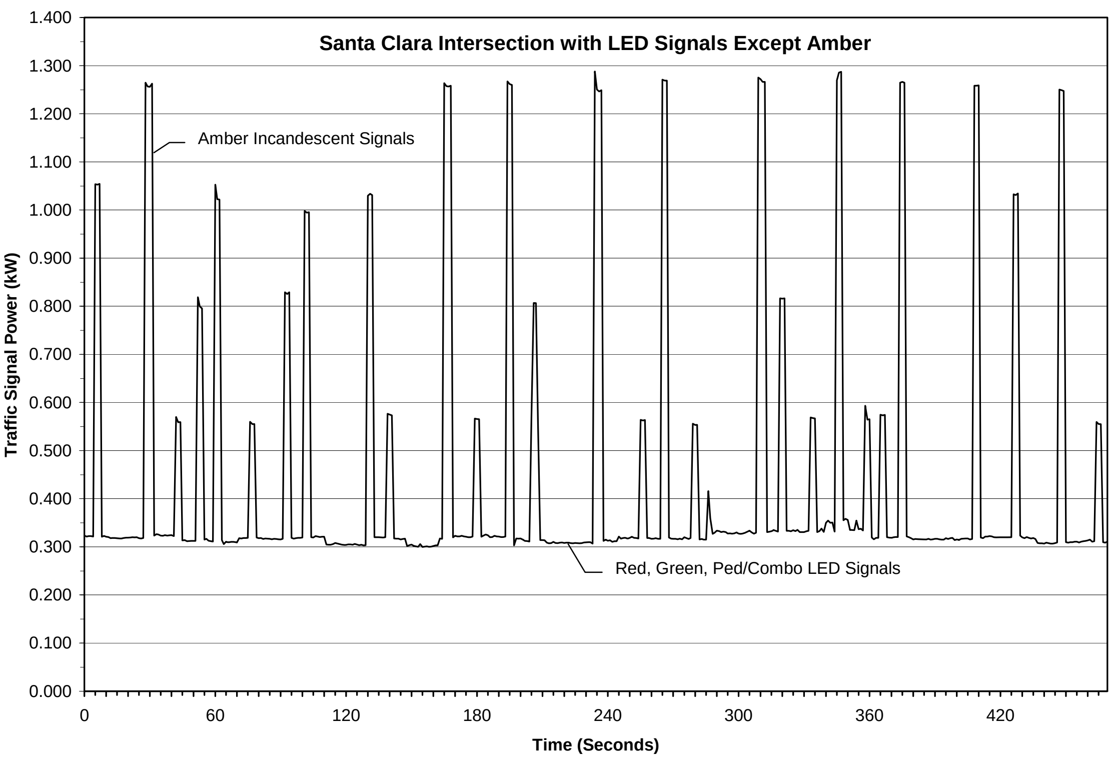


Figure 7.3 Santa Clara Intersection with LED Traffic Signals Except Amber



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 is combined with the Net-to-Gross Ratio (NTGR) to develop the Net Realization Rate (NRR) relative to planning. The effective useful lifetime of LED traffic signals is 16 years.[44]

7.5 M&V Findings for LED Traffic Signals

Findings of the M&V on-site audits are provided in **Tables 7.4** through **7.7** for the Lompoc, MID, and Santa Clara service areas.

Table 7.4 shows M&V savings versus billing data savings for 17 intersections and 890 LED traffic signals in Lompoc. M&V savings are within 1.2 percent of billing data savings indicating that the M&V calculation methodology is accurate regarding pre- and post-retrofit lamp Wattages and annual operational hours. M&V savings are based on Caltrans operational hours. The Caltrans operational hours provided M&V savings results that were closer to the billing data savings than the hours provided by Lompoc electric utility.

Table 7.5 shows that the M&V gross realization rates for Lompoc are 91 percent. This is due to using CalTrans operational hours and measured incandescent lamp baseline Wattages in the M&V calculations (i.e., 8 to 11 percent lower).

Table 7.6 shows that the M&V gross realization rates for MID are 91 percent. This is due to using CalTrans operation hours in the M&V calculations which are lower than the assumed ex-ante operational hours.[45]

Table 7.7 shows that the M&V gross realization rates for Santa Clara are 88 percent. This is due to using measured incandescent and LED lamp baseline Wattages in the M&V calculations. City of Santa Clara operational hours were verified with traffic engineering as well as measured data.

[44] See *Energy Efficiency Policy Manual*, Chapter 4, pages 21-22, prepared by the California Public Utilities Commission, 2001.

[45] A representative of the City of Modesto Traffic Engineering Division Engineering and Transportation Department verified that the CalTrans operational hours are reasonable and appropriate for Modesto.

Table 7.4 M&V Savings versus Billing Data Savings for 17 Intersections and 890 LED Signals in Lompoc

Signal Inter-section	Meter Number	Major Street	Cross Street	Red LEDs	Amber LEDs	Green LEDs	Red Arrows	Amber Arrow	Green Arrow	Ped-Head Combo	Total LEDs	Billing Data Savings	M&V Savings
1	17052910	Ocean	G	12	12	10	2	2	4	8	50	19,873	20,147
2	17043760	Central	Walmart	8	8	8	4	4	4	8	44	26,338	18,499
3	17161200	H	Longs Ent	10	10	10	4	4	4	8	50	13,252	20,560
4	17161160	Central	O	12	12	12	8	8	8	8	68	23,994	26,099
5	17172170	Central	H	8	8	8	8	8	8	8	56	22,902	21,975
6	17018610	Ocean	South A	10	10	8	2	2	8	8	48	19,191	18,367
7	17144980	Ocean	7th	11	11	11	4	4	4	8	53	19,654	21,591
8	17000930	College	H	10	9	9	5	6	7	8	54	28,243	21,128
9	17084270	Ocean	I	12	12	12	2	2	4	8	52	27,015	21,025
10	17161210	Central	L	12	12	12	8	8	8	8	68	24,055	26,099
11	17118860	H	Barton	10	10	10	4	4	4	6	48	16,467	18,867
12	17081540	H	Mission	10	10	10	4	4	4	6	48	16,929	18,867
13	17155190	Hwy 1	246	11	11	11	6	7	8	6	60	21,115	21,802
14	17172160	H	Pine	11	11	9	2	2	6	6	47	15,417	17,563
15	17019510	Ocean	O	12	12	10	2	2	4	8	50	24,337	20,147
16	17083800	H	Walnut	12	12	10	2	2	4	8	50	18,643	20,147
17	17011720	H	North	8	8	8	4	4	6	6	44	16,868	16,946
Subtotal				179	178	168	71	73	95	126	890	354,292	349,828

Table 7.5 M&V Summary for Lompoc LED Traffic Signals Program

#	Measure Description	Ex-Ante Qty.	Ex-Ante Pre W/fix	Ex-Ante Post W/fix	Ex-Ante Hrs/yr	Ex-Ante kW Savings	Ex-Ante kWh/y Savings	M&V Qty.	M&V Pre W/fix	M&V Post W/fix	M&V Hrs/yr	M&V kW Savings	M&V kWh/y Savings	M&V Gross Realization Rate kW	M&V Gross Realization Rate kWh/y
1	12" LED Red	113	167	10	5168.4	10.467	91,693	113	149	11	4746	8.449	74,009	0.81	0.81
2	8" LED Red	93	116	7	5168.4	5.981	52,392	93	107	8	4746	4.988	43,696	0.83	0.83
3	12" LED Red Arrow	77	167	8	7095.6	9.917	86,871	77	149	7.5	7771	9.665	84,669	0.97	0.97
4	12" LED Green	126	167	10	3328.8	7.517	65,850	126	149	12	3751	7.392	64,750	0.98	0.98
5	8" LED Green	93	116	7	3328.8	3.852	33,744	93	107	10	3751	3.863	33,838	1.00	1.00
6	12" LED Green Arrow	117	167	8	1401.6	2.976	26,074	117	149	10	726	1.348	11,807	0.45	0.45
7	12" LED Yellow	135	167	10	262.8	0.636	5,570	135	149	18	263	0.531	4,651	0.84	0.84
8	8" LED Yellow	93	116	7	262.8	0.304	2,664	93	107	13	263	0.262	2,299	0.86	0.86
9	12" LED Yellow Arrow	83	167	8	262.8	0.396	3,468	83	149	10	263	0.346	3,034	0.87	0.87
10	LED Ped/Combo	144	167	10	7884	20.347	178,241	144	149	9	8642	19.888	174,223	0.98	0.98
Total		1074				62.4	546,568	1074				56.7	496,976	0.91	0.91

Table 7.6 M&V Summary for Modesto Irrigation District LED Traffic Signals Program

#	Measure Description	Ex-Ante Qty.	Ex-Ante Pre W/fix	Ex-Ante Post W/fix	Ex-Ante Hrs/yr	Ex-Ante kW Savings	Ex-Ante kWh/y Savings	M&V Qty.	M&V Pre W/fix	M&V Post W/fix	M&V Hrs/yr	M&V kW Savings	M&V kWh/y Savings	M&V Gross Realization Rate kW	M&V Gross Realization Rate kWh/y
1	12" LED Green	1389	150	12	4,197.5	91.848	804,585	1389	149	12	3,850	83.633	732,628	0.91	0.91
2	8" LED Green	309	69	10	4,197.5	8.736	76,525	309	64	10	3,850	7.333	64,241	0.84	0.84
3	12" LED Green Arrow	411	150	10	730.0	4.795	42,004	411	149	10	726	4.735	41,476	0.99	0.99
Total		2109				105.4	923,114	2109				95.7	838,345	0.91	0.91

Table 7.7 M&V Summary for Santa Clara LED Traffic Signals Program

#	Measure Description	Ex-Ante Qty.	Ex-Ante Pre W/fix	Ex-Ante Post W/fix	Ex-Ante Hrs/yr	Ex-Ante kW Savings	Ex-Ante kWh/y Savings	M&V Qty.	M&V Pre W/fix	M&V Post W/fix	M&V Hrs/yr	M&V kW Savings	M&V kWh/y Savings	M&V Gross Realization Rate kW	M&V Gross Realization Rate kWh/y
1	12" LED Red	489	167	10	5168.4	45.296	396,794	489	149	11	5168.4	39.814	348,774	0.88	0.88
2	8" LED Red	77	116	7	5168.4	4.952	43,378	77	107	8	5168.4	4.498	39,399	0.91	0.91
3	12" LED Red Arrow	108	167	8	7095.6	13.909	121,846	108	149	7.5	7095.6	12.378	108,435	0.89	0.89
4	12" LED Red Flasher	6	167	10	4380	0.471	4,126	6	149	11	4380	0.414	3,627	0.88	0.88
5	12" LED Green	555	167	10	3328.8	33.111	290,055	555	149	12	3328.8	28.893	253,105	0.87	0.87
6	8" LED Green	74	116	7	3328.8	3.065	26,850	74	107	10	3328.8	2.728	23,894	0.89	0.89
7	12" LED Green Arrow	173	167	8	1401.6	4.401	38,554	173	149	10	1401.6	3.848	33,704	0.87	0.87
8	12" LED Yellow Flasher	17	167	10	4380	1.335	11,690	17	149	16	4380	1.131	9,903	0.85	0.85
9	12" LED Yellow Arrow	4	167	8	4380	0.318	2,786	4	149	10	263	0.017	146	0.05	0.05
10	LED Ped/Combo	238	167	10	7884	33.629	294,594	238	149	9	7884	29.988	262,695	n/a	n/a
Total		1741				140.5	1,230,673	1741				123.7	1,083,682	0.88	0.88

7.6 Participant Survey Findings

This study uses participant surveys to estimate the net-to-gross ratios for kWh and peak kW savings. Participant surveys were completed for 3 participants in three NCPA utility service areas, and this represents a census of all three decision makers. Participant Survey Findings for each program are presented in **Table 7.8**. The weighted average net-to-gross (NTG) ratio is 0.88 based on average participant survey results multiplied times savings for each program divided by total savings for all programs.[46] For comparison, a similar M&V LED Traffic Signals study conducted in 2000 found 0.828 for the ex-post NTG ratio.[47]

Table 7.8 Findings of Participant Surveys

NCPA Utility	Projects	Completed Surveys	Ex Post Program Savings kWh/yr	Ex Post Program Savings kW	Weighting Factor kWh/yr	Weighting Factor kW	Net-to-Gross Ratio	Weighted Net-to-Gross Ratio
Lompoc	1	1	546,568	62.4	0.218	0.218	0.87	0.189760
MID	1	1	923,114	105.4	0.428	0.428	0.87	0.372630
Santa Clara	1	1	1,230,673	140.5	0.354	0.354	0.89	0.314681
Total	3	3	2,700,355	308	1.000	1.000	0.88	0.88

8. Residential HVAC Rebate Programs

Residential Heating, Ventilating, and Air Conditioning (HVAC) Rebate Programs were implemented by Modesto Irrigation District (MID), Plumas Sierra Electric Cooperative (PSREC), Redding Electric Utility (REU), Roseville Electric, and Turlock Irrigation District (TID). The programs realized peak kW and kWh savings by paying rebates to consumers for installing high efficiency air conditioners. The programs provided 1,892 air conditioner rebates from 2001 through 2003 with $1,344,803 of SB5X funds administered by NCPA.

Ex ante program savings are summarized in **Table 8.1**, and ex post savings are summarized in **Table 8.2**. The gross program ex post evaluation savings are 970,263 ± 177,315 kWh/yr and 1,273 ± 114 kW at the 90 percent confidence level. Net program evaluation savings are 801,358 ± 145,753 kWh/yr and 1,053 ± 71 kW at the 90 percent confidence level. The net ex post lifecycle savings are 12,020,370 ± 2,186,295 kWh based on a 15-year effective useful life. The net realization rates are 0.30 for kWh savings and 0.56 for kW savings. Energy savings are based on billing regression analyses for 60 sites using the PRInceton Scorekeeping Method (PRISM). Peak demand savings are based on field measurements of peak kW for 21 units. The average net-to-gross ratio is 83 percent indicating 17 percent would have been purchased without the program.[48] M&V savings and realization rates are lower than anticipated due to lower baseline usage and lower net-to-gross ratios. If deemed savings from DEER had been used for the M&V study, the realization rates would have been 20 to 37 percent lower.

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[46] Participant survey results represent a census of the decision-makers who participated in the three programs.

[47] *Evaluation of Pacific Gas & Electric Company's Pre-1998 Commercial Energy Efficiency Incentives Program Carry-Over for Traffic Signal Technologies*, PG&E Study ID number 404D, prepared by Quantum Consulting, Inc., March 2000. The PG&E study NTG ratio is the sum of (1-FR) plus spillover, where FR is the free-ridership ratio. For this study we did not evaluate spillover, but our NTG ratio is reasonably close to the PG&E study.

[48] The net-to-gross ratios reflect what customers would have done in the absence of the program (see Section 3).

Table 8.1 Ex Ante Savings for NCPA SB5X Residential HVAC Rebate Programs

NCPA Utility	Qty.	Ex Ante Full-Year Unit kWh/yr	Ex Ante Unit kW	Ex Ante Net-to-Gross Ratio kWh/y	Ex Ante Net-to-Gross Ratio kW	Ex Ante Program Savings kWh/y	Ex Ante Program Savings kW
MID	316	350	0.64	1	1	110,645	201.2
PSREC-GSHP	82	16,001	3.96	1	1	1,312,082	324.7
Redding	704	666	0.76	1	1	469,104	536.3
Roseville	134	2,594	2.59	1	1	347,616	347.6
TID	656	721	0.74	1	1	472,845	483.2
Total or Average	**1,892**	**1,434**	**1.00**	**1.00**	**1.00**	**2,712,291**	**1,893**

Note: PSREC includes electric heating savings for the Ground Source Heat Pump (GSHP). Peak kW savings are for cooling only.

Table 8.2 M&V Ex Post Savings for NCPA SB5X Residential HVAC Rebate Programs

NCPA Utility	Qty.	M&V Gross Ex Post Savings kWh/y	M&V Gross Ex Post Savings kW	Net-to-Gross Ratio kWh/y	Net-to-Gross Ratio kW	M&V Net Ex Post Savings kWh/y	M&V Net Ex Post Savings kW	Net Realization Rate kWh/y	Net Realization Rate kW
MID	316	446	0.52	0.82	0.82	115,513	135.8	1.04	0.67
PSREC-GSHP	82	913	2.10	0.84	0.84	62,864	144.6	0.05	0.45
Redding	704	561	0.71	0.83	0.83	327,658	413.2	0.70	0.77
Roseville	134	581	0.79	0.86	0.86	67,011	91.2	0.19	0.26
TID	656	430	0.51	0.81	0.81	228,313	268.4	0.48	0.56
Total or Average	**1,892**	**513**	**0.67**	**0.82**	**0.82**	**801,358**	**1,053.3**	**0.30**	**0.56**

The M&V gross savings are based on in-situ 15-minute true RMS power measurements of 21 air conditioners. Each unit included in the random sample was measured for several weeks in order to obtain 15-minute average kW measurements during the 2 PM to 6 PM time frame. The peak kW for each unit is taken as the maximum kW that occurs during the 2 PM to 6 PM weekday time frame from the 15-minute data. Participant telephone surveys were used to evaluate program performance criteria and net-to-gross ratios.

A separate report titled, *Measurement & Verification Report for NCPA SB5X Residential HVAC Rebate Programs*, provides more detailed information. M&V on-site work was performed from 2002 through 2003. **Appendix A** provides the Decision-Maker Survey.

8.1 M&V Approach for Residential HVAC

The measurement and verification of energy and demand impacts of the Residential HVAC program are based on billing data, engineering analysis, calibrated DOE-2.2/eQuest computer simulations, and billing regression analyses using the PRInceton Scorekeeping Method (PRISM).[49] IPMVP Option B (i.e., retrofit isolation) and IPMVP Option C (i.e., whole facility billing regression analysis). Peak demand savings were determined using IPMVP Option B (i.e., retrofit isolation). PRISM billing regression analysis was used to estimate gross kWh/yr savings. Field measurements or air conditioner kW and energy efficiency ratios (EER) were used to estimate gross peak kW savings. These values were compared to peak demand savings based on manufacturer kW ratings for similar indoor and outdoor temperature conditions. The study examined proper refrigerant charge and airflow (RCA) for new and existing air conditioners and

[49] Ibid.

how improper RCA might be mitigated by the presence of a Thermostatic Expansion Valve (TXV) on the evaporator coil. The study examined this issue since the California Energy Commission 2001 Title 24 Building Energy Efficiency Standards (CEC Standards) include the Alternative Calculation Method (ACM) or TXV or proper RCA as compliance options for new air conditioners for new and existing residential buildings. Roseville Electric Company required a TXV on participating air conditioners.

The impact of improper installation on air conditioner efficiency was evaluated using field measurements of kW and EER to determine in-situ efficiency before and after correcting refrigerant charge and airflow (RCA) on a sample of 14 air conditioners with TXVs and seven air conditioners without TXVs. Return and supply temperatures were measured inside the return and supply plenums. Temperature and power were measured at one minute intervals. Airflow was measured before and after making any changes to the supply/return ducts, opening vents, or installing new air filters that would affect airflow. Return and supply enthalpies were derived from the temperature measurements using standard psychrometric algorithms.[50] EER was derived from the combination of enthalpy, airflow, and power measurements. Measurements were made to evaluate the relative change in efficiency not the absolute efficiency, and all measurements of air conditioner performance were made within minutes of any efficiency improvements, but at least 15 minutes after any refrigerant charge adjustments. Measurement tolerances are less important than the relative performance change. New and old systems were examined with labeled Seasonal Energy Efficiency Ratios (SEER) ranging from 7 to 16.[51]

Gross program evaluation kWh savings are based on sample mean savings estimates based on billing data analysis of 60 air conditioners. Billing data was collected from January 2001 through December 2004 to develop annual energy savings. Gross program kW savings are based on sample mean savings estimates and field measurements of 14 new high efficiency air conditioners and 7 existing air conditioners. Gross kW savings for the sampled units were compared to kW savings based on manufacturer kW ratings for similar indoor and outdoor temperature conditions. 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.

8.2 M&V Sample Design and Precision

The sample design for the M&V on-site audits and participant surveys achieved a minimum precision of plus or minus 10% at the 90% confidence level. The load impacts for kWh savings were evaluated with a random M&V sample of 60 program participants accounting for 4 percent of the total program kWh savings. The load impacts for kW savings were evaluated with a random M&V sample of 21 program participants accounting for 6 percent of the total program kW savings. The M&V participant survey sample size was 60. These sample sizes exceed the 90/10 confidence level. The weighted sample coefficient of variation for kWh savings is 0.11 the Cv for kW savings was 0.24, and the participant survey coefficient of variation is 0.15. To

[50] Kelsey, J. 2004. Get Psyched™ Psychrometric Software for MS Excel, Available online: www.kw-engineering.com. Oakland, Calif. kW Engineering.

[51] SEER is an adjusted rating based on steady-state EER measured at standard conditions of 82°F outdoor and 80°F drybulb/67°F wetbulb indoor temperature multiplied by the Part Load Factor with a default of 0.875 (ARI 2003).

achieve the 90/10 criteria with these Cv values required a sample size of 3 for estimating kWh savings, 15 for estimating kW savings, and 6 for the participant surveys. The billing data kWh sample was 60, the kW metering sample was 21, and the participant survey sample was 60.[52]

Sampling methods were used to analyze the data and extrapolate M&V savings estimates from the sample to the population of all program participants and to evaluate the statistical precision of the results. The M&V on-site survey sample of 61 participants provided relative precision of ±6.7% for MW and ±18.2% for GWh. The DMS sample of 60 participants yielded relative precision of ±3% for the survey results.

8.3 Baseline

The baseline kWh values are based on billing data and PRISM analyses, and the baseline kW values are based on metering results for a random sample of new high efficiency air conditioners and old standard air conditioners. The sample mean baseline full-year unit energy consumption for old air conditioners was 2,267 ± 311 kWh/yr at the 90 percent confidence level. The sample mean baseline kW varied from 3.75 ± 0.37 kW for 2.5 ton standard air conditioner to 6.01 ± 0.6 kW for 5-ton standard units. The baseline Unit Energy Consumption (UEC) values found in this study are higher than the 2004 California Statewide Residential Appliance Saturation Survey (RASS, available online at: http://websafe.kemainc.com/RASSWEB).[53] The 2004 RASS Study provides the following single family UEC values shown in **Table 8.3**.

Table 8.3 Average Residential Single Family UEC Values from 2004 RASS

End use	Climate Zone	Existing kWh/yr	New kWh/yr
Cooling (average)	All	1,215	1,423
Cooling (hottest climate zone)	7	1,908	n/a

The hottest climate zone 7 has a cooling UEC of 1,908 kWh per year. The M&V report for NCPA SB5X programs found an average cooling UEC of 2,267 kWh/yr and this is 18.6% higher than the highest 2004 RASS UEC values. The 2004 RASS is based on Conditional Demand Analysis of billing data for 21,153 homes. For space cooling the sample frame included 7,706 existing homes and 1,073 new homes. The baseline efficiency level for each measure was within the requirements of the Energy Policy Act of 1992 (EPACT). EPACT mandated minimum energy efficiency levels of cooling equipment manufactured for sale in the United States. These standards govern the minimum efficiency of packaged and split-system central air conditioners. The 2001 California Title 24 building codes were used to establish baselines for each measure.

[52] Samples were randomly selected in each utility service area. Billing data and electricity metering data of air conditioners were obtained for participants and non-participants in MID, PSREC, Redding, and Roseville.

[53] *California Statewide Residential Appliance Saturation Survey*. Prepared by KEMA-Xenergy, Inc. Prepared for the California Energy Commission. P300-00-004. June 2004.

8.4 M&V Findings for Residential HVAC

Field measurements of participant and non-participant air conditioners were made to determine in-situ efficiency before and after correcting RCA. Data loggers were installed at 21 sites to measure peak demand and energy use for standard and high efficiency air conditioners. Average field measured kW savings versus calculated kW savings based on manufacturer data are shown in **Table 8.4** and **8.5**.[54] The average measured kW savings are based on field measurements of existing and energy efficient air conditioners shown in **Figures 8.1** and **8.2**. For conventional units, the measured savings range from 0.59 kW for a 2.5-ton 14 SEER unit to 0.80 kW for a 5-ton 14 SEER unit. The maximum savings are 2.1 kW for ground source heat pumps (GSHP). The average age of existing units was 10 to 14 years as shown in **Table 8.5**.[55]

Table 8.4 Average Measured kW Savings vs. Derived Savings from Manufacturer Data

Air Conditioner Capacity Tons	Existing Unit Average Peak kW	Existing Unit SEER	New Unit Average Peak kW	New Unit SEER	Average Measured kW Savings	Manufacturer Rated kW Savings	Indoor & Outdoor Temperature °F
2.5	3.75	9	3.16	14	0.59	0.58	80/67/105
3.0	4.05	10	3.64	12	0.41	0.56	80/67/100
3.0	4.05	10	3.52	13	0.53	0.63	80/67/100
3.0	4.05	10	3.15	14	0.89	0.87	80/67/100
3.5	4.34	10	3.52	13	0.82	0.32	80/67/100
3.5	4.34	10	3.50	14	0.84	0.60	80/67/100
4.0	5.44	10	4.63	14	0.81	0.64	80/67/105
5.0	6.01	10	5.50	12	0.51	0.30	80/67/105
5.0	6.01	10	5.16	14	0.85	0.57	80/67/105
5.0 (GSHP)	6.01	10	4.0	16	2.1	1.59	80/67/110

Table 8.5 Measured kW Savings versus Calculated kW Savings from Manufacturer Data

Tons	Measured kW Baselines and Savings					Calculated kW from Manufacturer Data				
	Existing Unit kW	Age of Existing Unit	12 SEER ΔkW	13 SEER ΔkW	14 SEER ΔkW	Base 10 SEER kW	11 SEER ΔkW	12 SEER ΔkW	13 SEER ΔkW	14 SEER ΔkW
2	n/a	n/a				2.89	0.17	0.26	0.29	0.47
2.5	3.75	1991			0.59	3.36	0.20	0.29	0.37	0.58
3	4.05	1989	0.41	0.52	0.89	4.07	0.24	0.56	0.63	0.87
3.5	4.34	1988		0.82	0.84	4.29	0.17	0.17	0.32	0.60
4	5.44	1991			0.81	5.42	0.22	0.18	0.28	0.64
5	6.01	1992	0.51	0.85	0.80	6.25	0.19	0.30	0.14	0.57

Billing data were collected for 60 sites in MID, PSREC, Redding, and Roseville. These data were used as inputs for the PRInceton Scorekeeping Method (PRISM) to develop baseline cooling values for air conditioners and heating values for ground source heat pumps.[56] Energy savings are based on the program average SEER or COP improvement with respect to the baselines shown in **Table 8.6**. Ex post unit savings for TID are based on savings for MID and

[54] Manufacturer data is from *Residential and Light Commercial Products and Systems Catalog*, Volume 1, Carrier Corporation for units with similar cooling capacities and efficiencies.

[55] National Appliance Energy Conservation Act (P.L. 100-12, P.L. 100-357) required minimum 10 SEER for split-systems on 1-1-92 and for packaged systems on 1-1-93.

[56] Ibid.

scaled by the ratio of the average SEER. The kWh savings for PSREC exclude electric heating, due to uncertainty associated with heating savings and the focus of SB5X on summer peak loads.

Table 8.6 Baseline and High Efficiency SEER for Air Conditioners and COP for GSHP

NCPA Utility	Baseline SEER	Program Average SEER	Baseline Heating COP	Program Average Heating COP
MID	10	12.45	n/a	n/a
PSREC-GSHP	10	16	2	3.6
Redding	10	12.61	n/a	n/a
Roseville	10	13.81	n/a	n/a
TID	10	12	n/a	n/a

Figure 8.1 Measurements of 10 SEER and 14 SEER 4-ton Air Conditioners

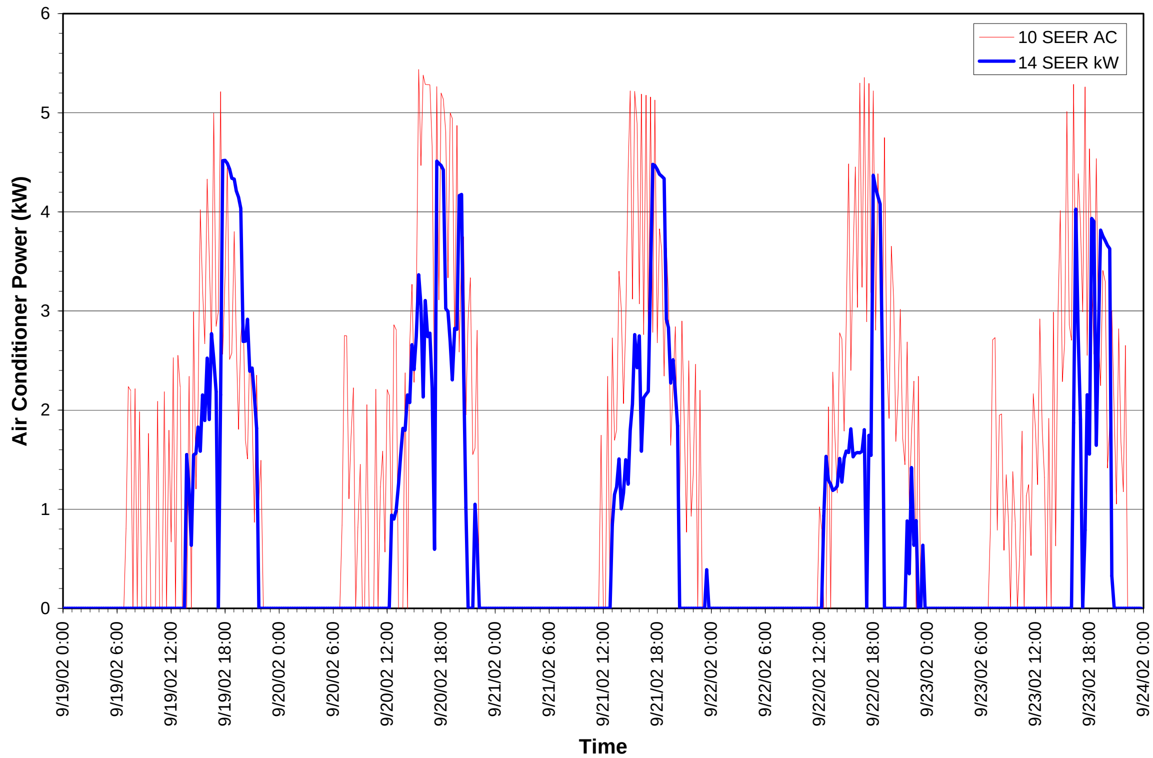
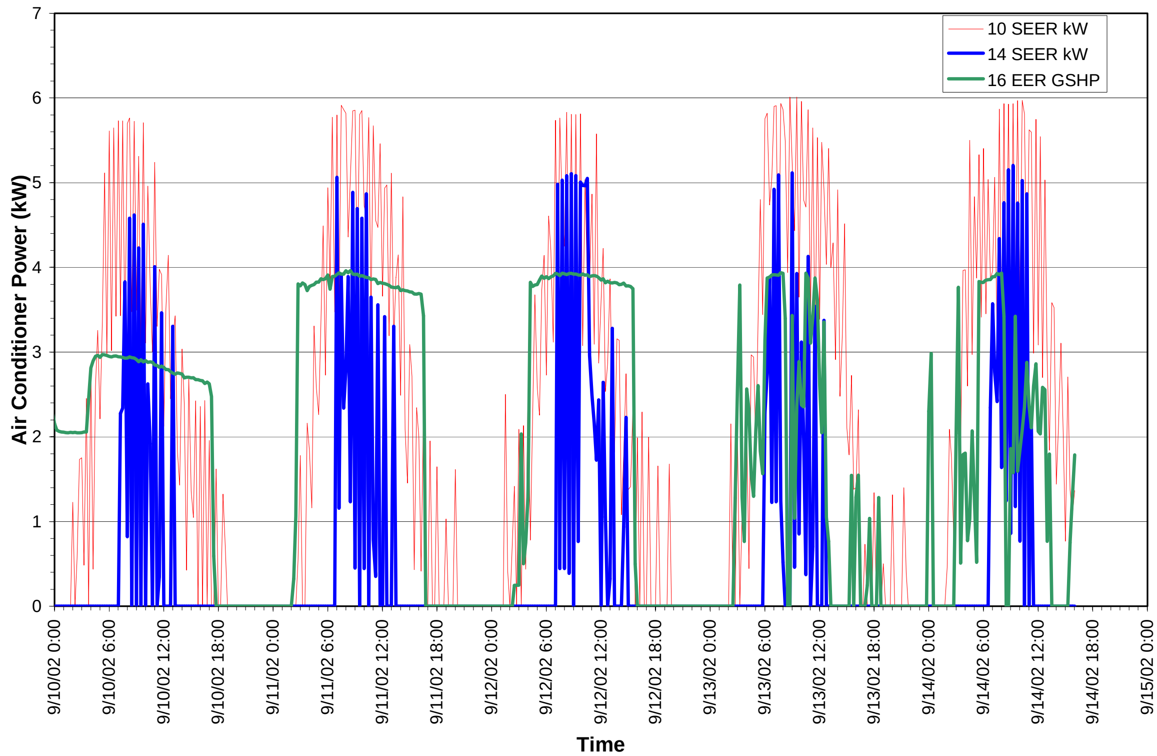


Figure 8.2 Measurements of 10 and 14 SEER 5-ton Air Conditioners and 16 SEER GSHP



The M&V savings for MID are shown in **Table 8.7**. The M&V savings for PSREC GSHP units are shown in **Table 8.8**. For PSREC, a follow-up survey was performed and only two participants previously had electric heat (i.e., baseboard or heat pumps). The others were planning to install propane heat. Another study performed for Redding Electric found ex post savings per GSHP of -1,355 ± 841 kWh per year, 2.1 ± 0.02 kW, and 545 ± 161 therms per year.[57] This study uses cooling-only savings for PSREC due to uncertainty associated with GSHP heating savings and the focus of SB5X funding on summer peak loads. The M&V savings for Redding are shown in **Table 8.9**. The M&V savings for Roseville are shown in **Table 8.10**.

[57] See *Evaluation, Measurement & Verification Report for the Residential Ground Source Heat Pump Program*, prepared for Redding Electric Utility, Robert Mowris & Associates, 2004.

Table 8.7 MID M&V Savings for Residential HVAC Units

Site	Base Cooling (kWh/yr)	Base Heating (kWh/yr)	Tons	SEER	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Ex Post Savings kWh/yr	M&V Ex Post Savings kW	IPMVP Option
1	5,822		5	12	435	0.79	491	0.51	B, C
2	71		4	12	348	0.63	12	0.56	B, C
3	3,762		2.5	12	218	0.4	627	0.38	B, C
4	4,025		2	12	174	0.32	671	0.35	B, C
5	1,570		3	12	261	0.47	262	0.41	B, C
6	2,432		3	12	261	0.47	405	0.41	B, C
7	931		2.5/3.5	12	804	1.46	155	0.44	B, C
8	7,170		3	12	261	0.47	1,195	0.41	B, C
9	896		3	14	261	0.47	256	0.89	B, C
10	1,347		3	14	261	0.47	385	0.89	B, C
Average	**2,802**		**3.14**	**12.45**	**353**	**0.64**	**446**	**0.52**	
90% CI	1,214		0.44	0.07	16	0.03	173	0.11	

Table 8.8 PSREC M&V Savings for 5-ton, 3.6 COP, 16 EER GSHP Units

Site	Base Cooling (kWh/yr)	Ex Post Cooling Savings (kWh/yr)	Base Heating (kWh/yr)	Ex Post Heating Savings (kWh/yr)	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Ex Post Savings kWh/yr	M&V Ex Post Savings kW	IPMVP Option
11	1,226	735	2,035	-6,300	16,001	3.96	735	2.10	B, C
12	2,055	771			16,001	3.96	771	2.10	B, C
13	339	203	1,212	-3,754	16,001	3.96	203	2.10	B, C
14	2,686	1,612	1,250	-3,869	16,001	3.96	1,612	2.10	B, C
15			1,098	-3,401	16,001	3.96			B, C
16	412	247	14,628	10,565	16,001	3.96	247	2.10	B, C
17	5,830	2,186			16,001	3.96	2,186	2.10	B, C
18	2,488	933			16,001	3.96	933	2.10	B, C
19	1,023	614			16,001	3.96	614	2.10	B, C
20			10,148	4,510	16,001	3.96			B, C
Average	**2,007**	**913**	**5,062**	**-375**	**16,001**	**3.96**	**913**	**2.10**	
90% CI	1,036	393	3,934	4,367			393	0.02	

Note: PSREC ex-post kWh savings do not include electric heating savings for the GSHP due to uncertainty. Heating savings for sites 11, 13, 14, and 15 are negative due to pre-retrofit propane heat. Site 16 previously had electric resistance heat and site 20 had an electric heat pump. PSREC cooling-only savings are 913 ± 420 kWh per year and 2.1 ± 0.02 kW.

Table 8.9 Redding M&V Savings for Residential HVAC Units

Site	Base Cooling (kWh/yr)	Base Heating (kWh/yr)	Tons	SEER	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Ex Post Savings kWh/yr	M&V Ex Post Savings kW	IPMVP Option
21	3,664		4	14	1,012	1.13	1,047	0.81	B, C
22	639		4	13	715	0.8	148	0.82	B, C
23	2,523		4	14	886	0.99	148	0.84	B, C
24	240		3	14	886	0.99	69	0.89	B, C
25	2,603		3	14	759	0.847	744	0.89	B, C
26	1,136		4	14	1,012	1.13	325	0.81	B, C
27	910		3	14	633	0.71	260	0.59	B, C
28	942		4	12	517	0.58	157	0.48	B, C
29	1,404		4	13	816	0.91	324	0.68	B, C
30	2,712		4	12	590	0.66	452	0.56	B, C
31	2,712		4	16	1,328	1.48	1,017	0.84	B, C
32	3,913		5	14	1,265	1.41	1,118	0.85	B, C

Table 8.9 Redding M&V Savings for Residential HVAC Units

Site	Base Cooling (kWh/yr)	Base Heating (kWh/yr)	Tons	SEER	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Ex Post Savings kWh/yr	M&V Ex Post Savings kW	IPMVP Option
33	2,626		3	12	443	0.49	438	0.41	B, C
34	655		4	12	517	0.58	109	0.48	B, C
35	3,247		3	16	996	1.11	1,218	0.75	B, C
36	3,691		5	12	738	0.82	615	0.51	B, C
37	1,432		4	13	818	0.91	331	0.68	B, C
38	5,517		4	14	886	0.99	1,576	0.84	B, C
Average	**2,254**		**3.59**	**12.61**	**666**	**0.72**	**561**	**0.71**	
90% CI	553		0.24	0.06	39	0.04	176	0.06	

Table 8.10 Roseville M&V Savings for Residential HVAC Units

Site	Base Cooling (kWh/yr)	Base Heating (kWh/yr)	Tons	SEER	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Ex Post Savings kWh/yr	M&V Ex Post Savings kW	IPMVP Option
39	685		2.5	14	1,821	1.821	196	0.59	B, C
40	2,121		4	14	2,914	2.914	606	0.81	B, C
41	3,445		3	13	2,018	2.018	795	0.53	B, C
42	903		3.5	14	2,550	2.55	258	0.84	B, C
43	2,977		3	14	2,186	2.186	851	0.89	B, C
44	2,511		3.5	14	2,550	2.55	603	0.84	B, C
45	2,018		5	14	3,643	3.643	576	0.85	B, C
46	3,038		5	14	3,643	3.643	868	0.85	B, C
47	1,405		5	13	3,363	3.363	324	0.68	B, C
48	1,977		4	14	2,914	2.914	565	0.81	B, C
49	2,478		4	14	2,914	2.914	575	0.81	B, C
50	1,416		3	13	2,018	2.018	327	0.53	B, C
51	1,421		4	14	2,914	2.914	406	0.81	B, C
52	782		3	14	2,186	2.186	224	0.89	B, C
53	1,234		3	14	2,186	2.186	353	0.89	B, C
54	3,035		2.5	14	1,821	1.821	867	0.59	B, C
55	1,226		3	14	2,186	2.186	350	0.89	B, C
56	3,095		3	14	2,186	2.186	884	0.89	B, C
57	3,912		3	14	2,186	2.186	1,118	0.89	B, C
58	3,827		3.5	14	2,550	2.55	1,093	0.84	B, C
59	1,145		4	14	2,914	2.914	327	0.81	B, C
60	2,197		3	14	2,186	2.186	628	0.89	B, C
Average	**2,129**		**3.5**	**13.86**	**2,594**	**2.59**	**581**	**0.79**	
90% CI	350		0.03	0.12	90	0.09	98	0.04	

8.5 Impact of Improper Refrigerant Charge and Airflow

Several studies indicate approximately 50 to 67 percent of new air conditioners have improper refrigerant charge and airflow (RCA), and this reduces efficiency by roughly 10 to 20 percent.[58] Improper refrigerant charge and airflow can also reduce the life of the air conditioner compressor. Excessive refrigerant charge increases compressor noise and can cause premature compressor failure. Insufficient refrigerant charge causes compressors to overheat and this can cause premature compressor failure. Low airflow and excessive refrigerant charge can result in icing of the coil and compressor failure.

Three studies have shown that improper RCA can be mitigated by installing a TXV device.[59] The studies found TXV systems only had a clear advantage when the system is undercharged, and found no difference in performance at the rating condition between TXV and non-TXV (i.e., fixed orifice) when systems were properly installed. Unfortunately, TXVs can have their own performance problems associated with incorrect installation leading to a phenomenon known as "valve hunting." This can occur when the evaporator coil experiences reduced heat loads caused by many problems including low airflow, low refrigerant charge, dirty evaporator coils, and icy evaporator coils due to over charging.[60] Under these circumstances the TXV can lose control and successively overfeed and then underfeed refrigerant to the evaporator while attempting to stabilize control causing reduced capacity and efficiency. Overfeeding liquid to the evaporator can also damage the compressor. The tendency for hunting can be reduced by correcting RCA, by relocating the TXV sensing bulb to a better location inside the evaporator coil box, and by insulating the sensing bulb.

TXV sensing bulbs are often installed without insulation, without adequate linear contact, and at incorrect orientations (see **Figure 8.3** and **8.4**).

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[58] Palani, M., O'Neal, D., and Haberl, J. 1992. *The Effect of Reduced Evaporator Air Flow on the Performance of a Residential Central Air Conditioner*, The Eighth Symposium on Improving Building Systems in Hot and Humid Climates. Parker, D. 1997. *Impact of Evaporator Coil Air Flow in Residential Air Conditioning Systems*, FSEC-PF-321-97. Cocoa, Fla.: Florida Solar Energy Center. Rodriguez, A. 1995. *The Effect of Refrigerant Charge, Duct Leakage, and Evaporator Air Flow on the High Temperature Performance of Air Conditioners and Heat Pumps*, Palo Alto, Calif.: Electric Power Research Institute.

[59] Farzad, M., O'Neal, D. 1993. "Influence of the Expansion Device on Air Conditioner System Performance Characteristics Under a Range of Charging Conditions." Paper 3622. *ASHRAE Transactions*. Atlanta, Ga.: American Society of Heating Refrigerating and Air-Conditioning Engineers. Davis, R. 2001a. *Influence of the Expansion Device on Performance of a Residential Split-System Air Conditioner.* Report No.: 491-01.4. San Francisco, Calif. Pacific Gas and Electric. Davis, R. 2001b. *Influence of Expansion Device and Refrigerant Charge on the Performance of a Residential Split-System Air Conditioner using R-410a Refrigerant.* Report No.: 491-01.7. San Francisco, Calif.: Pacific Gas and Electric.

[60] Tomczyk, J. 1995. *Troubleshooting and Servicing Modern Air Conditioning and Refrigeration Systems.* ESCO Press. Mt. Prospect, Ill.: Educational Standards Corporation.

Figure 8.3 Uninsulated TXV Bulb in Attic

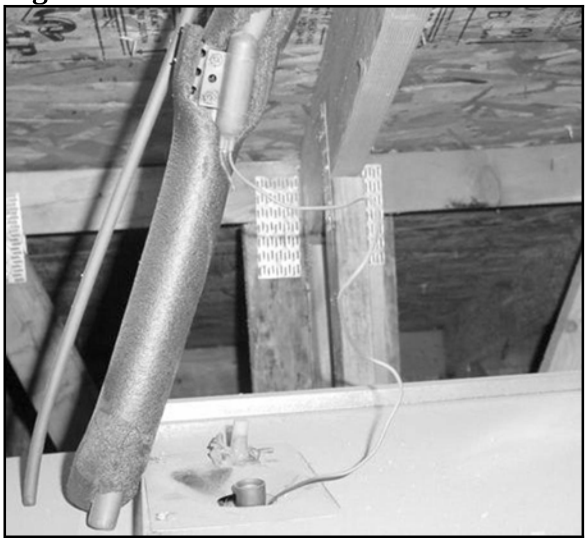
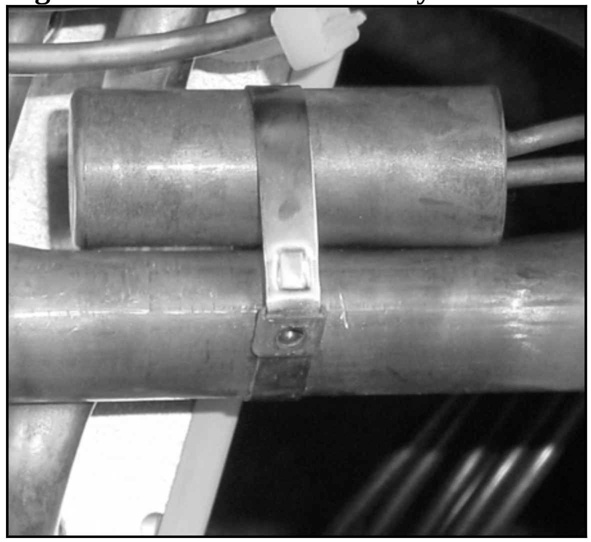


Figure 8.4 Uninsulated Factory TXV Bulb



Manufacturers recommend tightly clamping the sensing bulb to the vapor line with good thermal contact at the recommended orientation to guard against false readings due to air or liquid in the suction line. Manufacturers also recommend insulating the sensing bulb to prevent ambient air from causing false readings.[61] Factory-installed TXVs with un-insulated sensing bulbs inside the evaporator coil box will be influenced by mixed supply-air temperatures which are typically 10-20°F higher than vapor line temperatures. Field-installed TXVs with un-insulated sensing bulbs located in attics or garages will be influenced by attic or garage temperatures which are 50 to 80°F higher than vapor line temperatures (e.g., attic temperatures range from 110 to 130°F compared to vapor line temperatures of 35 to 50°F). The three laboratory studies measured TXV-equipped air conditioners with the evaporator coil, TXV, and well-insulated sensing bulb located in conditioned space and this is not typical of field conditions. Furthermore, none of these three studies recommended TXVs as a substitute for proper RCA.

The relative efficiency gains due to proper RCA for fourteen TXV and seven non-TXV air conditioners are shown in **Tables 8.11** and **8.12**. Sites labeled "n/a" had improper RCA but the customer either refused corrections or no refrigerant change was necessary. The TXV efficiency gain excludes sites where customers refused charge corrections, where the efficiency gain was undefined (i.e., pre-capacity and pre-EER were zero due to a leaky system with no refrigerant charge), and sites where no charge adjustment was necessary.

[61] Advanced Distributor Products (ADP). 2003. *TXV Installation Instructions.* 0991710-01 Rev 1, October 03. Stone Mountain, Ga.: Advanced Distributor Products, Available online: www.adpnow.com. AllStyle Coil Company, L.P. 2001. *Evaporator Coil Installation Instructions.* Brittmore, Texas: AllStyle Coil Company, L.P. Carrier Corporation. 2002. *Installation Instructions: Thermostatic Expansion Valve Kit for R22 and R410a*. Syracuse, N.Y.: Carrier Corporation. Emerson Climate Technologies, Inc. 1998. *Installation Instructions Expansion Valve Kits.* Lewisburg, Tenn.: Emerson Climate Technologies, Inc.

Table 8.11 EER Measurements and Efficiency Gain for TXV Air Conditioners

Site	Tons	Factory Charge oz.	Charge Adjust +Add –Remove	Pre-EER	Post-EER	Relative Efficiency Gain	Average Outdoor Temp °F	Ave. Ret. DB/WB Temp °F	Notes
1	5	114	Refused (9%)	10.4	n/a	n/a	82	75/64	R410A
39	2.5	96	-78%	8.3	11.8	43%	90	79/66	R410A
40	4	140	40%	11.2	13.1	17%	80	78/63	R410A
41	3	100	18%	9.9	12.1	22%	82	77/63	R22
42	3.5	100	16%	10.9	11.8	8%	79	75/62	R410A
44	3.5	170	Refused (6%)	n/a	n/a	n/a	80	74/61	R22
45	5	200	0%	10.8	n/a	n/a	96	75/65	R22
46	5	200	9%	10.5	11.3	8%	95	77/65	R22
47	5	176	11%	10.8	11.7	8%	88	70/60	R22
48	4	170	15%	10.3	12.4	20%	86	74/63	R22
49	4	170	Refused (7%)	11.6	n/a	n/a	89	77/65	R22
50	3	150	34%	9	12.3	37%	95	79/69	R22
51	4	162	n/a (100%)	0	n/a	n/a (100%)	86	85/69	R22
61	5	166	0%	11	n/a	n/a	84	77/65	R22
Ave	**4.0**	**151**	**25.0%**	**9.6**	**12.1**	**20.4%**	**86**	**77/64**	

Table 8.12 EER Measurements and Efficiency Gain for non-TXV Air Conditioners

Site	Tons	Factory Charge oz.	Charge Adjust +Add –Remove	Pre-EER	Post-EER	Relative Efficiency Gain	Average Outdoor Temp °F	Ave. Ret. DB/WB Temp °F	Notes
43	4	117	Okay	10.8	10.8	n/a	95	77/61	R22
62	3	130	Okay	9.9	9.9	n/a	81	70/59	R22
63	5	96	Okay	12.2	12.2	n/a	81	73/59	R22
64	3.5	130	-7%	9.6	10	4%	91	84/72	R22
65	3.5	82	Okay	9.3	9.3	n/a	84	76/66	R22
66	4	112	38%	8.5	9.9	16%	90	81/67	R22
67	5	158	-15%	8.6	9.8	14%	81	75/63	R22
Ave	**4**	**118**	**20.0%**	**9.8**	**10.3**	**11.3%**	**86**	**77/64**	

Charge adjustments in parentheses are software recommendations. The average efficiency gain was 20.4 ± 8 percent for TXV air conditioners with an average charge adjustment of 25 ± 14 percent. The average efficiency gain for non-TXV air conditioners was 11.3 ± 8 percent with an average charge adjustment of 20 ± 14 percent. The average measured airflow improvement was 9.8 ± 2.5 percent at the 90 percent confidence level. The average measured pre-retrofit airflow was 314 ± 28 cfm for non-TXV systems and 316 ± 16 cfm for TXV systems.

Three laboratory studies indicate the efficiency degradation for TXV units is roughly 5 percent at plus or minus 20 percent of the correct charging condition.[62] Findings from this study indicate an average efficiency degradation of 20.4 ± 8 percent for TXV air conditioners with an average charge adjustment of 25 ± 14 percent. The student t-test was used to evaluate the mean efficiency difference between field and laboratory measurements and the differences were found to be statistically significant (i.e., 0.008 probability of t less than 3.3). Findings from this study indicate TXVs are less effective than proper RCA in terms of delivering rated efficiency.

[62] Farzad and O'Neal, 1993, Davis 2000a, and Davis 2000b (above footnote).

Measurements of EER were made at non-standard temperature conditions (i.e., not at 95°F outdoor temperature or 80°F dry-bulb/67°F wet-bulb inlet conditions). The absolute EER measurements are not directly comparable to laboratory measurements of EER at standard conditions where airflow, return air temperatures, and condenser entering air temperatures are carefully controlled. The relative efficiency gains are applicable to normal operating conditions since laboratory studies indicate the change in EER (as a function of airflow and charge) is independent of operating conditions. The uncertainty associated with field measurements of capacity and EER was evaluated using the propagation of error technique including: sensor accuracy; recording system accuracy; data display or recording resolution; and sampling error.[63] The uncertainty associated with instrument error is ± 2.8 percent, and the measurement error is ± 3.4 percent. Therefore, the total uncertainty error is ± 4.4 percent and this is comparable to uncertainty errors reported in laboratory studies.[64]

8.6 Program Evaluation Savings Estimates and DEER

The Database for Energy Efficiency Resources (DEER) was used to evaluate the reasonableness of the M&V results.[65] The average M&V unit cooling-only savings for each utility are compared to savings from the 2001 DEER Update Study in **Table 8.13** (PSREC is excluded since DEER doesn't include GSHP units). The average M&V gross savings per unit are 503 ± 94 kWh/yr and 0.61 ± 0.06 kW. The average deemed savings from DEER are 418 kWh per year and 0.40 kW. The average M&V gross kWh savings per unit are 20% greater than DEER, and the average M&V gross kW savings per unit are 53% greater than DEER. The M&V savings would have been lower if deemed savings from DEER were used instead of basing the results on billing data and field measurements. If air conditioning diversity factors were included in the analyses, the M&V kW realization rates would be even lower.

Table 8.13 Average M&V Gross Savings per Unit Compared to DEER

NCPA Utility	Qty.	Program Average Tons	Program Average SEER	Ex Ante Unit kWh/yr	Ex Ante Unit kW	M&V Gross Unit kWh/yr	M&V Gross Unit kW	DEER Unit kWh/yr	DEER Unit kW
MID	316	3.2	12.45	350	0.64	446	0.52	430	0.42
Redding	704	3.6	12.61	666	0.76	561	0.71	453	0.44
Roseville	134	3.6	13.81	2,594	2.59	581	0.79	630	0.62
TID	656	3.0	12	721	0.74	430	0.51	306	0.30
Average		**3.4**	**12.50**	**801**	**0.87**	**503**	**0.61**	**418**	**0.40**

[63] American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE). 2002. *ASHRAE Guideline 14-2002 – Measurement of Energy and Demand Savings*. Atlanta, Ga.: ASHRAE. 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*, Appendix to Chapter 7: 191-195. Uncertainty Calculation. San Francisco, Calif.: California Public Utilities Commission.

[64] See Farzad and O'Neal, 1993, Davis 2000a, and Davis 2000b (above footnote).

[65] Energy and peak demand savings are from the 2001 DEER Update Study, High Efficiency Split A/C, prepared by XENERGY, Inc., prepared for the California Energy Commission, Contract 300-99-008, August 2001.

8.7 Participant Survey Findings

This study uses participant surveys to estimate the net-to-gross ratios for kWh and peak kW savings. Participant surveys were completed for 60 participants in five NCPA utility service areas. Findings of the participant surveys for each program are presented in **Table 8.14**. The weighted average net-to-gross ratio is 0.82 based on average participant survey results multiplied times savings for each program divided by total savings for all programs. The average net to gross ratio is consistent with the California Public Utilities Commission statewide residential program net-to-gross ratio of 0.80.[66]

Table 8.14 Findings of Participant Surveys

NCPA Utility	Rebate Qty.	Completed Surveys	Ex Post Program Savings kW	Weighting Factor	Actual Net-to-Gross Ratio	Coefficient of Variation Cv	Required Sample to Meet 90/10 Criteria	Weighted Net-to-Gross Ratio
MID	316	10	165.6	0.1301	0.82	0.15	6	0.11
PSREC-GSHP	82	11	172.1	0.1352	0.84	0.23	12	0.11
Redding	704	10	497.8	0.3911	0.83	0.17	8	0.32
Roseville	134	19	106.0	0.0833	0.86	0.10	3	0.07
TID	656	10	331.4	0.2603	0.81	0.16	7	0.21
Total	**1,892**	**60**	**1,273.0**	**1.0000**		0.15	**58**	**0.82**

The coefficient of variation was used to measure the sample size required to satisfy the 90 percent confidence level criteria for estimating mean net-to-gross ratios for the population. The required sample size with finite population corrected (FPC) to meet the 90% confidence and 10% relative precision (i.e., 90/10 criteria) for each program is shown in **Table 8.14**. The participant survey sample sizes met the 90/10 criteria (except for PSREC which was close with 11 surveys and a required sample size of 12).

9. Residential CFL Programs

Residential Compact Fluorescent Lamp (CFL) Programs were implemented by Biggs, Gridley, Healdsburg, Plumas-Sierra Rural Electric Cooperative (PSREC), and Redding. The programs realized peak kW and kWh savings by providing free CFLs to consumers.[67] 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 9.1**. The ex ante program savings are 1,883,234 kWh/yr and 1,951 kW. The M&V gross ex post program savings are 4,822,624 ± 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

[66] See *Energy Efficiency Policy Manual*, Chapter 4, page 23, prepared by the California Public Utilities Commission, 2001.

[67] City of Biggs provided incentives to consumers who purchased CFLs at local hardware stores.

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.[68]

Table 9.1 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

A separate report titled, *Measurement & Verification Report for NCPA SB5X Residential Compact Fluorescent Lamp Programs,* provides more detailed information. M&V work was performed from September 2001 through December 2003. **Appendix B** provides the Residential CFL Decision-Maker Survey.

9.1 M&V Approach for Residential CFLs

The measurement and verification of energy and demand impacts of Residential CFL programs are based on 62 participant surveys. The 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.

[68] 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.

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.

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.

9.2 M&V Sample Design and Precision

The sample design for metering and participant surveys was designed to achieve a minimum precision of plus or minus 10% at the 90% confidence level. Sampling methods were used to analyze the data and extrapolate mean savings estimates from the sample measurements to the population of all program participants and to evaluate the statistical precision of the results. Load impacts were evaluated with a random M&V sample of 62 program participants. The M&V participant survey sample size is 62. The weighted sample coefficient of variation of was 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. The participant survey coefficient of variation was 0.29, indicating a minimum 90/10 sample size of 23. The M&V participant survey sample size was 62.[69] These sample sizes meet or exceed the 90/10 confidence level.

Sampling methods were used to analyze the data and extrapolate M&V savings estimates from the sample to the population of all program participants and to evaluate the statistical precision of the results. The M&V on-site survey sample of 62 participants provided relative precision of ±5.7% for MW and ±10.3% for GWh. The DMS sample of 62 participants yielded relative precision of ±6.1% for the survey results.

9.3 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 for 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 customers. The

[69] 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.

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.

9.4 M&V Findings for Residential CFLs

Ex-ante savings for the residential CFL programs are shown in **Table 9.2**. Findings of the random M&V telephone surveys are provided in **Table 9.3**. The overall retention factor is 0.9 indicating that 90% of the CFLs are still installed 2 years after. 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.[70] The gross realization rates are further adjusted by the net-to-gross ratios. 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 9.2 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 9.3 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	Gross Realization Rate kW	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

9.5 Participant Survey Findings

Participant surveys were completed for 62 participants in five NCPA utility service areas. Findings of the participant surveys for each program are presented in **Table 9.4**. 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.[71]

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[70] 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.

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

Table 9.4 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	94,329	38.7	0.16	0.90	69.4	18.4	1,460	0.50	0.60
Gridley	1,117	20	126,126	52.0	0.32	0.95	65.3	20.9	1,424	0.60	0.71
Healdsburg	3,024	10	190,512	136.1	0.16	0.80	60.0	15.0	1,424	0.33	0.72
Redding	1,469	10	104,299	83.7	0.16	1.00	74.0	17.0	1,533	0.40	0.80
PSREC	65,610	12	1,367,968	1640.2	0.19	0.83	73.8	25.0	1,643	0.50	0.72
Average	72,627	62	1,883,234	1,951	1.00	0.90	68.1	19.7	1,489	0.49	0.72

9.6 Gross Realization Rates for Residential CFL Programs

Gross M&V program evaluation savings (i.e., kWh/yr and kW) are based on the average gross realization rates (AGRR) from the telephone survey sites. Gross M&V savings and average gross realization rates for the residential CFL programs are shown in **Table 9.5**. .

Table 9.5 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

10. Residential Refrigerator Recycling Programs

Refrigerator Recycling Programs were implemented by Biggs, Gridley, Lodi, Lompoc, Plumas-Sierra Rural Electric Cooperative (PSREC), and City of Santa Clara Electric Utility (Silicon Valley Power). The programs realized peak kW and kWh savings by paying rebates to consumers for the pick-up of their old, inefficient (yet operable) refrigerator(s) or freezer(s). The old appliances were taken to a recycling center where the refrigerant was removed and the unit was permanently disposed. Third-party contractors JACO and ARCA operated the programs in Lodi and Santa Clara respectively. In addition to recycling refrigerant, these contractors also recycled foam, plastic, metals, and other components. Biggs, Gridley, Lompoc, and Plumas-Sierra arranged with their local solid waste management companies to recycle the appliances. Approximately 1,609 refrigerators and freezers were recycled during 2001 and 2002 through programs sponsored by six utilities with $344,647 of SB5X funds administered by NCPA.

The M&V results are summarized in **Table 10.1**. The ex ante program savings are 2,431,274 kWh/yr and 335 kW. The M&V gross ex post program savings are 2,706,338 kWh/yr ± 198,127 kWh/yr and 582.5 ± 37.5 kW at the 90 percent confidence level. The M&V net ex post program savings are 1,723,798 ± 126,197 kWh/yr and 445 ± 29 kW. The effective useful lifetime for refrigerator and freezer recycling is 6 years.[72] Therefore, the net ex post lifecycle savings are 10,342,788 ± 757,182 kWh. The net realization rates are 0.71 for kWh and 1.33 for kW savings. M&V savings and net realization rates are lower than expected due to lower net-to-gross ratios.

Table 10.1 Summary of M&V Results for NCPA SB5X Refrigerator Recycling

NCPA Utility	Qty.	Ex Ante Full-Year Unit kWh/yr	Ex Ante Unit kW	M&V Full-Year Unit kWh/yr	M&V Unit kW	Net-to-Gross Ratio kWh/yr	Net-to-Gross Ratio kW	M&V Net Savings Program Total kWh/yr	M&V Net Savings Program Total kW	Realization Rate Relative to Planning kWh/yr	Realization Rate Relative to Planning kW
Biggs	2	1,053	0.22	1,682	0.362	0.91	1	3,061	0.7	1.45	1.68
Gridley	42	1,540	0.30	1,682	0.362	0.55	0.67	38,854	10.2	0.60	0.82
Lodi	541	1,593	0.18	1,682	0.362	0.69	0.76	627,874	148.8	0.73	1.53
Lompoc	77	1,593	0.18	1,682	0.362	0.61	0.79	79,004	22.0	0.65	1.59
Plumas-Sierra	200	958	0.38	1,682	0.362	0.62	0.79	208,568	57.2	1.09	0.76
Santa Clara	747	1,593	0.18	1,682	0.362	0.61	0.76	766,437	205.5	0.64	1.51
Total	1,609					0.64	0.76	1,723,798	444.5	0.71	1.33

Savings for refrigerators and freezers are calculated using the average M&V savings for both appliances based on field measurements of 107 units (weighted 85% refrigerators and 15% freezers).[73] The net-to-gross ratio is calculated based on part use and attribution regarding whether or not the unit would have been disposed of without the program. The average attribution factor was 76 percent meaning that roughly 24 percent of units would have been taken out of service without the program. Virtually 100 percent of units were operated during peak periods in the summer explaining the greater net-to-gross ratio for kW compared to kWh (approximately 17 percent of units were not operated during winter periods).[74]

Based on participant survey results, 57 percent of removed units were spares (without replacement) and 43 percent were primary units.[75] Refrigerators accounted for 85 percent of recycled units and freezers accounted for 15 percent. Survey responses indicated high customer satisfaction with the programs with an average overall score of 9.5 out of a possible 10 points.

The M&V study provides average gross savings per unit and net-to-gross ratios. The gross savings are based on in-situ 15-minute true RMS power measurements of 91 refrigerators and 16 freezers. Each unit included in the random sample was measured for several days in order to obtain 15-minute average kW measurements during the 2 PM to 6 PM time frame. The peak kW for each unit is taken as the maximum kW that occurs during the 2 PM to 6 PM weekday time frame from the 15-minute data. Daily kWh measurements were extrapolated to develop average M&V full-year unit energy consumption (UEC) values. Participant telephone surveys were used

[72] See *Statewide Residential Appliance Recycling Program*, PY2004/PY2005 Energy Efficiency Program Proposal, R. 01-08-028, prepared by Pacific Gas and Electric Company, prepared for the California Public Utilities Commission September 2003. Available Online at: ftp://ftp.cpuc.ca.gov/eep/pge1/.

[73] The average M&V full-year unit energy consumption for refrigerators and freezers is 1,682 kWh/yr and 0.36 kW. These values are based on 91 refrigerator and 16 freezer measurements. The mean refrigerator estimates are 1,625 kWh/yr (standard deviation of 788 kWh/yr) and 0.365 kW (standard deviation of 0.148 kW). The mean freezer estimates are 2,009 kWh/yr (standard deviation of 585 kWh/yr) and 0.348 kW (standard deviation of 0.141 kW).

[74] Conventional net-to-gross ratios reflect what customers would have done in the absence of the program. This study measures net-gross ratios using an attribution factor and part-use factors for kW and kWh (see Section 3).

[75] Recycled primary units are eliminated from possible re-use through the used refrigerator market.

to evaluate program performance criteria and net-to-gross ratios. The net-to-gross ratio for kWh/yr is the average savings that can be credited to the program for removal of a unit as a fraction of a full year UEC. A separate net-to-gross ratio for kW was developed to estimate peak demand savings.

A separate report titled, *Measurement & Verification Report for NCPA SB5X Refrigerator Recycling Programs*, provides more detailed information. M&V on-site work was performed from 2001 through 2002. **Appendix C** provides the Residential Refrigerator Recycling Decision-Maker Survey.

10.1 M&V Approach for Refrigerator Recycling

The measurement and verification of energy and demand impacts of Refrigerator Recycling programs are based on 107 short-term field measurements of electrical power and 110 participant surveys. The ex post energy and peak demand savings were determined using IPMVP Option B (i.e., retrofit isolation). This study uses metered data to estimate gross kW and kWh savings for recycled refrigerators and freezers. Several earlier M&V studies of recycled refrigerator programs used AHAM/DOE ratings to estimate annual kWh savings or developed savings estimates using the AHAM/DOE test methods.[76] Metering data are used for this study for the following reasons.

1. The primary purpose of SB5X-funded Refrigerator Recycling Programs is to reduce peak kW demand, and the AHAM/DOE ratings do not provide kW ratings.
2. AHAM/DOE ratings are for new units and old recycled units have dirty coils, worn out compressors, worn out gaskets, and damaged insulation panels that can cause significantly different energy use than the AHAM/DOE ratings would indicate.
3. AHAM/DOE ratings are based on 90 degree Fahrenheit ambient conditions and recycled refrigerators and freezers are either spare units kept in garages or primary units kept inside kitchens. Typical in-situ operating conditions for spare and primary refrigerators and freezers are 65F to 110F or higher and not the 90F conditions used for the AHAM/DOE ratings.

Field metering of refrigerators and freezers was performed using fourteen custom-built “plug-in” electric power data loggers consisting of a 4” x 6” x 8” plastic box with a 4-channel true RMS poly-phase data logger mounted inside the plastic box. A power cord and electric power plug-in receptacles are mounted inside the plug-in data logger. Fifteen minute kW and kWh data were collected using the plug-in data loggers for time periods that varied from 2 days to three weeks from October 2001 through September 2002. Standard methods were used to develop annual energy consumption values from metered data.[77]

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[76] See *Impact Evaluation of the Spare Refrigerator Recycling Program*, CEC Study #537 Final Report, Prepared by XENERGY, Inc., Prepared for Southern California Edison Company, San Dimas, CA, April 1998. Also see Refrigerator/Freezer UEC Estimation, 1996 ARCA/SCE Turn-in Program, John Peterson, Athens Research.

[77] In-situ metering was performed at customer sites and warehouses in unconditioned spaces. The ambient temperature during metering was in the range of 80 to 105 degrees Fahrenheit. The DOE Test Method uses an ambient temperature of 90F. While the in-situ measurements are not exactly equivalent, they are more typical of normal operating conditions for spare refrigerators that are kept in unconditioned garages or outdoors. See *Method for Determining the Energy Consumption of Household Refrigerators*, Association of Home Appliance

Gross program evaluation savings (i.e., kWh/yr and kW) are based on sample mean measurements of 91 refrigerators and 16 freezers. Gross savings for the sampled units were compared to AHAM/DOE ratings and other sources. 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.

10.2 M&V Sample Design and Precision

The sample design for metering and participant surveys was designed to achieve a minimum precision of plus or minus 10% at the 90% confidence level. Sampling methods were used to analyze the data and extrapolate mean savings estimates from the sample measurements to the population of all program participants and to evaluate the statistical precision of the results. Load impacts were evaluated with a random M&V sample of 107 program participants who accounted for 6.6 percent of the total program savings. The weighted sample coefficient of variation for the metering sample was 0.46 and the participant survey coefficient of variation was 0.45. These coefficients of variation indicate a sample size of 57. The metering sample size was 107 (i.e., 91 refrigerators and 16 freezers) and the participant survey sample size was 110.[78] These sample sizes exceed the 90/10 confidence level. The M&V on-site survey sample of 107 participants provided relative precision of ±6.48% for MW and ±7.3% for GWh. The DMS sample of 110 participants yielded relative precision of ±7.2% for the survey results.

10.3 Baseline

The baseline kWh and kW values are extrapolated from metering results for a random sample of 91 recycled refrigerators and 16 recycled freezers. The sample mean baseline full-year unit energy consumption for refrigerators and freezers is 1,682 kWh/yr ± 123 kWh/yr and the sample mean baseline kW is 0.362 kW ± 0.023 kW at the 90 percent confidence level.

10.4 M&V Findings for Refrigerator Recycling

Metering results for 91 recycled refrigerators and 16 recycled freezers are shown in **Table 10.2**. Statistical analysis of the refrigerator and freezer data is shown in **Table 10.3**. The average M&V full-year unit energy consumption for refrigerators and freezers is 1,682 kWh/yr ± 122 kWh/yr and 0.362 kW ± 0.02 kW at the 90 percent confidence level. The mean refrigerator savings are 1,625 kWh/yr ± 134 kWh/yr and 0.365 kW ± 0.03 kW at the 90 percent confidence level. The mean freezer savings are 2,009 kWh/yr ± 241 kWh/yr and 0.348 kW ± 0.06 kW at the 90 percent confidence level. Field measurements of the 54 recycled refrigerators and freezers are shown in **Figure 10.1**. The kW values plotted in **Figure 10.1** show spikes ranging from 0.4 to 0.93 kW. The average of these spikes is 0.36 kW over the 2 PM to 6 PM weekday time period.

Manufacturers (AHAM), AHAM HRF-1-2001 (Revision of ANSI/AHAM HRF-1-1998) and The DOE Test Method as specified in 10 CFR, Section 430.23(b), 1995.

[78] Samples were randomly selected in each utility service area. Electric metering of refrigerators and freezers was performed on participating recycled units in the following utility service areas: Biggs, Gridley, Lompoc, Plumas-Sierra, and Santa Clara. In addition, 15 non-participant recycled units were metered in the TID service area.

Table 10.2 Summary of Field Metering Data for 91 Refrigerators and 16 Freezers

#	*kWh/yr*	*kW*	Make	Model	Size	Style	Defrost	Age	Utility
1	1,143	0.268	Frigidaire	FRD-16BI	22	BFTR	FF	1978	SVP
2	1,814	0.404	Sears	2537603712	20	SBS	FF	1974	SVP
3	2,928	0.628	Montgomery Ward	HMG289606A	28	SBS	FF	1976	SVP
4	1,069	0.372	Frigidaire	FPE-19V3JWO	19.1	SBS	FF	1979	SVP
5	1,755	0.500	Hotpoint	CSX22BC	21.7	SBS	FF	1979	SVP
6	1,803	0.404	Amana	SR119B-L	19	SBS	FF	1979	SVP
7	2,578	0.936	GE	TFF24DMB	24	SBS	FF	1979	SVP
8	1,512	0.376	JCPenny	86706224	21.8	SBS	FF	1979	SVP
9	1,762	0.513	Kenmore	106.8602	n/a	SBS	FF	1980	Lompoc
10	2,086	0.400	Kenmore	8611460	19.1	SBS	FF	1980	SVP
11	1,907	0.296	MagicChef	RC24CACAI	25	SBS	FF	1980	SVP
12	2,323	0.424	Signature	HMG227303H	22	SBS	FF	1980	SVP
13	3,252	0.772	GE	TFF24RVD	23.5	SBS	FF	1980	SVP
14	1,358	0.472	GE	TFFADWP	22	SBS	FF	1981	SVP
15	4,359	0.532	GE	TFG24RVD	25	SBS	FF	1981	SVP
16	855	0.168	Hotpoint	CSF20EBC	19.6	SBS	FF	1982	SVP
17	2,422	0.448	GE	TFF24RCM	23.5	SBS	FF	1982	SVP
18	1,831	0.782	Kenmore	106.8620680	22	SBS	FF	1983	PSREC
19	1,893	0.480	Amana	SR25N-AG	25	SBS	FF	1985	SVP
20	721	0.160	Amana	SX25JL	25	SBS	FF	1985	SVP
21	2,242	0.424	Kenmore	106.8620G82	22.2	SBS	FF	1985	SVP
22	1,914	0.340	Whirlpool	FD25DQXVDO2	25	SBS	FF	1986	SVP
23	1,310	0.496	Hotpoint	CSX24DHR	23.5	SBS	FF	1986	SVP
24	1,088	0.280	Whirlpool	FD25SMXLU10	25	SBS	FF	1988	SVP
25	1,736	0.268	Amana	SBI20MW	21	SBS	FF	1989	SVP
26	1,255	0.344	Frigidaire		20.3	SBS	FF	1990	SVP
27	1,167	0.220	Hotpoint	CS622GLL	22	SBS	FF	1990	SVP
28	1,506	0.284	GE	TRF22RKD	22	SBS	FF	1990	SVP
29	1,840	0.424	Amana	SR250-L	25	SBS	FF	1990	SVP
30	2,245	0.292	GE	TFX22PLK	22	SBS	FF	1990	SVP
31	1,143	0.348	Kenmore	363.9505	24	SBS	FF	1990	TID
32	1,603	0.326	Whirlpool	ED19AK	19	SBS	FF	1990	TID
33	2,246	0.284	Norse	CDNS24V9A	24	SBS	FF	1991	SVP
34	2,585	0.498	GE	TFX27FHC	27	SBS	FF	1991	TID
35	1,255	0.284	Hotpoint	CSX22DLB	21.6	SBS	FF	1992	SVP
36	2,097	0.592	GE	TFX27FJB	26.7	SBS	FF	1993	SVP
37	2,558	0.580	Whirlpool	EHD252SMRI	24.9	SBS	FF	1993	SVP
38	1,495	0.308	KitchenAid	KSAB22QABL	22	SBS	FF	1993	SVP
39	2,846	0.460	GE	TFF22RSD	22.2	SBS	FF	1994	SVP
40	1,492	0.371	Montgomery Ward		22	SBS	FF		Lompoc
41	4,737	0.614	Whirlpool	ELD251MMDR1	25	SBS	FF		Lompoc
42	2,800	0.416	White-Westinghse	RS2298801	23	SBS	FF		Lompoc
43	1,879	0.504	Sears	1066676601	16	TFBR	FF	1968	SVP
44	3,006	0.429	GE	TBF-21RVD	21	TFBR	M	1977	Gridley
45	1,648	0.272	Kelvinator	TDK160FNW7	18	TFBR	FF	1978	SVP
46	953	0.296	Whirlpool	EET202MKNRO	19.6	TFBR	FF	1981	SVP
47	2,521	0.297	Montgomery Ward	HNG1942-4	19	TFBR	FF	1982	Gridley
48	1,115	0.296	J.C. Penny	867.0121.4210	21	TFBR	FF	1982	TID
49	1,720	0.207	Kenmore	106.874	19.2	TFBR	FF	1983	Lompoc
50	1,031	0.280	Westinghouse	RT187ACW1	14	TFBR	FF	1983	SVP
51	1,069	0.556	Whirlpool	ET22MK1LN11	22	TFBR	FF	1983	SVP
52	1,910	0.392	Montgomery Ward	HMG1452	14	TFBR	FF	1983	Biggs
53	781	0.367	Magic Chef	RB17GA-3A	17	TFBR	FF	1983	TID
54	1,599	0.364	GE	TBF17DBB1	17	TFBR	FF	1983	TID
55	1,679	0.404	Amana	D75597	20	TFBR	FF	1984	TID
56	1,388	0.252	Kenmore	7689360	19.2	TFBR	FF	1985	SVP
57	1,818	0.396	Whirlpool	EPT14IELO	14	TFBR	FF	1986	SVP
58	3,749	0.571	Frigidaire	FPCT-205TS	21	TFBR	FF	1986	TID

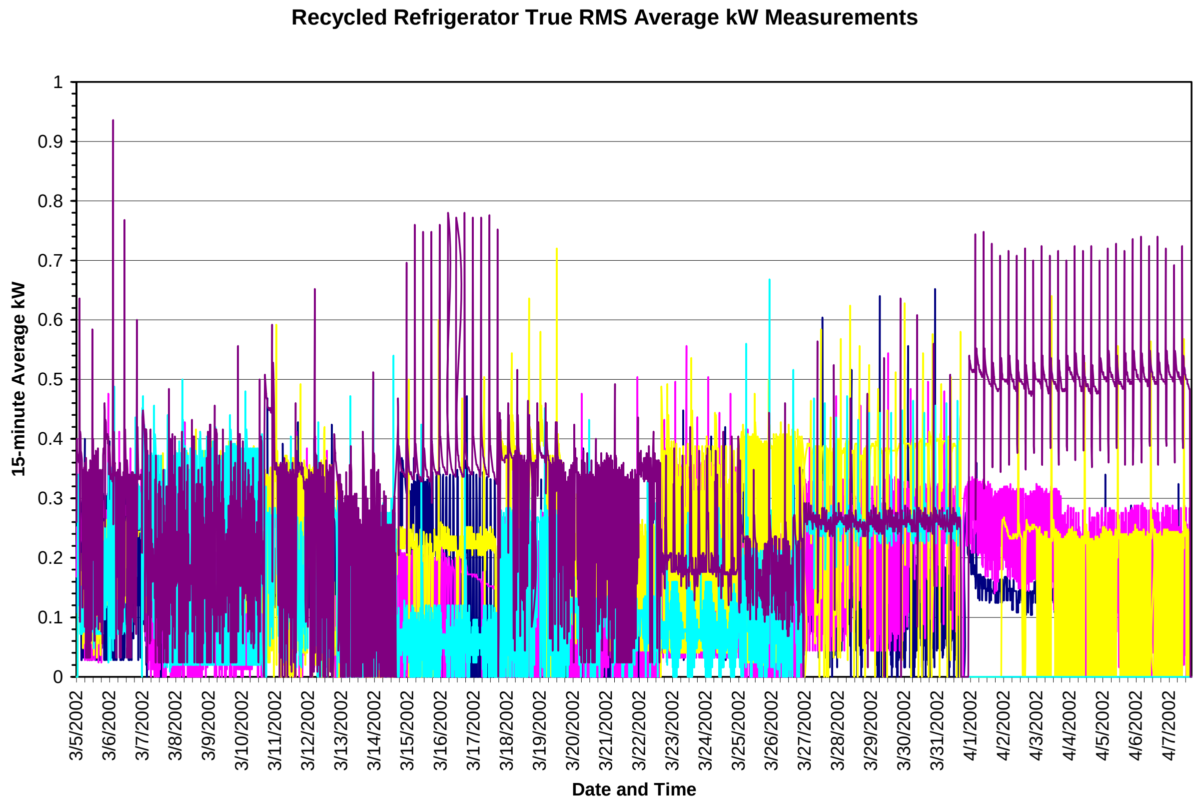
Table 10.2 Summary of Field Metering Data for 91 Refrigerators and 16 Freezers

#	*kWh/yr*	*kW*	Make	Model	Size	Style	Defrost	Age	Utility
59	1,243	0.305	Kenmore	E63052543	18	TFBR	FF	1987	Lompoc
60	822	0.332	GE	TBX21ZKC	21	TFBR	FF	1987	SVP
61	1,157	0.242	Whirlpool	EHT141AKNRO	14	TFBR	FF	1987	TID
62	1,385	0.398	Kenmore	106.8688	18	TFBR	FF	1988	Lompoc
63	977	0.292	Kenmore	1068739580	18	TFBR	FF	1988	SVP
64	513	0.120	Kenmore	8637710	17	TFBR	FF	1989	SVP
65	1,642	0.388	Whirlpool	EET151JTWLO	15	TFBR	FF	1989	SVP
66	1,349	0.156	Sanyo	SR1520N	15	TFBR	FF	1989	TID
67	1,562	0.399	GE	TBX20AZHB	20	TFBR	FF	1990	TID
68	838	0.368	Hotpoint	CTX18G	18.2	TFBR	FF	1991	Lompoc
69	691	0.184	Amana	TC20HL	19.7	TFBR	FF	1991	SVP
70	542	0.136	Whirlpool	ET14JKXMNL5	14.1	TFBR	FF	1991	SVP
71	884	0.236	Kenmore	106.9701	20	TFBR	FF	1991	TID
72	387	0.156	Whirlpool	ET22DKSXWOO	21.7	TFBR	FF	1992	SVP
73	793	0.264	Whirlpool	ET22PKXWN10	19	TFBR	FF	1992	SVP
74	1,488	0.396	GE	TBX20ZJB	20	TFBR	FF	1992	SVP
75	1,825	0.236	Whirlpool	ET18CKXMNRO	18	TFBR	FF	1993	SVP
76	790	0.241	Amana	TXI21A3W	17	TFBR	FF	1993	Biggs
77	993	0.209	Kenmore	363.9662	20	TFBR	FF	1993	TID
78	1,240	0.146	Amana	TX18Q2W	23	TFBR	FF	1994	TID
79	946	0.202	Frigidaire	MRT18GRGWO	18	TFBR	FF	1998	Lompoc
80	1,760	0.503	Whirlpool	ED1171NKGR2	17	TFBR	FF	2001	Lompoc
81	1,041	0.319	Gibson	RT19F3WMGC	19	TFBR	FF		Gridley
82	1,046	0.535	MagicChef	RB19EA-1A	19	TFBR	FF		Lompoc
83	1,166	0.254	Kenmore	E11822410	20	TFBR	FF		Lompoc
84	1,054	0.202	GE	FB14SCB	18	TFBR	FF		Lompoc
85	1,773	0.436	Hotpoint	CTF15CC	18	TFBR	FF		Lompoc
86	1,512	0.432	Whirlpool	EET202MKG	19.6	TFBR	FF		Lompoc
87	663	0.394	Kenmore	106.9729	18	TFBR	FF		Lompoc
88	1,156	0.378	Admiral	HMG191247	18.6	TFBR	FF		Lompoc
89	1,116	0.229	Frigidaire		15	TFBR	M		Lompoc
90	1,256	0.222	Norge	NNT196G2A	19	TFBR	FF		Lompoc
91	1,838	0.231	GE	TB14SLO	19	TFBR	M		Lompoc
92	1,262	0.340	Sears	198713640	24	CF	M	1974	SVP
93	2,585	0.650	Marquette	1965-68		UF	M	1965	PSREC
94	1,751	0.336	Frigidaire	UFD-156W	27	UF	M	1968	SVP
95	3,153	0.440	Sears	106724240	19	UF	FF	1976	Gridley
96	1,618	0.328	Signature	FFT464000H	18	UF	M	1978	SVP
97	1,775	0.228	Frigidaire	UF-160	16	UF	FF	1980	TID
98	1,907	0.244	GE	CA276YCW	21	UF	M	1982	Gridley
99	1,857	0.280	GE	CA276YCW	21	UF	M	1982	Gridley
100	2,278	0.294	Continental	SF199	19	UF	M	1982	Gridley
101	2,938	0.345	Kenmore	7577283130	27	UF	M	1982	Gridley
102	1,289	0.246	Montgomery Ward	FFT-4969	19	UF	M		Gridley
103	1,751	0.205	Gibson	FV21M1DHFA	21	UF	M		Gridley
104	2,516	0.312	Frigidaire	UF-211	21	UF	M		Gridley
105	1,531	0.686	Montgomery Ward	FFT464007B	16	UF	M		Gridley
106	2,515	0.364	Kenmore	7577293130	27	UF	M		Gridley
107	1,411	0.268	Kelvinator	HCM253K-1	25	UF	M		Gridley
Mean	1,682	0.362			20.5				
Std. Dev.	771	0.146							
90% Confid	122	0.02							
Cv	0.46	0.40							

Table 10.3 Statistical Results for Refrigerator and Freezer Metering Data

Description	M&V Gross Savings kWh/yr	M&V Gross Savings kW
Refrigerator Average	**1,625**	**0.365**
Refrigerator STDEV	778	0.148
90% Confidence Interval	134	0.03
Freezers Average	**2,009**	**0.348**
Freezers STDEV	585	0.138
90% Confidence Interval	241	0.06
Total Refrigerators and Freezers Average	**1,682**	**0.362**
STDEV	771	0.146
90% Confidence Interval	122	0.023

Figure 10.1 Field Measurements of 54 Recycled Refrigerators and Freezers



10.5 Comparison Metering Results to AHAM/DOE Ratings

Metering results are compared to AHAM/DOE ratings in **Table 10.4**. For this small sample, the average difference between field metered kWh usage and the AHAM/DOE rating is 6%. However, differences between individual units are significant. For #21 (22.2 c.f. Kenmore) the difference is 665 kWh/yr or 30 percent. For #75 (18 c.f. Whirlpool) the difference is 866 kWh/yr more 47 percent. On the other hand some differences are small such as units #56, and #81. AHAM/DOE ratings for most of the units listed in **Table 10.2** are unavailable and there are no AHAM/DOE ratings for peak kW usage.

Table 10.4 Field Measurements Compared to AHAM/DOE Ratings

#	Manufacturer	Model	Size	Age	Style	kW	kWh	AHAM kWh	Delta kWh
	New Frigidaire	FFU20FC4AW	20.3	2001	UF	0.15	621	763	-142
21	Kenmore	106.8620G82	22.2	1985	SBS	0.42	2,242	1,577	665
64	Kenmore	8637710	17	1989	TFBR	0.12	513	874	-361
75	Whirlpool	ET18CKXMNRO	18	1993	TFBR	0.24	1,825	959	866
81	Gibson	RT19F3WMGC	18.6		TFBR	0.32	1,041	1110	-69
73	Whirlpool	ET22PKXWN10	19	1992	TFBR	0.26	793	958	-165
56	Kenmore	7689360	19.2	1985	TFBR	0.25	1,388	1472	-84
60	GE	TBX21ZKC	21	1987	TFBR	0.33	822	942	-120
	Average						**1,156**	**1,082**	**74**

10.5 Participant Survey Findings

This study uses participant surveys to estimate the net-to-gross ratios for kWh and peak kW savings. Participant surveys were completed for 110 participants in six NCPA utility service areas.

10.6 Participant Survey Methodology

Participant surveys were used to develop net-to-gross ratios for calculating net kW and kWh savings as shown in **Equations 10.1** and **10.2**.[79]

Eq. 10.1 $NTGR_{kWh} = AF \times PF_{kWh}$

Where,

$NTGR_{kWh}$ = Net-To-Gross Ratio for kWh savings,

AF = Attribution Factor defined as the number of units that would not have been recycled without the program divided by the total number of units recycled through the program,

PF_{kWh} = Part-use Factor for kWh defined as the fraction of the year that units would have been operated if they were not picked up and recycled.

Eq. 10.2 $NTGR_{kW} = AF \times PF_{kW}$

Where,

$NTGR_{kW}$ = Net-To-Gross Ratio for kW savings,

PF_{kW} = Part-use Factor for kW defined as the fraction of time that units would have operated in the summer during peak electrical demand periods.

[79] Conventional net-to-gross ratios reflect what customers would have done in the absence of the program. This study measures net-gross ratios using an attribution factor and part-use factors for kW and kWh since refrigerator energy use is typically reported for a full year. The study combines the attribution factor with part-use factors to develop a "one-step" procedure to calculate net kW and kWh impacts.

10.6.1 Attribution Factor

The attribution factor is used to estimate the fraction of free riders who would have otherwise recycled and rendered their refrigerator or freezer inoperable in the absence of the program. Six participant survey questions are used to assess the attribution factor and free riders as shown in **Table 10.5**. The attribution score is based on the following set of rules.

1. If the answer to question 12 is "kept as spare and used," then the attribution is 1, irrespective of answers to other questions.
2. If the answer to question 16 is "no" (i.e., were not planning to recycle old unit before heard about program), then the attribution is 1 as long as the answer to question 7 is "no."
3. Otherwise if the answer to question 7 is yes, the attribution is 0.58 (i.e., assuming the old unit continues to be used as a spare).[80]
4. If the answer to question 16 is "yes," then attribution is the average score based on answers to questions 12 through 16. The attribution average score cannot exceed 0.58 if the answer to question 7 is yes. No score is assigned to responses of "don't know", "refused to answer," or "other."

Table 10.5 Attribution Factor Participant Survey Questions and Scoring

#	Question	Answer	Score
7	Was purchasing a new refrigerator or freezer the major reason for recycling your old unit?	Yes	0.58
		No	1
12	What would you have done with your old unit if the recycling service had not been available?	Kept and used	1
		Kept unplugged	
		Given away	1
		Recycled	0
		Other pickup	0.5
		Left when moved	0.5
13	The Utility Program was nice but it was unnecessary to get me to permanently remove my old refrigerator(s). (Assign number between 0 and 10 where 0 is complete disagreement and 10 is complete agreement.)	0 to 10	0=1, 10=0
14	We would not have recycled our old refrigerator(s) without the Utility Program. (Assign number between 0 and 10 where 0 is complete disagreement and 10 is complete agreement.)	0 to 10	0=0, 10=1
15	If the Program had not been available would you have gotten rid of your refrigerator(s) permanently.	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
16	Were you planning to recycle or dispose of your old refrigerator before you heard about the Program?	Yes	0
		No	1

10.6.2 Part-use Factors for kW and kWh

Two participant questions are used to develop part-use factors as shown in **Table 10.6**.

1. Answers to question 11 are used to estimate the Part-use Factor for kWh defined as the fraction of the year that units would have been operated if they were not picked up and recycled.

[80] Purchasing a new unit and keeping the old unit as a spare is scored as 0.58 (i.e., 1 – 700/1682) based on NAECA standard average new use of 700 kWh/yr and 0.15 kW compared to average old use of 1,682 kWh/yr and 0.362 kW (see *Qualifying List of Energy Star Refrigerators and NAECA Standards for Refrigerators* from 4.9 to 38.9 cubic feet, http://www.energystar.gov/index.cfm?c=refrig.pr_refrigerators).

2. Answers to question 11a are used to estimate the Part-use Factor for kW defined as the fraction of time that units would have operated in the summer during peak electrical demand periods.

The average score for these questions in the participant sample are multiplied times the average attribution factor to estimate the average net-to-gross ratios for kW and kWh savings.

Table 10.6 Part-use Factor Participant Survey Questions and Scoring

#	Question	Answer	Score
11	If you had not recycled the unit, about how many months during the next year would it have been turned on? (Read List, Enter Months as Fractions, i.e., 9 months = 9/12 = 0.75)	kWh/yr Part-use	0 to 1
11a	If answer to Q.11 is less than one year ask if unit was turned on during the Summer (i.e., May to October).	Summer	1
		Winter	0

10.7 Findings of the Participant Surveys

Results of the participant surveys for each program are presented in **Table 10.7**. The average attribution factor is 0.76. The average part-use factor is 0.83 for kWh savings and 1.0 for kW savings. The average net-to-gross ratio is 0.64 for kWh savings and 0.76 for kW savings.

Table 10.7 Findings of Participant Surveys for SB5X Refrigerator Recycling Programs

NCPA Utility	Qty.	Completed Surveys	Attribution Factor	Part-use Factor kWh/yr	Part-use Factor kW	Net-to-Gross Ratio kWh/yr	Net-to-Gross Ratio kW
Biggs	2	1	1.00	0.91	1.00	0.91	1.00
Gridley	42	19	0.67	0.83	1.00	0.55	0.67
Lodi	541	28	0.76	0.90	1.00	0.69	0.76
Lompoc	64	16	0.79	0.77	1.00	0.61	0.79
Plumas-Sierra	68	13	0.79	0.79	1.00	0.62	0.79
Santa Clara	747	33	0.76	0.80	1.00	0.61	0.76
Total	1,464	110	0.76	0.83	1.00	0.64	0.76

11. Miscellaneous Programs

Miscellaneous Rebate Programs were implemented by Lodi, Lompoc, Modesto Irrigation District (MID), Roseville Electric, Turlock Irrigation District (TID), and Santa Clara (Silicon Valley Power). The programs realized peak kW and kWh savings by paying incentives to customers for installing high efficiency miscellaneous measures. The programs provided 1,726 incentives for 68,698 measures from 2001 through 2003 with $246,519 SB5X funds administered by NCPA.[81]

Ex ante and ex post program savings are summarized in **Tables 11.1** and **Table 11.2**. The ex ante program savings are 921,903 kWh/yr and 427 kW. The M&V gross ex post program savings are 454,806 ± 24,239 kWh/yr and 240 ± 29 kW at the 90 percent confidence level. The M&V net ex post savings for the program are 387,196 ± 19,339 kWh per year and 182 ± 20 kW. The net ex post lifecycle savings are 5,064,053 ± 290,760 kWh as shown in **Table 11.3**. The average effective useful lifetime for all miscellaneous measures is 13.08 years. Ex post kWh savings are

[81] MID, TID, and Lodi reported 441 rebates for approximately 67,000 ft^2 of window film.

based on billing data analyses, sub-metered data, engineering analyses, and previously published M&V studies. The net-to-gross ratio is calculated based on decision maker surveys regarding whether or not the unit would have been installed without rebates from the programs. The average net-to-gross ratio is 85 percent indicating approximately 15 percent of measures would have been purchased anyway without the program.[82] The net realization rates are 0.42 for kWh and kW savings. The M&V savings and realization rates are lower than anticipated due to missing measures and lower baselines, lower savings, and lower net-to-gross ratios.

Table 11.1 Ex Ante Savings for NCPA SB5X Miscellaneous Programs

NCPA Utility	Rebates	Qty.	Ex Ante Full-Year kWh/yr	Ex Ante kW	Ex Ante Net-to-Gross Ratio kWh/y	Ex Ante Net-to-Gross Ratio kW	Ex Ante Program Savings kWh/y	Ex Ante Program Savings kW
Roseville - Vender Misers	56	115	212,900	19.3	1	1	212,900	19.3
MID - Res ESW	310	44872	98,718	179.5	1	1	98,718	179.5
MID - Comm SS	19	16243	51,978	65.0	1	1	51,978	65.0
MID - Res SS	99	5881	12,938	23.5	1	1	12,938	23.5
MID - Res WHF	23	24	6,600	12.0	1	1	6,600	12.0
MID – Refrig.	704	704	371,893	80.4	1	1	371,893	80.4
Lompoc – Kits	500	500	36,850	13.0	1	1	36,850	13.0
Lompoc - WB Pad	1	1	900	0.3	1	1	900	0.3
Lodi - Win. Film	9	9	900	0.6	1	1	900	0.6
TID - Win. Film	1	34	5,376	5.6	1	1	5,376	5.6
SVP-Plug Sensors	2	315	122,850	28.05	1	1	122,850	28.1
Total	**1,726**	**68,698**	**921,903**	**427**	**1.00**	**1.00**	**921,903**	**427**

Table 11.2 M&V Ex Post Savings for NCPA SB5X Miscellaneous Programs

NCPA Utility	Qty.	M&V Gross Ex Post Savings kWh/y	M&V Gross Ex Post Savings kW	Net-to-Gross Ratio kWh/y	Net-to-Gross Ratio kW	M&V Net Ex Post Savings kWh/y	M&V Net Ex Post Savings kW	Net Realization Rate kWh/y	Net Realization Rate kW
Roseville - Vender Misers	115	178,710	11.5	0.96	0.96	171,562	11.0	0.81	0.57
MID - Res ESW	44872	98,718	134.6	0.65	0.65	64,167	87.5	0.65	0.49
MID – Comm SS	16243	43,856	24.4	0.96	0.96	42,102	23.4	0.81	0.36
MID - Res SS	5881	9,410	4.1	0.48	0.48	4,517	2.0	0.35	0.08
MID - Res WHF	24	4,872	4.8	0.66	0.66	3,216	3.2	0.49	0.26
MID – Refrig.	704	46,464	9.9	0.80	0.80	37,171	7.9	0.10	0.10
Lompoc – Kits	500	33,500	11.5	0.80	0.80	26,800	9.2	0.73	0.71
Lompoc – WB Pad	1	270	0.1	0.80	0.80	216	0.1	0.24	0.24
Lodi - Win. Film	9	635	0.2	0.96	0.96	610	0.2	0.68	0.36
TID - Win. Film	34	4,516	2.1	0.96	0.96	4,335	2.0	0.81	0.36
SVP-Plug Sensors	85	33,856	36.6	0.96	0.96	32,501	35.1	0.26	1.25
Total	**68,468**	**454,806**	**239.8**	**0.85**	**0.76**	**387,196**	**181.6**	**0.42**	**0.42**
Roseville - Vender Misers	115	178,710	11.5	0.96	0.96	171,562	11.0	0.81	0.57

[82] The net-to-gross ratios reflect what customers would have done in the absence of the program (see Section 3).

Table 11.3 Ex Post Lifecycle Savings for NCPA SB5X Miscellaneous Programs

NCPA Utility	Qty.	M&V Net Ex Post Annual Savings kWh/yr	Effective Useful Lifetime	M&V Net Ex Post Lifecycle Savings kWh	90% CI kWh/yr
Roseville - Vender Misers	115	171,562	13	2,230,301	126,298
MID - Res ESW	44872	64,167	20	1,283,339	233,334
MID – Comm SS	16243	42,102	10	421,019	77,966
MID - Res SS	5881	4,517	10	45,166	5,363
MID - Res WHF	24	3,216	15	48,233	15,444
MID – Refrig.	704	37,171	12	446,054	8,635
Lompoc – Kits	500	26,800	8	214,400	25,280
Lompoc – WB Pad	1	216	5	1,080	108
Lodi - Win. Film	9	610	10	6,096	1,129
TID - Win. Film	34	4,335	10	43,352	8,028
SVP-Plug Sensors	85	32,501	10	325,013	84,048
Total	**68,468**	**387,196**	**13.08**	**5,064,053**	**290,760**

Note: The total 90% confidence interval (CI) kWh is the square root of the sum of the squares of the 90% CI for each pr

The M&V study provides average gross savings per unit and net-to-gross ratios. The gross savings are based on billing analyses, engineering analyses, and previous studies. Participant telephone surveys were used to evaluate program performance criteria and net-to-gross ratios. A separate report titled, *Measurement & Verification Report for NCPA SB5X Miscellaneous Programs,* provides more information. **Appendix A** provides the Decision-Maker Survey.

11.1 M&V Approach for C&I Custom

The measurement and verification of energy and demand impacts of miscellaneous programs are based on billing data, sub-metered data, engineering analyses, and previously published M&V studies such as the Database for Energy Efficiency Resources (DEER).[83] The ex post energy and peak demand savings were determined using IPMVP Option A (i.e., partially measured retrofit isolation), Option B (i.e., retrofit isolation), and IPMVP Option C (whole facility billing regression analysis). Energy savings for Vender Misers are based on sub-metered data from previously published M&V studies. Energy savings for Energy Star windows (ESW), sun screens, window film, and whole house fans are based on billing regression and engineering analyses using PRISM. Energy and peak demand savings for Energy Star refrigerators, conservation kits and water heater mattress pads are based on previously published M&V studies. Energy and peak demand savings for plug load sensors are based on sub-metered data. Billing data for relevant sites was collected for a 4-year period from January 2001 through December 2004.

11.2 M&V Sample Design and Precision

The sample design for metering and participant surveys was designed to achieve a minimum precision of plus or minus 10% at the 90% confidence level. Sampling methods were used to analyze the data and extrapolate mean savings estimates from the sample measurements to the population of all program participants and to evaluate the statistical precision of the results. Load impacts were evaluated with a random M&V sample of 50 participants. The M&V participant

[83] 2001 DEER Update Study, prepared by XENERGY, Inc., prepared for the CEC, Contract 300-99-008, Aug. 2001.

survey sample size is 24. The weighted sample coefficient of variation for kWh savings was 0.03, the weighted Cv for kW savings was 0.07, and the weighted participant survey coefficient of variation was 0.19. The kWh billing data sample included 40 sites. The field measurement and sub-metered data sample included 10 sites. Energy and peak demand savings for plug load sensors are based on sub-metered data. The M&V sample of 50 participants provided relative precision of ±11.2% for MW and ±5% for GWh. The DMS sample of 24 participants yielded relative precision of ±7.4% for the survey results.

11.3 Baseline

The baseline kWh values are based on billing data, PRISM analyses, and field measurements. The baseline kW values are based on metering results for a random sample of sites, deemed values from the 2001 DEER Update Study, engineering analyses, and previously published M&V studies.

11.4 M&V Findings for Miscellaneous Programs

M&V findings and load impacts are provided for vending misers, Energy Star windows, solar sun screens, whole house fans, conservation kits, water heater mattress pads, solar window film, and plug load sensors.

11.4.1 Findings for Vending Misers

The vending miser measures accounted for 23.1 percent of total ex ante kWh savings and savings and 4.5 percent of total ex ante kW savings for the SB5X Miscellaneous Programs. Vending misers reduce energy use in vending machines by using a passive infrared sensor to power down a vending machine when the area surrounding it is unoccupied and automatically re-powers the machine when the area is reoccupied. The vending miser controller uses fuzzy logic to learn from the habits of the building occupants, and modifies the time-out period accordingly. An optional Sensor Repeater allows the control of a bank of vending machines with a single sensor, minimizing installation time and visual impact. Additionally, Vending misers monitor the ambient temperature while the vending machine is powered down. Using this information, Vending misers automatically power up the vending machine at appropriate intervals, independent of occupancy, to ensure that the vended product stays cold. Vending misers also monitor electrical current used by the vending machine. This ensures that Vending Miser will never power down a vending machine while the compressor is running, so a high head pressure start never occurs. In addition, the current sensor also ensures that every time the vending machine is powered up, the cooling cycle is run to completion before again powering down the vending machine.

Load impacts for vending misers are based on a study from the University of Illinois at Urbana-Champaign showing average savings of 1,554 ± 88 kWh/year and 0.1 ± 0.01 kW for Vending Misers.[84] The ex ante savings per vending miser were 1,600 kWh/year and 0.1 kW. The gross ex

[84] Luo, J. 2003. Express Efficiency 2004-05 Workbook. 2-MeasureableEEActivities, Vending Machine Controller, San Francisco, Calif: Pacific Gas and Electric Company (PG&E). Taguchi, H., Jeong Lee, H., Pansare, P., Gentry,

post savings per measure are 1,544 ± 88 kWh/yr and 0.1 ± 0.01 kW. The Roseville Electric database reported incentives for 115 Vending Misers at 58 sites. The vender miser program ex ante savings are 212,900 kWh/year and 19.29 kW. The ex post savings are 178,710 ± 10.186 kWh/yr and 11.5 ± 0.7 kW. An evaluation study by Foster-Miller, Inc., found an effective useful lifetime for the vending miser of 13 years.[85] Based on findings from Foster-Miller a 13 year EUL is used for this study.

11.4.2 Findings for Residential Energy Star Windows

The Energy Star window measures accounted for 10.7 percent of total ex ante kWh savings and savings and 42 percent of total ex ante kW savings for the SB5X Miscellaneous Programs. Billing data were collected from 12 sites in MID. These data were used as inputs for the PRInceton Scorekeeping Method (PRISM) to develop pre- and post-retrofit Normalized Annual Consumption (NAC) kWh values and energy savings as shown in **Table 11.4**.[86] Peak kW savings are based on the peak demand-to-energy ratio times the estimated kWh savings using the following equation.[87]

Eq. 11.1 $$\text{kW Savings}_{unit} = \frac{0.001172\ \text{kW}}{\text{kWh}} \times \text{kWh Savings}_{\text{unit}}$$

Where,

$PDER_i$ = Peak demand-to-energy ratio is 0.001172 kW/kWh.

The ex ante savings per square foot of residential Energy Star windows were 2.2 kWh/yr-ft^2 and 0.004 kW/ft^2. The ex post savings per square foot are 2.2 ± 0.4 kWh/yr-ft^2 and 0.003 ± 0.0006 kW/ft^2. The *2001 DEER Update Study* provides average unit savings per square foot of 2 ± 0.12 kWh/yr-ft^2 and 0.002 ± 0.0001 kW/ft^2.[88] The MID tracking database reported 44,872 square feet of Energy Star windows. The MID Energy Star Window program ex ante savings are 98,718 kWh/year and 179 kW. The ex post savings are 98,718 ± 19,744 kWh/yr and 134.6 ± 26.9 kW. The net to gross ratio is 0.65 and the effective useful lifetime (EUL) is 20 years.[89]

T. 2002. *The Vending Miser: A Pilot Study of Its Use at the University of Illinois at Urbana-Champaign.* Urbana-Champaign, Ill.: University of Illinois. The Illinois study had the most conservative savings of 39 studies.

[85] Foster-Miller, Inc. 2000. *Vending Machine Engineering Evaluation and Test Report*. Waltham, MA.: Foster-Miller, Inc.

[86] Fels, M., Kissock, K., Marean, M., Reynolds, C. 1995. *PRISM Advanced Version 1.0 User's Guide*. Princeton, New Jersey. Princeton University, Center for Energy and Environmental Studies.

[87] SCE Energy-Efficiency Potential Study, prepared by XENERGY, Inc., Oakland, CA, prepared for Southern California Edison Company, 1992.

[88] Energy and peak demand savings are based on the 2001 DEER Update Study, page 6-54, Double-pane medium low-E coating windows, prepared by XENERGY, Inc., prepared for the CEC, Contract 300-99-008, August 2001.

[89] The net-to-gross ratio and effective useful lifetime (EUL) are taken from the *Energy Efficiency Policy Manual*, Chapter 4, page 22, prepared by the California Public Utilities Commission, 2001.

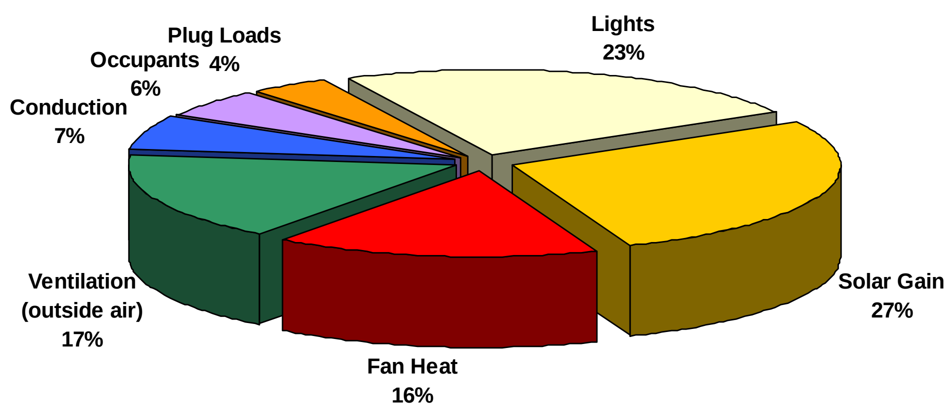
Table 11.4 MID Baselines and M&V Savings for Residential Energy Star Windows

Site	Pre-Retrofit NAC (kWh/yr)	Post-Retrofit NAC (kWh/yr)	Affected Window Area ft^2	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option
1	7,224	6,473	71	156	0.284	751	0.880	C
2	3,040	2,738	169	372	0.676	301	0.353	C
3	4,848	4,535	45	99	0.180	313	0.367	C
4	8,963	9,159	150	330	0.600	-196	-0.230	C
5	12,975	13,574	145	319	0.580	-599	-0.702	C
6	5,436	6,033	101	222	0.404	-597	-0.700	C
7	9,903	10,178	24	53	0.096	-275	-0.322	C
8	12,203	10,741	190	418	0.760	1,462	1.714	C
9	5,452	3,525	205	451	0.820	1,928	2.260	C
10	6,880	6,908	403	887	1.612	-28	-0.033	C
11	13,977	13,864	184	405	0.736	114	0.133	C
12	9,086	8,119	178	392	0.712	968	1.134	C
Average	**8,332**	**7,987**	**155**	**342**	**0.622**	**345**	**0.404**	
Ave/ft^2				**2.2**	**0.004**	**2.2**	**0.003**	

11.4.3 Findings for Commercial Solar Sun Screens

The commercial solar sun screen measures accounted for 5.6 percent of total ex ante kWh savings and savings and 15.2 percent of total ex ante kW savings for the SB5X Miscellaneous Programs. The ex ante unit savings per square foot for commercial solar sunscreens were 3.2 kWh/yr-ft^2 and 0.004 kW/ft^2. Average commercial building loads for a typical office building in California are shown on **Figure 11.1**. Solar heat gains represent the largest building load at 27%.

Figure 11.1 Air Conditioning Loads in Commercial Buildings



The program maximum solar heat gain coefficient (SHGC) was 0.35 for sunscreens (see **Table 11.5**). Solar sunscreens can reduce solar heat transmission by 51.6% and save approximately 13.9% on cooling (i.e., 0.516 x 0.27 = 0.139). The engineering estimate of ex post energy savings for reflective window film are 13.9 ± 2.6% or 2.7 ± 0.5 kWh/yr-ft^2 (i.e., 0.139 x [EUI of 3.95 kWh/yr-ft^2] ÷ [20% window-to-floor area ratio] = 2.7 kWh/yr-ft^2). The engineering estimate of ex post kW savings are 0.0015 ± 0.0003 kW/ft^2 assuming 13.9 ± 2.6% savings, coincident demand factor of 0.85, and baseline of 1.3 kW/ton (i.e., 0.139 x 0.85 x 1.3 kW/ton ÷ [20% window-to-floor area ratio x 500 ft^2/ton]= 0.0015 kW/ft^2). The MID tracking database reported 16,243 square feet of solar sunscreens. The ex ante cooling savings for commercial sunscreens were 51,978 kWh per year and 65 kW. The ex post savings are 43,856 ± 8,122 kWh/yr and 24.4 ± 4.7 kW. The M&V gross realization rate is 0.84 ± 0.16 for kWh and 0.38 ± 0.07 for kW. The net to gross ratio is 0.96 and the effective useful lifetime is 10 years.[90]

Table 11.5 Solar Sunscreen Performance

Glass Type	Visible Light Transmission (%)	Solar Heat Transmission (%)	Solar Heat Gain Coefficient
Clear ¼ inch	89	83	0.84
Clear ¼ inch with Solar Sunscreens	61	40	0.35

11.4.4 Findings for Residential Solar Sun Screens

The residential solar sun screen program measures accounted for 1.4 percent of the ex ante kWh savings and savings and 5.5 percent of the ex ante kW savings for the SB5X Miscellaneous Programs. Billing data were collected from 10 sites in MID. PRISM was used to develop pre- and post-retrofit NAC kWh values and energy savings (see **Table 11.6**). Peak kW savings are based on peak demand-to-energy ratio times the estimated kWh savings using **Equation 11.1**.

The ex ante savings per square foot of residential sun screens were 2.2 kWh/yr-ft^2 and 0.004 kW/ft^2. The ex post savings per square foot are 1.6 ± 0.19 kWh/yr-ft^2 and 0.0007 ± 0.000145 kW/ft^2. The *2001 DEER Update Study* provides average unit savings per square foot of 1.7 ± 0.19 kWh/yr-ft^2 and 0.001 ± 0.0001 kW/ft^2.[91] The MID tracking database reported 5,881 square feet of residential sun screens. The MID Energy Residential Sun Screens program ex ante savings are 12,938 kWh/year and 23.5 kW. The ex post savings are 9,410 ± 1,117 kWh/yr and 4.1 ± 0.85 kW. The net to gross ratio is 0.48 and the effective useful lifetime is 10 years.[92]

Table 11.6 MID Baseline Cooling and M&V Savings for Residential Sun Screens

Site	Pre-Retrofit NAC (kWh/yr)	Post-Retrofit NAC (kWh/yr)	Affected Window Area ft^2	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option
1	6,123	6,073	30	66	0.12	50	0.06	C
2	8,536	8,492	33	73	0.13	44	0.05	C
3	12,622	12,141	576	1,267	2.30	481	0.56	C
4	4,809	4,757	71	156	0.28	52	0.06	C
5	9,946	9,783	99	218	0.40	163	0.19	C
6	23,076	21,964	240	528	0.96	1,112	1.30	C
7	6,197	6,156	26	57	0.10	41	0.05	C

[90] Ibid.

[91] Energy and peak demand savings are based on the 2001 DEER Update Study, page 6-54, Double-pane medium low-E coating windows, prepared by XENERGY, Inc., prepared for the CEC, Contract 300-99-008, August 2001.

[92] The net-to-gross ratio and EUL are taken from the *Energy Efficiency Policy Manual*, Chapter 4, page 21-23, prepared by the California Public Utilities Commission, 2001.

Table 11.6 MID Baseline Cooling and M&V Savings for Residential Sun Screens

Site	Pre-Retrofit NAC (kWh/yr)	Post-Retrofit NAC (kWh/yr)	Affected Window Area ft^2	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option
8	4,598	4,537	56	123	0.22	61	0.07	C
9	14,604	14,494	129	284	0.52	110	0.13	C
10	14,142	13,952	152	334	0.61	190	0.22	C
Average	**10,465**	**10,235**	**141**	**311**	**0.56**	**230**	**0.30**	
Ave/ft^2				2.2	0.004	1.6	0.0007	
90% CI						0.1899	0.000145	

11.4.5 Findings for Residential Whole House Fans (WHF)

The residential whole house fan measures accounted for 0.7 percent of total ex ante kWh savings and savings and 2.8 percent of total ex ante kW savings for the SB5X Miscellaneous Programs. Billing data were collected from 18 sites in MID. These data were used as inputs for PRISM to develop base cooling values. The cooling savings are based on the average percentage savings of 10.2 ± 5.6 percent from the 2001 DEER Update Study.[93] Baseline cooling and savings values for MID are summarized in **Table 11.7**. The unit ex ante savings per WHF were 275 kWh/yr and 0.5 kW. The ex post savings are 203 ± 65 kWh per year and 0.02 ± 0.006 kW. The MID tracking database reported 24 whole house fans. The ex ante cooling savings for whole house fans were 6,600 kWh per year and 12 kW. The ex post savings are 4,878 ± 1,554 kWh/yr and 0.45 ± 0.14 kW. The net to gross ratio is 0.66 and the effective useful lifetime is 15 years.[94]

Table 11.7 MID Baseline Cooling and M&V Savings for Whole House Fans

Site #	Pre-retrofit NACC (kWh/yr)	Ex Ante Savings kWh/yr	Ex Ante Savings kW	M&V Savings kWh/yr	M&V Savings kW	IPMVP Option
1	2,029	275	0.5	208	0.02	A, C
2	197	275	0.5	20	0.00	A, C
3	2,040	275	0.5	209	0.02	A, C
4	3,207	275	0.5	329	0.03	A, C
5	303	275	0.5	31	0.00	A, C
6	4,261	275	0.5	437	0.04	A, C
7	822	275	0.5	84	0.01	A, C
8	326	275	0.5	33	0.00	A, C
9	1,159	275	0.5	119	0.01	A, C
10	424	275	0.5	43	0.00	A, C
11	2,834	275	0.5	290	0.03	A, C
12	3,446	275	0.5	353	0.03	A, C
13	1,093	275	0.5	112	0.01	A, C
14	3,293	275	0.5	337	0.03	A, C
15	6,033	275	0.5	618	0.06	A, C
16	1,382	275	0.5	142	0.01	A, C
17	1,402	275	0.5	144	0.01	A, C
18	1,454	275	0.5	149	0.01	A, C
Average	**1,984**	**275**	**0.5**	**203**	**0.02**	
90% CI	**632**			**65**	**0.006**	

[93] Energy and peak demand savings are based on the 2001 DEER Update Study, page 6-45, Whole House Fan, prepared by XENERGY, Inc., prepared for the California Energy Commission, Contract 300-99-008, August 2001.
[94] Ibid.

11.4.6 Findings for Energy Star Refrigerators

The MID Energy Star refrigerator rebate program accounted for 40.3 percent of total ex ante kWh savings and savings and 18.8 percent of total ex ante kW savings for the SB5X Miscellaneous Programs. Annual energy savings for Energy Star refrigerators are based on the *Qualifying List of Energy Star Refrigerators and NAECA Standards for Refrigerators* from 4.9 to 38.9 cubic feet. The Energy Star database included 355 new refrigerators and the annual energy consumption for each product was provided along with the corresponding NAECA standard product for each size and type (i.e., top-freezer, bottom-freezer, and side-by-side).[95] The peak demand savings are based on data logger measurements of Energy Star and NAECA standard units. The average measured refrigerator load factor was 0.000214 ± 0.00000414 kW/kWh. The average ex ante savings per Energy Star refrigerator were 528.3 ± 44.5 kWh/year and 0.11 ± 0.01 kW. The gross ex post savings per refrigerator were 66 ± 1.3 kWh/year and 0.014 ± 0.0003 kW. The MID database reported incentives for 704 Energy Star refrigerators. The MID refrigerator rebate program ex ante savings were 371,893 kWh/year and 80.4 kW. The ex post savings are 46,464 ± 899 kWh/yr and 9.9 ± 0.19 kW. The net to gross ratio is 0.80 and the effective useful lifetime is 12 years.[96] The ex post savings for MID are considerably lower than the ex ante savings. This is because MID assumed some old units were recycled and removed from the secondary refrigerator market based on customer self reporting. The actual recycling of old units could not be verified. Therefore, no credit was give for recycled units. For future programs, we recommend smaller rebates for Energy Star refrigerators of $25 per unit, and recycling old units by a third-party contractor in order to receive credit for energy and peak demand savings from documented recycling of each unit including refrigerant, foam, plastic, metals, and other components.

11.4.7 Findings for Residential Conservation Kits

The residential conservation kits accounted for 4 percent of total ex ante kWh savings and savings and 3 percent of total ex ante kW savings for the SB5X Miscellaneous Programs. The kits included the following nine measures: 1) Refrigerator Thermometer; 2) Outlet Safety Cap; 3) Faucet Repair Kit; 4) V-type Weather Stripping; 5) Tub of Caulking; 6) LimeLite Night Light; 7) 22W CFL; 8) Garden Hose Nozzel with Positive Shut-off; and 9) Conservation Booklet. The unit ex ante savings per kit were 73.7 kWh/yr and 0.26 kW. The ex post unit savings are 67 ± 7.9 kWh/yr and 0.023 ± 0.0016 kW based on savings for only the 22W CFL lamps taken from the Measurement & Verification Report for NCPA SB5X Residential Compact Fluorescent Lamp Programs. The Lompoc database reported 500 conservation kits. The ex ante savings for 500 kits were 36,850 kWh per year and 13 kW. The ex post savings are 33,500 ± 3,946 kWh/yr and 11.5 ± 0.8 kW. The net to gross ratio is 0.80 and the effective useful lifetime is 8 years.[97]

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[95] Available online: http://www.energystar.gov/index.cfm?c=refrig.pr_refrigerators).

[96] Ibid.

[97] Ibid.

11.4.8 Findings for Water Bed Mattress Pad

The Lompoc water bed mattress pad measures accounted for 0.1 percent of total ex ante kWh savings and savings and 0.1 percent of total ex ante kW savings for the SB5X Miscellaneous Programs. The ex ante savings were 900 kWh/yr and 0.3 kW. According to Home Energy Magazine, average energy consumption for a water bed is 900 kWh/yr and savings for mattress pads or insulating comforters are 30 percent.[98] Therefore, the ex post savings for the mattress pad are approximately 270 kWh/yr and 0.09 kW. The net to gross ratio is 0.80 and the effective useful lifetime is 5 years.[99]

11.4.9 Findings for Commercial Window Film

The Lodi and TID commercial window film rebate programs accounted for 0.7 percent of total ex ante kWh savings and savings and 1.3 percent of total ex ante kW savings for the SB5X Miscellaneous Programs. Average commercial building loads for a typical office building in California are shown on **Figure 11.1**. The assumed solar heat gain coefficient (SHGC) for window film is 0.45 (see **Table 11.8**). High performance window film can reduce solar heat transmission by 45.7% and save approximately 12.3% on cooling. The engineering estimate of ex post energy savings for reflective window film are 12.3% ± 2.3% or 2.4 ± 0.45 kWh/yr-ft^2 (i.e., 0.123 x [EUI of 3.95 kWh/yr-ft^2] ÷ [20% window-to-floor area ratio] = 2.8 kWh/yr-ft^2). The engineering estimate of ex post kW savings are 0.0014 ± 0.00026 kW/ft^2 assuming 12.3% savings, coincident demand factor of 0.85, and baseline of 1.3 kW/ton (i.e., 0.123 x 0.85 x 1.3 kW/ton ÷ [20% window-to-floor area ratio x 500 ft^2/ton]= 0.0014 kW/ft^2).

The Lodi and TID tracking databases did not report square feet of reflective window film, nor did they provide ex ante savings on per square foot basis. Therefore, the savings for these programs will be based on the M&V gross realization rates for MID commercial sun screens of 0.84 ± 0.16 for kWh and 0.38 ± 0.07 for kW. The ex ante savings for 10 sites were 6,276 kWh per year and 6.22 kW. The ex post savings are 5,272 ± 824 kWh/yr and 2.36 ± 0.17 kW. The net to gross ratio is 0.96 and the effective useful lifetime is 10 years.[100]

Table 11.8 Reflective Window Film Performance

Glass Type	Visible Light Transmission (%)	Solar Heat Transmission (%)	Solar Heat Gain Coefficient
Clear ¼ inch	89	83	0.84
Clear ¼ inch with Solar Window Film	70	45	0.40

11.4.10 Findings for Commercial Plug Load Sensors

The commercial plug load sensors accounted for 13.3 percent of total ex ante kWh savings and savings and 6.6 percent of total ex ante kW savings for the SB5X Miscellaneous Programs. Silicon Valley Power provided incentives for 85 units at site #1 and 230 units at site #2 for a

[98] Trends in Energy, Miscellaneous Water Under the Energy Bridge, Home Energy Magazine Online Mar/Apr 1999, http://homeenergy.org/archive/hem.dis.anl.gov/eehem/99/990304.html.

[99] Ibid.

[100] Ibid.

total of 315 units. M&V findings for the commercial plug load motion sensors are based on field verification of installed units and field measurements from ten (10) units installed in cubicles at a large high-technology office building located in Santa Clara, California. Measurements were made from February 7 through February 26, 2002. Pacific Science and Technology (PS&T) data loggers were used to obtain measurements of true RMS kilowatts (kW) and kilowatt-hours (kWh). M&V results for the ten cubicles are shown in **Table 11.9**. Pre- and post-retrofit field measurements for each plug load sensor are provided in **Figures 11.2** through **11.6**. The figures show a distinct reduction in energy use with sensor-controlled switched loads properly plugged into the sensors.[101] Savings are highest in cubicles where the occupant previously left their task lights on 24-hours per day (Data Logger I). Savings are lowest where occupants manually turned off their task lights and peripheral equipment prior to the plug load sensors being installed (Data Loggers J, M, O).

The ex ante unit savings were 390 kWh per year and 0.089 kW. The M&V ex post unit savings for plug load motion sensors are 398.3 ± 103 kWh per year and 0.43 kW ± 0.11 kW. The ex ante savings for 315 plug load sensors were 122,850 kWh/yr and 28.05 kW. Field verification found 85 units installed at site #1, but 230 units were not installed at site #2 and these units were not located at the site. Therefore, annual savings for 85 plug load sensors are 33,855 ± 8.729 kWh per year and 3.66 ± 0.95 kW. Plug load sensors must be installed as per manufacturer's directions in order to achieve these savings.[102] The effective useful lifetime (EUL) of plug load motion sensors is 10 years.[103]

Table 11.9 Measured kW and kWh savings for Watt Stopper Plug Load Sensors

Plug Load Sensor	Pre kW	Pre kWh/yr	Post kW	Post kWh/yr	M&V Savings kW	M&V Savings kWh/yr
B	0.158	1,237	0.103	663	0.055	574
D	0.230	1,836	0.194	1,402	0.036	434
G	0.156	1,154	0.122	890	0.034	264
H	0.262	1,906	0.217	1,491	0.044	415
I	0.219	1,531	0.124	696	0.095	835
J	0.182	1,200	0.160	993	0.022	207
L	0.185	1,354	0.142	977	0.043	377
M	0.201	1,350	0.165	1,068	0.036	282
O	0.124	988	0.095	733	0.029	255
X	0.194	1,335	0.157	995	0.036	339
Average	**0.191**	**1,389**	**0.148**	**991**	**0.043**	**398**

[101] Pre- versus post kWh measurements are indicated by a break in the kWh data.

[102] As per manufacturer's instructions, computers must be plugged into non-switching sockets and monitors, lights, and other peripheral equipment must be plugged into the sensor-controlled switching sockets.

[103] The effective useful lifetime (EUL) for plug load sensors is taken from the *Energy Efficiency Policy Manual*, Chapter 4, page 22, prepared by the California Public Utilities Commission, 2001.

Figure 11.2 Logger B and D Plug Load Motion Sensor Field Measurements

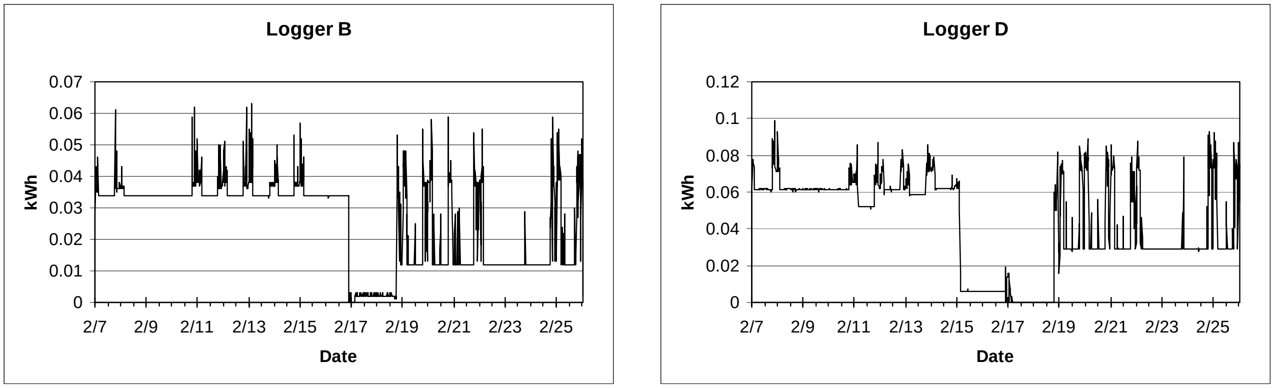


Figure 11.3 Logger G and H Plug Load Motion Sensor Field Measurements

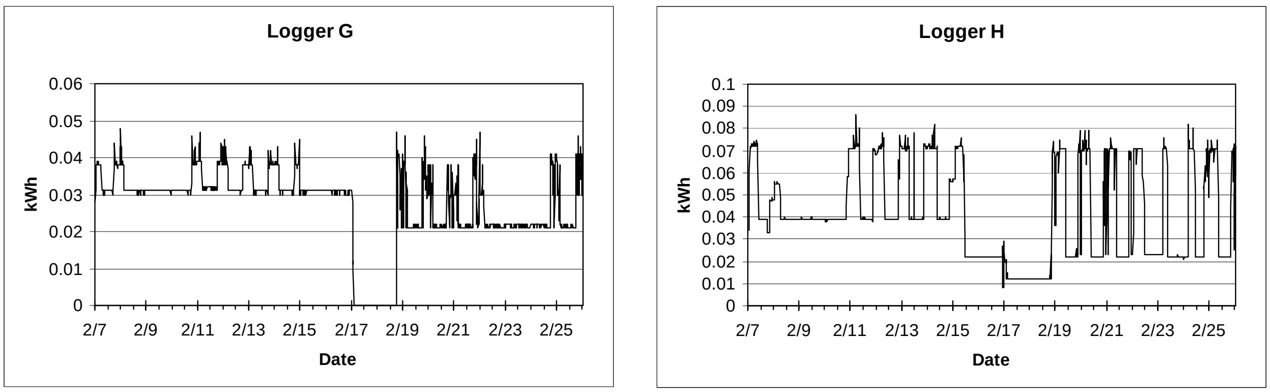


Figure 11.4 Logger I and J Plug Load Motion Sensor Field Measurements

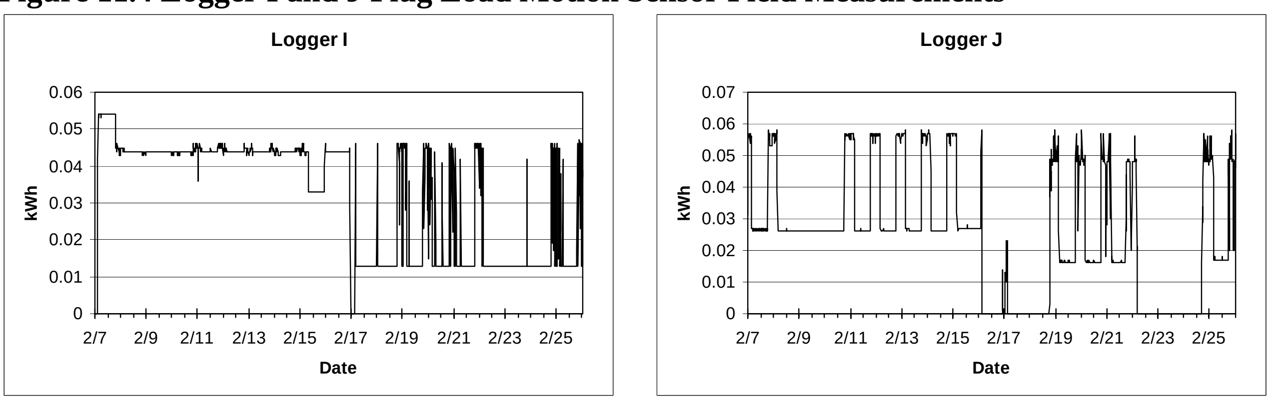


Figure 11.5 Logger L and M Plug Load Motion Sensor Field Measurements

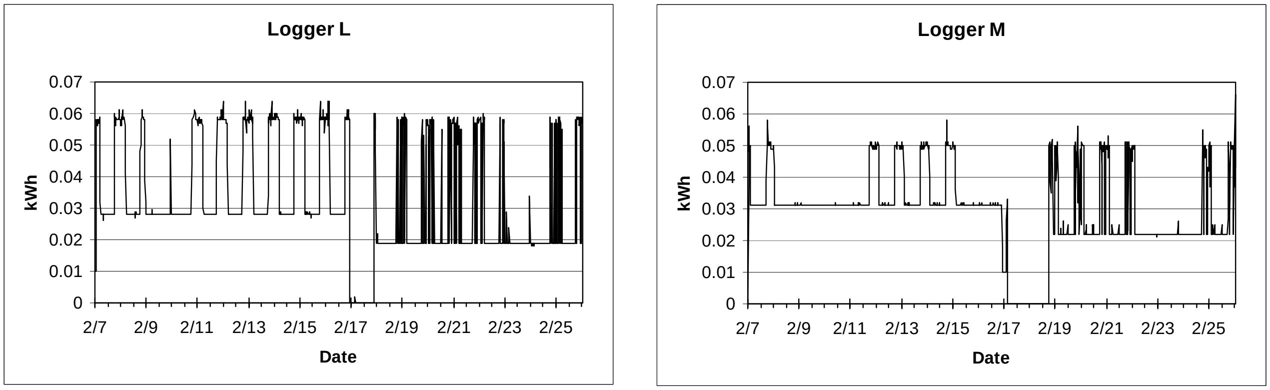
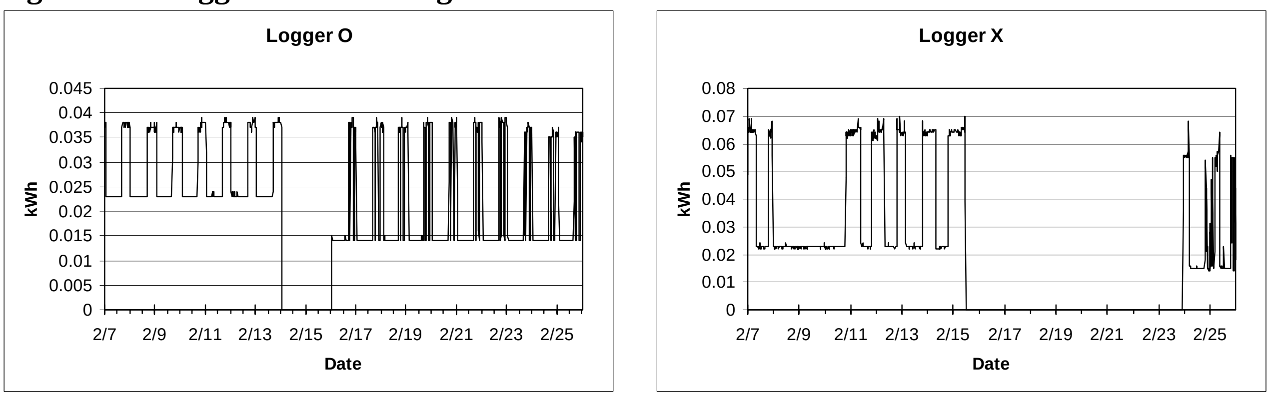


Figure 11.6 Logger O and X Plug Load Motion Sensor Field Measurements



11.5 Participant Survey Findings

This study used participant surveys to estimate the net-to-gross ratios for kWh and peak kW savings. Participant surveys were completed for 24 participants in three NCPA utility service areas. This sample size exceeded the M&V plan of 20 sites. Findings of the participant surveys for each program are presented in **Table 11.10**. The weighted average net-to-gross ratio is 0.851 based on average participant survey results multiplied times savings for each program divided by total savings for all programs.[104] Programs where it wasn't possible to conduct participant surveys assume default values from the California Public Utilities Commission Energy Efficiency Policy Manual. [105]

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

[105] The NTGR factor represents the net program load impact divided by the gross program load impact. *Energy Efficiency Policy Manual*, Chapter 4, page 23, prepared by the California Public Utilities Commission, 2001.

Table 11.10 Findings of Participant Surveys for SB5X Miscellaneous Programs

NCPA Utility	Rebates	Completed Surveys	Gross Ex Post Program Savings kWh/yr	Gross Ex Post Program Savings kW	Weighting Factor	Actual Net-to-Gross Ratio	Weighted Net-to-Gross Ratio
Roseville - Vender Misers	115	n/a	178,710	11.5	0.393	0.96	0.377
MID - Res ESW	44872	5	98,718	134.6	0.217	0.65	0.141
MID - Comm SS	16243	n/a	43,856	24.4	0.096	0.96	0.093
MID - Res SS	5881	6	9,410	4.1	0.021	0.48	0.010
MID - Res WHF	24	5	4,872	4.8	0.011	0.66	0.007
MID – Refrig.	704	n/a	46,464	9.9	0.102	0.8	0.082
Lompoc - Kits	500	n/a	33,500	11.5	0.074	0.8	0.059
Lompoc - WB Pad	1	n/a	270	0.1	0.001	0.8	0.000
Lodi - Win. Film	9	n/a	635	0.2	0.001	0.96	0.001
TID - Win. Film	34	7	4,516	2.1	0.010	0.96	0.010
SVP-Plug Sensors	85	1	33,856	36.6	0.074	0.96	0.071
Total	**68,468**	**24**	**454,806**	**240**	**1.000**		**0.851**

12. Load Control Programs

Residential Air Conditioner Load Control Programs were implemented by Modesto Irrigation District (MID) and Turlock Irrigation District (TID) and Commercial and Industrial (C&I) Load Control Programs implemented by the City of Palo Alto. MID and TID realized peak kW savings by providing monthly bill credits to customers in exchange for the installation of residential AC load controllers. The MID program installed 3,234 Load Control Receivers and the TID program installed 1,502 AC load control programmable thermostats.[106] City of Palo Alto realized peak kW savings by implementing load curtailment at the City Hall, Main Library, and Water Quality Control Plant (WQCP). The programs are in effect for the May through September cooling season with $1,600,740 of SB5X funds administered by NCPA.

The M&V results are summarized in **Table 12.1**. Total ex ante savings for the programs are 4,615 kW. The net to gross ratio is not applicable since these programs would not have been implemented without SB5X funding. The total net M&V ex post savings are 4,640 kW ± 58.9 kW at the 90 percent confidence level. The net realization rate for kW savings is 1.01. The M&V savings are based on system-wide electrical power field measurements of AC load controllers using real-time Supervisory Control and Data Acquisition (SCADA) before, during, and after turning off LCR 5000 load controllers. For MID, the LCR 5000 units were turned off during periods of high outdoor temperatures (i.e., greater than 100 degrees Fahrenheit, F). The M&V savings for TID are extrapolated from M&V savings for MID based on the number of units installed since the TID program installation was not completed until after the cooling season was over. The M&V savings for City of Palo Alto were based on SCADA measurements of affected

[106] The MID program installed LCR 5000 AC controllers that use 900 MHz paging technology installed on the outdoor condensing unit of split-system air conditioners. The TID program installed AC load control programmable thermostat that use 152.8 MHz paging technology and replace existing air conditioner thermostats. Participating MID and TID controllers are cycled off for an average of 10 minutes per 30 minute period, and are pre-programmed into different load groups and are normally stagger-cycled. Both controllers are used to shut off the air conditioner compressor. In emergency situations, participating AC load controllers can be cycled off to reduce electricity demand in the MID or TID service areas.

equipment or similar equipment. The effective useful lifetime of the load controllers is assumed to be 15 years. The net-to-gross ratio isn't applicable to load control programs since customers aren't able to participate without a controller installed on their air conditioner or C&I equipment.

Table 12.1 Summary of M&V Results for NCPA SB5X Load Control

NCPA Utility	Sites	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 MWh/yr	M&V Net Program Savings kW	Net Realization Rate Relative to Planning kWh/yr	Net Realization Rate Relative to Planning kW
MID	3,234	n/a	3,000	n/a	3,095	n/a	n/a	3,095	n/a	1.03
TID	1,502	n/a	1,500	n/a	1,437	n/a	n/a	1,437	n/a	0.96
Palo Alto	3	n/a	115	n/a	108	n/a	n/a	108	n/a	0.94
Total	**4,739**	n/a	**4,615**	n/a	**4,640**	n/a	n/a	**4,640**	n/a	**1.01**

A separate report titled, *Measurement & Verification Report for NCPA SB5X Load Control Programs*, provides detailed M&V reports for MID, TID, and Palo Alto. M&V site work was performed at customer sites from June 2002 through October 2003.

12.1 M&V Approach for Load Controllers

The measurement and verification of peak demand impacts of the Load Control programs are based on field measurements and engineering analyses for a statistically significant sample of participating customers. Ex post energy savings were determined using the following IPMVP Options. MID air conditioner load controllers were evaluated using IPMVP Option C (i.e., whole facility power use) for all sites (a census) with on-site verification at random sites. TID air conditioner load controllers were evaluated by extrapolating savings from MID using IPMVP Option A (i.e., stipulated or deemed values). Palo Alto commercial and industrial load controllers were evaluated using IPMVP Options A and B (i.e., retrofit isolation). Gross and net program evaluation savings (i.e., kW) are based on sample mean measurements of 3,234 LCR 5000 AC load controllers and three C&I load curtailment projects.

12.2 Sample Design and Precision

The sample design for the M&V field measurements and participant surveys achieved a minimum precision of plus or minus 10% at the 90% confidence level. Sampling methods were used to analyze the data and extrapolate M&V savings estimates from the sample to the population of all program participants and to evaluate the statistical precision of the results. A census was performed for the MID AC load controllers and the Palo Alto load curtailment programs. The M&V results for MID AC load controllers were extrapolated to TID AC load controllers since both utilities deployed similar strategies and measures in the same geographic climate zone. For MID, the load impact measurements were made during a ten-minute deployment of 3,234 LCR 5000 AC Load Controllers on July 10, 2002, when outdoor temperatures were approximately 105 F and on July 11, 2002, when outdoor temperatures were approximately 102 F. For Palo Alto, the load impact measurements for the Water Quality Control Plant were made by curtailing two out of three sets of recirculation and discharge pumps. Two sets run at any time with one set in standby. The other Palo Alto load curtailment projects were evaluated using detailed engineering estimates or extrapolated from field measurements of similar equipment. The weighted sample coefficient of variation for kW savings is 0.32. The Cv value is relatively small because 68.9 percent of program savings are based on direct field measurements of load controllers during actual operation. The M&V on-site survey sample of 3,237 participants provided relative precision of ±1.3% for MW.

12.3 Baseline

The baseline is the same as the measure savings since the AC units or C&I loads are either on or off. Total system baseline measurements were made before, during, and after turning off the units. For MID, the LCR 5000 units were measured during periods of high outdoor temperatures (i.e., greater than 100 degrees Fahrenheit, F). Baseline measurements were made on July 10, 2002, when outdoor temperatures were approximately 105 F and on July 11, 2002, when outdoor temperatures were approximately 102 F. The average baseline AC usage was 0.957 kW/unit. This measured value includes the diversity factor (i.e., probability of units being on). The baseline for the City of Palo Alto C&I load curtailment program was based on field measurements of the affected equipment or similar equipment (i.e., the 30-ton RTU).

12.4 M&V Findings for Load Controllers

Electrical power field measurements were made to determine in-situ energy and peak demand savings for load controllers using real-time Supervisory Control And Data Acquisition (SCADA) systems. The M&V findings for the MID air conditioner (AC) load controllers are discussed in **Section 12.4.1**, M&V findings for the TID AC load controllers are discussed in **Section 12.4.2**, and M&V findings for the Palo Alto load curtailment projects are discussed in **Section 12.4.3**.

12.4.1 M&V Findings for MID AC Load Control

MID provided an ex ante peak load reduction estimate of 3,000 kW for 3,000 LCR 5000 AC Load Controllers. MID actually installed 3,234 controllers, and customers agreed to have their air conditioners turned off for ten minutes over a 30 minute time period. Therefore, MID can turn off 33 percent of the installed LCR 5000 units on a continuous basis. MID kW savings are based on average savings of 3 kW per LCR 5000 controller (see **Equation 12.1**). MID assumed no kWh savings for the LCR 5000 AC Load Controllers.

Eq. 12.1 $$\text{MID Ex Ante Savings} = 3{,}000\ \text{LCR5000} \times \left[\frac{3\ \text{kW}}{\text{LCR5000}}\right] \times 33\% = 3{,}000\ \text{kW}$$

The M&V savings are based on system-wide electrical power measurements of AC load controllers before, during, and after turning off units during periods of high outdoor temperatures (i.e., greater than 100 degrees Fahrenheit, F). Measurements were made during a ten-minute deployment of 3,234 LCR 5000 controllers on July 10, 2002, when outdoor temperatures were approximately 105 F and on July 7, 2002, when outdoor temperatures were approximately 102 F. The average measured load reduction is 3,095 kW for both days based on 33 percent of the units turned off continuously (see following equation and **Tables 12.2** and **12.3**). The total measured load reduction was 9,118 kW on 7-10-2002 at approximately 3PM (see **Figure 12.1)** and 9,450 kW on 7-11-2002 at approximately 5PM (see **Figure 12.2**). The load reduction is greater at 5 PM due to more AC systems being on. Savings are calculated using **Equation 12.2**.

Eq. 12.2

$$\acute{Y}_{MID} = \frac{\left(\overline{KW}_{Normal} - \overline{KW}_{LCR\,5000}\right)_{7-10-02} + \left(\overline{KW}_{Normal} - \overline{KW}_{LCR\,5000}\right)_{7-11-02}}{2} \times 33\%$$

$$= \frac{(590{,}375 - 581{,}257)_{7-10-02} + (587{,}405 - 577{,}955)_{7-11-02}}{2} \times 33\% = 3{,}095 \text{ kW}$$

Mean savings per AC Load controller are calculated using **Equation 12.3**.

Eq. 12.3

$$\bar{y} = \text{Mean savings} = \frac{1}{n}\sum_{j=1}^{n} y_j = \frac{1}{3{,}234 \text{ Units}} \times 3{,}095 \text{ kW} = 0.957 \text{ kW}$$

The standard deviation, s, of the mean is calculated using **Equation 12.4**.

Eq. 12.4

$$s = \text{Standard Deviation} = \sqrt{\frac{\sum_{j=1}^{n}\left(y_j - \bar{y}\right)^2}{n-1}} = 0.305 \text{ kW/Unit}$$

The confidence interval for the mean savings is calculated using **Equation 12.5**.

Eq. 12.5

$$\text{Confidence Interval} = \bar{y} \pm t\,\frac{s}{\sqrt{n}} = 0.957 \text{ kW} \pm 0.010 \text{ kW}$$

Where,

t = The value of the normal deviate corresponding to the desired confidence probability of 1.645 at the 90 percent confidence level.

The MID program savings are 3,095 kW ± 39 kW at the 90 percent confidence level. The expected lifetime for the LCR 5000 units is 15 years.

Table 12.2 Measured kW Savings for the LCR 5000 Load Controllers on 7-10-2002

Date/Time	System Load (kW)	Outdoor Temp. (F)	Notes
7/10/2002 14:57	586,650	104.07	Normal Operation
7/10/2002 14:58	586,430	104.42	Normal Operation
7/10/2002 14:59	585,528	104.51	Normal Operation
7/10/2002 15:00	586,057	104.51	Paging Signal Sent to Turn off 3,234 LCR 5000 Units
7/10/2002 15:01	582,964	104.60	Processing Signal
7/10/2002 15:02	581,341	104.51	Processing Signal
7/10/2002 15:03	581,801	104.51	LCR 5000 Units Turned Off
7/10/2002 15:04	579,735	104.51	LCR 5000 Units Turned Off
7/10/2002 15:05	580,134	104.51	LCR 5000 Units Turned Off
7/10/2002 15:06	581,124	104.77	LCR 5000 Units Turned Off
7/10/2002 15:07	581,212	104.95	LCR 5000 Units Turned Off
7/10/2002 15:08	581,595	104.95	LCR 5000 Units Turned Off
7/10/2002 15:09	581,793	104.95	LCR 5000 Units Turned Off
7/10/2002 15:10	582,330	104.42	LCR 5000 Units Turned Off
7/10/2002 15:11	581,501	104.42	LCR 5000 Units Turned Off
7/10/2002 15:12	582,930	104.42	LCR 5000 Units Turned Off
7/10/2002 15:13	586,421	104.42	Transition to Normal Operation
7/10/2002 15:14	590,779	104.69	Transition to Normal Operation
7/10/2002 15:15	592,633	104.69	Transition to Normal Operation
7/10/2002 15:16	591,095	104.69	Normal Operation
7/10/2002 15:17	592,973	104.69	Normal Operation
7/10/2002 15:18	593,673	104.69	Normal Operation
7/10/2002 15:19	593,783	104.86	Normal Operation
7/10/2002 15:20	581,498	104.69	Normal Operation

Figure 12.1 MID LCR 5000 AC Load Control versus Temperature (7-10-2002)

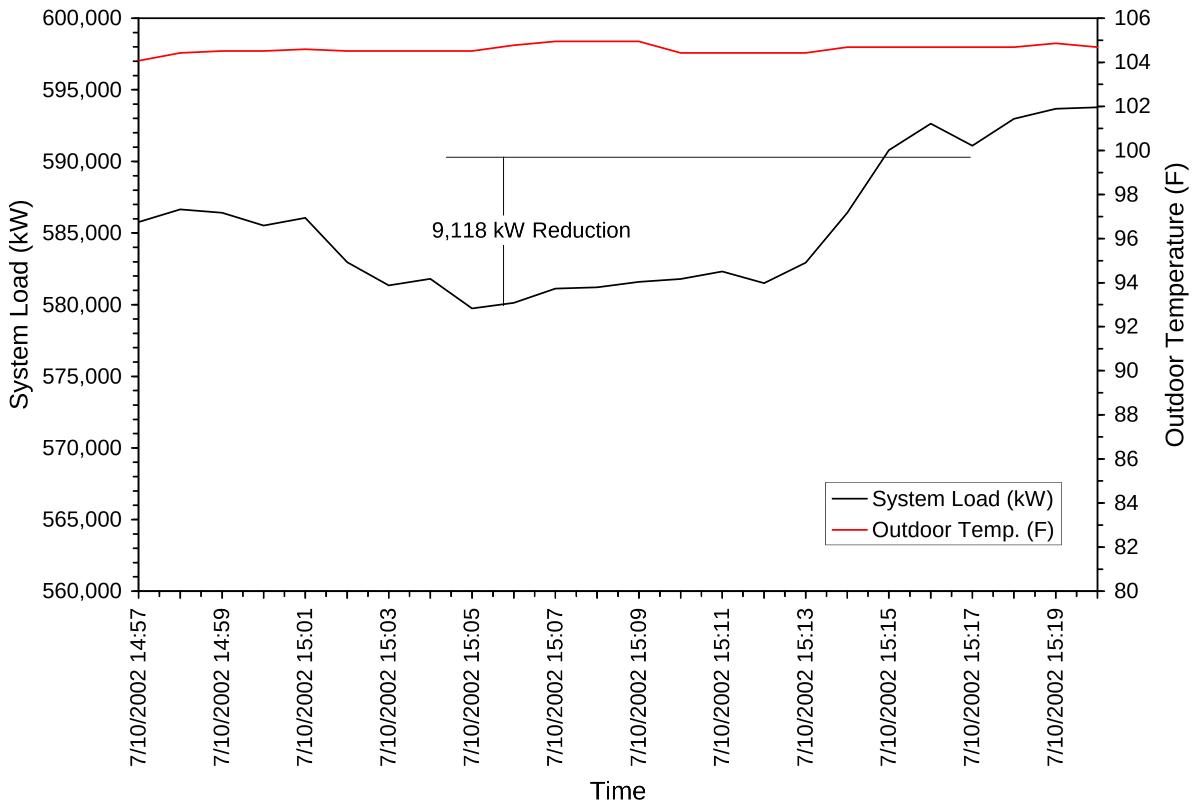
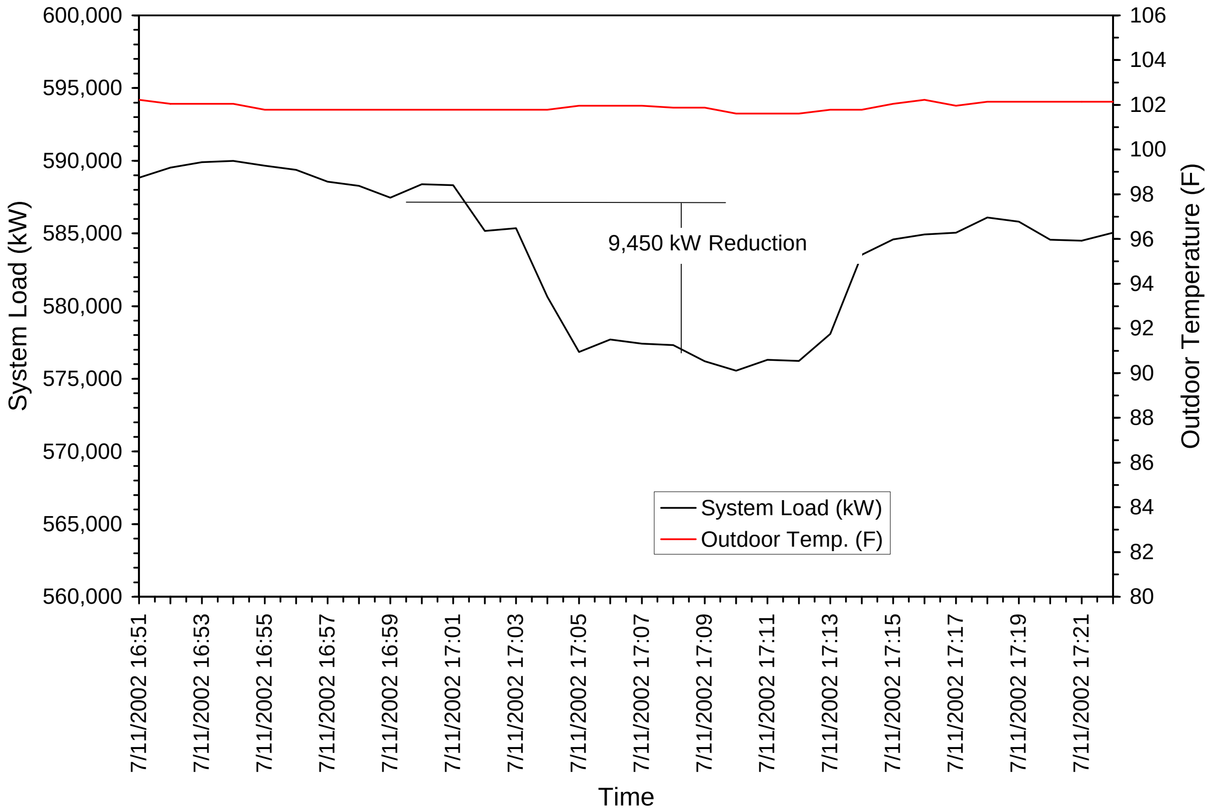


Table 12.3 Measured kW Savings for the LCR 5000 Load Controllers on 7-11-2002

Date/Time	System Load (kW)	Outdoor Temp. (F)	Notes
7/11/2002 16:51	588,835	102.22	Normal Operation
7/11/2002 16:52	589,518	102.05	Normal Operation
7/11/2002 16:53	589,906	102.05	Normal Operation
7/11/2002 16:54	589,996	102.05	Normal Operation
7/11/2002 16:55	589,659	101.79	Normal Operation
7/11/2002 16:56	589,373	101.79	Normal Operation
7/11/2002 16:57	588,557	101.79	Normal Operation
7/11/2002 16:58	588,267	101.79	Normal Operation
7/11/2002 16:59	587,452	101.79	Normal Operation
7/11/2002 17:00	588,372	101.79	Paging Signal Sent to Turn off 3,234 LCR 5000 Units
7/11/2002 17:01	588,316	101.79	Processing Signal
7/11/2002 17:02	585,166	101.79	Processing Signal
7/11/2002 17:03	585,355	101.79	LCR 5000 Units Turned Off
7/11/2002 17:04	580,639	101.79	LCR 5000 Units Turned Off
7/11/2002 17:05	576,843	101.96	LCR 5000 Units Turned Off
7/11/2002 17:06	577,705	101.96	LCR 5000 Units Turned Off
7/11/2002 17:07	577,425	101.96	LCR 5000 Units Turned Off
7/11/2002 17:08	577,319	101.87	LCR 5000 Units Turned Off
7/11/2002 17:09	576,193	101.87	LCR 5000 Units Turned Off
7/11/2002 17:10	575,545	101.61	LCR 5000 Units Turned Off
7/11/2002 17:11	576,299	101.61	LCR 5000 Units Turned Off
7/11/2002 17:12	576,234	101.61	LCR 5000 Units Turned Off
7/11/2002 17:13	578,076	101.79	Transition to Normal Operation
7/11/2002 17:14	583,523	101.79	Transition to Normal Operation
7/11/2002 17:15	584,587	102.05	Transition to Normal Operation
7/11/2002 17:16	584,926	102.22	Transition to Normal Operation
7/11/2002 17:17	585,047	101.96	Normal Operation
7/11/2002 17:18	586,083	102.14	Normal Operation
7/11/2002 17:19	585,802	102.14	Normal Operation
7/11/2002 17:20	584,566	102.14	Normal Operation
7/11/2002 17:21	584,487	102.14	Normal Operation
7/11/2002 17:22	585,048	102.14	Normal Operation

Figure 12.2 MID LCR 5000 AC Load Control versus Temperature (7-11-2002)



12.4.2 M&V Findings for TID AC Load Control

TID provided an ex ante peak load reduction estimate of 1,500 kW for 1,500 units. It was not possible to perform field measurements for TID since the installation was not completed until after the cooling season was over. TID M&V savings are extrapolated from MID M&V savings of 0.957 kW/unit times the number of units installed according to **Equation 12.6**.[107]

Eq. 12.6 $\hat{Y}_{TID} = 1{,}502 \text{ Units}_{TID} \times 0.957 \text{ kW/Unit} = 1{,}437 \text{ kW}$

The TID program savings are 1,437 kW ± 13 kW at the 90 percent confidence level. TID assumed no kWh or therm savings for the AC load control programmable thermostats even though TID chose these controllers to provide energy savings in addition to load control. Typical savings for programmable thermostats are in the range of 8-15 percent for cooling and heating. The M&V study takes no credit for these additional savings.

[107] The assumed MID savings of 0.957 kW/unit is close to the M&V savings of 0.94 kW/unit found by KEMA-XENERGY in an M&V study of AC load control programmable thermostats installed in the San Diego Gas and Electric Company (SDG&E) service area. The KEMA-XENERGY study found savings of 0.94 kW/unit for an 8F reset temperature for hour 16 with an outdoor temperature of 95F (see Table A-8, page A-8, *2002 Smart Thermostat Program Evaluation*, prepared for San Diego Gas and Electric Company, prepared by KEMA-XENERGY, February 2003). The MID savings are for an average outdoor temperature of 103.5F. Using the MID savings as a proxy for TID is reasonable, given that TID and MID have similar weather conditions and each program uses similar control strategies (i.e., unit cycled off as opposed to an 8F reset).

12.4.3 M&V Findings for Palo Alto C&I Load Curtailment

City of Palo Alto provided an ex ante peak load reduction estimate of 115 kW for the following three C&I sites.

1. City Hall load curtailment of 4 kW from 97 2-lamp T8F32 fluorescent fixtures with electronic ballasts.
2. Main Library load curtailment of 15 kW from a 30-ton roof-top air conditioner.
3. Water Quality Control Plant load curtailment of 96 kW from three sets of recirculation and discharge pumps. Two sets run at any time with one set in standby. Each recirculation pump motor is rated at 100 horsepower and each discharge pump motor is rated at 30 horsepower.

The M&V kW savings for the City Hall load curtailment are calculated using **Equation 12.7**.

Eq. 12.7 $$\text{kW Savings}_j = \sum_{a=1}^{q} \text{Quantity} \times \left[\text{kW}_{pre} - \text{kW}_{post}\right]$$

Where,

kW Savings_j = kW savings for site j.

Quantity = Quantity of fixtures.

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

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

The lighting fixture kW use per fixture was verified with field measurements at the site (see NCPA C&I Lighting M&V Final Report). The M&V estimate from the City Hall load curtailment project is 5.044 ± 0.5 kW as shown in **Table 12.4**.

Table 12.4 Palo Alto City Hall Load Curtailment

Pre-Retrofit	Qty	W/fix	kW	Post-Retrofit	Qty	W/fix	kW	kW Savings
T8F32-2 Lamp Fixtures No Curtailment	97	52.0	5.044	T8F32-2 Lamp Fixture Load Curtailment	97	0	0	5.044

The Palo Alto Main Library 30-ton RTU air conditioner load curtailment project was completed after the cooling season. Therefore, M&V savings are extrapolated from field measurements of a 25-ton roof top unit (RTU) air conditioner measured in Modesto during the summer of 2002 as shown in **Figure 12.3**.[108] Extrapolated kW values for the 30-ton RTU are based on **Equation 12.8**.

Eq. 12.8 $$kW_{30-ton} = kW_{25-ton} \times \frac{30}{25}$$

Where,

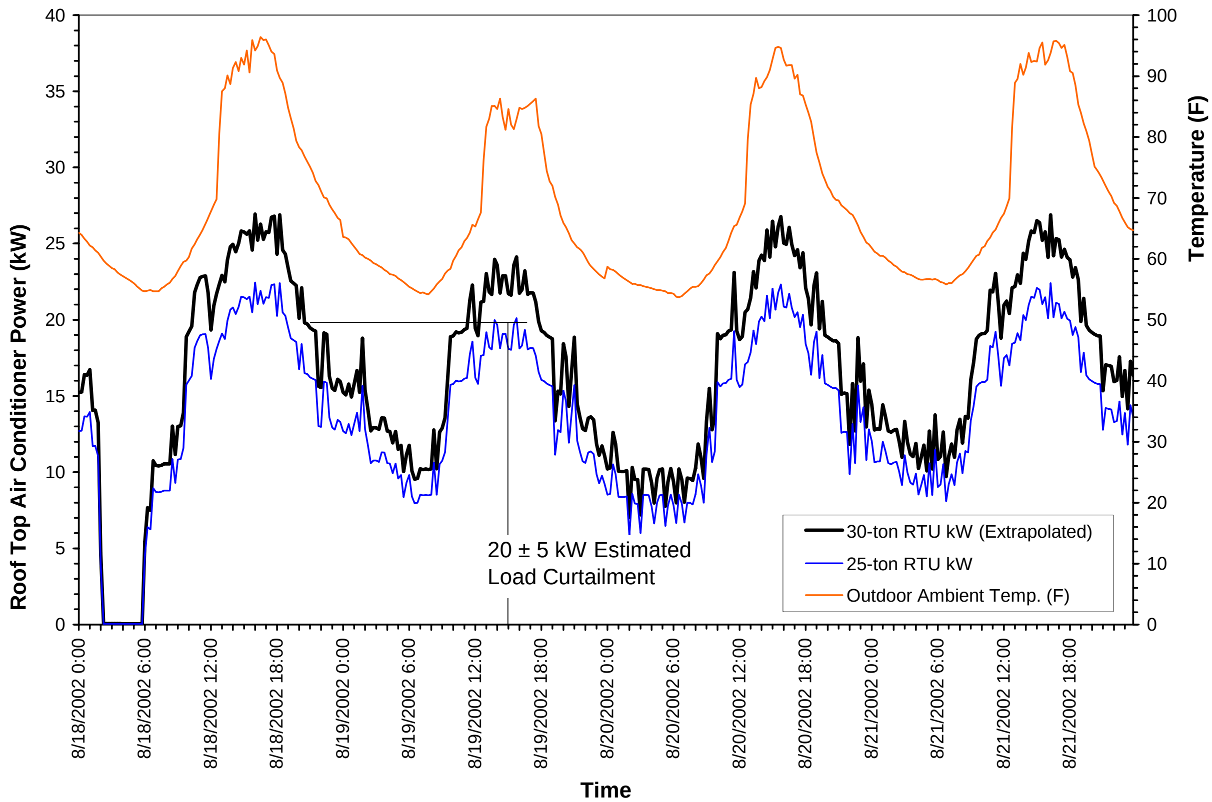
kW_{25-ton} = kW measurement for the 25-ton unit.

[108] Field measurements of the 25-ton RTU were made in Modesto on days when maximum outdoor temperatures ranged from 86°F to 96°F. These outdoor temperatures are similar to the 93°F cooling design condition for San Jose (nearest site to Palo Alto) from the *2001 ASHRAE Fundamentals Handbook*, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329.

kW_{30-ton} = Extrapolated kW for the 30-ton unit.

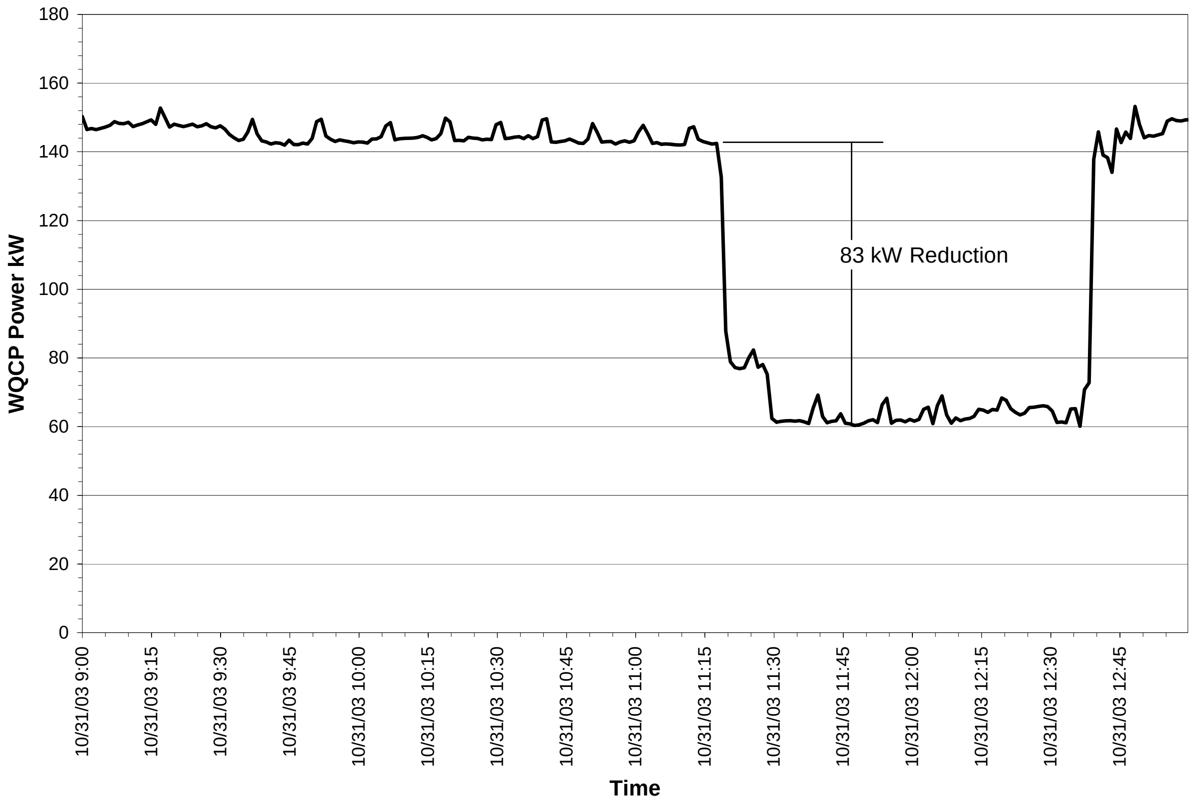
Based on the extrapolated curve, the M&V estimate for the 30-ton RTU load curtailment project is 20 ± 5 kW as shown in **Figure 12.3**.

Figure 12.3 Roof Top Air Conditioner Load Curtailment



The M&V kW savings for the Palo Alto Water Quality Control Plant load curtailment are based on field measurements from the site made in October 2003 as shown in **Figure 12.4**. The M&V estimate for the WQCP load curtailment project is 83 ± 1.4 kW as shown in **Figure 12.4**.

Figure 12.4 City of Palo Alto Water Quality Control Plant Load Curtailment



Palo Alto implemented load curtailment measures at three sites controlling a quantity of 97 lighting fixtures, 1 roof-top air conditioner, and 3 pumps. The Palo Alto load curtailment program ex ante savings are 115 kW and the ex post savings are 108 ± 6.9 kW as shown in **Table 12.5**.

Table 12.5 Summary of M&V Results for Palo Alto Load Curtailment Program

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
City Hall	97	n/a	4	n/a	5	n/a	n/a	5	n/a	1.25
Library	1	n/a	15	n/a	20	n/a	n/a	20	n/a	1.33
WQCP	3	n/a	96	n/a	83	n/a	n/a	83	n/a	0.86
Total	**101**	n/a	**115**	n/a	**108**	n/a	n/a	**108**	n/a	**0.94**

Appendix A: Decision-Maker Survey for C&I Lighting, C&I HVAC, C&I Refrigeration, C&I Custom, LED Traffic Signals, Residential HVAC, and Miscellaneous Programs

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 will 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.

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

Introduction

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.
Contact the person and explain the purpose of the entire data collection effort. Then ask whom to speak to complete this section of the survey. Record names of the people you need to talk with for this section of the survey in the table below.

Begin Survey

1. When and how did you first learn about the Utility Program? [**Only ask this question <u>once,</u> for the first recommendation for each site.**]

   ____

   1 Didn't know there was a program (**Go to Q.3**)

2. Keeping that in mind, did you learn about the program BEFORE or AFTER you [describe installed the energy efficiency measure]? (**Circle One**)

   1 Before **2** After (**Go to Q.4**) **98** Don't Know **99** Refused to Answer

3. Did the Utility Program influence your decision to install the measures BEFORE or AFTER you [describe implemented recommendation]? (**Circle One**)

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

4. 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 [describe implemented recommendation]?

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

5. If the rebate or service had not been available, how likely is it you would have done exactly the *same* thing [**if equipment was installed that has specific efficiency ratings such as SEER, COP, KW/TON add --** with the same efficiency rating]. 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: ____

DECISION-MAKER SURVEY (Continued)

Special Instruction for Contradictory Responses: If [**Q.4 is 0,1,2** *and* **Q5 is 0,1,2**] *or* [**Q.4 is 8,9,10** *and* **Q.5 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 4 and 5 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: ____

6. What would you say the role of the Utility Program was in your decision to [**describe implemented recommendation**]? [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

Say: Here are some statements that may be more or less true for your company about the Utility Program [**describe recommendation**]. Please assign a number between 0 and 10 to register how true it is. 10 indicates that it is completely true, and 0 indicates that it is completely untrue.

7. The Utility Program was nice but it was unnecessary to cause the [**describe recommendation**] to be implemented.

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

DECISION-MAKER SURVEY (Continued)

8. The Utility Program was a critical factor in implementing [**describe recommendation**].

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

9. We would not have implemented the [**describe recommendation, including its efficiency rating if applicable**] without the Utility Program.

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

10. If you had not received the rebate or service from the Utility, would you have implemented the *same* [**describe recommendation, including its efficiency rating if applicable**] ...

	Count	%	
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**

	Count	%	
8	_____	____	...less than one year?
9	_____	____	...one year or more?

99	_____	____	...Refused to Answer

Time relative to the installation date. For recommendations that consist of more than one piece of equipment, the Count and % columns allow you to record changes which would have occurred over time. Ultimately, you must indicate the % that would have occurred in each period. 100% will appear in one period for single piece items. The percentages must always sum to 100%.

Repeat questions 2 through 10 for each installed measure or service.

Appendix B: 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 will 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

11. 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

12. 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

13. 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

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

    ____

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

15. 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

16. 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)

17. 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

18. 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: ____

19. 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
    7 Clarified benefits that we were *somewhat* aware of before
    8 Recommendation had no role
    9 Other ____
    98 Don't Know
    100 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.

20. 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

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

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

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

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

<u>**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**]</u>.

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: ____

23. 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

    <u>**Time relative to the installation date**</u>**. 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.**

Appendix C: Residential Refrigerator Recycling Decision-Maker Survey

Interview Instructions for Decision-Maker Survey

1. Purpose

The purpose of the Decision-Maker Survey is to obtain sufficient information to improve the program and calculate gross savings and the Net-to-Gross Ratio (NTGR). You will need to interview the customer who was responsible for the decision to recycle the refrigerator. If this person is unavailable attempt to locate someone who is at least familiar with how that decision was made.

2. Selection of Respondent

The **decision-maker** must be the person who decided to participate in the program.

3. How to Start a Survey

Complete the following steps to start one of these surveys:

1. Check database information to avoid asking unnecessary questions (if available).
2. Telephone person and explain purpose of the Survey. Tell them that survey results are strictly confidential and will not be shared with anyone.

REFRIGERATOR RECYCLING DECISION-MAKER SURVEY

Customer Name:_____________________________ Date: ______________________________________

Phone Number:______________________________ City/Utility:__________________________________

Start Call Time: _____________________________ End Call time:_________________________________

Surveyor Initials: ____________________________ Survey Completed: Y NA R NP BN

Y = yes, NA = no answer, R = refused, WB = non-participant, BN = bad number

Introduction

Say: "Hello. My name is _______ and I'm conducting a survey regarding the [Biggs, Gridley, Lodi, Lompoc, Plumas-Sierra, or Santa Clara] Refrigerator Recycling Programs. This survey will take less than 10 minutes." **If respondent is unsure say:** "This program helped customers recycle their old refrigerators or freezers. Do you recall participating in this program?" **If yes, begin survey. If no, thank respondent and terminate call.**

Survey Questions

1. How did you learn about the Utility Refrigerator Recycling Program?
(**Do Not Read List and Check all that apply**)

1 Newspaper advertisement
2 TV advertisement
3 Radio advertisement
4 Advertising on side of truck
5 Utility bill insert/information with utility bill
6 Separate mailing
7 Toll-free 800 telephone number
8 Media stories about the program
9 From a friend, relative or neighbor
10 Appliance retailer
11 Don't Know
12 Somewhere else (SPECIFY) ____________

2. Why did you decide to participate in the Program?
(Do Not Read List and Check all that apply)

1 Save electricity (i.e., Conservation)
2 Save money on electric bill
3 Incentive from utility (if applicable)
4 Refrigerator was unnecessary
5 Convenience of free pick-up service (if applicable)
6 Environmentally safe disposal (i.e., Recycling)
7 Recommendation of a friend/relative
8 Recommendation of a retailer/dealer
9 Don't Know
10 Other ______________

REFRIGERATOR RECYCLING DECISION-MAKER SURVEY (cont'd)

3. What was the approximate size of the recycled unit in cubic feet (i.e., 18, 20, 22, 24 c.f.)?

_____ (Size in Cubic Feet) ___ **98** Don't Know

4. What was the approximate age of the recycled unit?

_____ (Year of Manufacturer, e.g., 1980) ___ **98** Don't Know

5. What was the style of the recycled unit?

1 Side-by-Side Refrigerator
2 Top Freezer, Bottom Refrigerator
3 Bottom Freezer, Top Refrigerator
4 Single Door Refrigerator
5 Upright Freezer
6 Chest Freezer
7 Don't Know

6. What type of defrost did the recycled unit have? Was the defrost type …

___ **1** (Manual) ___ **2** (Automatic) ___ **98** (Don't Know)

7. Was purchasing a new refrigerator or freezer the major reason for recycling your old unit?

___ **1** (Yes) ___ **2** (No) ___ **98** (Don't Know)

8. At the time when you recycled the unit, was it the main refrigerator or freezer for your household or was it being used as a spare?

___ **1** (Main Unit) ___ **2** (Spare) ___ **98** Don't Know

9. If spare, how long was it used as a spare? (**Enter Months as Fractions, i.e., 9 months = 9/12 = 0.75)**

___ **1** (Years) ___ **2** (Months) ___ **98** Don't Know

10. At the time the unit was recycled, what condition was it in?

___ **1** (Working) ___ **2** (Working, but needs repairs) ___ **3** (Not Working) ___ **98** Don't Know

11. If you had not recycled the unit, about how many months during the next year would it have been turned on? (**Read List, Enter Months as Fractions, i.e., 9 months = 9/12 = 0.75)**
___ **1** (All Year) ___ **2** (Number of Months) ___ **3** (None) ___ **98** Don't Know

11a. If answer to **Q.11** is less than one year ask if unit was on during Summer (i.e., May to October).

___ **1** (Summer) ___ **2** (Winter) ___ **98** Don't Know

REFRIGERATOR RECYCLING DECISION-MAKER SURVEY (cont'd)

12. What would you have done with your old unit if the recycling service had not been available? (**Accept only one answer.**)
    1 Kept as spare and used
    2 Kept unit but unplugged it
    3 Given unit away or donated to charity
    4 Taken unit to recycling center where it would be disabled or disposed
    5 Hired someone to pick up unit
    6 Participated in local government refrigerator pick-up program
    7 Have appliance retailer pick up unit
    8 Left unit in house when moved
    9 Don't Know
    10 Other____________________

Say: Here are some statements with which you may agree or disagree regarding your participation in the Utility Refrigerator Recycling Program. Please assign a number between 0 and 10 where a 10 indicates that you completely agree, and 0 indicates that you completely disagree.

13. The Utility Program was nice but it was unnecessary to get me to permanently remove my old refrigerator(s).

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

14. We would not have recycled our old refrigerator(s) without the Utility Program.

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

Special Instruction for Contradictory Responses: If [**Q.13 is 0,1,2,** *and* **Q.14 is 8,9,10**] *or* [**Q.13 is 8,9,10** *and* **Q.14 is 0,1,2**].
When you answered "8, 9 or 10" 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 "not recycling your old refrigerator without the Utility Program." I want to check to see if I understand your answers or if the questions are clear.
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 13/14**. If the answer doesn't allow you to decide what answer should be changed, write the answer down and continue the interview.
Answer: ____

REFRIGERATOR RECYCLING DECISION-MAKER SURVEY (cont'd)

15. If the Utility Refrigerator Recycling Program had not been available would you have gotten rid of your refrigerator(s) permanently..

    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

16. Were you planning to recycle or dispose of your old refrigerator(s) **before** you heard about the Utility Program?

    ___ **1** (Yes)   ___ **2** (No)   ___ **98** (Don't Know)

17. Using a 10 point scale where "10" means you were very satisfied and "0" means you were very dissatisfied, please tell me your overall satisfaction with the Refrigerator Recycling Program.

    ___ Response (**0-10**)   ___ **98** (Don't Know)

18. Do you have any comments or suggestions regarding the Refrigerator Recycling Program.

    ___ **1** (Yes)   ___ **2** (No)

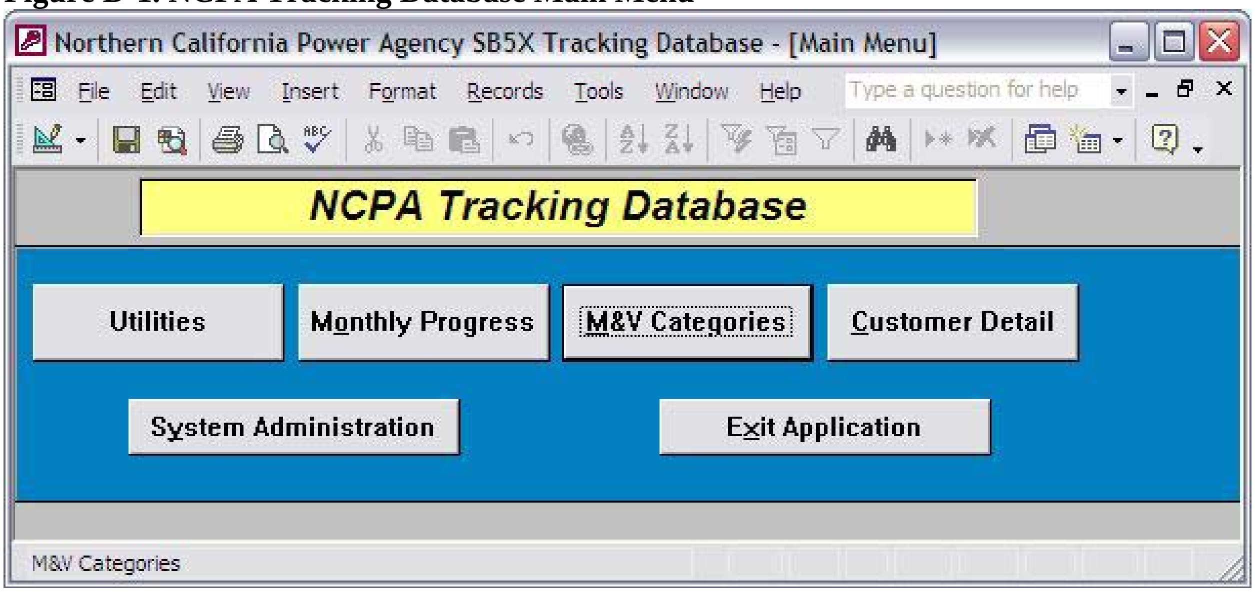
    Comments/Suggestions: ________________________________

Appendix D: NCPA Tracking Database

D.1 Database Interface

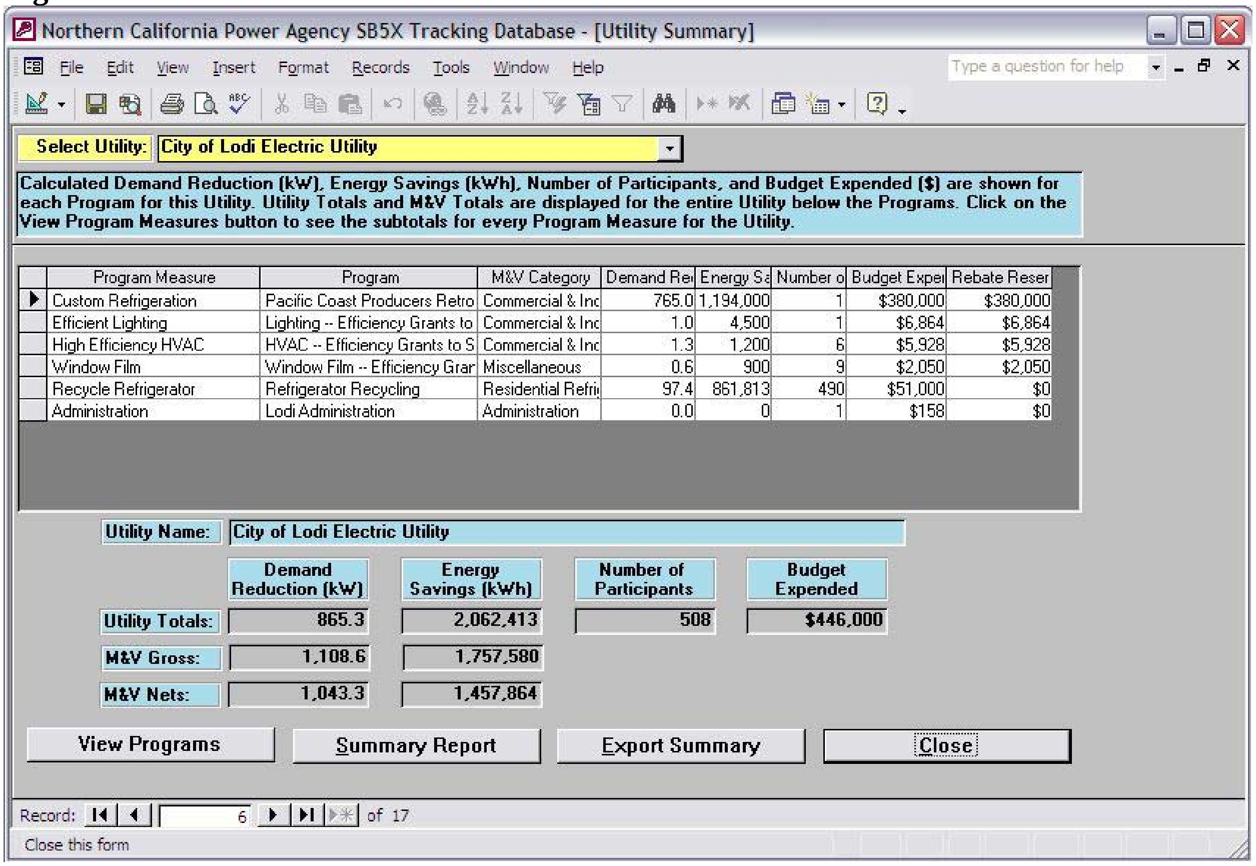
Users of the database application have an icon on their Windows desktop to start the application. The program starts by displaying a Main Menu/Switchboard screen with push buttons for the user to perform the main functions of the application and “drill down” into the database (see **Figure D-1**). Forms in Access are individual windows that display data or receive user input. They differ from “reports”, which are not interactive and are primarily designed for printer output.

Figure D-1. NCPA Tracking Database Main Menu



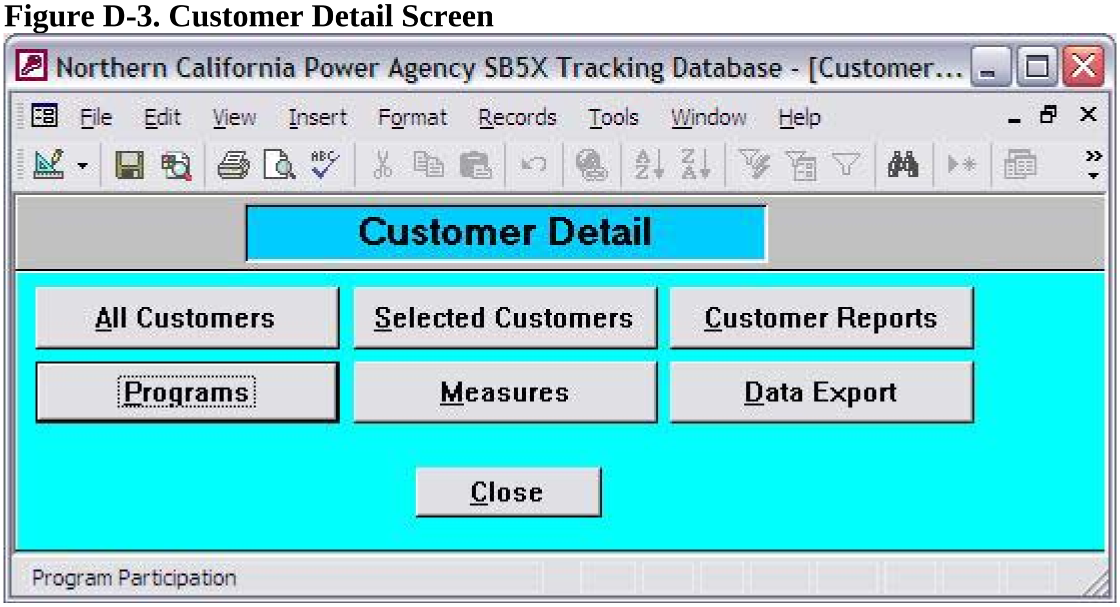
From the Main Menu, users can push buttons to “drill down” into the database using the Utilities button to view existing customer records, or create new customer records. The Utilities screen for City of Lodi Electric Utility is shown in **Figure D-2**.

Figure D-2. Utilities Screen



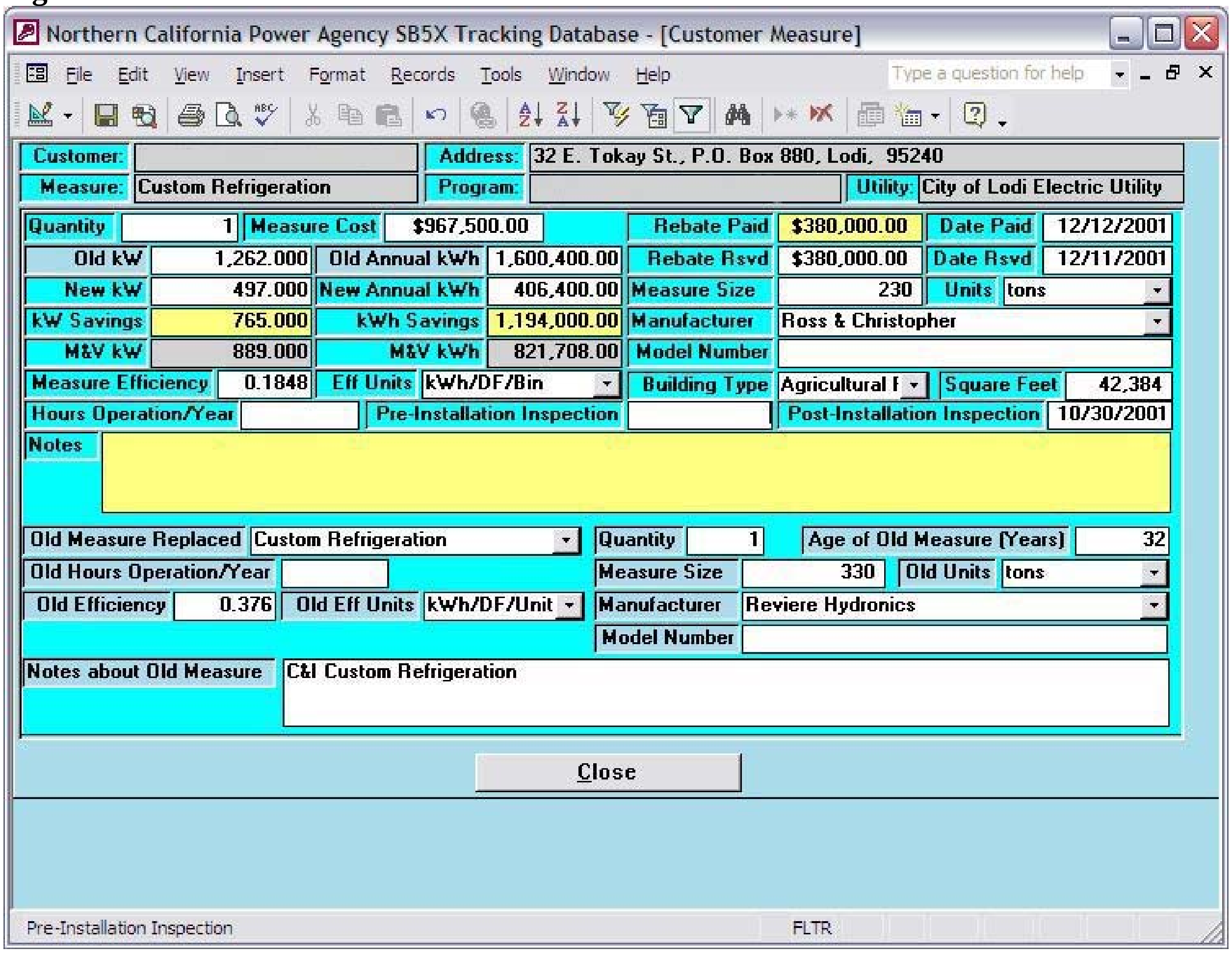
The Customer Detail button shown in **Figure D-3** is used to view customer measure information.

Figure D-3. Customer Detail Screen



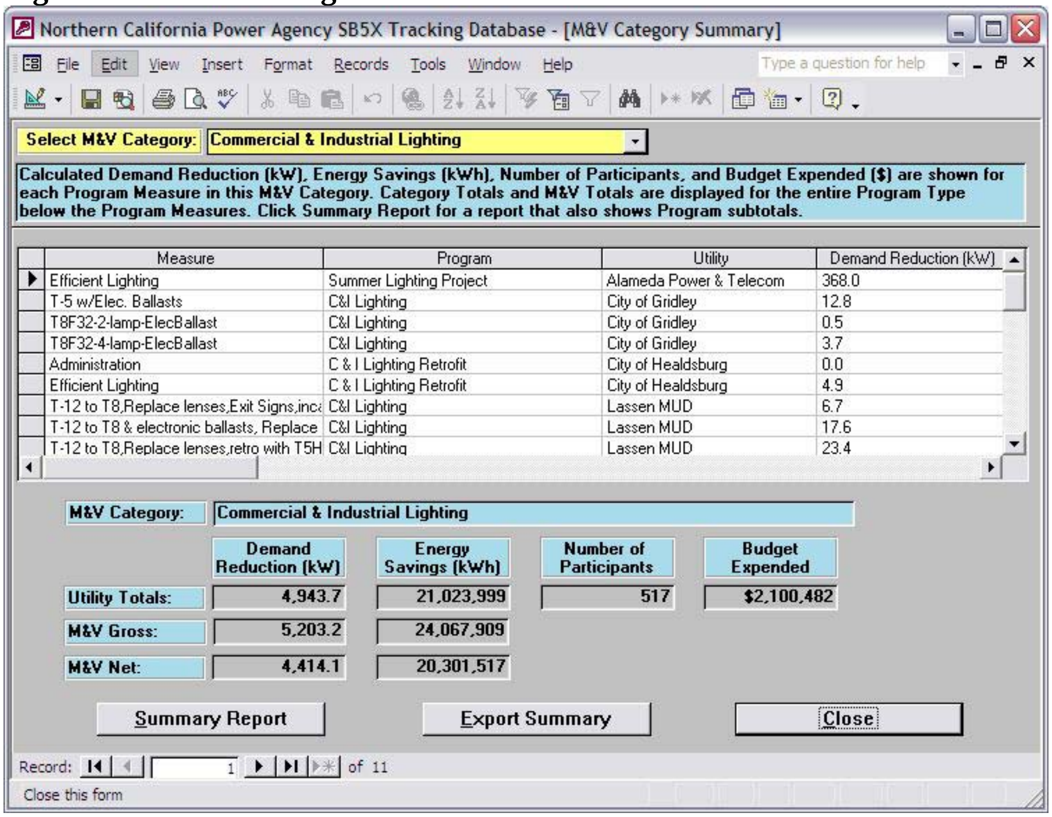
To drill down to a specific Customer Measure screen, the user must select: 1) Programs button in the Customer Detail screen, 2) pull-down menu to select a utility, 3) highlight a specific customer record, and 4) select View Measure in Detail. Shown in **Figure D-4** is a Customer Measure screen for City of Lodi Electric Utility.

Figure D-4. Customer Measure Screen



Options from the Main Menu also include listing customers by program/project, listing customers by energy efficiency measure, viewing M&V program category data, printing reports about customer participation in projects, or exporting and importing data from/to Excel spreadsheets. The M&V Categories screen from the Main Menu is shown in **Figure D-5**. This screen is used to view ex ante and M&V gross and net ex post savings results.

Figure D-5. M&V Categories Screen from Main Menu



The Access menu bar is displayed across the top of the screen when the application is open. In general, most user interaction is performed directly from the buttons provided on the forms. The application is designed to let users “drill-down” to more specific data about a customer or energy efficiency measure. Most forms display database records. The data in each field can be directly edited or changed by selecting from a dropdown menu of options. There are form buttons to add new records, or delete the current record. Modifications to a record are saved as soon as the user moves to another record on the form, or closes the form. To undo accidental changes to a record, the Escape key can be pressed before the record is saved.

Reports are usually displayed on the screen, giving the user the option to print the output. Most reports are generated after the user has selected criteria from a preliminary report setup form. Users can examine the output to verify the correct criteria were selected before sending the report to the printer.

The choices available to users on dropdown menus are managed in a System Administration module, where the items available in “lookup tables” are entered and edited. This structure makes the application “data-driven”, which means selection choices can be altered without having to modify the program code. Entry into the System Administration module is controlled by a “password” to prevent inexperienced users from altering the selection choices.

The following forms are used in the application:

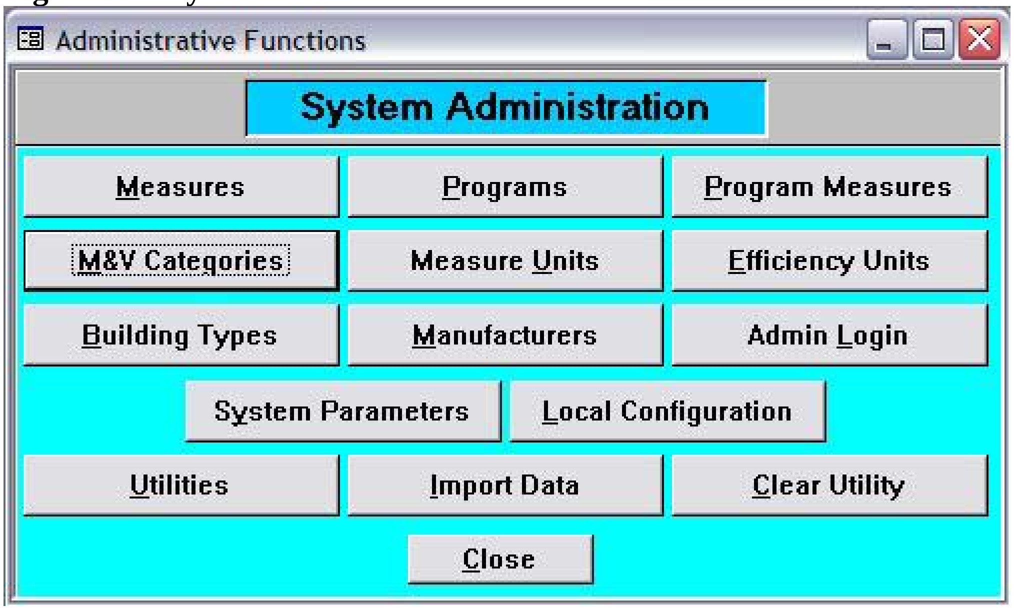
1. **Main Menu/Switchboard –** this form is the entry point for the application. The user selects the function to perform by clicking on a button, such as Customers, Programs, Measures, Customer Reports, or Data Export. There is an Exit button on the Main Menu that closes the database and the Access program, returning the user to the Windows desktop.
2. **Utilities –** this form displays program information for each utility including ex ante and ex post savings, number of participants and budget expenditures.
3. **M&V Categories –** this form displays M&V information by program category including ex ante savings and M&V gross and net ex post savings.
4. **Customers –** this form displays information about each utility customer. It allows editing of existing customers, and an "Add New" button for creating new customer records. Customers can be selected by name from a dropdown menu at the top of the form. The customer records can be viewed one-by-one on the entire screen (in form view), or the whole list of customers can be displayed at once (in datasheet view). A subform on the screen shows each program measure adopted by the customer. By clicking a "View Measure in Detail" button, the user can drill down to the "Customer Measure" form to view and edit details about the energy efficiency measure.
5. **Customer Measure –** this form displays all the data values generally common to all energy efficiency measures (e.g. measure size, kW savings, inspection results, old measure replaced). From this form, data that are unique to a measure can be viewed for different measure types.
6. **Program Participation –** this form displays a list of all the participants in each program or project. Programs can be selected by name from a dropdown menu at the top of the form. A subform on the screen shows one record for each measure within the program adopted by the customer. By selecting a customer name in the list, the user can drill down to the Customers form to display all information about the customer. Similarly, the user can drill down into the Customer Measure form to view all the details about the retrofit.
7. **Measures Applied –** this form displays a list of all the customers that have adopted each measure. Measures can be selected by name from a dropdown menu at the top of the form. A subform on the screen shows one record for each customer for the measure. By selecting a customer name in the list, the user can drill down to the Customers form to display all information about the customer. Similarly, the user can drill down into the Customer Measure form to view all the details about the retrofit.
8. **Selected Customers –** this setup form lets the user select a filtered set of customers based on criteria they define. Options include viewing all customers that have adopted a retrofit of any kind, customers participating in a specified program, customers adopting a specified measure, and selecting customers by account number. After the user has selected their criteria from the setup form, the main Customers form is opened, showing only the filtered set of customer records.
9. **Reports –** this setup form lets the user choose between a set of different report formats, and then select a filtered set of customers for inclusion in those reports. Report choices are Customer List in alphabetical order, Customer List grouped by Program, Customer List grouped by Measure, Customer Details in alphabetical order, Customer Details grouped by Program, Customer Details grouped by Measure, Mail Labels sorted by customer name, and Mail Labels sorted by zip code. Filtering options include program name, measure name, account number, rebate number, service city, service zip code range, application dates, and

dates rebates were paid. After the user has selected their criteria from the setup form, the selected report is opened containing only the filtered set of customer records. The user can then view the report, send selected pages to the printer, or export the report into Word.

10. **System Administration** – this menu/switchboard form lets a System Administrator select the forms that control program parameters and determine the choices users have in pull-down menus. The System Administrator form can only be opened by entering an application-level password, which prevents inexperienced users from altering selection choices. The following forms are opened from the System Administration menu.
    - **Data Import** – this form lets the user import data from pre-formatted Excel export spreadsheets.
    - **Data Export** – this setup form lets the user choose between a set of different Excel export formats, and then select a filtered set of customers for inclusion in those spreadsheets. Format choices are Customer List Sorted by Name, Customer Measures (includes the adopted measure data with the customer information), and Customer Measures in Import Format (for exporting both customer and retrofit data to the Master database). Filtering options include program name, measure name, account number, rebate number, service city, service zip code range, application dates, and dates rebates were paid. After the user has selected their criteria from the setup form, the selected spreadsheet is opened in Excel containing only the filtered set of customer records. The user can then use Excel to perform further analysis, print the data, or attach the spreadsheet to Email for export to the Master database.
    - **M&V Categories** – this form displays net-to-gross ratios and realization rates and allows for users to modify these values based on the M&V results.
    - **Programs and Projects** – this form, opened from System Administration, is used to add and edit the NCPA programs and projects for the utility.
    - **Measures**– this form, opened from System Administration, is used to add and edit the NCPA measures that are available.
    - **Program Measures** – this form, opened from System Administration, is used to define which NCPA measures are available for each utility program or project.
    - **Project Types** – this form, opened from System Administration, is used to add and edit the generic types of NCPA programs and projects.
    - **Measure Units** – this form, opened from System Administration, is used to add and edit the list of available measure units (Watts, tons, hp, CFM, etc.) on pulldown menus.
    - **Efficiency Units** – this form, opened from System Administration, is used to add and edit the list of available efficiency units (SEER, EER, kW/ton, etc.) on pulldown menus.
    - **Manufacturers** – this form, opened from System Administration, is used to add and edit a list of common Manufacturer names that can be selected from pulldown menus .
    - **Admin Login** – this form, opened from System Administration, is used to change the privilege level for a user from “Normal” to “Admin”, giving them access to more advance functions for controlling the program.
    - **System Parameters** – this form, opened from System Administration, is used to configure the system parameters that are specific to each utility.
    - **Local Configuration** – this form, opened from System Administration, is used to configure the local configuration parameters that are specific to each client PC.

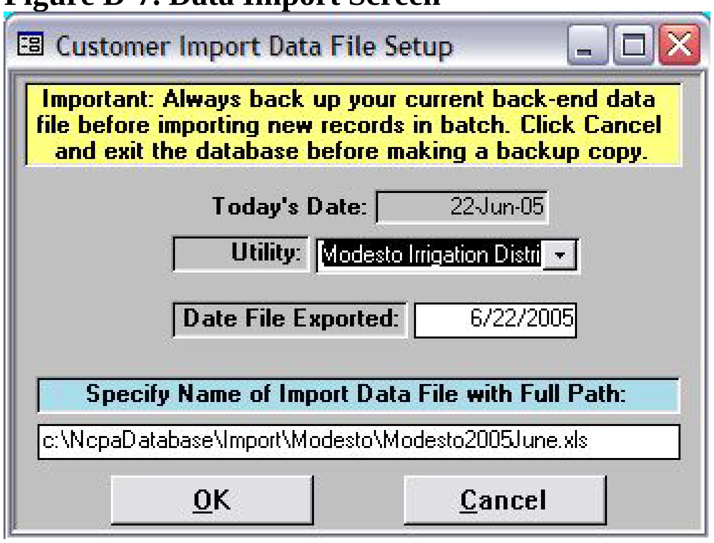
The System Administration menu/switchboard screen is shown in **Figure D-6**.

Figure D-6. System Administration Menu Screen



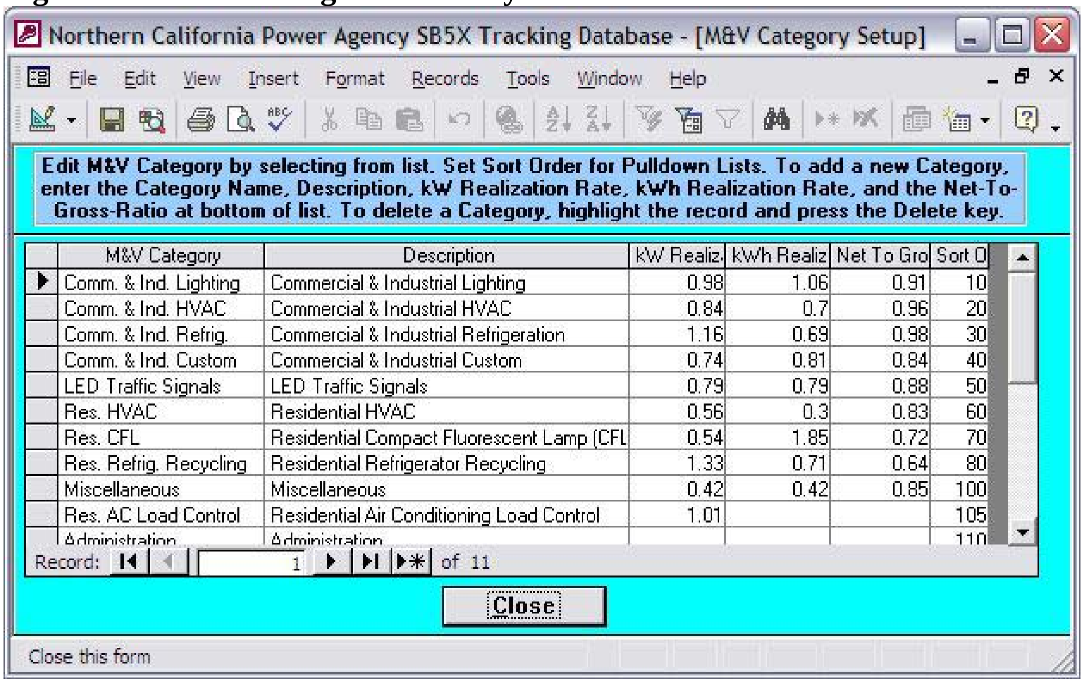
The Data Import screen used to import measure-specific program data from pre-formatted Excel spreadsheets is shown in **Figure D-7.**

Figure D-7. Data Import Screen



The M&V Categories screen from the System Administration screen is used to enter M&V net-to-gross ratios and net realization rates for kWh and kW savings as shown in **Figure D-8**.

Figure D-8. M&V Categories from System Administration



M&V Category	Description	kW Realiz	kWh Realiz	Net To Gro	Sort O
Comm. & Ind. Lighting	Commercial & Industrial Lighting	0.98	1.06	0.91	10
Comm. & Ind. HVAC	Commercial & Industrial HVAC	0.84	0.7	0.96	20
Comm. & Ind. Refrig.	Commercial & Industrial Refrigeration	1.16	0.69	0.98	30
Comm. & Ind. Custom	Commercial & Industrial Custom	0.74	0.81	0.84	40
LED Traffic Signals	LED Traffic Signals	0.79	0.79	0.88	50
Res. HVAC	Residential HVAC	0.56	0.3	0.83	60
Res. CFL	Residential Compact Fluorescent Lamp (CFL	0.54	1.85	0.72	70
Res. Refrig. Recycling	Residential Refrigerator Recycling	1.33	0.71	0.64	80
Miscellaneous	Miscellaneous	0.42	0.42	0.85	100
Res. AC Load Control	Residential Air Conditioning Load Control	1.01			105
Administration	Administration				110

D.2 Database Files

The NCPA Tracking Database system is designed to support the Master database that stores records from all utilities and the separate Satellite databases at each utility. Records from each Satellite database or Excel spreadsheets are collected on a periodic basis and imported into the Master database. All imported records are tagged with a Utility Code to keep track of them in the Master database.

The Satellite database or Excel spreadsheet records are exported using an Export Utility, which exports the customer, program, and measure data in an Excel format. The Excel file can be transferred via Email or on a disk to the site of the Master Database, which contains an Import Utility for collecting the records. The customer records can also be imported from other sources if they are placed in the Excel spreadsheet format, or they can be manually entered into the database.

As described earlier, each “Satellite” database has a file-server architecture, with a “front-end” user interface file and a “back-end” data file. These files are given unique names for each utility to prevent data loss or corruption. Because different utilities may have different versions of Microsoft™ Office, the files need to reflect the version in their names. The back-end data files will all be Access 97, which can be combined with any version of front-end file. The front-end files will be Access 97 or Access 2000, depending on the utility’s version of Office (Access 2000 is very similar to Access 2002 and can run under 2002 without a problem, but Access 97 programs differ markedly from Access 2000; Access 97 programs opened under 2000 give the user a prompt to convert the file.)

All the front-end user interface files will be stored in a folder named C:\NcpaDatabase on the client PCs. The back-end data files will be stored in the same folder if run on a standalone PC. In a networked environment, the back-end files will be stored on a mapped network drive, and the Access Linked Table Manager will be used to link the front-end to the back-end file. The following files make up the entire system:

Utility	Filenames	Notes
Alameda Power & Telecom	AlamedaData97.mdb	Access 97 Back-End
	AlamedaFront97.mdb	Access 97 Front-End
	AlamedaFront2000.mdb	Access 2000 Front-End
Biggs	BiggsData97.mdb	Access 97 Back-End
	BiggsFront97.mdb	Access 97 Front-End
	BiggsFront2000.mdb	Access 2000 Front-End
Gridley	Gridley Data97.mdb	Access 97 Back-End
	GridleyFront97.mdb	Access 97 Front-End
	GridleyFront2000.mdb	Access 2000 Front-End
Healdsburg	HealdsburgData97.mdb	Access 97 Back-End
	HealdsburgFront97.mdb	Access 97 Front-End
	HealdsburgFront2000.mdb	Access 2000 Front-End
Lassen MUD	LassenData97.mdb	Access 97 Back-End
	LassenFront97.mdb	Access 97 Front-End
	LassenFront2000.mdb	Access 2000 Front-End
Lodi	LodiData97.mdb	Access 97 Back-End
	LodiFront97.mdb	Access 97 Front-End
	LodiFront2000.mdb	Access 2000 Front-End
Lompoc	LompocData97.mdb	Access 97 Back-End
	LompocFront97.mdb	Access 97 Front-End
	LompocFront2000.mdb	Access 2000 Front-End
Merced Irrigation District	MercedData97.mdb	Access 97 Back-End
	MercedFront97.mdb	Access 97 Front-End
	MercedFront2000.mdb	Access 2000 Front-End
Modesto Irrigation District	ModestoData97.mdb	Access 97 Back-End
	ModestoFront97.mdb	Access 97 Front-End
	ModestoFront2000.mdb	Access 2000 Front-End
Port of Oakland	OaklandData97.mdb	Access 97 Back-End
	OaklandFront97.mdb	Access 97 Front-End
	OaklandFront2000.mdb	Access 2000 Front-End
Palo Alto	PaloAltoData97.mdb	Access 97 Back-End
	PaloAltoFront97.mdb	Access 97 Front-End
	PaloAltoFront2000.mdb	Access 2000 Front-End
Plumas-Sierra REC	PlumasData97.mdb	Access 97 Back-End
	PlumasFront97.mdb	Access 97 Front-End
	PlumasFront2000.mdb	Access 2000 Front-End
Redding	ReddingData97.mdb	Access 97 Back-End
	ReddingFront97.mdb	Access 97 Front-End
	ReddingFront2000.mdb	Access 2000 Front-End
Roseville Electric	RosevilleData97.mdb	Access 97 Back-End
	RosevilleFront97.mdb	Access 97 Front-End
	RosevilleFront2000.mdb	Access 2000 Front-End

Utility	Filenames	Notes
Shasta Lake	ShastaData97.mdb	Access 97 Back-End
	ShastaFront97.mdb	Access 97 Front-End
	ShastaFront2000.mdb	Access 2000 Front-End
Silicon Valley Power	SvpData97.mdb	Access 97 Back-End
	SvpFront97.mdb	Access 97 Front-End
	SvpFront2000.mdb	Access 2000 Front-End
Trinity PUD	TrinityData97.mdb	Access 97 Back-End
	TrinityFront97.mdb	Access 97 Front-End
	TrinityFront2000.mdb	Access 2000 Front-End
Truckee Donner PUD	TruckeeData97.mdb	Access 97 Back-End
	TruckeeFront97.mdb	Access 97 Front-End
	TruckeeFront2000.mdb	Access 2000 Front-End
Turlock Irrigation District	TurlockData97.mdb	Access 97 Back-End
	TurlockFront97.mdb	Access 97 Front-End
	TurlockFront2000.mdb	Access 2000 Front-End
Ukiah	UkiahData97.mdb	Access 97 Back-End
	UkiahFront97.mdb	Access 97 Front-End
	UkiahFront2000.mdb	Access 2000 Front-End
Master Database	NcpaData97.mdb	Access 97 Back-End
	NcpaFront97.mdb	Access 97 Front-End
	NcpaFront2000.mdb	Access 2000 Front-End

D.3 Database Tables

The NCPA Tracking Database has five different types of database tables:

1. **Primary Tables –** these are the tables that store the core information unique to each utility (e.g. customers and measures applied).
2. **Control Tables –** these are tables used to manage the operation of the database, and store parameters specific to the utility and its particular programs.
3. **Lookup Tables –** these are tables that are common to all utilities, and are used to determine the selections available from dropdown menus
4. **Local Tables –** these are tables contained in the front-end file and are used to configure a local client PC for its particular software environment.
5. **Temporary Tables –** these are tables used to hold data temporarily during processing. They are contained in the front-end file to aid in performance.

A.3.1 Primary Tables

The Primary Tables store data about the utility customers and the program measures they have adopted. There is a one-to-many relationship between customers and the adopted measures (i.e. one customer may have adopted multiple program measures). In addition to the common fields stored for all measures (e.g. measure type, measure size, kW Savings, etc.), there are a variety of unique measurements stored for specific measures. The unique data is stored in separate tables for each type of data. Following are descriptions of the main primary tables:

Customers

The Customers table is named tblCustomers (a prefix is used on object names like tables following the Reddick VBA Naming Convention in use by most Access developers; the convention provides self-referencing tags to aid in program maintenance; it is generally not applied to field names). There is one record for each utility customer.

Field Name	Data Type	Notes
ID	Long Integer	Primary Key, Access autonumber
UtilityName	Text	Utility Code for import (e.g. SVP)
CustLastName	Text	
CustFirstName	Text	
CustBusName	Text	Business
CustBusContact	Text	Business Contact
ListName	Text	Lookup Name (e.g. Doe, John or Acme Industries)
CustServiceAddress	Text	
CustServiceCity	Text	
CustServiceState	Text	
CustServiceZip	Text	
CustMailingAddress	Text	
CustMailingCity	Text	
CustMailingState	Text	
CustMailingZip	Text	
Phone	Text	
Fax	Text	
Email	Text	
AccountNum	Text	Utility Account Number
RebateNum	Text	Rebate Number
DateRebate	Short Date	Date of Rebate Application or Reservation
RebateReservedAmt	Currency	Rebate Reservation Amount
DateRebatePaid	Short Date	Date Rebate Paid
RebatePaidAmt	Currency	Rebate Paid Amount
Notes	Text	Miscellaneous notes about customer
DateAdded	Short Date	Date record added to database

Customer Measures

The Customer Measures table is named tblCustomerMeasures. There is one record for each measure adopted by a utility customer. Each record references the program and the type of measure, as well as the measurements obtained for this measure. It also references the "old" measure that was replaced.

Field Name	Data Type	Notes
ID	Long Integer	Primary Key, Access autonumber
UtilityName	Text	Utility Code for import (e.g. SVP)
CustomerID	Long Integer	Foreign key to tblCustomers.ID
ProgramCode	Text	Foreign key to tblPrograms.ProgramCode
MeasureID	Long Integer	Foreign key to tblProgramMeasures.ID
MeasureCode	Text	Foreign key to tblMeasures.MeasureCode
MeasQty	Double	The number of this measure type installed
MeasHours	Double	Measure Hours Operation Year (AC = Full Load Hours)
MeaskWSavings	Double	kW savings
MeaskWhSavings	Double	kWh/yr savings
MeasMfgr	Text	Manufacturer
MeasModelNum	Text	Manufacturer Model Number
MeasSize	Double	Measure Size
MeasUnits	Text	Units for the Size (Watts, tons, hp, CFM, etc.)

MeasEff	Double	Measure Efficiency
MeasEffUnits	Text	Units for the Efficiency (SEER, EER, kW/ton, etc.)
MeasNotes	Text	Miscellaneous notes about measure
PreInspect	Text	Pre-Installation inspection (Pass, Fail, Enter Data)
PostInspect	Text	Post-Installation inspection (Pass, Fail, Enter Data)
OldMeasure	Text	Foreign key to tblMeasures.MeasureCode
OldMeasQty	Double	The number of this old measure type replaced
OldMfgr	Text	Old Manufacturer for replaced unit
OldModelNum	Text	Old Manufacturer Model Number
OldMeasSize	Double	Old Measure Size
OldMeasUnits	Text	Units for the Old Size (Watts, tons, hp, CFM, etc.)
OldMeasEff	Double	Old Measure Efficiency
OldMeasEffUnits	Text	Units for the Old Efficiency (SEER, EER, etc.)
OldAge	Double	Old Measure Age (in years)
OldMeasNotes	Text	Miscellaneous notes about old measure
DateAdded	Short Date	Date record added to database

Only fields generally common to all measures are stored in the Customer Measures table. Measurements that are unique to a specific type of measure are stored in the following Measure Specific Tables:

Table Name	**Type of Measure**
tblAC	Load Control-AC
tblAC	Load Control-Tstat
tblLights	Compact Fluorescent Lights
tblLights	CFL Hard Wired
tblLights	4ft T8
tblLights	4ft T8 HO
tblLights	8ft T8
tblLights	8ft T8 HO
tblLights	4ft T5
tblLights	LED EXIT
tblLights	LED Traffic
tblLights	HID Interior
tblLights	HID Exterior
tblLights	Occ Sensor
tblLights	Photo Cell
tblLights	Custum Lighting
tblAppliance	Recycle Refrigerator
tblAppliance	Recycle Freezer
tblAppliance	Refrigerator Estar
tblAppliance	Freezer Estar
tblAppliance	Dishwasher Estar
tblAppliance	Clotheswasher Estar
tblAppliance	Low Flow Showerheads
tblAC	Room AC Estar
tblWalls	Ceiling Insulation
tblWalls	Wall Insulation
tblWalls	Floor Insulation
tblWalls	Radiant Barrier
tblAC	Duct Sealing
tblAC	AC Diagnostics
tblAC	Split AC Estar

Table Name	Type of Measure
tblAC	Split AC EStar TXV
tblAC	Evap Cond
tblAC	Pkg AC Estar
tblWalls	Low Ewindow
tblWalls	Low E2 Window
tblWalls	Window Film
tblWalls	Sun Screen
tblAC	Chiller EE
tblAC	Cooling Tower EE
tblAC	CoolingTower VSD
tblAC	Cooling Tower 2spd
tblMotors	Fan EE
tblMotors	Fan VSD
tblMotors	Fan 2spd
tblMotors	Pump EE
tblMotors	Pump VSD
tblMotors	Pump 2Spd
tblMotors	Comp Air Controls
tblMotors	Comp Air Fix Leaks
tblMotors	Comp Air Storage

D.3.2 Control Tables

The Control Tables store information about the programs and program-specific measures being used by each utility. Although many programs are similar between utilities, the name for each program or project is treated as unique for each utility. The different programs can be grouped in the Master database by the Program Type assigned to each program or project. These types are:

1. Commercial & Industrial Lighting
2. Commercial & Industrial HVAC
3. Commercial & Industrial Refrigeration
4. Commercial & Industrial Custom
5. LED Traffic Signals
6. Residential HVAC
7. Residential CFLs
8. Residential Refrigerator Recycling
9. Miscellaneous
10. Load Control Programs

There is a one-to-many relationship between programs and the measures available in each program (i.e. one program may allow multiple measures). Following are descriptions of the main control tables:

Programs

The Programs table is named tblPrograms. There is one record for each program or project. The user interface form for adding new programs or modifying program names in this table is only available through the System Administration module.

Field Name	Data Type	Notes
ID	Long Integer	Primary Key, Access autonumber
UtilityName	Text	Utility Code for import (e.g. SVP)
ProgramCode	Text	Internal name used to identify program
ProgramName	Text	External name viewed in forms and reports
ProgramType	Text	Category of program or Project
SortOrder	Integer	Number used to control sort order on dropdown menus

Program Measures

The Program Measures table is named tblProgramMeasures. There is one record for each type of measure available in a program or project. The user interface form for assigning program measures using this table is only available through the System Administration module.

Field Name	Data Type	Notes
ID	Long Integer	Primary Key, Access autonumber
UtilityName	Text	Utility Code for import (e.g. Alameda, TDPUD, etc.)
ProgramCode	Text	Foreign key to tblPrograms.ProgramCode
MeasureCode	Text	Foreign key to tblMeasures.MeasureCode

Parameters

The Parameters table is named tblParameters. There is only one record in this table. It stores control parameters unique to each utility. Some of the parameters include:

- The Utility Code that will be automatically placed in all customer and retrofit records to distinguish the records once exported to the Master database.
- The Utility Name for display on forms and reports.
- Application-level passwords to control access to the System Administration module (Note: passwords used in the database application are primarily designed to simplify the interface for users by letting them know they are in the wrong part of the application; they are not meant as high security devices).

The user interface form for adjusting the parameters is only available through the System Administration module. This insures that only users who know the password can revise the password (Note: if the password is forgotten, there are simple steps provided in a System Administration Manual for recovering it).

Field Name	Data Type	Notes
ID	Long Integer	Primary Key, Access autonumber
ParmCategory	Text	The parameter category – not editable
ParmText	Text	The actual value/setting for the parameter
SortOrder	Integer	Number used to control sort order on the Admin form

D.3.3 Lookup Tables

The Lookup Tables are common to all utilities. They supply the choices available on drop-down menus in data entry forms. Lookup tables aid in database management in the following ways:

1. They insure that consistent data is entered into certain fields by limiting the choices available on dropdown menus (for example, when entering the Measure Name for a retrofit record, the user must select one of the predetermined choices available for that program; this insures that summary calculations for that measure are not lost due to a misspelling).

2. They provide consistent spellings and aid to users on dropdown menus for fields where the user can enter items not in the list, but would like to refer to a set of choices (for example, when selecting measure manufacturers, a list of common choices are available, but the user can type in a name not in the list).
3. They allow editing of descriptive names for items while maintaining data consistency in existing records (for example, a code name is used for measure types and is the only value stored for measures adopted by customers; the descriptive name that is viewed by the user on forms and reports can be revised in the lookup table if misspelled or incomplete; the existing records do not have to be edited for the change because the code is joined to the description in the lookup table).
4. They increase performance and minimize storage because descriptions are stored in the lookup tables only, not in the actual data files (for example, as described in the item above, only the measure code is stored, not the much longer description).

Following are descriptions of the main lookup tables:

Utilities

The Utilities table is named tblUtilities. There is one record for each utility participating in the NCPA M&V database. The user interface form for adding new utilities or modifying utility names in this table is available only through the System Administration module of the Master database. While the utility table is contained in each of the Satellite databases, it is included only to aid the System Administrator in assigning the proper Utility Code and Utility Name in the System Parameters table.

Field Name	Data Type	Notes
UtilityCode	Text	Primary Key, unique code for each utility
Description	Text	The descriptive Utility Name
SortOrder	Integer	Number used to control sort order on dropdown menus

Program Types

The Program Types table is named tblProgramTypes. There is one record for each type of program. Every program or project is assigned to a Program Type, which is a higher level grouping category. The user interface form for assigning program types is available only through the System Administration module.

Field Name	Data Type	Notes
ProgramType	Text	Primary Key, unique code for each type
Description	Text	The descriptive name for the program type
SortOrder	Integer	Number used to control sort order on dropdown menus

Measure Units

The Measure Units table is named tblMeasureUnits. There is one record for each type of unit that can be assigned to qualify the recorded size of a measure (for example, Watts, tons, hp, CFM, cubic feet, SqFt). Every type of measure is associated with a Default Measure Unit that is automatically assigned to each new retrofit record based on the type of measure. The user can override this assignment if necessary by selecting a different Measure Unit from a dropdown menu of units, which is based on this lookup table. The user interface form for assigning Measure Units is available only through the System Administration module.

Field Name	Data Type	Notes
ID	Long Integer	Primary Key, Access autonumber
MeasureUnit	Text	Unique name for each unit (Watts, tons, hp)
Description	Text	Descriptive name for the unit for internal reference
SortOrder	Integer	Number used to control sort order on dropdown menus

Efficiency Units

The Efficiency Units table is named tblEfficiencyUnits. There is one record for each type of efficiency unit that can be assigned to qualify the measure efficiency (for example, SEER, EER, kW/ton, Lumens/Watt, u-Value, SHGC, %, kWh/yr, kW/hp, etc.). Every type of measure is associated with a Default Efficiency Unit is automatically assigned to each new retrofit record based on the type of measure. The user can override this assignment if necessary by selecting a different Efficiency Unit from a dropdown menu of efficiency units, which is based on this lookup table. The user interface form for assigning efficiency units is available only through the System Administration module.

Field Name	Data Type	Notes
ID	Long Integer	Primary Key, Access autonumber
EfficiencyUnit	Text	Unique name for each unit (SEER, EER, kW/ton)
Description	Text	Descriptive name for the unit for internal reference
SortOrder	Integer	Number used to control sort order on dropdown menus

Measures

The Measures table is named tblMeasures. There is one record for each type of measure, whether a new measure, an old measure that is being replaced, or both (a measure type that can be added and replaced). Every retrofit available in any program or project must have a corresponding measure type stored in this table. The user interface form for adding and editing measures is available only through the System Administration module.

Field Name	Data Type	Notes
ID	Long Integer	Primary Key, Access autonumber
MeasureCode	Text	Unique code for each type of measure
MeasureName	Text	The descriptive name for the measure
DefaultUnits	Text	The default unit type to assign from tblMeasureUnits
DefaultEffUnits	Text	The efficiency unit type to assign from tblEfficiencyUnits
IsNewMeasure	Boolean (yes/no)	Whether the measure can be selected as a new retrofit
IsNewMeasure	Boolean (yes/no)	Whether the measure can be replaced as an old measure
SortOrder	Integer	Number used to control sort order on dropdown menus
MeasureCategory	Text	Category (Lights, AC, Refrig, Etc.)

Manufacturers

The Manufacturers table is named tblManufacturers. There is one record for each manufacturer. This lookup table provides users with a list of common manufacturers to choose from when entering a measure retrofit record. The user is not required to enter the names on the dropdown menu, and can type in a new name not n this list. However, by supplying a common list of manufacturers, differences in spelling can be avoided and record entry can be faster. The user interface form for adding and editing manufacturers is available only through the System Administration module.

Field Name	Data Type	Notes
Manufacturer	Text	Primary Key, short name for manufacturer
Description	Text	Longer descriptive name used for internal reference
SortOrder	Integer	Number used to control sort order on dropdown menus

D.3.4 Local Tables

The Local Table tblLocalSystem is contained in the front-end, user interface file and is used to configure a local client PC. Because the particular software environment for a client may vary, even within the same utility, it is necessary to have a convenient way to configure the local client using a data table owned by the particular client. Examples of local system parameters include:

- Drive mapping for the shared network drive that holds the back-end database
- Location of the front-end file if the C: drive has inadequate storage space
- Location of client applications like Word and Excel

The user interface form for adjusting the Local Table parameters is only available through the System Administration module.

Field Name	Data Type	Notes
ParmCategory	Long Integer	Primary Key, the name of the parameter
ParmText	Text	The actual value/setting for the parameter
SortOrder	Integer	Number used to control sort order on the Admin form

D.3.5 Temporary Tables

Temporary tables are contained in the front-end, user interface file and are used to hold records during processing, such as exporting to Excel. They are placed in the front-end file to increase performance, since the front-end file resides on the local PC and the back-end database may be accessible only over a network.

Following are descriptions of some of the temporary tables:

Customers Temp

The Customers Temp table is named tblCustomersTemp. This table is used to collect the records specified by the user before exporting to Excel. The Export Setup form allows the user to filter the set of customer records they wish to export. The Customers Temp table also provides field names that are more readily recognized when exported to Excel (within the database tables, field names are assigned using a standard Mixed Case convention (e.g. CustLastName instead of Customer Last Name); spaces in the names are avoided to aid in programming and make the database tables portable to other database systems).

Field Name	Data Type	Notes
Customer	Text	Lookup Name (e.g. Doe, John or Acme Inc.)
Business	Text	
Business Contact	Text	
Service Address	Text	
Service City	Text	
Service State	Text	
Service Zip	Text	
Mailing Address	Text	
Mailing City	Text	
Mailing State	Text	
Mailing Zip	Text	
Phone	Text	
Fax	Text	
Email	Text	
Account Number	Text	Utility Account Number
Rebate Number	Text	Rebate Number
Date of Rebate Application	Short Date	Date of Application or Reservation
Rebate Reservation Amount	Currency	Rebate Reservation Amount
Date Rebate Paid	Short Date	Date Rebate Paid
Rebate Paid Amount	Currency	Rebate Paid Amount

Measures Temp

The Measures Temp table is named tblMeasuresTemp. This table is used to collect the records about energy efficiency measures specified by the user before exporting to Excel. The Export Setup form allows the user to filter the set of customer measure records they wish to export. The Measures Temp table also provides field names that are more readily recognized when exported to Excel. There is one record exported for each customer measure. The customer data is repeated in each row, but the measure-specific data varies.

Field Name	Data Type	Notes
Customer	Text	Lookup Name (e.g. Doe, John or Acme Inc.)
Business	Text	
Business Contact	Text	
Service Address	Text	
Service City	Text	
Service State	Text	
Service Zip	Text	
Mailing Address	Text	
Mailing City	Text	
Mailing State	Text	
Mailing Zip	Text	
Phone	Text	
Fax	Text	
Email	Text	
Account Number	Text	Utility Account Number
Rebate Number	Text	Rebate Number
Date of Rebate Application	Short Date	Date of Application or Reservation
Rebate Reservation Amount	Currency	Rebate Reservation Amount
Date Rebate Paid	Short Date	Date Rebate Paid
Rebate Paid Amount	Currency	Rebate Paid Amount
Program	Text	Name of the program or project

Field Name	Data Type	Notes
Measure	Text	Name of the energy efficiency measure
Quantity	Double	The number of this measure type installed
Hours Operation/Year	Double	Measure Hours Operation per Year
kW Savings	Double	kW savings
kWh Savings	Double	kWh/yr savings
Manufacturer	Text	Manufacturer
Model Number	Text	Manufacturer Model Number
Measure Size	Double	Measure Size
Units	Text	Units for the Size (Watts, tons, hp, CFM, etc.)
Efficiency	Double	Measure Efficiency
Efficiency Units	Text	Units for the Efficiency (SEER, EER, kW/ton, etc.)
Measure Notes	Text	Miscellaneous notes about measure
Pre-Installation Inspection	Text	(Pass, Fail, Enter Data)
Post-Installation Inspection	Text	(Pass, Fail, Enter Data)
Old Measure Replaced	Text	Foreign key to tblMeasures.MeasureCode
Old Quantity	Double	The number of this old measure type replaced
Old Manufacturer	Text	Old Manufacturer for replaced unit
Old Model Number	Text	Old Manufacturer Model Number
Old Measure Size	Double	Old Measure Size
Old Measure Units	Text	Units for the Old Size (Watts, tons, hp, CFM, etc.)
Old Efficiency	Double	Old Measure Efficiency
Old Efficiency Units	Text	Units for the Old Efficiency (SEER, EER, etc.)
Age of Old Measure	Double	Old Measure Age (in years)
Old Measure Notes	Text	Miscellaneous notes about old measure
DateAdded	Short Date	Date record added to database

Customers Import Temp

The Customers Import Temp table is named tblCustImportTemp. This table is used to collect records about energy efficiency measures specified by the user before exporting to Excel. The Export Setup form allows the user to filter sets of customer measure records for export. The Customers Import Temp table exports data in a format used by the Master Database when importing records. Fields match the spreadsheet columns used for manual entry and transfer of data to the Master database. To have the same data with field names that are more easily identified, the Measures Temp table is used from the Data Export form. There is one record exported for each customer measure. The customer data is repeated in each row, but the measure-specific data varies.

Field Name	Data Type	Notes
UtilityName	Text	Utility Code for import (e.g. SVP)
ProgramName	Text	Program Code for import (e.g. Refrigerator)
CustLastName	Text	
CustFirstName	Text	
CustBusName	Text	Business
CustBusContact	Text	Business Contact
CustServiceAddressNum	Text	Used if utility keeps address number separate
CustServiceAddress	Text	
CustServiceCity	Text	
CustServiceState	Text	
CustServiceZip	Text	
CustMailingAddressNum	Text	Used if utility keeps address number separate
CustMailingAddress	Text	

Field Name	Data Type	Notes
CustMailingCity	Text	
CustMailingState	Text	
CustMailingZip	Text	
Phone	Text	
Fax	Text	
Email	Text	
AccountNum	Text	Utility Account Number
RebateNum	Text	Rebate Number
DateRebate	Short Date	Date of Rebate Application or Reservation
RebateReservedAmt	Currency	Rebate Reservation Amount
DateRebatePaid	Short Date	Date Rebate Paid
RebatePaidAmt	Currency	Rebate Paid Amount
Measure	Text	Measure Code for import (e.g. 8ftT8HO)
MeasQty	Double	The number of this measure type installed
MeasHours	Double	Measure Hours Operation per Year
MeaskWSavings	Double	kW savings
MeaskWhSavings	Double	kWh/yr savings
MeasMfgr	Text	Manufacturer
MeasModelNum	Text	Manufacturer Model Number
MeasSize	Double	Measure Size
MeasUnits	Text	Units for the Size (Watts, tons, hp, CFM, etc.)
MeasEff	Double	Measure Efficiency
MeasEffUnits	Text	Units for the Efficiency (SEER, EER, kW/ton, etc.)
MeasNotes	Text	Miscellaneous notes about measure
PreInspect	Text	Pre-Installation inspection (Pass, Fail, Enter Data)
PostInspect	Text	Post-Installation inspection (Pass, Fail, Enter Data)
OldMeasure	Text	Measure Code for import (e.g. Incandescent)
OldMeasQty	Double	The number of this old measure type replaced
OldMfgr	Text	Old Manufacturer for replaced unit
OldModelNum	Text	Old Manufacturer Model Number
OldMeasSize	Double	Old Measure Size
OldMeasUnits	Text	Units for the Old Size (Watts, tons, hp, CFM, etc.)
OldMeasEff	Double	Old Measure Efficiency
OldMeasEffUnits	Text	Units for the Old Efficiency (SEER, EER, etc.)
OldAge	Double	Old Measure Age (in years)
OldMeasNotes	Text	Miscellaneous notes about old measure