Aloha Systems

Evaluation, Measurement, and Verification Final Report

RCA Verification Program for New and Existing Residential and Commercial Air Conditioners

CPUC Reference Numbers 1385-04, 1395-04 and 1437-04

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EXECUTIVE SUMMARY

The Refrigerant Charge and Airflow Verification Program (RCAVP) was implemented by Robert Mowris & Associates. Its purpose was to verify the refrigerant charge and airflow in 12,000 air conditioners located within the three major investor-owned electric utilities' service territories and to adjust the charge and airflow as needed to optimize system performance and energy efficiency. In doing so, the program estimated a net annual energy savings of 5,037,027 kWh and a peak demand reduction of 4,348 kW.

The program met its goals. It fully documented the RCA verification of 12,453 units. The participating contractors also reported an additional 1,059 units verified that were not fully documented because incentive funds had run out. Therefore a total of 13,512 air conditioners were verified as a result of the program.

The net energy savings achieved by the statewide program were 5,700,679 kWh per year, with a peak demand reduction of 5,925 kilowatts. This is 113% of the energy savings goal of 5,037,027 kWh/yr and 136% of the demand reduction goal of 4,348 kW. This does not include the savings achieved from codes and standards activities and the change the California Energy Commission is planning to make to Title 24, partly as a result of this program's information. While we believe those savings will be very substantial, they are difficult to accurately enumerate, and their evaluation is beyond the scope of this report.

Table 0: Net Savings Summary

Utility	Residential kWh/year	Residential kW	Commercial kWh/year	Commercial kW	**Total kWh/year**	**Total kW**
PG&E	522,647	637.8	2,654,027	2,137.8	**3,176,674**	**2,775.6**
SCE	1,318,689	1,586.5	264,748	207.9	**1,583,437**	**1,794.4**
SDG&E	748,418	1,200.0	192,150	155.3	**940,568**	**1,355.3**
Total	2,589,754	3,424.3	3,110,925	2,501.0	**5,700,679**	**5,925.3**

Participant contractors were pleased with the training they received. On-site inspections of previously verified HVAC units demonstrated that the technicians were using the software correctly to properly charge the units they were installing or repairing. Participating contractors generally felt the program enhanced customer service and quality within the industry.

The number of technicians trained and Verified™ RCA jobs completed exceeded the program goals by a large margin. The program trained 353 technicians with outreach to small, medium, and large HVAC contractors. These contractors verified proper RCA on 13,512 air conditioners and verified proper TXV installations on 1,357 TXV-equipped air conditioners. The program trained and equipped 237 technicians from small HVAC companies, representing 67% of the total the technicians who were trained. Small contractors performed approximately 32% of all the jobs submitted by the program. A

larger marketing, training, and equipment budget would have facilitated the ability to train and equip more contractors and reach average utility customers with mass marketing information. However, with a very limited marketing budget, the program successfully exceeded all goals and delivered its message to the HVAC industry, including small, medium, and large C-20 (HVAC) contractors, manufacturers, government agencies, builders, schools, and thousands of utility customers.

The need for the program was substantiated by the statistics gathered from each individual site. The database of the 12,453 fully documented verifications includes whether a refrigerant charge adjustment was necessary and exactly how much was required. Of the old air conditioners verified, 65% of them needed charge adjustments. Of the new units verified shortly after their installation, 45% needed charge adjustments. Therefore it can be assumed that approximately half of all the air conditioners in the state would increase their operating efficiency by being precisely charged through participation in the RCAVP.

RMA has recommended that the California Energy Commission require refrigerant charge verification for all air conditioners in the 2008 standards. Our observations while evaluating this program support this recommendation. We note, however, that such a requirement would not supplant the need for continuing public goods charge-funded programs that verify and adjust the refrigerant charge and airflow of *existing* air conditioners in both residential and commercial settings. The database developed in conjunction with this program demonstrates that nearly two-thirds of existing air conditioning units will benefit by refrigerant charge adjustment.

This study was conducted at the request of the California Public Utilities Commission. The study was managed by Aloha Systems, Incorporated. It was funded through the public goods charge (PGC) for energy efficiency and is available for download at www.calmac.org.

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INTRODUCTION

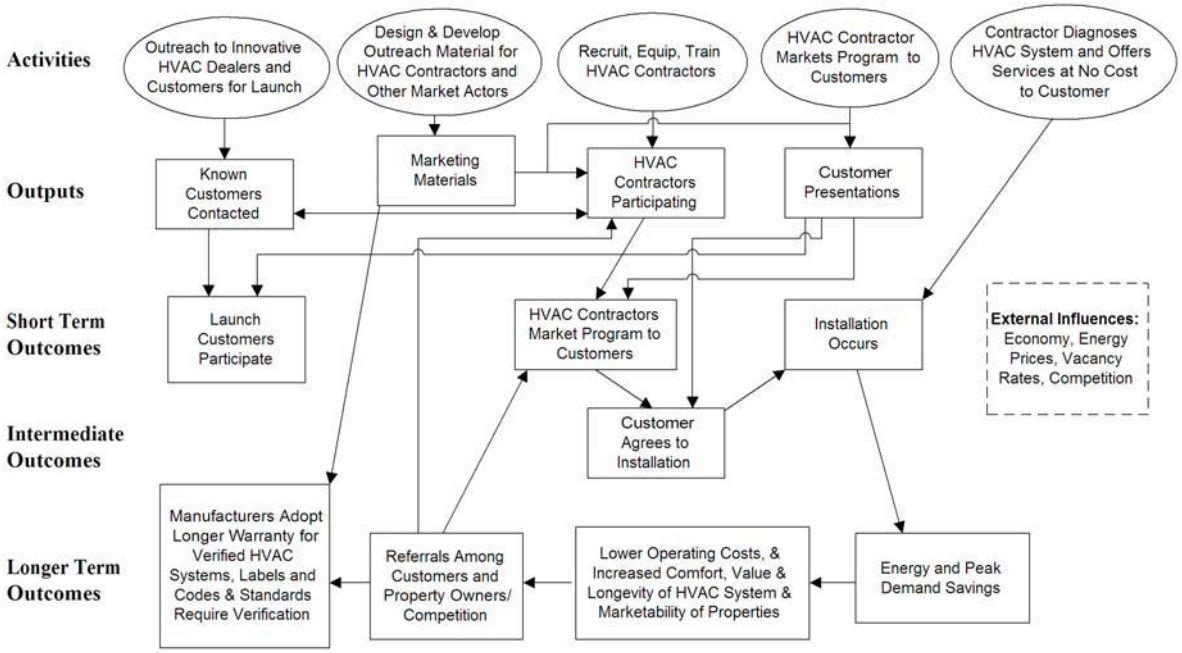
The Refrigerant Charge and Airflow Verification Program (RCAVP) was implemented and managed by Robert Mowris & Associates (RMA). The RCAVP is an air conditioning energy efficiency program designed to specifically target the inefficiencies of improperly installed air conditioning units throughout the state of California in the Pacific Gas & Electric, San Diego Gas & Electric, and Southern California Edison service territories. The RCAVP developed a software system that verified the proper refrigerant charge and airflow of an air conditioning unit. If improper charge or airflow were encountered, the software gave specific adjustment instructions to the technician. The RCAVP enabled air conditioning dealers and technicians, home builders, and contractors to use this system. The program goal was to verify and, if necessary, adjust 12,000 air conditioning units.

The long-term intent of the program is to instill an awareness of the importance of proper charge and airflow among installers, repair technicians, and consumers and also to make them aware of a precise but relatively easy-to-use means of assuring the units are operating optimally.

Program Theory

The program theory was based upon the idea that air conditioners were frequently installed without proper refrigerant charge and airflow, and this caused a significant decline in operational efficiency. A graphical representation of the program theory and logic model is shown in Figure 1.

Figure 1. Logic Model for RCA Verification Program



The program theory, assumptions, and activity statements represent a series of hypotheses about how the program worked in the market place. The program hypothesized that if it were implemented through large HVAC distributors and small, medium, and large HVAC contractors who have pre-existing relationships with builders and commercial and residential property owners, that these relationships would convince owners of air conditioners to demand RCA Verification services to achieve the program goals. The program theory focused on the following market actors to achieve energy and peak demand savings.

- HVAC contractors who install air conditioners in residential and commercial buildings.
- Customers and building owners who are not currently considering RCA verification services, but who could be convinced to demand these services with marketing and educational information.
- HVAC technicians who install and service air conditioners who can be convinced to use properly calibrated equipment and receive proper in-field training, incentives, and state-of-the-art software to help them offer RCA verification services.
- HVAC wholesale distributors who sell air conditioner equipment who can be convinced to promote RCA verification services to dealers and technicians.
- HVAC manufacturers who can be convinced to promote RCA verification by offering longer warranties for verified HVAC efficiency.
- Government agencies such as the California Energy Commission (CEC), US Department of Energy, Environmental Protection Agency (EnergyStar), and Federal Trade Commission (FTC) who can be convinced of the importance of establishing codes, standards, and labels (i.e., FTC yellow label) to support RCA verification.
- Professional trade associations such as the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), and the Institute for Heating and Air Conditioning Industries (IHACI) who can be convinced of the need to promote RCA verification.

The implementer (RMA) hypothesized that through these market actors the program would deliver a specific level of energy and demand savings to California's energy markets. RMA estimated that it would capture energy and peak demand savings through the following activities based upon the program assumptions concerning the market and the consequences.

- Work with a set of early adopter HVAC dealers and building owners.
- Contact HVAC dealers and describe in detail the benefits and operation of calibrated equipment, field training, expert-system PDA software,

incentives, improved customer satisfaction, quality control, and energy savings.

- Design, develop and deliver program marketing and outreach materials to contractors and customers.
- Convince HVAC dealers to recommend RCA verification to "known" customers installing new air conditioners or service for existing air conditioners or when HVAC dealers determine customers or potential customers are good candidates for the program.
- Assist HVAC dealers as necessary concerning training, equipment, PDA expert-system software, proper installation, RCA verification, permanent labels, Novent caps, and incentives.
- Enable participating HVAC dealers to use program equipment and software to conduct RCA verification services to save energy offer proposed RCA verification services to customers with the incremental cost paid by program incentives.
- Facilitating discussion between building owners and HVAC dealers leading to the owner agreeing to installation of RCA verification services.
- Provide RCA verification upgrades and install permanent labels and locking Novent caps to achieve energy and peak demand savings.

Studies published by the American Council for an Energy-Efficient Economy (ACEEE), the U.S. Environmental Protection Agency, and the Electric Power Research Institute (EPRI) indicate 50 to 70% of air conditioners are installed with improper refrigerant charge and airflow, reducing efficiency by 10 to 50%.[1] Improperly calibrated equipment and inadequately trained technicians caused most of these problems. Many technicians rely on rules of thumb for adjusting refrigerant charge when installing or servicing air conditioners rather than relying on sophisticated measurement. Thus refrigerant charge and airflow are usually sufficient to make the air conditioners operate, but insufficient to make them operate at their rated capacity and efficiency.

The program theory identified many market barriers to RCA verification including performance uncertainty, higher start-up costs, lack of information, misplaced or split

[1] Chris Neme, *National Energy Savings Potential from Addressing HVAC Installation Problems*, prepared for US Environmental Protection Agency, March 1998. Michael Blasnik, *Assessment of HVAC Installations in New Air Conditioners in SCE's Service Territory*, EPRI, 1995. Jeff Hammarlund, *Enhancing the Performance of HVAC and Distribution Systems in Residential New Construction*, 1992 ACEEE Summer Study on Energy Efficiency in Buildings. Robert Mowris, Anne Blankenship, and Ean Jones, *Field Measurements of Air Conditioners with and without TXVs*, 2004 ACEEE Summer Study on Energy Efficiency in Buildings, August 2004. M. Palani, D. O'Neal, J. Haberl, *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, 1992. D. Parker, *Impact of Evaporator Coil Air Flow in Residential Air Conditioning Systems*, FSEC-PF-321-97. A. Rodriguez, *The Effect of Refrigerant Charge, Duct Leakage, and Evaporator Air Flow on the High Temperature Performance of Air Conditioners and Heat Pumps*, EPRI, 1995.

incentives, organizational practices, and service availability. The RCAVP addressed these barriers by offering training, equipment, incentives, and computer diagnostic software. Technicians used the computer diagnostic software to determine whether or not there is a problem, and the software provided recommendations for correcting problems to verify proper RCA. The program provided the following four platforms to verify proper RCA: (1) personal digital assistant (PDA) software, (2) cell-phone interactive voice response (IVR) telephony, (3) notebook/laptop PC software, or (4) toll-free telephone support with an EPA-certified technician. The PDA software was available for Palm and Pocket PC operating systems. The software platforms were demonstrated to technicians at training sessions, and most technicians preferred the PDA software. The telephone IVR system was operational for the entire 2004-05 program.

The program inspected a random sample of RCA verified jobs using EPA certified technicians for quality assurance purposes and to guarantee that the program delivered energy and peak demand savings. The program provided internet verification certificates and educational materials to participating customers. The program planned to provide significant energy savings by increasing and maintaining the operational efficiency of 12,000 air conditioning units in the residential and commercial sectors. Energy savings were maintained by technicians keeping their Verified™ PDA software (after the program was completed), tracking database, quality control inspections, Verified™ labels (RCA and TXV), and Novent™ locking Schrader caps (on liquid and suction lines) to prevent future mal-adjustments, tampering, and refrigerant leaks once the unit is properly charged. The Novent™ caps are color-coded and laser-etched to prevent mixing of refrigerants. They have secondary o-ring seals and built-in torque limitations to avoid over-tightening, over-compressing, and damaging the o-ring seal. The “bumper-sticker” quality Verified™ labels are printed on vinyl with UV-inhibitors for long life.

Program Goals

Table 1 shows the program goals:

Table 1: Program Goals			
Description	**PG&E**	**SCE**	**SDG&E**
HVAC Technicians Trained and Using the RCA Verification System	48 Techs	36 Techs	15 Techs
Residential Units with Verified RCA	3,880 Units	2,900 Units	1,220 Units
Small Commercial Units with Verified RCA	1,940 Units	1,450 Units	610 Units
Hard-to-Reach Small Commercial and Residential Units	10%	10%	10%
Peak Demand Savings	1,944 kW	1,520 kW	884 kW
Annual kWh Savings	2,187,602	1,983,499	865,926
Lifecycle kWh Savings	32,814,033	29,752,478	12,988,883

The program goals also included meetings regarding the program and the importance of refrigerant charge and airflow for proper air conditioner efficiency. Those meetings planned by the program implementers were:

- With manufacturers to adopt longer warranty for RCA-verified air conditioners and shorter warranty for non-verified units.
- With the California Energy Commission's Title 24 codes and standards programs to recommend requiring RCA verification on new air conditioners for new buildings.
- With the U.S. Department of Energy to suggest future efficiency standards for new air conditioners require RCA verification.
- With the U.S. Environmental Protection Agency to recommend EnergyStar labels for new air conditioners require RCA verification.
- With the Federal Trade Commission to suggest the yellow efficiency labels for new air conditioners discuss the importance of proper RCA verification and include information about RCA verification.

Researchable Issues

The RCA Verification Program encompassed many researchable issues that needed to be assessed in order to complete a successful EM&V project. A list of these vital researchable issues and the methods used to evaluate them are presented in the table below.

Table 2: Researchable Issues

Issue	Method of Assessment
How many RCA verifications were conducted?	Tabulate data from RCAVP database.
What are the total energy savings and demand reductions?	Multiply verification by appropriate per-unit values based on geography.
Did the contractors properly complete the RCAVP process?	On-site inspection of sample of units verified.
What portion of A/C units needed the service?	Review recommendations tracked in RCAVP database.
Were builders, contractors, and technicians aware of the relationship between refrigerant charge and operating efficiency?	Survey manufacturers, distributors, and contractors, builders, and customers.
What is current industry practice?	Survey manufacturers, distributors, and contractors, builders, and customers.
What are reasons for participating or not participating?	Survey manufacturers, distributors, and contractors, builders, and customers.
How can the process be improved?	Directly observe and interview team players.
Are program training and materials effective?	Review materials and interview technicians.
Do any specific contractors or technicians need additional training?	Track any problems observed to see if any source is salient.

DISCUSSION OF CPUC OBJECTIVES

Evaluation of the RCAVP was specifically designed to target verification of physical hardware correction as well as changes in contractor and installer attitude, behavior, and installation practices. In order to complete a successful EM&V program, we followed the guidelines set forth by the CPUC regarding EM&V. These specific objectives, from Chapter 6 of the CPUC's *Energy Efficiency Policy Manual*, were covered in this plan as discussed in the following sections:

Measuring level of energy and peak demand savings achieved. The *ex-ante* evaluation was a relatively straightforward assessment of energy savings and demand reduction achieved by making adjustments to air conditioning units. These quantities were derived from verification of actual RCAVP activities and the per-unit savings attributable to them in the implementation plan spreadsheets.

We also developed a "near *ex-post*" evaluation that assessed the program's savings to a greater degree of accuracy. Rather than rely on savings estimates that were generic across utility service territories, we analyzed installations at the next level of detail. The utility average parameters, for example, were derived from assumptions about proportions of unit installations in each weather zone. Our near-*ex-post* evaluation accounted for the proportion of actual quantities of RCAVP activities in each weather zone as well as other variations.

Measuring cost-effectiveness. The energy savings and demand reduction numbers provided through our analysis will be usable as revised parameters for calculations of the standard cost-effectiveness tests. Combined with RMA's actual costs for implementing various aspects of the program, *ex-post* cost-effectiveness calculations can be determined not only for the project as a whole but for its individual components as well.

Providing up-front market assessments and baseline analysis. For the RCAVP, the baseline analysis was a matter of RCA verification as well as vendor/contractor/installer awareness of the potential energy savings and increased efficiencies of properly installed air conditioners. For the most part, the processes were straightforward, such as physical verification of proper RCA. The primary baseline issue was assessing prior awareness of the various technologies and behaviors taught through the components of the project. We surveyed participants to help determine this.

We also conducted surveys of non-participants who were eligible for the program, but did not participate. This helped determine the baseline of awareness and usage of the various efficiency techniques. It also enabled us to better estimate the market transformation component of the program. For example, there was potentially some energy savings that may have been achieved in the competitive air conditioning vending arena, even among those vendors not initially participating. When one company saw that its competitors have their installed air conditioning units verified for proper RCA, the non-participant company might review its practices and look into participating in this program.

(We actually do know of one company interviewed for the non-participant survey that went on to become a participant as a result of the awareness gained through our survey.)

Providing ongoing feedback and corrective and constructive guidance regarding the implementation of the programs. Aloha Systems personnel were in frequent and ongoing communication with RMA personnel through meetings, emails, memoranda, etc. throughout the program's duration. This sort of communication allowed for the free exchange of assessments and observations obtained during the ongoing evaluation process as well as anecdotal information gathered from participating residents, businesses, and vendors, and ways that we believed the overall energy savings or cost-effectiveness (*i.e.*, energy savings per dollar expended) could be increased. This feedback proved valuable to RMA staff members as they moved onward in the project.

Measuring indicators of the effectiveness of specific programs, including testing of the assumptions that underlie the program theory and approach. We reviewed the underlying assumptions in a number of ways. The program assumptions regarding location and size of verified HVAC units were directly tested through our analysis of the data collected during the RCA verification process. The assumptions regarding the portion of HVAC units with improper charge or airflow were tested by reviewing the charge/discharge recommendations for the participant units and determining a percentage that require action.

The assumptions regarding the actual savings achieved by correcting the charge of an improperly charged unit have been substantiated in research and published papers.[2] We reviewed this research and saw that it was accurately applied to the program's savings calculations. Verification of this research or independent assessment of the savings achieved by properly charging a unit is beyond the scope of this EM&V work.

Assessing the overall levels of performance and success of the program. As with almost every aspect of the RCAVP, its overall performance and success was based upon a number of factors. The directly attributable kWh savings and kW reductions were clearly a major component. Indirect effects, such as contractors performing the RCAVP process outside the IOU service territories or after available incentives ran out, have been assessed through the interview and survey process.

Informing decisions regarding compensation and final payments. The information we analyzed and presented has enabled RMA and the CPUC to accurately determine whether the program has met its stated objectives.

Helping to assess whether there is a continuing need for the program. Ultimately, this is was most important question of the entire EM&V process. Given the apparent quantity of improperly installed HVAC units and the RCAVP's estimated savings, we provide greater insight regarding the need for continued expansion of the RCAVP.

[2] Ibid.

Installations

Each time a technician used the PDA to verify an air conditioning unit, specific data about the AC unit and its operation, as well as the customer, were entered into the PDA. This was then downloaded into the master program tracking database maintained by RMA. This database contains detailed records of each RCA verification conducted. The complete database was provided to Aloha Systems for analysis.

The energy savings attributable to the program were derived from the 2001 DEER based upon assumptions of unit size, climate zone location (for residential units), or building type (for commercial units). The following table lists the number of installations and the total cooling capacity in tons for each zip code in which RCA verification was performed:

Table 3: RCA Verficiations by Zip Code

Zip Codes	City	Climate Zone	Utility	Residential		Commercial	
				Units	Tons	Units	Tons
90222	Compton	8	SCE	30	115.5		
90241	Downey	8	SCE	1	5.0		
90247-48	Gardena	8	SCE	65	237.0		
90506	Torrance	8	SCE	33	150.0		
90620	Buena Park	8	SCE	2	8.0		
90630	Cypress	8	SCE	1	3.5		
90703	Cerritos	8	SCE	2	8.5		
90740	Seal Beach	6	SCE	13	55.0		
90746	Carson	8	SCE	1	4.0		
90807	Long Beach	8	SCE	3	10.0		
91708-10	Chino	10	SCE	46	202.5		
91730	Rancho Cuc	10	SCE	225	528.0		
91741	Glendora	9	SCE	23	82.5		
91752	Mira Loma	10	SCE	1	4.0		
91761-62	Ontario	10	SCE	2	6.0		
91763	Montclair	10	SCE			34	155.0
91765	Diamond Bar	9	SCE	1	4.0		
91784-86	Upland	10	SCE	110	395.0	3	15.0
91912-24	Chula Vista	7	SDGE	123	409.5		
91941	La Mesa	7	SDGE	10	36.0		
91950	National City	7	SDGE	9	22.5		
91977	Santee	10	SDGE	3	10.0		
92004-09	Carlsbad	7	SDGE	353	1152.5		
92019-20	El Cajon	10	SDGE	4	12.0	3	6.0
92025-26	Escondido	10	SDGE	55	138.0	1	3.0
92064	Poway	10	SDGE	7	25.0		
92078	San Marcos	10	SDGE	82	312.0		
92081	Vista	10	SDGE	1	4.0		
92082	Valley Center	10	SDGE	11	38.0		
92091	Rancho Santa Fe	7	SDGE	32	97.5		
92101-04	San Diego	7	SDGE	11	31.5	14	58.0

Table 3: RCA Verficiations by Zip Code							
Zip Codes	City	Climate Zone	Utility	Residential		Commercial	
				Units	Tons	Units	Tons
92111-26	San Diego	7	SDGE	1	5.0	242	966.0
92127-30	San Diego	7	SDGE	208	646.0		
92131-45	Scripps Ranch	7	SDGE	113	365.5		
92194	San Diego	7	SDGE	2	6.0		
92210	Indian Wells	15	SCE	118	435.5	2	10.0
92220	Banning	15	SCE	1	4.0		
92223	Beaumont	10	SCE	76	245.0		
92241	Desert Hot Springs	15	SCE	2	6.0		
92262	Palm Springs	15	SCE	1	4.0		
92307	Apple Valley	14	SCE	8	34.0	2	7.0
92315	Big Bear	16	SCE	1	4.0		
92316	Bloomington	10	SCE	3	10.0		
92324	Colton	10	SCE	1	3.0		
92334-36	Fontana	10	SCE	153	547.5		
92342	Silver Lakes	14	SCE	2	6.0		
92345	Hesperia	14	SCE	3	11.0	27	135.0
92346	Highland	10	SCE	3	13.0		
92359	Mentone	10	SCE	49	181.0		
92374	Redlands	10	SCE	1	4.0		
92377	Rialto	10	SCE	3	13.0		
92392	Victorville	14	SCE	9	35.0	10	26.0
92399	Yucaipa	10	SCE	1	3.0		
92404-11	San Bernardino	10	SCE	13	45.5		
92503-09	Riverside	10	SCE	37	142.0		
92530	Lake Elsinore	10	SCE	92	316.5		
92553-57	Moreno Valley	10	SCE	2	7.5	2	4.0
92562	Murrieta	10	SCE	608	1503.5		
92570	Perris	10	SCE	16	60.0		
92591-93	Temecula	10	SCE	638	2035.0		
92595	Wildomar	10	SCE	0	0.0	1	3.5
92603	Irvine	8	SCE	510	1909.5	81	496.5
92610	Foothill Ranch	8	SDGE	1	2.0		
92612-14	Irvine	8	SCE	147	538.5	2	8.0
92620	Irvine	8	SCE	122	443.5		
92626	Costa Mesa	6	SCE	2	8.0	7	24.5
92630	Lake Forest	8	SCE	10	37.0		
92646-48	Huntington Beach	6	SCE	6	21.0		
92651	Laguna Hills	6	SDGE	12	41.0		
92653	Laguna Hills	6	SDGE	5	21.0		
92653	Laguna Hills	6	SCE	4	14.0		
92656	Aliso Viejo	6	SCE	3	10.5		
92657-63	Newport Beach	6	SCE	207	720.5	57	152.5
92672	San Clemente	6	SDGE	47	155.5	16	73.0
92673	San Clemente	6	SDGE	302	1102.5	12	42.0
92675	San Juan Capistrano	6	SDGE	19	76.5		
92677	Laguna Niguel	6	SDGE	56	217.5		
92677	Laguna Niguel	6	SCE	3	9.0		
92679	Coto de Caza	8	SCE	2	6.0		
92683	Westminster	6	SCE	5	20.5		
92688	Rancho Sta Margarita	8	SCE	2	9.0	2	10.0

Table 3: RCA Verficiations by Zip Code							
Zip Codes	City	Climate Zone	Utility	Residential		Commercial	
				Units	Tons	Units	Tons
92688	Rancho Sta Margarita	8	SDGE	1	3.0		
92691-92	Mission Viejo	8	SCE	20	69.5		
92692	Mission Viejo	8	SDGE	1	3.0		
92694	Ladera Ranch	8	SCE	17	63.5		
92694	Ladera Ranch	8	SDGE	414	1516.0		
92701-07	Santa Ana	8	SCE	18	74.0	3	11.0
92708	Fountain Valley	6	SCE	2	7.0		
92780-82	Tustin	8	SCE	209	684.5		
92804-07	Anaheim	8	SCE	5	19.5	6	20.0
92808	Orange	8	SCE	2	10.0		
92823	Brea	8	SCE	1	5.0		
92833-35	Fullerton	8	SCE	2	6.0		
92840-45	Garden Grove	8	SCE	12	52.5		
92856	Orange	8	SCE	18	77.0		
92860	Norco	10	SCE	74	280.0		
92863-69	Orange	8	SCE	14	55.0	1	4.0
92870	Placentia	8	SCE	1	4.0	4	20.0
92879-83	Corona	10	SCE	263	944.5		
92886	Yorba Linda	8	SCE	12	43.5		
93208	Springville	13	SCE	1	5.0	1	5.0
93212	Corcoran	13	PGE	4	7.5		
93219	Earlimart	13	SCE	31	46.5		
93223	Farmersville	13	SCE	38	97.5		
93247	Lindsay	13	SCE	0	0.0	8	23.0
93256	Pixley	13	SCE	22	36.0		
93274	Tulare	13	SCE	14	40.5	5	25.0
93277	Visalia	13	SCE	5	18.0		
93301-07	Bakersfield	13	PGE	15	59.5	1	3.5
93308-13	Bakersfield	13	PGE	288	971.5	15	53.5
93601	Ahwhanee	13	PGE	1	4.0		
93610	Chowchilla	13	PGE	72	131.5		
93612	Clovis	13	PGE	6	20.0		
93614	Coarsegold	13	PGE	17	69.5	2	7.5
93618	Dinuba	13	PGE	10	20.0		
93622	Firebaugh	13	PGE			7	14.0
93624	Five Point	13	PGE			1	2.5
93626	Friant	13	PGE	3	11.5		
93630	Kerman	13	PGE	28	45.5		
93631	Kingsburg	13	PGE	17	36.5		
93635	Los Banos	12	PGE	115	416.5	23	105.5
93637-38	Madera	13	PGE	40	121.0	1	4.0
93640	Mendota	13	PGE	27	49.0		
93643	North Fork	16	PGE	4	13.5		
93644	Oakhurst	16	PGE	41	97.5	25	117.5
93645	O'Neals	13	PGE	1	5.0		
93653	Raymond	13	PGE	2	7.0		
93660	San Joaquin	13	PGE	60	95.0		
93703-06	Fresno	13	PGE	9	21.0	22	70.0
93710	Fresno	13	PGE	14	42.0	1	3.0
93720	Fresno	13	PGE	61	154.0	48	168.0

Table 3: RCA Verficiations by Zip Code							
Zip Codes	City	Climate Zone	Utility	Residential		Commercial	
				Units	Tons	Units	Tons
93722-27	Fresno	13	PGE	8	25.0	18	89.0
93934	Carmel Valley	3	PGE	1	5.0		
94510	Benicia	12	PGE	1	3.0		
94513	Brentwood	12	PGE	5	19.5		
94514	Discovery	12	PGE	3	7.5		
94526	Danville	12	PGE	1	5.0		
94528	Diablo	12	PGE	3	12.5		
94533	Fairfield	12	PGE	39	93.5		
94541-44	Hayward	3	PGE	2	7.0	275	983.5
94545	Hayward	3	PGE			103	378.5
94550	Livermore	12	PGE	40	135.0		
94558	Napa	2	PGE	1	4.0		
94566	Pleasanton	12	PGE	1	5.0	2	4.0
94583	San Ramon	12	PGE	4	15.0		
94585	Suisun City	12	PGE			3	11.0
94587	Union City	3	PGE	1	5.0		
94588	Pleasanton	12	PGE	1	3.0	5	110.0
94589-90	Vallejo	2	PGE	1	2.5	3	12.0
94596	Castro Valley	12	PGE	4	14.0		
94903	San Rafael	2	PGE			5	17.5
95124	San Jose	4	PGE	1	3.0		
95203-05	Stockton	12	PGE	2	6.0	183	1448.5
95206	Stockton	12	PGE	5	11.5	25	90.5
95207-15	Stockton	12	PGE			59	249.0
95222	Angels Camp	12	PGE	205	487.5	5	13.5
95240-41	Lodi	12	PGE	0	0.0	6	36.0
95247	Murphys	12	PGE	25	40.5		
95301	Atwater	12	PGE	2	8.0		
95304-06	Tracy	12	PGE	9	34.0		
95307	Ceres	12	PGE	1	2.0		
95330	Lathrop	12	PGE	37	171.5		
95336-37	Manteca	12	PGE	10	45.5	1	5.0
95338	Mariposa	12	PGE	105	223.0		
95340	Merced	12	PGE	0	0.0	15	96.0
95355	Modesto	12	PGE	1	3.5		
95360	Newman	12	PGE	6	17.5		
95361	Oakdale	12	PGE	0	0.0	12	84.0
95363	Patterson	12	PGE	1	5.0		
95366	Ripon	12	PGE	4	19.0	1	3.0
95367-77	Tracy	12	PGE	121	490.0	95	380.2
95422	Clearlake	2	PGE	27	54.0		
95451	Kelseyville	2	PGE	27	41.5		
95453	Lakeport	2	PGE	24	48.0		
95476	Sonoma	2	PGE			2	5.5
95482	Ukiah	2	PGE	21	126.0		
95485	Upper Lake	2	PGE	25	72.0		
95492	Windsor	2	PGE	65	168.5		
95602-03	Auburn	11	PGE	134	280.5		
95616	Davis	12	PGE	96	186.5	737	4007.9
95619	Diamond Springs	12	PGE	110	188.5		

Table 3: RCA Verficiations by Zip Code							
Zip Codes	City	Climate Zone	Utility	Residential		Commercial	
				Units	Tons	Units	Tons
95642	Jackson	12	PGE	21	45.5		
95645	Knights Landing	11	PGE	0	0.0	17	88.0
95648	Lincoln	11	PGE	127	295.0		
95650	Loomis	11	PGE	2	9.0		
95661	Linda	11	PGE	1	3.0		
95665	Pine Grove	12	PGE	1	3.5		
95667	Placerville	12	PGE	137	274.5	1	3.0
95674	Rio Oso	11	PGE	1	3.0		
95677	Rocklin	11	PGE			6	28.0
95682	Shingle Springs	12	PGE	3	5.5		
95688	Vacaville	12	PGE			2	9.0
95691	West Sacramento	12	PGE	2	7.0		
95692	Wheatland	11	PGE	1	2.5		
95694	Winters	12	PGE	38	57.0	132	626.5
95695	Woodland	12	PGE			336	1960.3
95762	El Dorado Hills	12	PGE	1	3.5		
95901	Marysville	11	PGE	12	38.0	279	1427.0
95918	Browns Valley	11	PGE	2	6.0		
95935	Dobbins	11	PGE	1	2.0		
95948	Gridley	11	PGE	2	7.0		
95949	Grass Valley	11	PGE	1	3.0		
95953	Live Oak	11	PGE	3	9.0		
95959	Nevada City	11	PGE	6	19.0	2	8.0
95961	Olivehurst	11	PGE	1	3.5	54	252.5
95962	Oregon House	11	PGE	1	3.0		
95963	Orland	11	PGE	48	94.5		
95977	Smartville	11	PGE	2	7.5		
95991	Yuba City	11	PGE	162	444.5	414	1993.8
95993	Yuba City	11	PGE	14	54.5	269	1245.3
96001	Redding	11	PGE	1	4.0		
96080	Red Bluff	11	PGE	1	4.0		
	Total			**8694**	**27225.0**	**3759**	**18518.0**

The program's goals were 8,000 residential units and 4,000 commercial units, for a total of 12,000 units. A total of 12,453 units were fully documented in the tracking system. This includes 453 units that were verified but did not receive incentives because the 12,000 allocated incentives had run out. (The contractors were aware that the 12,000 incentives would be paid on a first-come first-served basis.)

In addition to the 12,453 units that were fully verified and documented in the system, the contractors submitted partial information on 1,059 units that were also verified. Since the incentives ran out, the contractors did not enter customer information details into the master customer database, so exact addresses and customer meter numbers were not known. However, they did receive the locking caps and stickers and their refrigerant charge and airflow were verified and corrected if necessary. The total units verified through the program therefore are 13,512, which is 113% of the program goal.

Verification of Work

We conducted on-site visits to demonstrate that verifications had been conducted properly. Together with RMA staff, we used the same methodology and tools of the RCA Verification Program to inspect the work of contractors and builders. We inspected 124 HVAC units to assure that the refrigerant charges and airflows of the units were correct (*i.e.*, that the verification software did not recommend a change) and that the stickers and locking caps were in place. The sample size of 1% (120 units) was selected based upon the available budget.

Temperature, pressure, and airflow measurements were entered into the program PDA. Verification of proper completion of the RCA at any given site would have been indicated by the PDA showing that no changes to the system were required. All of the units inspected showed proper charge and airflow. In one location we observed that locking caps had not been installed. RMA verified that this contractor had used up its supply of caps and the contractor was aware of the problem and had already flagged the units to have the caps installed upon receipt of more.

Residential Gross Energy Savings

The residential energy savings estimates were based upon the 2001 DEER Update as well as specific assumptions about the size, climate zone (residential), or building type (commercial) of the units verified. The approved EM&V plan specified that the size, location, and building type assumptions would be verified and the energy savings estimates would be generated with actual values for these parameters, rather than the ex-ante assumptions made in the program implementation plan. The EM&V plan also specifically limited the evaluation to those parameters, stating that it was clearly beyond the scope of this research to ascertain whether the underlying kWh/yr-ton energy savings and kW/ton demand reduction values in the DEER accurately represented the savings achieved by the verification of refrigerant charge and airflow.

These DEER values had been deemed appropriate approximations of the energy savings of an average RCA verification in each utility service territory. This "average RCA verification" included both those that required charge modifications and those that did not. It represented a blend of new units and existing units as well as those with and without TXVs installed. We concurred with that assessment when developing the EM&V plan and do not revisit it.

The original residential program savings estimates for each utility service territory were calculated by RMA based upon the "Basic HVAC Diagnostic" component of the 2001 DEER Update Study. The following tables provide kWh/yr and kW savings per ton for residential sites by utility service area. These tables are the same as those presented in the EM&V plan and are consistent with the implementer's program implementation plan. The

ex-ante savings estimates were generated by multiplying the average per-unit savings for a given service territory by the number of verifications in that service territory (thus ignoring both climate zone and unit cooling capacity [tons]). The average assumed an equal distribution of customers throughout the forecast zones for each utility. For example, PG&E's customers were assumed to be 25% in the Sacramento forecast zone, 25% in Fresno, 25% in San Jose, and 25% in Napa.

Table 4a: PG&E Residential Verified RCA Baseline Assumptions and Measure Savings								
City	**CEC Forecast Zone**	**Baseline UEC (kWh/yr)**	**Baseline UED (kW)**	**kWh/yr Savings**	**kW Savings**	**Implicit Size (tons)**	**kWh/yr-ton Savings**	**kW/ton Savings**
Sacramento	2	1,424	1.935	177	0.254	3.0	59.0	0.085
Fresno	3	3,419	3.187	444	0.420	3.0	148.0	0.140
San Jose	4	1,295	2.023	161	0.266	3.0	53.7	0.089
Napa	1	1,337	2.227	165	0.290	3.0	55.0	0.097
Average		**1,869**	**2.343**	**237**	**0.307**	3.0	79.0	0.102

Table 4b: SCE Residential Verified RCA Baseline Assumptions and Measure Savings								
City	**CEC Forecast Zone**	**Baseline UEC (kWh/yr)**	**Baseline UED (kW)**	**kWh/yr Savings**	**kW Savings**	**Implicit Size (tons)**	**kWh/yr-ton Savings**	**kW/ton Savings**
Fresno	7	3,419	3.20	444	0.420	3.0	148.0	0.140
Long Beach	8	1,337	2.20	171	0.290	3.0	57.0	0.097
Burbank	9	1,931	2.70	253	0.350	3.0	84.3	0.117
San Bern	10	2,395	2.80	318	0.370	3.0	106.0	0.123
Palm Springs	15	4,821	2.80	640	0.370	3.0	213.3	0.123
Average		**2,781**	**2.74**	**365**	**0.360**	3.0	121.7	0.120

Table 4c: SDG&E Residential Verified RCA Baseline Assumptions and Measure Savings								
City	**CEC Forecast Zone**	**Baseline UEC (kWh/yr)**	**Baseline UED (kW)**	**kWh/yr Savings**	**kW Savings**	**Implicit Size (tons)**	**kWh/yr-ton Savings**	**kW/ton Savings**
San Diego	13	1,574	2.80	296	0.570	3.0	98.7	0.190
El Cajon	10	2,395	2.80	493	0.600	3.0	164.3	0.200
Average		**1,985**	**2.80**	**394**	**0.585**	3.0	131.3	0.195

We mapped zip codes into forecast zones (which are different from but related to the CEC climate zones listed in the zip code table above). This enabled us to determine the number of units and the total number of cooling tons in each of the forecast zones. The savings values were then calculated for each utility based upon the DEER values for that forecast zone, rather than the assumed equal distribution between zones and the assumed 3-ton average unit size.

Table 5: Residential RCA Verifications									
Zone Descriptor City	CEC Frcst Zone	kWh/yr per ton Savings	kW/ton Reduc-tion	Fully Detailed Units	Full Detail Tons	Extra Units	Extra Tons	kWh/yr Savings	kW Reduced
Sacramento	2	59.0	0.085	1,728	4,470	65	228	277,182	399.3
Fresno	3	148.0	0.140	683	1,896			280,608	265.4
San Jose	4	53.7	0.089	5	20			1,074	1.8
Napa	1	55.0	0.097	191	516			28,380	50.1
PG&E Total				**2,607**	**6,902**	**65**	**228**	**587,244**	**716.6**
Fresno	7	148.0	0.140	111	243			35,964	34.0
Long Beach	8	57.0	0.097	245	866			49,362	84.0
Burbank	9	84.3	0.117	1,286	4,736	300	1,050	487,760	677.0
San Bern	10	106.0	0.123	2,418	7,493			794,258	921.6
Palm Springs	15	213.3	0.123	144	536			114,329	65.9
SCE Total				**4,204**	**13,874**	**300**	**1,050**	**1,481,673**	**1,782.6**
San Diego	13	98.7	0.190	1,303	4,386	75	262	458,758	883.1
El Cajon	10	164.3	0.200	580	2,063	75	263	382,162	465.2
SDG&E Total				**1,883**	**6,449**	**150**	**525**	**840,919**	**1,348.3**
Grand Total				**8,694**	**27,225**	**515**	**1,803**	**2,909,836**	**3,847.5**

Commercial Gross Energy Savings

Commercial installations were categorized by building use rather than forecast zone. The following tables present the per-ton savings in each of the utility service territories. The implementers used an average based on an assumption that 1/3 of the installations would be retail establishments, 1/3 small offices, and 1/3 restaurants. The numbers were also based upon a 17% energy savings and a 57.5% "applicability factor" meaning that 57.5% of the verifications were assumed to require some sort of RCA modification.

Table 6a: PG&E Commercial Verified RCA Baseline Assumptions and Measure Savings								
Building	CEC Forecast Zone	Baseline EUI (kWh/yr)	Baseline (W/sf)	kWh/yr Savings	kW Savings	Implicit Size (tons)	kWh/yr-ton Savings	kW/ton Savings
Retail	All	3.47	3.48	509	0.390	4	127.3	0.098
Small Office	All	4.46	4.721	654	0.529	4	163.5	0.132
Restaurant	All	8.29	5.488	1,216	0.615	4	304.0	0.154
Average		**5.41**	**4.56**	**793**	**0.512**	**4**	198.3	0.128

Table 6b: SCE Commercial Verified RCA Baseline Assumptions and Measure Savings								
Building	**CEC Forecast Zone**	**Baseline EUI (kWh/yr)**	**Baseline (W/sf)**	**kWh/yr Savings**	**kW Savings**	**Implicit Size (tons)**	**kWh/yr-ton Savings**	**kW/ton Savings**
Retail	All	5.65	3.480	828	0.390	4	207.0	0.098
Small Office	All	3.95	4.181	579	0.469	4	144.8	0.117
Restaurant	All	6.92	4.581	1,015	0.514	4	253.8	0.129
Average		**5.51**	**4.08**	**807**	**0.458**	**4**	201.8	0.114

Table 6c: SDG&E Commercial Verified RCA Baseline Assumptions and Measure Savings								
Building	**CEC Forecast Zone**	**Baseline EUI (kWh/yr)**	**Baseline (W/sf)**	**kWh/yr Savings**	**kW Savings**	**Implicit Size (tons)**	**kWh/yr-ton Savings**	**kW/ton Savings**
Retail	All	5.65	3.480	828	0.390	4	207.0	0.098
Small Office	All	3.95	4.181	579	0.469	4	144.8	0.117
Restaurant	All	6.92	4.581	1,015	0.514	4	253.8	0.129
Average		**5.51**	**4.08**	**807**	**0.458**	**4**	201.8	0.114

We categorized the commercial units into these three categories. A large number of the units were in schools, and we were unable to locate parallel energy usage values specifically for schools. However, we compared equivalent HVAC units in similarly sized buildings called "schools" and "small offices" on the 2004 SPC estimating software and found that the "school" energy values ranged from 95% to 105% of the "small office" values. We therefore categorized the schools as "small offices." This category was also used for medical offices and most of the other customers for which we had no clear description. (We had customer names and used internet searches, but it was not always clear what the business was.)

We had unit-specific information on how much charge was required after verification. We were thus able to assess the "applicability" factor for each utility and each building type. This number is the percent of units verified that actually needed charge adjustments. In some cases it was higher than the assumed 57.5%, and in other cases it was lower. We calculated "equivalent tons" as the total number of actual cooling tons (for both the recorded units and the extra ones verified without full data) multiplied by the ratio of the specific applicability factor divided by the generic applicability factor (0.575).

For example, for small offices in the SCE service territory, 1053 tons were fully recorded and an additional 375 verified without site-specific details, making a total of 1,428 cooling tons. But 68.6% of the units needed charge adjustments, so more of these units achieved energy savings than in the original assumption. We multiplied 1428 tons by the ratio of 0.686/0.575 to arrive at 1,704 equivalent cooling tons. That is, if 1,704 tons had been verified and only 57.5% needed adjustment, the savings would have been the same as from these 1,428 tons where 68.6% needed adjustment. These results for all building types and utilities are shown in the table below.

Table 7: Commercial RCA Verifications										
Building Type	**Units**	**Tons**	**Applic Factor**	**Extra Units**	**Extra Tons**	**Equiv Tons**	**kWh/ yr-ton**	**kW/ ton**	**kWh/yr Savings**	**kW Reduced**
Retail	101	532	0.475			439	127.3	0.098	55,885	43.0
Small Office	3098	15598	0.511	444	2220	15835	163.5	0.132	2,589,023	2090.2
Restaurant	18	105	0.167			30	304.0	0.154	9,120	4.6
PG&E Total	**3217**	**16235**		**444**	**2220**	**16304**			**2,654,027**	**2137.8**
Retail	34	155	0.324			87	207.0	0.098	18,009	8.5
Small Office	236	1053	0.686	75	375	1704	144.8	0.117	246,739	199.4
Restaurant						0	253.8	0.129	0	0.0
SCE Total	**270**	**1208**		**75**	**375**	**1791**			**264,748**	**207.9**
Retail							207.0	0.098	0	0.0
Small Office	272	1075	0.636	25	125	1327	144.8	0.117	192,150	155.3
Restaurant							253.8	0.129	0	0.0
SDG&E Total	**272**	1075		**25**	**125**	**1327**			**192,150**	**155.3**
Grand Total	**3759**	**18518**		**544**	**2720**	**19422**			**3,110,925**	**2501.0**

Total Gross Energy Savings

The total gross energy savings are summarized in the following table:

Table 8: Gross Savings Summary						
Utility	Residential kWh/year	Residential kW	Commercial kWh/year	Commercial kW	**Total kWh/year**	**Total kW**
PG&E	587,244	716.6	2,654,027	2,137.8	**3,241,271**	**2,854.4**
SCE	1,481,673	1,782.6	264,748	207.9	**1,746,421**	**1,990.5**
SDG&E	840,919	1,348.3	192,150	155.3	**1,033,069**	**1,503.6**
Total	2,909,836	3,847.5	3,110,925	2,501.0	**6,020,761**	**6,348.5**

Net Energy Savings

The implementer used the default 0.89 net-to-gross ratio for the "residential contractor programs" as delineated in Table 4.2 of the CPUC *Energy Efficiency Policy Manual*.[3] We believe that free-ridership is close to zero and that, if anything, the 0.89 NTG ratio was conservatively low. We therefore did not propose re-evaluation of this stipulated value and incorporated it in our assessment of net energy savings and demand reduction.

The implementer also used the 0.89 net-to-gross ratio for commercial customers. However, the Energy Efficiency Policy Manual assigns a value of 1.00 to commercial "comprehensive space conditioning" measures.[4] We note also that Proctor Engineering's CheckMe program used an NTG of 0.89 for its residential refrigerant charge and airflow measures, but 1.00 for its commercial RCA measures.

We concur with this separation of residential and commercial measures, in part because we believe the residential number may be higher than 0.89 and the commercial number is probably slightly less than 1.00. Our net energy savings are therefore based on an NTG of 0.89 for residential measures and 1.00 for commercial measures.

The following table presents the net energy savings numbers. They are derived from the gross savings table above multiplied by the appropriate residential (0.89) or commercial (1.00) NTG ratio.

Table 9: Net Savings Summary

Utility	Residential kWh/year	Residential kW	Commercial kWh/year	Commercial kW	Total kWh/year	Total kW
PG&E	522,647	637.8	2,654,027	2,137.8	**3,176,674**	**2,775.6**
SCE	1,318,689	1,586.5	264,748	207.9	**1,583,437**	**1,794.4**
SDG&E	748,418	1,200.0	192,150	155.3	**940,568**	**1,355.3**
Total	2,589,754	3,424.3	3,110,925	2,501.0	**5,700,679**	**5,925.3**

[3] California Public Utilities Commission Energy Division, *Energy Efficiency Policy Manual Version 2*, p. 19. (San Francisco: CPUC, Aug 2003).
[4] *Ibid.*

Life-Time Energy Savings

The implementer used 15 years as the expected useful life of the measure. The rationale for this value is given the program implementation plan:

> **"Estimated Measure Life: 15 years.** This is equivalent to the EUL for "Air Conditioners – High Efficiency" (see Table 4.1, page 17, chapter 4 of the CPUC EEPM). The CPUC EEPM does not list an effective useful lifetime for RCA verification. Other programs have used 8 years and 10 years for proper RCA in retrofit applications assuming that the measure lasts as long as the remaining lifetime of an older air conditioner. The rationale for using a 15-year EUL is based on the fact that the air conditioner is new and will last 15 years. The program requires installation of permanent Verified™ RCA labels and Novent™ locking Schrader valve caps (on liquid and suction lines) to prevent future mal-adjustments, tampering, and refrigerant leaks once the unit is properly charged. Novent™ locking Schrader caps have secondary o-ring seals and built-in torque limitations to avoid over-tightening, over-compressing, and damaging the o-ring seal. Novent™ caps are laser-etched and color-coded to prevent mixing of refrigerants as HCFC refrigerants are phased out beginning in 2010 with final phase-out in 2030 (see http://www.epa.gov/spdpublc/title6/phaseout/hcfc.html)."[5]

We verified this with regards to other programs and found that the CheckMe program does indeed use 8 years for its EUL based upon the assumption that the average air conditioner lasts 18 years and the average existing air conditioner participating in the program is 10 years old. Thus CheckMe, like RCAVP, assumes that the adjustments will last for the remaining life of the air conditioner.[6] There might be some doubt as to whether this is true for either program. However, RMA's assertions about the RCAVP's longevity do present logical arguments. The Novent™ locking Schrader caps tend to prevent leaks, purposeful discharge (such as refrigerant theft or "sniffing"), or adjustments by amateurs or non-qualified technicians. The Verified™ RCA sticker also serves as a flag to both customers and repair technicians that the refrigerant charge had been fine-tuned in the past.

Rigorous evaluation of the EUL values is beyond the scope of this evaluation. Future longevity studies would be well suited to verify the proper charge and airflow of the air conditioners of participants several years after their participation. Ideally, the RCAVP software should indicate that no adjustments were needed even after a long duration of operation. We do offer the following analysis of known information about the RCAVP in support of the 15-year EUL. Of the verifications, 71.2% of them were on new units and 29.8% on existing units. Comparing this with the assumptions in the CheckMe program (18 year AC life and 10 year average age of an existing unit, from which they get an 8 year EUL), we arrive at an expected useful life of a RCAVP verification of 15.2 years:

$$(18\text{yr} \times 0.712) + (8\text{yr} \times 0.298) = 15.2\ \text{yr}$$

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[5] Robert Mowris & Associates. *RCA Verification Program for New Air Conditioners*. Program Implementation Plan Section IV.B.2.

[6] Proctor Engineering Group, *CheckMe! Verified AC System Optimization.* Program Implementation Plan, Section 4, Page 5. Here PEG cites its references for the 18-year life, which differs from the 15-year value in the CPUC Policy Manual.

The 15 year EUL therefore appears reasonable and consistent with other similar programs and is accepted. Table 10 delineates the life-time energy savings based upon this EUL.

Table 10: Net Life-Time Energy Savings			
Utility	Residential kWh/year	Commercial kWh/year	**Total kWh/year**
PG&E	7,839,705	39,810,405	**47,650,110**
SCE	19,780,335	3,971,220	**23,751,555**
SDG&E	11,226,270	2,882,250	**14,108,520**
Total	38,846,310	46,663,875	**85,510,185**

2004/2005 Breakout of Energy Savings

The CPUC reporting spreadsheets require breakdown of net savings estimates by year. In order to break out the 2004 and 2005 savings estimates, we multiplied the two-year net savings values by the percent of each measure group reported installed during 2004 to calculate the 2004 savings. These values are shown in Table 11.

Table 11: Calculation of 2004 One-Year Net Savings					
	Two-Year Savings		**2004 Installation Percent**	**2004 Savings**	
Sector	**kWh per yr**	**Peak kW**		**kWh per yr**	**Peak kW**
PGE Res	522,647	637.8	1.99%	10,401	12.7
PGE Com	2,654,027	2,137.8	0.71%	18,844	15.2
PGE Total	**3,176,674**	**2,775.6**		**29,245**	**27.9**
SCE Res	1,318,689	1,586.5	6.47%	85,319	102.6
SCE Com	264,748	207.9	21.85%	57,847	45.4
SCE Total	**1,583,437**	**1,794.4**		**143,166**	**148.0**
SDGE Res	748,418	1,200.0	3.13%	23,425	37.6
SDGE Com	192,150	155.3	0.74%	1,422	1.1
SDGE Tot	**940,568**	**1,355.3**		**24,847**	**48.7**
Totals	**5,700,679**	**5,925.3**		**197,258**	**224.6**

The four CPUC program reporting spreadsheets (SCE, PGE, SDGE, and the combined program total) are shown on the following four pages. The Peak MW values used are those defined in the 2001 DEER update study, "Average demand savings between noon and 6:00 p.m. from May through October."

SCE Program Energy Impacts for This 2004-2005 Program

Program ID:	1385-04							
Program Name:	RCA Verification Program for New and Existing Residential and Commercial Air Conditioners							
	Year	**Calendar Year**	**Gross Program-Projected MWh Savings**	**Net Evaluation Confirmed Program MWh Savings**	**Gross Program-Projected Peak MW Savings**	**Evaluation Projected Peak MW Savings****	**Gross Program-Projected Therm Savings**	**Net Evaluation Confirmed Program Therm Savings**
	1	2004		143		0.148		
	2	2005	2,229	1,583	1.708	1.794		
	3	2006	2,229	1,583	1.708	1.794		
	4	2007	2,229	1,583	1.708	1.794		
	5	2008	2,229	1,583	1.708	1.794		
	6	2009	2,229	1,583	1.708	1.794		
	7	2010	2,229	1,583	1.708	1.794		
	8	2011	2,229	1,583	1.708	1.794		
	9	2012	2,229	1,583	1.708	1.794		
	10	2013	2,229	1,583	1.708	1.794		
	11	2014	2,229	1,583	1.708	1.794		
	12	2015	2,229	1,583	1.708	1.794		
	13	2016	2,229	1,583	1.708	1.794		
	14	2017	2,229	1,583	1.708	1.794		
	15	2018	2,229	1,583	1.708	1.794		
	16	2019	2,229	1,440	1.708	1.646		
	17	2020						
	18	2021						
	19	2022						
	20	2023						
	TOTAL	**2004-2023**	33,431	23,751			0	0

PG&E Program Energy Impacts for This 2004-2005 Program

Program ID:	1395-04							
Program Name:	RCA Verification Program for New and Existing Residential and Commercial Air Conditioners							
	Year	**Calendar Year**	**Gross Program-Projected MWh Savings**	**Net Evaluation Confirmed Program MWh Savings**	**Gross Program-Projected Peak MW Savings**	**Evaluation Projected Peak MW Savings****	**Gross Program-Projected Therm Savings**	**Net Evaluation Confirmed Program Therm Savings**
	1	2004		29		0.028		
	2	2005	2,458	3,177	2.184	2.776		
	3	2006	2,458	3,177	2.184	2.776		
	4	2007	2,458	3,177	2.184	2.776		
	5	2008	2,458	3,177	2.184	2.776		
	6	2009	2,458	3,177	2.184	2.776		
	7	2010	2,458	3,177	2.184	2.776		
	8	2011	2,458	3,177	2.184	2.776		
	9	2012	2,458	3,177	2.184	2.776		
	10	2013	2,458	3,177	2.184	2.776		
	11	2014	2,458	3,177	2.184	2.776		
	12	2015	2,458	3,177	2.184	2.776		
	13	2016	2,458	3,177	2.184	2.776		
	14	2017	2,458	3,177	2.184	2.776		
	15	2018	2,458	3,177	2.184	2.776		
	16	2019	2,458	3,148	2.184	2.748		
	17	2020						
	18	2021						
	19	2022						
	20	2023						
	TOTAL	**2004-2023**	36,870	47,655				

SDG&E Program Energy Impacts for This 2004-2005 Program

Program ID:	1437-04							
Program Name:	RCA Verification Program for New and Existing Residential and Commercial Air Conditioners							
	Year	**Calendar Year**	**Gross Program-Projected MWh Savings**	**Net Evaluation Confirmed Program MWh Savings**	**Gross Program-Projected Peak MW Savings**	**Evaluation Projected Peak MW Savings****	**Gross Program-Projected Therm Savings**	**Net Evaluation Confirmed Program Therm Savings**
	1	2004		25		0.049		
	2	2005	973	941	0.993	1.355		
	3	2006	973	941	0.993	1.355		
	4	2007	973	941	0.993	1.355		
	5	2008	973	941	0.993	1.355		
	6	2009	973	941	0.993	1.355		
	7	2010	973	941	0.993	1.355		
	8	2011	973	941	0.993	1.355		
	9	2012	973	941	0.993	1.355		
	10	2013	973	941	0.993	1.355		
	11	2014	973	941	0.993	1.355		
	12	2015	973	941	0.993	1.355		
	13	2016	973	941	0.993	1.355		
	14	2017	973	941	0.993	1.355		
	15	2018	973	941	0.993	1.355		
	16	2019	973	916	0.993	1.306		
	17	2020						
	18	2021						
	19	2022						
	20	2023						
	TOTAL	**2004-2023**	14,595	14,109				

Sum Of Energy Impacts for This 2004-2005 Program

Program IDs*:	1385-04; 1395-04; 1437-04							
Program Name:	RCA Verification Program for New and Existing Residential and Commercial Air Conditioners							
	Year	**Calendar Year**	**Gross Program-Projected MWh Savings**	**Net Evaluation Confirmed Program MWh Savings**	**Gross Program-Projected Peak MW Savings**	**Evaluation Projected Peak MW Savings****	**Gross Program-Projected Therm Savings**	**Net Evaluation Confirmed Program Therm Savings**
	1	2004		197		0.225		
	2	2005	5,660	5,701	4.885	5.925		
	3	2006	5,660	5,701	4.885	5.925		
	4	2007	5,660	5,701	4.885	5.925		
	5	2008	5,660	5,701	4.885	5.925		
	6	2009	5,660	5,701	4.885	5.925		
	7	2010	5,660	5,701	4.885	5.925		
	8	2011	5,660	5,701	4.885	5.925		
	9	2012	5,660	5,701	4.885	5.925		
	10	2013	5,660	5,701	4.885	5.925		
	11	2014	5,660	5,701	4.885	5.925		
	12	2015	5,660	5,701	4.885	5.925		
	13	2016	5,660	5,701	4.885	5.925		
	14	2017	5,660	5,701	4.885	5.925		
	15	2018	5,660	5,701	4.885	5.925		
	16	2019	5,660	5,504	4.885	5.700		
	17	2020						
	18	2021						
	19	2022						
	20	2023						
	TOTAL	**2004-2023**	84,896	85,515				

Hard-to-Reach Customers

The program implementers set a goal of achieving at least 10% of the measures in "hard-to-reach" (HTR) customers. The database kept track of the various HTR categories for each customer. Although it allowed for categorizing a customer as HTR because of either language or income, technicians did not appear to use these categories. (Five non-English customers and no low-income customers were identified.) The geographic, housing type (multifamily or mobile home), and tenant categories were recorded.

The CPUC defines geographically hard-to-reach customers as those that live outside of the San Francisco Bay Area, the San Diego Area, the Los Angeles Basin, or Sacramento.[7] However, these terms themselves are not exactly defined. Many people in Santa Rosa, for example, do not think of themselves living in the San Francisco Bay Area, yet Sonoma and Marin counties are commonly referred to as "the North Bay." Many Orange County residents tout themselves as different from Los Angeles, yet it would be hard to argue that Orange County was any harder to reach than Los Angeles County. The so-called "Inland Empire" of metropolitan Riverside and San Bernardino is even less certain as to whether it is "hard to reach" by definition or is part of the "Los Angeles Basin."

For the sake of precision (if not perfect accuracy), we defined the San Francisco Bay Area as including zip codes 945xx, 949xx, and 951xx (as well as others in which there were no RCAVP customers). We defined the Los Angeles Basin as including zip codes 902xx, 905xx, 906xx, 907xx, 908xx, 917xx, 926xx, 927xx, and 928xx (again as well as others in which there were no RCAVP customers); this essentially included Los Angeles and Orange counties but only the westernmost portions of Riverside and San Bernardino counties. The "San Diego Area" was defined as zip code 921xx, and we also included the Orange County zip codes 926xx that are part of SDG&E territory. Surely parts of zip codes 919 and 920 should be included as well, but then SDG&E would seem not to have any geographically hard-to-reach areas in its service territory.

We know that this definition may not necessarily be uniformly agreed to. However, the database itself defined many customers even in these areas as geographically hard to reach, so we excluded them. Furthermore, the goal of 10% HTR customers was far exceeded no matter what logical definitions one would use for the vaguely defined Bay, Los Angeles, and San Diego areas.

Table 12 presents a summary of the quantities of hard to reach customers by utility service territory. Note that the "total HTR" quantity is less than the sum of the various HTR categories because many customers fulfilled the criteria for more than one category (such as a renter in a multifamily dwelling in a rural area).

[7] CPUC *Energy Efficiency Policy Manual Version 2*, page 43.

Table 12: "Hard-to-Reach" Customers						
Utility/Type	**Total**	**Geographic HTR**	**Multi-family**	**Tenants**	**Total HTR**	**Percent HTR**
PG&E Com	3217	2821	N/A	0*	2821	88%
PG&E Res	2611	2503	1101	1423	2542	97%
SCE Com	270	54	N/A	3*	57	21%
SCE Res	4202	1947	487	313	2196	52%
SDG&E Com	272	3	N/A	0*	3	1%
SDG&E Res	1881	692	58	0*	750	40%
Total	**12,453**	**8,020**	**1,646**	**1,739**	**8,369**	**67%**

* It appears as if commercial customers were not diligently categorized as owners or tenants.

Outreach to small HTR contractors was an important focus of the program. The program trained and equipped 237 technicians from small HVAC companies or 67% of the total participants. Small contractors performed approximately 32% of all the jobs submitted by the program. Schools accounted for 21 percent of the total jobs under the program. Multi-family accounted for 13% and single-family accounted for 57% of all jobs. The remaining 9% of jobs were miscellaneous commercial jobs (i.e., hotels, retail, offices, etc.). Most of the residential jobs were performed at new homes, which was a primary focus of the program.

Comparison of Goals and Results

Table 13 compares the implementer's goals and our verified results for net program savings in the various categories delineated for each utility service territory. Note that the ratio of residential and commercial units – proposed as 2/3 and 1/3, respectively, for each territory – was not consistently met. However, the total number of units in each utility service territory exceeded the goal and the statewide totals for energy savings were exceeded.

Table 13: Goals and Results Comparison

Utility/Measure	Implementer Goal	Verified Results	Percent of Goal
PG&E			
Residential Units	3,880	2,673	**69%**
Commercial Units	1,940	3,661	**189%**
Total Units	5,820	6,334	**109%**
Hard To Reach Percent	10%	92%	**920%**
Peak Demand Savings kW	1,944 kW	2,776	**143%**
Net Annual kWh Savings	2,187,602	3,176,674	**145%**
Lifecycle kWh Savings	32,814,033	47,650,110	**145%**
SCE			
Residential Units	2,900	4,504	**155%**
Commercial Units	1,450	345	**24%**
Total Units	4,350	4,849	**111%**
Hard To Reach Percent	10%	50%	**500%**
Peak Demand Savings kW	1,520	1,794	**118%**
Annual kWh Savings	1,983,499	1,583,437	**80%**
Lifecycle kWh Savings	29,752,478	23,751,555	**80%**

Table 13: Goals and Results Comparison			
Utility/Measure	**Implementer Goal**	**Verified Results**	**Percent of Goal**
SDG&E			
Residential Units	1,220	2,033	**167%**
Commercial Units	610	297	**49%**
Total Units	1,830	2,330	**127%**
Hard To Reach Percent	10%	35%	**350%**
Peak Demand Savings kW	884	1,355	**153%**
Annual kWh Savings	865,926	940,568	**109%**
Lifecycle kWh Savings	12,988,883	14,108,520	**109%**
Statewide Total			
Residential Units	8,000	9,210	**115%**
Commercial Units	4,000	4,303	**108%**
Total Units	12,000	13,513	**113%**
Hard To Reach Percent	10%	67%	**670%**
Peak Demand Savings	4,348	5,926	**136%**
Annual kWh Savings	5,037,027	5,700,679	**113%**
Lifecycle kWh Savings	75,555,394	85,510,185	**113%**

Training Goals and Accomplishments

The program implementers set a goal of training 99 technicians – 48 in PG&E territory, 36 in SCE territory, and 15 in SDG&E territory.

Technicians were assigned specific PDAs by serial number when they were trained. RMA kept a database of the PDAs containing the name of the technician, the name of the contractor, PDA serial number, technician measurement equipment (and calibration), and the EPA registration number of the technician. We were provided a complete copy of this database. A total of 353 technicians were trained. Of these, 206 worked in PG&E territory, 123 worked in SCE territory, and 67 worked in SDG&E territory. (This totals to more the 353 because some technicians work in two utility service territories.)

Thus the number of technicians trained was three to five times as great in each utility territory and 357% of the overall goal.

Meeting Goals and Accomplishments

The program implementers had goals to meet with various people to promote the RCA Verified concept. The meetings planned by the program implementers were:

- With manufacturers to adopt longer warranty for RCA-verified air conditioners and shorter warranty for non-verified units
- With the California Energy Commission's Title 24 codes and standards programs to recommend requiring RCA verification on new air conditioners for new buildings
- With the U.S. Department of Energy to suggest future efficiency standards for new air conditioners require RCA verification
- With the U.S. Environmental Protection Agency to recommend EnergyStar labels for new air conditioners require RCA verification
- With the Federal Trade Commission to suggest the yellow efficiency labels for new air conditioners discuss the importance of proper RCA verification and include information about RCA verification.

All of these meetings were accomplished.

Manufacturer. On July 20, 2005, Robert Mowris spoke by telephone with Don Schuster, engineer, and Ram Motupalli, regional manager, of Carrier Corporation. The meeting discussed the importance of the verification of proper refrigerant charge and airflow and duct testing and sealing with respect to improved energy efficiency and warranties for new air conditioners. A PowerPoint presentation was then sent to them, and follow-up emails discussed the California Title 24 standards regarding quality installation and the inclusion of proper RCA and duct testing and sealing.

California Energy Commission. Robert Mowris spoke with Tav Cummins of the CEC regarding the possibility of having Title 24 codes and standards programs require RCA verification on new air conditioners. Robert presented the results of RMA's studies and his rationale for requiring RCA verification. Robert also made a presentation to the CEC 2008 Building Energy Efficiency Standards Workshop on March 28, 2006, and coordinated that presentation with Ram Verma of the CEC. The presentation is on the CEC website at http://www.energy.ca.gov/title24/2008standards/documents/index.html#032806.

We contacted Ram Verma, the senior engineer of the California Energy Commission who is responsible for revisions to the 2008 revisions to the building standards. Ram verified that it is the intent of the CEC to incorporate Robert Mowris' recommendation to require RCA verification on all new split-system and packaged unit air conditioners, both commercial and residential, with and without a TXV. He also indicated that research presented by RMA, including information gathered through this program, was instrumental in this endeavor.

The CPUC has begun to allocate energy savings to the utilities' codes and standards programs based upon the utilities' work to influence changes to these standards, and thereby to produce savings in the future when these regulations become effective. We believe that it is appropriate to allocate such savings to the RCAVP because the implementer was able to provide specific information to the CEC regarding the need for RCA adjustment in both new and existing residential and commercial AC units, including those with TXVs. This information was clearly influential in the CEC's proposal to expand the situations in which RCA verification is required.

The allocation of such savings is extremely complex. Methodologies have just recently been developed for the overall utility efforts.[8] Calculation of such savings is clearly beyond the scope of this evaluation report. That does not mean, however, that we do not believe these savings will be very significant. We note, for example, that 45% of new residential air conditioners with TXVs required an RCA adjustment, and 66% of new commercial air conditioners with TXVs required an adjustment. The overall increased efficiency of newly installed units will thus be greatly improved when RCA verification is required of all units. These savings track, at least indirectly, to the RCAVP because it is through its database and its implementer's diligent conviction regarding this need that the Energy Commission chose to revise the standards.

Federal Government Agencies. The implementers met with Jean Boulin, codes and standards outreach director, and Richard Karney, director of EnergyStar products, of the Department of Energy, and Andrew Fanara, EnergyStar product development manager of the Environmental Protection Agency, during the 2004 ACEEE Summer Study held August 22-27, 2004, at Pacific Grove, California. They discussed the possibility of addressing RCA verification in future efficiency standards and EnergyStar programs for new air conditioners. They recommended that a third-party verification of proper refrigerant charge and airflow for new units be required in order for them to receive the EnergyStar label.

[8] See, for example, Douglas Mahone et al, *Codes and Standards White Paper on Methods for Estimating Savings*, April 13, 2005, available as Study SCE0240.01 at www.calmac.org.

These people are also the DOE advisors to the Federal Trade Commission, and they were given the recommendation that the yellow Energy Guide Labels be revised to include information about refrigerant charge and airflow verification. In addition to these in-person meetings, RMA staff also spoke by telephone with Rolf Butters, USDOE inventions portfolio manager, David Korn and Buck Taylor of CADMUS Group (consultants to the DOE), Harvey Sachs of the American Council for an Energy-Efficiency Economy (ACEEE), and John Taylor of the Consortium for Energy Efficiency (CEE) concerning federal requirements and recommendations for RCA verification.

PROCESS EVALUATION

Participant and Non-Participant Contractor Interviews

A list of program participants and non-participants[9] was received from the implementers. Attempts were made to contact 100% of the survey population. The evaluation method for this report included interviews with 24 of the 38 contractors listed as participants and 12 of the 46 contractors listed as non-participants. Following is a summary of these interviews. These interviews were conducted in 2004, and the summary information was provided to the program implementers for their awareness and as a means for them to address any remediable issues mid-stream.

REASONS FOR PARTICIPATION

- Eleven of the 22 participant contractors (50%) stated that they decided to participate because of the program's accuracy and precision in verifying refrigerant charge and airflow.

- The handheld PDA was another factor that led to their decision to participate. The PDA, unlike traditional methods, provides an instantaneous display of the information necessary to assess and perform a proper refrigerant charge. Twenty of 23 contractors (87%) believed the PDA recommended adjustments are "very accurate," while 13% felt they are "somewhat accurate."

- Several respondents said that they felt it was their duty to provide the best service to their customers, and this program facilitated that goal. Other reasons for participation included customer benefits, additional revenue (rebate) received, and a selling advantage over their competitors.

- One respondent said "I found it's better than what we were doing; we were undercharging the system."

REASONS FOR NON-PARTICIPATION:

- One non-participant cited the perceived amount of time it would take to join the program, while another cited lack of interest in changing old methods of verifying refrigerant charge.

- Several non-participants felt that the rebate was not enough to cover the cost of change from their previous methods regardless of the potential benefits of the program.

[9] "Non-participants" in this case being contractors who had been contacted by RMA but at the time of contact had not chosen to participate in the program.

- Other non-participants felt that they would need to change their organizational structure, computer system, and filing systems of their office to accommodate this program. Many felt that this "necessary" change was too much of an expense and therefore not worthwhile.

PARTICIPANT INITIAL RESPONSE TO PROGRAM:

- Of the 24 participants interviewed in the survey, 22 of them entered into the program with completely optimistic and positive outlook.

- One participant was initially concerned and skeptical that such a program was possible. That participant in a later question said that since his company's involvement in the program, his views on the effectiveness, benefits, and capacity of the RCA Verification program have positively changed.

NON-PARTICIPANT INITIAL RESPONSE TO PROGRAM:

- Of the 13 non-participants who addressed why they did not participate in the program, 10 stated they had never heard of the program or did not remember being contacted by RMA. (The implementer reports that the program's limited "marketing" budget affected their ability to market the program to all contractors in California.) This response also supports the contractors' claims that they are too busy and do not have time to participate in programs like these. (The implementers report that they called and left messages with each contractor at least five or six times, yet, as one participant stated, "No one knew anything until they showed up at our door.")

- Two of the thirteen non-participants recalled their initial response to the program. One of the non-participants was fairly encouraged when approached by an RMA associate but maintained that he had no time to implement such a program. The other non-participant recalled in great detail spending time with an RMA associate testing the product. This non-participant felt that the algorithms used to calculate the charge did not take into consideration certain situations unique to his climate zone, yet conceded that if those issues were resolved, revisiting the program would be possible.

OTHER PROGRAMS USED TO VERIFY RCA:

- Both participants and non-participants were asked whether they participated in any other program to verify refrigerant charge and airflow. Table 14 represents the breakdown of the responses of the 36 respondents. Note that over half (53%) did not participate in any such programs:

Table 14: What other programs have you used to verify refrigerant charge and air flow?

Other Program	Frequency	Percent
CheckMe	8	22.2
E-nalysis	1	2.8
Utility training programs	3	8.3
Other	3	8.3
Don't know	1	2.8
No other programs	19	52.8
Total	36	100.0

- 22% (8 of 36) respondents (non-participants and participants) stated they had participated in the CheckMe program.
- Five participants were involved in the CheckMe program. Of these, four (80%) stated they are more satisfied with the RCA Verification Program than with CheckMe.
- Both participants and non-participants were asked whether or not they were more, less, or equally satisfied with the RCA Verification program compared to other programs that they had used before; 97% said that they were more satisfied the RCA Verification program, and 3% said their satisfaction with the RCA Verification program was about the same.

PERCENTAGE OF INSTALLATIONS/SERVICES THAT USE RCA VERIFICATION PROGRAM:

- Nine of 24 of participant respondents (37%) stated 100% of their jobs use the RCA Verification program. Four participants indicated 0-30% of their jobs use the program; 6 participants indicated 40-50% of their jobs use the program; 2 participants indicated 60-75% of their jobs use the program; and 3 participants indicated 90-95% of their jobs use the program.

DEGREE CONTRACTORS FEEL INCORRECTLY CHARGED AIR CONDITIONING SYSTEMS ARE AN ISSUE IN THE INDUSTRY

- 88% (21 of 24) participants and 50% (6 of 12) of non-participants stated that they felt incorrectly charged air conditioning systems are a major issue in the industry. 33% (4 of 12) non-participants felt it was somewhat of an issue in the industry.

Table 15: To what degree do you feel incorrectly charged air conditioning systems are an issue in the industry?

	Participants		Non-Participants	
	Count	**Percent**	**Count**	**Percent**
Major Issue	21	88 %	6	50%
Somewhat of an issue	1	4%	4	33%
Not an issue	1	4%	1	8%
Don't know	1	4%	1	8%

- Many of the participants felt that California was going to, and needed to, create a universal system of verification standards in the HVAC industry. One contractor commented, "If you look outside my company, other companies don't train their techs. The technicians don't even know what superheat and subcooling are."

DOES THE PROGRAM ADDRESS THE PROBLEM OF AIRFLOW?

- 71% of participants stated that the program addresses the problem of airflow.

- Most respondents said that the problem of airflow has too many variables that need to be considered when verifying; it was difficult for some participants to say whether or not the RCA Verification program is sufficient given other variables that are difficult to account for (*e.g.*, ducts).

CONTRACTOR SATISFACTION WITH PROGRAM MARKETING EFFORTS

- A combined total of 28% of participants and non-participants felt very satisfied with the marketing efforts of the program; 38% of program participants were very satisfied; 38% were somewhat satisfied; and 4% were not satisfied.

- Most of those who participated heard about the program from fellow contractors and colleagues rather than the RMA associates. Table 16 illustrates how participants heard about the program:

Table 16: How did you hear about the RCA Verification program?

Source	Frequency	Percent
Supervisor	1	4.2
Colleague	3	12.5
RMA rep	6	25.0
Distributor	3	12.5
Other	10	41.7
Don't know	1	4.2
Total	24	100.0

MANUFACTURER AND DISTRIBUTOR AWARENESS

- 67% of participant contractors stated their manufacturers and distributors are aware of the program.

- 79% of participants felt it would help awareness if distributors or manufacturers recommended Verified RCA installations or services.

- 79% of participants have informed builders or home owners of their participation in this program.

- 88% of participants felt it would help if the program had better advertising to builders and homeowners.

PERCENT OF RCAV JOBS PERFORMED OUTSIDE OF UTILITY SERVICE TERRITORIES

- 9 of 20 participants indicated that 100% of the jobs performed are within their utility territory. Four participants indicated that 1-5% of jobs are performed outside their utility territory, while 4 participants indicated that at least 10% of their jobs are performed outside their utility territory, and 3 participants did not know. *(Note that all jobs receiving incentives were performed within the IOU service territories.)*

PERFORMANCE ENHANCEMENT OF TECHNICIANS

- 87% of participants felt the RCA Verification Program has enhanced their technicians' performance on the job.

- The reason most commonly given was that the PDA reduces the amount of error that was typical with the traditional methods; therefore the business as a whole and the technicians can be more productive and effective.

BENEFIT OF THIRD PARTY VERIFICATION OF A/C INSTALLATIONS OR SERVICES

- 56% of participants felt it would be beneficial to have a third party verification of A/C installations and services, 9% said it would be somewhat beneficial, and 35% said it would not be beneficial

- Several participants replied that if the HVAC industry had higher standards that were enforced, third party verification would not be necessary.

LINKAGE TO OTHER UTILITY PROGRAMS

- 87% (14 of 16) of participants felt that the RCA Verification Program should be linked to existing utility rebate programs. Two participants didn't know if it should be linked.

- 56% (9 of 16) of participants felt linking the RCA Verification Program to existing utility rebate programs would enhance the program benefits and rebate amount their company would receive. Three participants didn't know, and three participants felt the linkage would not enhance the program benefits and rebate amount.

- 75% of participants and 40% of non-participants felt existing utility rebate programs and independent third party rebate programs should be linked together to enhance program benefits.

PROGRAM RECOGNITION, EFFECTIVENESS, AND EXPANSION THOUGH THE HVAC INDUSTRY

- When asked how participants anticipate the program expanding throughout the HVAC industry, the following responses were received:

    - Hope it will become mandatory
    - It should continue to expand
    - Put it out more to contractors and Title 24, more advertising
    - It should become mandatory
    - More contractors need to realize how much it saves
    - It preserves the integrity of us all
    - Hope it does
    - Time

- Many respondents said that if it spread throughout the industry, it would create a higher and more stringent standard for contractors to follow, which would ultimately benefit the entire industry.

- The main concern regarding program expansion was funding. General comments received from participants indicated that most contractors are not willing to spend their personal money on fixing a problem that they "are not ultimately responsible for."

- Regardless of the cost, most participants agreed that higher standards were seriously needed in the industry.

- 96% (21 of 22) participants felt this program should be recognized for its effectiveness in correctly verifying refrigerant charge and airflow, while one participant said it should not.

PROGRAM STRENGTHS AND CONTRACTOR SATISFACTION WITH THE PROGRAM

- 96% (23 of 24) of participants stated they felt this program should be continued.
- 83.3% of the participants felt that their technicians' performance had improved since program inception.
- 63% of participants would or have recommended this program to other contractors or installers. One participant who said he would not recommend this program to other contractor or installers stated it in an essentially positive manner, "Why would I do that? I have a competitive edge over my competition, and I'm not going to give it away."
- 75% of participants stated they are "very satisfied" with the program, while 25% stated they were "somewhat satisfied."
- Feedback given regarding strengths of the program was very positive and diverse. The most common response was that the PDA and the whole program in general gives them a sense of receiving the most accurate and correct information available about the charge. Other comments mentioned that an accurate charge results in "less call backs," "the customer is getting what they paid for," and the program has saved time and energy for their business.
- The PDA and software are considered easy to use. One contractor mentioned that the PDA "was fairly easy to use and it allows you to make corrections."
- Businesses are beginning to receive recognition from homeowners and homebuilders for their involvement in the program.
- Technicians are benefiting from the training and the software, "Making sure the customer gets the best from their A/C." One participant mentioned that technology has finally caught up with them, and that they are going to need to learn how to use computers in order to stay competitive in the industry. This participant said by being involved in the program, they are "getting a head-start on the rest of the competition who has yet to learn about the new technology."

SUGGESTIONS FOR PROGRAM IMPROVEMENT

- A common criticism was that the participants felt the government (*e.g.* the Contractor's State License Board) was not doing its part to support this program.
- Participants felt that additional funding and support should be given to the RCA Verification program because it is more efficient and effective than other programs.
- The PDA was cited for losing data when the battery died. Whenever the PDA would charge down all the information would be lost on the PDA. The "penguin"

Verified RCA icon would disappear and the contractors would have to return to the site to allow it to recharge. *(This issue occurred in the early start-up phase of the program. After it was brought to RMA's attention, all technicians received a wall and car charger and were notified to keep the PDA plugged in when not in use. They were also told to upload job data as soon as possible to avoid losing jobs. Participants had only reported losing 10 jobs out of 2,671 jobs turned in as of the survey date of May 20, 2005.)*

- A few contractors indicated a desire to have a larger screen to input and read the data, as well as a backlight.

OTHER INTERESTING COMMENTS

Several interesting comments from contractors about the HVAC industry surfaced during the course of the survey process:

- More than one respondent said many manufacturers do not care about whether or not their products are properly charged.

- Several respondents who were involved in the "new home" industry said that many manufacturers do not care about the air conditioners they are making because "when they are sold to the contractors it becomes the contractor's or developer's responsibility to provide a warranty for the products, not the manufacturer." This contractor recommended that the government to not only create higher standards for the contractors, but for the "entire industry" as well.

- Most of the participants who were not reaching their job attainment quotas were having difficulty training some of their "less computer savvy employees" and several even alluded to the fact that the employees were resisting "not the principle of the program, but rather the technological concept itself."

- One respondent suggested that [California] not limit its focus to new developments, but also old homes as well. He felt that [California] is targeting only new homes in the form of rebates to encourage energy efficiency in new developments. His suggestion is that even older homes can be energy efficient and that targeting newer developments is not addressing the issue of energy conservation as a complete issue but rather focusing all the funds and issues on one sector of the industry.

Technician Pre- and Post-Training Surveys Interviews

Written questionnaires were given to technicians before and after receiving training from the program implementer's staff. The surveys strove to ascertain prior knowledge and techniques as well as assess the quality of the training and the technician's views on the importance of proper refrigerant charge and airflow. A total of 32 technicians completed the pre-training questionnaire; 25 of these also completed the post-training questionnaire. The survey instruments and their tabulated responses are included in the appendix.

Respondents varied significantly in their experience in the industry. Seven (22%) had four years or less experience, and five (17%) had 20 years or more experience, with the other dispersed between those ranges.

The technicians used a variety of tools. They also had a variety of means to determine proper refrigerant charge and airflow. About half of them used the cardboard calculators provided by some HVAC manufacturers. Fourteen of 25 respondents (56%) reported having received prior training regarding proper refrigerant charge and airflow.

All respondents indicated that they had never had a customer ask for Verified RCA installations or services.

The training sessions enhanced the technicians' awareness of the effectiveness and accuracy of their previous equipment and rules of thumb. Table 17 shows before and after responses to these questions. Note the general trend that the technicians' opinions of their prior equipment *decreased* as a result of their training. This was the intended result, as they were being trained on the importance of accurately using proper equipment. The responses on the pre-training questionnaire are highlighted in pink; those from the post-training questionnaire are highlighted in green.

Table 17: Technician Ranking of Previous Equipment Before (Pink) and After (Green) RCAVP Training

Question	Poor	Fair	Aver-age	Good	Very Good	Excel-lent	Don't Know
How would you rate the *effectiveness* of the equipment you've used in the past to ensure proper refrigerant charge and air flow?	0%	3%	23%	17%	40%	13%	3%
	4%	12%	24%	28%	24%	8%	0%
How would you rate the accuracy of the equipment you currently use to ensure proper refrigerant charge and air flow?	0%	3%	23%	17%	43%	10%	3%
	0%	8%	24%	32%	28%	8%	0%
How would you rate the effectiveness of the "rules of thumb" you currently use to ensure proper refrigerant charge and air flow?	3%	0%	24%	21%	31%	17%	3%
	21%	21%	17%	24%	17%	0%	0%

In the post-training survey, the technicians were also asked about the PDA and software. Table 18 presents the results. In general, it ranked higher in effectiveness than it did in user-friendliness or speed.

Table 18: Technician Views of PDA and Software

Question	Poor	Fair	Aver-age	Good	Very Good	Excel-lent	Don't Know
Effectiveness of PDA software	4%	0%	8%	16%	48%	24%	0%
User-Friendliness of PDA software	4%	4%	12%	24%	36%	20%	0%
Speed of PDA and software	4%	4%	16%	36%	24%	16%	0%
Likelihood of using PDA during installations and services	0%	0%	4%	21%	33%	42%	0%

The technicians were also asked about their agreement with certain statements about the program and its various components. Table 19 delineates those responses.

Table 19: Technician Views of Program Components and Effects

Question	Strongly Disagree	Disagree	Moder-ately Disagree	Moder-ately Agree	Agree	Strongly Agree	Don't Know
I am confident the Verified RCA stickers will help identify and maintain proper refrigerant charge.	0%	0%	0%	7%	43%	43%	7%
I am confident the locking Schrader caps will identify and maintain proper refrigerant charge.	4%	0%	0%	4%	40%	52%	0%
I am confident our customers will benefit from using the Verified RCA PDA software.	43%	0%	0%	14%	36%	0%	7%
I am confident our business will benefit from using the Verified RCA PDA software.	0%	8%	4%	20%	24%	40%	4%
I *personally* favor using the Verified RCA PDA software over the "old method."	14%	0%	7%	7%	43%	22%	7%
The Verified RCA PDA software is easy to use.	0%	7%	0%	14%	43%	36%	0%
The Verified RCA PDA software is easy to understand.	4%	8%	4%	40%	24%	20%	0%

Virtually everyone agreed that the Verified™ stickers and the locking Schrader caps would help identify and maintain proper refrigerant charge.

Most of the technicians felt that the program would be beneficial to their companies, but there was a strong split of opinion regarding whether it would be beneficial to the customer. Half of the technicians "agreed" or "moderately agreed" that it would be beneficial. However, 43% "strongly disagreed" with this idea, and no one "strongly agreed" with it. We find this result intriguing. It appears to indicate that these technicians did not learn that finely-tuned proper RCA makes an air conditioner work more efficiently, which would therefore reduce a customer's electric costs and therefore benefit the customer.

Finally, we asked the technicians about the training itself and the implementer's training staff. For the most part, the training was well received. Table 20 delineates specific responses.

Table 20: Technician Views of Training

Question	Strongly Disagree	Disagree	Moder-ately Disagree	Moder-ately Agree	Agree	Strongly Agree	Don't Know
The training workshop was worthwhile.	0%	0%	0%	16%	40%	40%	4%
Today's instruction and training were easy to understand.	4%	4%	4%	36%	32%	20%	0%
	Poor	Fair	Average	Good	Very Good	Excel-lent	Don't Know
Satisfaction with today's training workshop.	0%	8%	4%	12%	48%	28%	0%
Satisfaction with the PDA demonstration.	0%	4%	0%	20%	48%	28%	0%
Ability of the instructors to answer your questions.	0%	0%	4%	12%	24%	60%	0%
Effectiveness of the hands-on experience using the PDA software.	4%	0%	8%	28%	32%	28%	0%

Half of the technicians indicated they would like to receive further instruction on the PDA and software. When asked what recommendations they had for improving the training, most left the question blank and some wrote "none." Four respondents (16%) wrote in that they would like more hands-on training. When asked for recommendations for improving the PDA and software, most also left this question blank. (Note that the question was asked just after training, but prior to actual on-the-job use of the PDA.) Two mentioned comments about it taking too much information. Another respondent indicated that it was hard to tell when the Schrader caps were on tight because they keep spinning (due to built-in torque limit to prevent over-compressing the o-ring seal). Some specifically commented that the instructors were very good and that they liked the program.

Observation of Implementation Processes

PDA Issues. The initial PDAs had volatile memory. If they discharged, they would lose all of the data that had been input. This became a critical issue when data had been stored at field locations and PDAs discharged in technician trucks on the way back to the office. The problem was initially remedied by emphasizing the vital importance of keeping the PDA plugged into its charger when not in use. Later, new models of PDA with non-volatile memories were obtained, eliminating this problem. This was a major step forward.

A few technicians complained that the PDAs were difficult to use. There are several causes of this belief, and it presumably varies from technician to technician. For some it may be the matter of having to enter so much information. For others, however, it may be more related to the way in which data is entered. For those who are not already familiar with using a personal data assistant, there is a certain difficulty inherent with learning how to poke numbers with a small stylus in a small area. We note that other versions of the program are available, including a windows-PC version of the software and telephone interactive voice response (IVR) software on a toll-free line. According to the implementer, the PDA platform was chosen by most technicians based on size (fit into a pocket), rugged design, ease of use, reliability, and lowest cost.

Training. Aloha Systems staff attended several training functions. We found the training to be very good and at the appropriate level for the audience. The RMA employees who provided the training did a very good job, knew their material well, and patiently and accurately answered the questions of the technician-students. This perception of quality was supported by the surveys of the students.

Some students wished that they could have more hands-on training time. At some training sessions it was difficult to provide a full complement of hands-on training either because there were not enough AC units for each student to test or because weather conditions did not facilitate accurate use of the PDA and software. (The algorithms cannot verify proper refrigerant charge when it is too cold outside.)

We do not necessarily believe more training time is required. However, one possible suggestion would be to provide the PDA and software to the technicians a week or so before the training, along with written instructions. They should then be encouraged to try it out. They would then be coming to class already having questions in mind and an understanding of what they most needed to learn.

We remain puzzled as to why 43% of the technicians surveyed immediately after their training did not feel the program would benefit the customers. While it seems obvious that benefit to the contractor or technician may be a gray area, benefit to the customer – who will benefit by having a more efficient air conditioner – should be obvious. Perhaps the training sessions need a simply stated, relatively brief discussion regarding this chain of events that underlies the program theory: (1) many air conditioners do not have proper RCA; (2) only with precisely proper RCA does an air conditioner run at its full rated efficiency; (3) when an air conditioner runs at its full efficiency it saves energy, which is

why the utilities support the program; and (4) by saving energy the customers benefit. The training materials and presentations provided this information to technicians, but the survey responses indicate that this was not always clearly understood.

Budgeting and Money Flow. According to the implementers, the original statewide marketing budget was $120,000, but only $40,000 was approved. The implementer's final report states "Lack of sufficient marketing budget to inform customers, builders, and dealers about the importance of RCA verification slowed progress towards goal attainment."[10] We concur with this belief and cite the responses of participant and non-participant contractors in support. Ten out of 13 non-participants interviewed did not actually remember being contacted, even though RMA contacted them by telephone five or six times. Some participants indicated really paying attention to the program only after an RMA employee visited them in person.

The program met its quantity, kWh, and kW goals. However, we should note that the majority of the work (68%) was performed by medium and large contractors. Most of the commercial work (70%) was performed for large customers such as school districts. What suffered from the limited marketing budget was the program's ability to get the message out to all utility customers that RCA verification is important. This might have been enhanced if more small contractors who participated in the program had performed the number of jobs they committed to perform. The program had more than ten thousands commitments from small contractors, and reaching out to small contractors was a major focus of the program. Small contractors were generally under-staffed and had high employee attrition, which caused them not meet their commitments. Nevertheless, the program trained and equipped 237 technicians from small HVAC companies, or 67% of the total technician participants, and small contractors performed approximately 32% of all jobs submitted by the program.

The budgeting process for the 2004-05 non-utility programs was both too complicated and too inflexible. Obviously program implementers should be limited to the total number of dollars allocated to their program. However, categories such as "administration," "marketing," and "incentives" should be viewed as estimates rather than rigid assignments, and implementers should be able to change allocations in manners that they believe would enhance the overall performance of their program. If they are still held to the bottom-line performance of *X* kWh for *Y* dollars, they would most likely increase the outreach value and the energy savings by being given this flexibility.

Cash flow was also problematic for this program. The payment system used for these programs had too many time delays in it. There are several layers of workers in the RCAVP and other programs. Contractors have to pay their technicians according to payroll schedules. It is not fair to these contractors, some of whom are very small businesses, to float money for two or more months. The implementer is also a small business and had to rely on debt financing for some aspects of the program. Cash flow and timing did not show

[10] Robert Mowris & Associates, *RCA Verification Program for New and Existing Residential and Commercial Air Conditioners: Final Report Prepared for the California Public Utilities Commission*, p. 5. (Olympic Valley, CA: RMA, May 1, 2006.)

up in surveys as a reason for not participating, but it was also unknown to the contractors at the time of their decision. It is imperative for the long term success and productivity of energy efficiency programs for the utilities to figure out how to get funds through the implementer and into the hands of the actual working subcontractors in no longer than 30 days from completion of a job.

Government Enforcement of Quality. Several participants felt that the government should do more to enforce quality standards within the HVAC industry.

The 2005 residential buildings standards (Title 24) require verification of proper refrigerant charge by HERS raters in new residential installations. However, there are a number of notable exceptions. Most prominent is the installation of a thermostatic expansion valve (TXV). When a TXV is installed, proper RCA is not required by Title 24. This exception contradicts research by RMA and published technical manuals indicating that improper refrigerant charge and low airflow decrease the energy efficiency of HVAC systems that have TXVs caused by a phenomenon known as "valve hunting." This occurs when the evaporator coil experiences reduced heat loads caused by low airflow, dirty or icy coils, and low refrigerant charge.[11] 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. Besides verifying proper RCA, program participants also verified proper TXV installations and indicated this by installing Verified™ TXV labels on units equipped with a TXV.

Another exception is that additional measures, such as better glazing and/or higher-efficiency HVAC units, can exempt a home from needing verification of proper refrigerant charge. This exemption is contrary to the fact that all air conditioners require proper RCA in order to achieve their rated efficiency. A premium-efficiency unit without proper refrigerant charge will not achieve its premium efficiency, so the benefit is not achieved. We also note that commercial systems are not required to have independent verification of RCA under any circumstances.

Some contractors mentioned the possibility of the Contractors State License Board (CSLB) enforcing quality standards. Robert Mowris and Mark Shirilau also had detailed discussions about this subject. Mark consults to the CSLB to help it write licensing examinations for general (B) and electrical (C10) contractors and is very familiar with its processes. It could be possible, particularly since proper refrigerant charge is part of Title 24, for the HVAC (C20) contractor examination to contain a question regarding proper RCA. However, this would not be an effective means for either enforcing it or teaching contractors about it. Only the responsible managing officer (RMO) of a contracting firm is required to take the exam, and once it is passed it need not be taken again. So addition of a test question would do nothing for existing contractors and would not likely lead to any sort of deep education of newly licensed contractors.

The CSLB's enforcement jurisdiction is primarily related to the contractor law. A contractor that violates these laws can be disciplined. However, that jurisdiction does not

[11] John Tomczyk. *Troubleshooting and Servicing Modern Air Conditioning and Refrigeration Systems*. page 42, (1995. Mt. Prospect, Ill.: ESCO Press).

extend into the arena of trade practices. The board does not enforce the National Electric Code, the Title 24 building standards, or any other technical trade-related quality standards. Even if it were given such authority by legislation, it would not have a practical means of doing so.

We agree that proper RCA is a product quality and quality of service issue. We agree with those HVAC contractors who felt that their whole industry needs a greater focus on quality. Proper RCA is both misunderstood and undervalued (or even unvalued). It is misunderstood by many contractors and technicians, who confuse effectiveness and efficiency, because an air conditioner can work effectively (*i.e.*, cool a building) with close, but not necessarily precisely proper, RCA, while its efficiency depends upon this precision. It is undervalued by contractors both because of this level of ignorance and by a lack of ability to pass on the added costs. This in turn is caused by customers having little or no understanding of the subject an therefore giving proper RCA either very little or no value.

We also agree that the government should enforce it to the extent possible. The CEC is the proper venue from which this enforcement should emanate, as is presently the case in the few situations where refrigerant charge verification is required. The methods are already in place to provide enforcement of Title 24 through local building departments and code enforcement officials.

The program implementer has done an exemplary job of encouraging this enforcement. On March 28, 2006, Robert Mowris presented testimony to the CEC regarding the 2008 Building Energy Efficiency Standards. He stated, among other things, that third-party verification of proper RCA and TXV installation should be required for all air conditioners, including those with TXVs and premium-efficiency models. We concur with Robert's statements and encourage the CEC to adopt this revision in the 2008 standards.

We note, however, that no agency has either the authority or the ability to enforce proper RCA in existing HVAC units or, for that matter, to assure that new units are kept at proper charge once they have passed inspection. Air conditioner repairs are typically not permitted through building departments. While proper RCA could become the norm in new construction, there is no assurance that it will become the norm in HVAC repair.

Furthermore, even if proper RCA verification were to become the norm among repair technicians, there is no legal method of correcting the problem in existing units that are not being repaired. Nearly two-thirds (65%) of old air conditioners that were checked in the RCAVP required refrigerant charge adjustment. It is reasonable to assume, therefore, that two thirds of air conditioners presently operating in California would benefit from a check of their refrigerant charge and adjusting it if necessary.

While it probably would be cost-effective to the average customer to pay to have this done, customers are almost entirely unaware of this fact. This is why utility programs are necessary even if proper RCA is fully incorporated into future editions of Title 24.

REVISITING THE "RESEARCHABLE ISSUES"

In the EM&V Plan and in the beginning of this report, we presented the specific researchable issues to be addressed by this evaluation. Table 21 summarizes the answers to the various issues raised.

Table 21: Researchable Issue Results

Issue	Method of Assessment
How many RCA verifications were conducted?	13,512, of which 12,453 were fully documented in the tracking system and an additional 1,059 were completed by contractors but not submitted because they knew that rebates had run out. This is 113% of the program goal.
What are the total energy savings and demand reductions?	The net program energy savings are 5,700,994 kWh/year and 5,926 kW demand reduction. This is 113% of the energy goal and 136% of the demand goal.
Did the contractors properly complete the RCAVP process?	Yes. We checked 124 completed jobs and found that all of them had proper refrigerant charge and airflow.
What portion of A/C units needed the service?	65% of old air conditioners checked needed refrigerant charge modifications, and 45% of new air conditioners checked needed refrigerant charge modification.
Were builders, contractors, and technicians aware of the relationship between refrigerant charge and operating efficiency?	Generally not. There is general awareness that proper (as opposed to *precisely* proper) charge is necessary for good operation of a system, but general lack of understanding of the closely linked relationship between exact charge and actual operating efficiency.
What is current industry practice?	Gages, calculator tables, and rules of thumb are used to establish "proper," but not *precisely* proper, charge. Almost 2/3 of existing units, and nearly half of new units do not have precisely proper refrigerant charge.
What are reasons for participating or not participating?	Reasons varied. Generally participants liked the accuracy and precision of the program and felt the PDA made achieving this accuracy easier. Some also felt it was part of giving top-notch customer services. Non-participants tended to site lack of time, not wanting to change, and not feeling the rebates would cover their internal costs. Many non-participants also had not remembered being told about the program.
How can the process be improved?	See the "Recommendations" section following.
Are program training and materials effective?	Yes. We attended several training sessions and surveyed technicians after training. Both our observations and student opinions demonstrate quality training and knowledgeable training staff.
Do any specific contractors or technicians need additional training?	This problem was not apparent at the program level. It appears that in-house contractor training and/or follow-up support from the implementers was sufficient to resolve any difficulties any particular technician may have had.

RECOMMENDATIONS

Based upon our observations and research, we offer the following recommendations with respect to the Refrigerant Charge and Airflow Verification Program (RCAVP) implemented by Robert Mowris & Associates (RMA).

1. The program should continue. Nearly all (97%) participant contractors felt this. The program found that 65% of old air conditioners needed refrigerant charge adjustments when checked. Although some requirements for RCA verification exist for new construction, there is no means by which regulation can address the problem in existing units. Customers are unaware of the importance of precision RCA and the efficiency benefits they would receive, so they are unlikely to readily pay for such services. Utility incentive programs are the best way to instill this awareness and solve the problem of inefficiently operating existing units.

2. Future programs should have sufficient marketing and administrative funding to reach out to smaller contractors. In addition to the direct energy savings achieved by tuning an air conditioner, the program should strive to instill awareness both in the technical HVAC community and among the general population. Contractors serving school districts achieve good savings, but awareness of the issue in the general population will increase when Mary Homeowner calls Joe Repairman to fix her air conditioner and she learns from him the importance of proper RCA and then go and tell her neighbor.

3. Technician training should add additional emphasis to the connection between proper RCA, the energy efficiency of the HVAC unit, and the customer's energy savings because of it. (While technicians were taught this in training, some appear to have not recognized that RCA verification and adjustment directly benefits the users of the air conditioner by reducing energy bills.)

4. Technicians performing RCAVP services should always explain the service to the customer. This will help build the awareness of the relationship between proper RCA and energy efficiency.

5. Program budgets should be considered flexible enough for implementers to readjust category allocations for the betterment of their program so long as they stay within the overall total budget.

6. The money flow from utility to implementer to subcontractor should be streamlined so there is never more than a 30 day delay between when a subcontractor does work and gets paid. The utility administrators could advance a sufficient amount of cash to the implementer to enable this proper timeliness without causing financial hardship on the implementer or the subcontractor.

7. The California Energy Commission should eliminate the TXV and premium-efficiency exemptions in the next edition of the building standards and should require proper refrigerant charge verification for all new air conditioners, both residential and

commercial. *(As of this writing it appears as if they will do this, primarily because of Robert Mowris's input.)*

8. Manufacturers should either consider requiring proper RCA verification in order for their warranties to be valid or should provide an extended warranty if proper RCA verification is provided.

9. Longevity studies should be conducted to determine the true expected useful life (EUL) of the RCAVP services. The implementer provided survival function, hazard rate, and retention study analyses of the EUL for the RCAVP in the final report. An estimate of the EUL was provided for programs that do and don't provide locking caps and verification stickers to ascertain the value added by these services. More important than simply measuring an obscure parameter such as EUL, future studies should determine the need for *re-verification* of air conditioners and enable the industry to develop standards as to how long (if ever) after an original RCA verification a unit should be re-verified.

10. A detailed assessment of contractor participation sensitivity to the incentive amount should be made. Some non-participant contractors felt that the program did not pay them sufficiently for the technician time it took to implement the service. Some participants felt they may have not "broken even" on it. Others felt the amount is adequate. The amount of necessary incentive is also likely to decrease after awareness and regulation increase the amount of RCA verification being done and technicians become more familiar and adept with the process. However, a study to optimize the proper level of incentive at this time would be worthwhile.

CONCLUSION

The Refrigerant Charge and Airflow Verification Program (RCAVP) implemented by Robert Mowris & Associates met its goals. Setting out to verify the refrigerant charge and airflow of 12,000 air conditioners, it fully documented 12,453 units and contractors reported an additional 1,059 units verified that were not fully documented because incentive funds had run out. Therefore a total of 13,512 air conditioners were verified as a result of the program.

The net energy savings achieved by the statewide program were 5,700,679 kWh per year, with a peak demand reduction of 5,925 kilowatts. This is 113% of the energy savings goal of 5,037,027 kWh/yr and 136% of the demand reduction goal of 4,348 kW. This does not include the savings achieved from codes and standards activities and the change the California Energy Commission is planning to make to Title 24, partly as a result of this program's information. While we believe those savings will be very substantial, they are difficult to accurately enumerate, and their evaluation is beyond the scope of this report.

Table 22: Net Savings Summary

Utility	Residential kWh/year	Residential kW	Commercial kWh/year	Commercial kW	Total kWh/year	Total kW
PG&E	522,647	637.8	2,654,027	2,137.8	**3,176,674**	**2,775.6**
SCE	1,318,689	1,586.5	264,748	207.9	**1,583,437**	**1,794.4**
SDG&E	748,418	1,200.0	192,150	155.3	**940,568**	**1,355.3**
Total	2,589,754	3,424.3	3,110,925	2,501.0	**5,700,679**	**5,925.3**

Participant contractors were pleased with the training they received. On-site inspections of previously verified HVAC units demonstrated that the technicians were using the software correctly to properly charge the units they were installing or repairing. Participating contractors generally felt the program enhanced customer service and quality within the industry. Most felt that the government should enforce better standards within the HVAC industry. Some non-participating contractors felt that the program would take too much time to implement and would increase the service time of a repair or installation beyond the amount compensated by the incentive. A large number of non-participants did not remember being contacted by RMA in spite of having received several telephone contacts. In-person marketing to contractors was much more effective, but limited marketing budgets inhibited this activity.

In spite of a constrained marketing budget, the program was able to successfully train and equip 353 technicians from small, medium, and large HVAC companies throughout California. The goal of training 99 technicians was exceeded by a large margin. The program trained and equipped 237 technicians from small HVAC companies or 67% of the total the technicians who were trained. Small contractors performed approximately

32% of all the jobs submitted by the program. The program had more than ten thousand commitments from small contractors. Small contractors were generally under-staffed and had high employee attrition which caused them to fall short of their commitments. When small contractors failed to meet their commitments, the medium and larger contractors were given greater commitments in order to accomplish the program goals.

Schools accounted for 21 percent of the total jobs under the program. Multi-family residences accounted for 13% and single-family accounted for 57% of all jobs. The remaining 9% of jobs were miscellaneous commercial jobs (i.e., hotels, retail, offices, etc.). Most of the residential jobs were performed at new homes, which was the primary focus of the program. The program reached a wide range of new and existing residential and commercial customers and this contributed to allowing the program to deliver its message to HVAC industry and average utility customers. The program provided free RCA verification services to the Emerging Communities Energy Efficiency Program in SCE and the Moderate Income Comprehensive Attic Program (MICAP) in PG&E. MICAP installed locking Novent caps on 263 jobs. A larger marketing budget would have allowed the program to reach more utility customers and stimulate demand for RCA/TXV verification services as well as promote the program to help small contractors deliver their commitments. Larger per-verification incentives might have increased participation, although our research did not delve into the fine detail of assessing whether the present incentive level was optimal. Clearly it was sufficient to reach the program's goals.

The need for the program was substantiated by the statistics gathered from each individual site. The database has extensive information on all of the 12,453 fully documented verifications. This includes whether a refrigerant charge adjustment was necessary and exactly how much was required. Of the old air conditioners verified, 65% of them needed charge adjustments. Of the new units verified shortly after their installation, 45% needed charge adjustments. This is a sample of residential and commercial split system and packaged units throughout the state. Therefore it can be assumed that approximately half of all the air conditioners in the state would increase their operating efficiency by being precisely charged through participation in the RCAVP.

RMA has recommended that the California Energy Commission require refrigerant charge verification for all air conditioners in the 2008 standards. Based upon our observations while evaluating this program, we concur with this recommendation. We note, however, that such a requirement would not supplant the need for continuing public goods charge-funded programs that verify and adjust the refrigerant charge and airflow of *existing* air conditioners in both residential and commercial settings. The database developed in conjunction with this program demonstrates that nearly two-thirds of these units will benefit by refrigerant charge adjustment.

Verified™ Refrigerant Charge and Airflow (RCA)
Training Workshop Survey #1 Given Before Training

*** Thank you for taking the time to complete this survey. Aloha Systems, Inc. is an independent evaluation group and not affiliated with the sponsors of today's event. Your responses will be kept confidential.*

(1) How did you come to know about the Verified™ RCA training program? **31 Responses**

☐ Employer ☐ Friend ☐ Recommendation ☐ Program Brochure ☐ Phone Call ☐ Other _____

20 (65%) **0 (0%)** **0 (0%)** **0 (0%)** **0 (0%)** **11 (35%)**

(2) What do you expect to learn from today's workshop? **40 Responses**

☐ How to Measure Superheat, Subcooling, Temperature Split **10 (25%)** ☐ How to Verify Proper Refrigerant Charge and Airflow **4 (10%)**

☐ How to Calibrate Equipment **4 (10%)** ☐ Proper Equipment to Use **12 (30%)** ☐ Don't know **1 (3%)** ☐ Other _____ **9 (22%)**

(3) How long have you worked in the air conditioning industry? **31 Responses**

☐ < 1 year ☐ 1 to 4 Years ☐ 5 to 9 Years ☐ 10 to 14 Years ☐ 15 to 19 Years ☐ 20 Years or More ☐ N/A

1 (3%) **6 (19%)** **7 (22%)** **3 (9%)** **7 (22%)** **5 (17%)** **1 (3%)**

(4) What are the **primary** tools/equipment you currently use when servicing an air conditioner for proper refrigerant charge and air flow? (Please list only those that **you** use.) **Multiple responses allowed.**

14 Refrig. Compound Pressure Gauge with Low-Loss Fittings
7 Refrig. Compound Pressure Gauge w/o Low-Loss Fittings
10 Digital Psychrometer for Measuring Wetbulb
6 Manual Sling Psychrometer for Measuring Wetbulb
13 R-22 Refrigerant Recovery Tank
16 Schrader Valve Core and Replacement Tool
16 Multi-meter (for electrical measurements)
17 6-in-1 Screw Driver for Opening Panels
16 Digital Temperature Equipment (i.e., Fluke 52)
7 Digital Pipe Clamp Probe (i.e. Fluke 80PK-8)
4 Digital Probe (i.e., Fluke 80PK-1 for Air Temp.)
0 Digital Probe w/ cotton wick wetbulb (i.e., Fluke 80PK-1)
8 Digital Refrigerant Scale (i.e., CPS, Ritchie)
4 R-410a Refrigerant Recovery Tank
9 Refrigeration Valve Allen Key and Ratchet
☐ Other _____

(5) What "rules of thumb" do you use to service an air conditioner for proper refrigerant charge and air flow?

5 Add or Remove Refrigerant Until Suction Line is 6-pack cold

1 Add or Remove Refrigerant Until Suction Pressure is 70 psig

0 Add or Remove Refrigerant Until Liquid Line Pressure is < 250 psig

16 Other ____chart, superheat & subcool, temp & pressure, ambient temp, gauge & amps

(6) Do you currently use a Carrier (or York, or other) cardboard calculator method to check superheat, subcooling or airflow?

12 Yes 4 Have it, but don't use it 4 No, Don't Have it 1 Don't Know 11 Other__no answer_____

Please answer the following questions by marking the appropriate responses

	Poor	Fair	Average	Good	Very Good	Excellent	Don't know
(7) How would you rate the effectiveness of the *equipment* you currently use to ensure proper refrigerant charge and air flow? **30 responses**	❍ **0 (0%)**	❍ **1 (3%)**	❍ **7 (23%)**	❍ **5** (17%)	❍ **12 (40%)**	❍ **4 (13%)**	❍ **1 (3%)**
(8) How would you rate the accuracy of the *equipment* you currently use to ensure proper refrigerant charge and air flow? **30 responses**	❍ **0 (0%)**	❍ **1 (3%)**	❍ **7 (23%)**	❍ **5** (17%)	❍ **13 (43%)**	❍ **3 (10%)**	❍ **1 (3%)**
(9) How would you rate the effectiveness of the "rules of thumb" you currently use to ensure proper refrigerant charge and air flow? **29 responses**	❍ **1 (3%)**	❍ **0 (0%)**	❍ **7 (24%)**	❍ **6** (21%)	❍ **9 (31%)**	❍ **5 (17%)**	❍ **1 (3%)**

(10) On average, how much time does it take you to service an air conditioner for proper refrigerant charge and air flow? **28 resp**	15 minutes or less	30 minutes	45 minutes	1 hour	1 ½ hours	More than 1 ½ hours	Don't know
	❍ **4(14%)**	❍ **13 (46%)**	❍ **4 (14%)**	❍ **6** (21%)	❍ **1 (4%)**	❍ **0**	❍ **0**

(11) Which of the following do you measure when checking the operation of an air conditioner? (Please mark all that apply.)

- 17 Outside drybulb temperature
- 3 Outside wetbulb temperature
- 24 Suction line temperature
- 17 Liquid line temperature
- 11 Weight of refrigerant added
- 13 Inside supply airflow
- 7 Airflow through condenser
- 16 Inside drybulb temperature
- 13 Inside wetbulb temperature
- 20 Inside supply air temperature
- 3 Condenser exhaust temperature
- 24 High side pressure
- 25 Low side pressure
- 2 Other: __superheat, liquid line temp____
- ☐ None of the ones listed

We would like to contact you for a future follow-up survey. Your name and information will remain confidential. Please print the following:

First Name:	Last Name:	Date:
Phone #: ( )	Company:	

***** Thank you for taking the time to complete this survey *****

Verified™ Refrigerant Charge and Airflow (RCA) Training Workshop Survey #2 Given After Training

*** Thank you for taking the time to complete this survey. Aloha Systems, Inc. is an independent evaluation group and not affiliated with the sponsors of today's event. Your responses will be kept confidential.*

Please answer the following questions by marking the appropriate response.	Yes	No	Don't know
1. Have you previously received proper refrigerant charge and airflow training? **25 Responses**	❍ **14 (56%)**	❍ **10 (40%)**	❍ **1 (4%)**
2. Have any of your customers ever asked for Verified™ RCA installations or services? **25 Responses**	❍ **0 (0%)**	❍ **24 (96%)**	❍ **1 (4%)**

Please mark your response to the following questions:	Poor	Fair	Average	Good	Very Good	Excellent	Don't Know
3. After attending this workshop, how would you rate the *effectiveness* of the equipment you've used in the past to ensure proper refrigerant charge and air flow? **25 Responses**	❍ **1 (4%)**	❍ **3 (12%)**	❍ **6 (24%)**	❍ **7 (28%)**	❍ **6 (24%)**	❍ **2 (8%)**	❍ **0 (0%)**
4. After attending this workshop, how would you rate the *accuracy* of the equipment you've used in the past to ensure proper refrigerant charge and air flow? **25 Responses**	❍ **0 (0%)**	❍ **2 (8%)**	❍ **6 (24%)**	❍ **8 (32%)**	❍ **7 (28%)**	❍ **2 (8%)**	❍ **0 (0%)**
5. After attending this workshop, how would you rate the effectiveness of the "rules of thumb" you've used in the past to ensure proper refrigerant charge and air flow? **24 Responses**	❍ **5 (21%)**	❍ **5 (21%)**	❍ **4 (17%)**	❍ **6 (24%)**	❍ **4 (17%)**	❍ **0 (0%)**	❍ **0 (0%)**

Please rate the PDA software on the following:	Poor	Fair	Average	Good	Very Good	Excellent	Don't Know
6. Effectiveness **25 Responses**	❍ **1 (4%)**	❍ **0 (0%)**	❍ **2 (8%)**	❍ **4 (16%)**	❍ **12 (48%)**	❍ **6 (24%)**	❍ **0 (0%)**
7. User-friendliness **25 Responses**	❍ **1 (4%)**	❍ **1 (4%)**	❍ **3 (12%)**	❍ **6 (24%)**	❍ **9 (36%)**	❍ **5 (20%)**	❍ **0 (0%)**
8. Speed **25 Responses**	❍ **1 (4%)**	❍ **1 (4%)**	❍ **4 (16%)**	❍ **9 (36%)**	❍ **6 (24%)**	❍ **4 (16%)**	❍ **0 (0%)**

Please rate the following statements by marking the most appropriate response:	Strongly Disagree	Disagree	Moderately Disagree	Moderately Agree	Agree	Strongly Agree	Don't Know
9. I am confident the Verified™ RCA stickers will help identify and maintain proper refrigerant charge. **14 Responses**	❍ **0 (0%)**	❍ **0 (0%)**	❍ **0 (0%)**	❍ **1 (7%)**	❍ **6 (43%)**	❍ **6 (43%)**	❍ **1 (7%)**
10. I am confident the locking Schrader caps will identify and maintain proper refrigerant charge. **25 Responses**	❍ **1 (4%)**	❍ **0 (0%)**	❍ **0 (0%)**	❍ **1 (4%)**	❍ **10 (40%)**	❍ **13 (52%)**	❍ **0 (0%)**

Please rate the following statements by marking the most appropriate response:	Strongly Disagree	Disagree	Moderately Disagree	Moderately Agree	Agree	Strongly Agree	Don't Know
11. I am confident our customers will benefit from using the Verified™ RCA PDA software. **14 Responses**	6 (43%)	0 (0%)	0 (0%)	2 (14%)	5 (36%)	0 (0%)	1 (7%)
12. I am confident our business will benefit from using the Verified™ RCA PDA software. **25 Responses**	0 (0%)	2 (8%)	1 (4%)	5 (20%)	6 (24%)	10 (40%)	1 (4%)
13. I *personally* favor using the Verified™ RCA PDA software over the "old method." **14 Responses**	2 (14%)	0 (0%)	1 (7%)	1 (7%)	6 (43%)	3 (22%)	1 (7%)
14. The training workshop was worthwhile. **25 Responses**	0 (0%)	0 (0%)	0 (0%)	4 (16%)	10 (40%)	10 (40%)	1 (4%)
15. Today's instruction and training was easy to understand. **25 Responses**	1 (4%)	1 (4%)	1 (4%)	9 (36%)	8 (32%)	5 (20%)	0 (0%)
16. The Verified™ RCA PDA software is easy to use. **14 Responses**	0 (0%)	1 (7%)	0 (0%)	2 (14%)	6 (43%)	5 (36%)	0 (0%)
17. The Verified™ RCA PDA software is easy to understand. **25 Responses**	1 (4%)	2 (8%)	1 (4%)	10 (40%)	6 (24%)	5 (20%)	0 (0%)

Please answer the following questions by marking the most appropriate response.	**Poor**	**Fair**	**Average**	**Good**	**Very Good**	**Excellent**	**Don't Know**
18. Likeliness that you will use the PDA software during installations and services **24 Responses**	0 (0%)	0 (0%)	1 (4%)	5 (21%)	8 (33%)	10 (42%)	0 (0%)
19. Satisfaction with today's training workshop **25 Responses**	0 (0%)	2 (8%)	1 (4%)	3 (12%)	12 (48%)	7 (28%)	0 (0%)
20. Satisfaction with PDA demonstration **25 Responses**	0 (0%)	1 (4%)	0 (0%)	5 (20%)	12 (48%)	7 (28%)	0 (0%)
21. Ability of the instructors to answer your questions **25 Responses**	0 (0%)	0 (0%)	1 (4%)	3 (12%)	6 (24%)	15 (60%)	0 (0%)
22. Effectiveness of hands-on experience using the PDA software **25 Responses**	1 (4%)	0 (0%)	2 (8%)	7 (28%)	8 (32%)	7 (28%)	0 (0%)

Please answer the following questions by marking the most appropriate response.					
23. Would you like to receive further PDA software instruction? **25 Responses**	Yes 12 (48%)	No 12 (48%)	Don't know 1 (4%)		
24. Which of the following best describes your educational background? **25 Responses**	Some high school 2 (8%)	High school graduate 5 (20%)	Some college 14 (56%)	College graduate 4 (16%)	Post graduate 0 (0%)

25. What recommendations do you have for improving the training?

Trainers were great (2x)

Lunch break

More hands on; more time (4x)

None (4x) *[They wrote "none" as opposed to leaving it blank]*

left blank (12x)

26. What recommendations do you have for improving the PDA software?

"Takes too long to learn your way to charge a system"

More training

On job

Not sure

"Not having to enter so much about the job; the utilities probably want that, though."

"None, works better than expected."

None (5x)

left blank (14x)

27. Comments:

Do not like the PDA

Cannot tell when caps are tight, they just keep spinning

Instructors/training were very good, easy to understand (3x)

Give certificates of training

No more guessing; the PDA tells exactly what to do

Like the program

We would like to contact you for a future follow-up survey. Your name and information will remain confidential.

First Name:	Last Name:	Date:
Company:	Phone Number: ( )	Email:
Address:	City:	Zip:

***** Thank you for taking the time to complete this survey *****