Section 4 ECAA Loan Program

4.1 BACKGROUND OF PROGRAM ELEMENT

The California Energy Commission's Energy Conservation Assistance Act (ECAA) has been in existence since 1979. In April 2001, AB29X provided $50 million to the ECAA account for low-interest rate loans and grants to fund the installation of energy saving projects, and for technical assistance to identify energy saving opportunities. Since ECAA was established, over 500 loans have been issued, of which 65 are from AB29X funding. The interest rate for the AB29X-funded projects is fixed at three percent for the term of the loan, which is up to 11 years.

Projects with proven energy (kWh or therm) and/or electrical demand (kW) savings are eligible for loan funding, as are energy audits and feasibility studies. Energy efficiency projects funded by ECAA involve lighting efficiency and controls; heating, ventilating, and air-conditioning (HVAC) measures; light-emitting diode (LED) traffic signals; and other energy saving technologies.

Participants must repay loans (including principal and interest) for audits and studies within two years. Equipment loans (principal and interest) must be repaid within 11 years; the loan cannot exceed the useful life of the loan-funded equipment. Repayment of the loan is accomplished through reduction in utility bills due to the installed measures. This can occur through a reduction in energy savings, or through peak-demand savings, if the loan recipient is subject to a utility rate that charges for peak-demand usage.

Loan applications are accepted on a first-come, first-served basis until the funds are exhausted, or until a new notice is issued. Eligible loan applicants include cities, counties, special districts, public or non-profit schools, and public or non-profit hospitals and care facilities. Priority consideration was given to applicants who completed and installed their projects before May 1, 2002, and thereby provided quantifiable energy savings for the summer of 2002. Those who completed the installation of their projects by May 1, 2002 were eligible for a service contract rebate of between three and 15 percent of the loan funds drawn, depending on the actual project completion date.

The maximum loan amount is $2 million per application and $5 million per entity (for example, a school district). There is no minimum loan amount. In most cases, no matching funds are required to receive an ECAA loan. The Energy Commission reviews loan applications. Projects must demonstrate technical and economic feasibility in addition to meeting minimum energy efficiency criteria as established by the Energy Commission. Only project-related costs that are paid for after approval by the Energy Commission may be included in the loan request, preventing pre-existing projects from receiving loans.

4.2 STATUS OF PROGRAM ELEMENT

As of July 31, 2003, loans totaling $38.2 million have been committed through AB29X. The Energy Commission will approve more loans when funds become available as a result of project cancellations or repayments, or when final project costs are less than the original budgeted amount. The number of project loans varies over time as some loan participants drop out and others are added.[1]

At this time, there are 65 approved loans in various stages in this program element. The projects funded by AB29X are listed below in Table 4-1. As shown in the table, some loan recipients have more than one loan. A loan application may include multiple projects (energy efficiency measures), such as a lighting project that saves electrical energy (kWh) combined with an HVAC project that saves gas (therms). The 65 approved loans represent a total of 87 distinct projects. If all loan-funded projects in Table 4-1 are installed, the estimated demand savings would be 10.6 MW. As of July 31, 2003, the total reported demand savings of installed projects funded from AB29X, indicated as "Complete" in Table 4-1, is 9.8 MW.

Table 4-1: ECAA Projects as of July 31, 2003

Loan Recipient	Project Type(s)	Loan Amount	Reported kW Savings	Reported kWh Savings	Reported Therm Savings	Project Status
Alameda County	Miscellaneous	$1,071,000	515	823,330	0	Complete
Antelope CCD	HVAC	$544,680	109	475,000	0	Complete
Antelope CCD	Lighting	$1,090,020	230	1,040,000	0	Complete
Antelope CCD (Solar Heating)	Miscellaneous	$61,628	0	0	12,700	Complete
Apple Valley USD	Lighting	$199,261	190	238,236	0	Complete
Barstow Unified School District	Lighting	$119,696	46.2	284,008	0	Complete
Burbank USD	Lighting	$121,000	13.7	103,000	0	In progress
Capistrano USD	Lighting	$185,885	39.8	275,771	0	Complete
Capistrano USD	Lighting	$901,306	52.2	549,090	0	Complete
City & County of San Francisco	LED traffic signals	$1,765,014	313	2,737,772	0	Complete
City & County of San Francisco	LED traffic signals	$1,627,203	402	3,524,111	0	Complete
City of Auburn	LED traffic signals	$112,060	11	97,150	0	Complete
City of Bellflower	LED traffic signals	$128,502	77	673,498	0	Complete
City of Belmont	LED traffic signals	$20,000	11	95,635	0	Complete
City of Culver City	LED traffic signals	$279,078	90	786,645	0	Complete
City of El Centro	LED traffic signals	$74,857	29	251,808	0	Complete
City of Fairfield	Lighting, HVAC	$2,002,821	274	1,818,820	282,950	Complete
City of Fresno - Water Division	Miscellaneous	$276,915	107	751,437	0	Complete
City of Indio	LED traffic signals	$144,309	45	393,867	0	Complete
City of Manteca	Misc. (2), LED traffic signals	$1,991,717	521	3,892,000	456,782	Complete
City of Manteca	Lighting, Misc.	$648,780	230	670,252	0	Complete

[1] For example, at the end of the third quarter of 2002, the program had 72 project loans funded through AB 29X, totaling $47.8 million of committed funds.

Loan Recipient	Project Type(s)	Loan Amount	Reported kW Savings	Reported kWh Savings	Reported Therm Savings	Project Status
City of Modesto	LED traffic signals	$191,836	82	721,242	0	Complete
City of Napa	LED traffic signals	$42,353	15	131,935	0	Complete
City of Oakland	Lighting, HVAC, Misc.	$438,100	228	650,000	-507	In progress
City of Redlands	Miscellaneous	$1,500,000	970	8,072,340	0	Complete
City of Redlands	LED traffic signals	$253,272	97	851,981	0	Complete
City of San Buenaventura	LED traffic signals	$255,654	79	687,938	0	Complete
City of San Carlos	HVAC	$657,303	16	383,923	40,447	Complete
City of San Juan Capistrano	LED traffic signals	$75,693	16	140,701	0	Complete
City of Santa Rosa	Miscellaneous	$1,090,567	350	4,000,000	0	Complete
City of Sausalito	Lighting	$31,000	14	38,000	0	Complete
City of Susanville	Miscellaneous	$150,000	74	360,000	0	In progress
City of Westlake Village	LED traffic signals	$190,986	34	295,976	0	Complete
Clovis USD	Lighting	$388,533	133.7	685,980	0	Complete
Contra Costa County	HVAC	$384,881	50	525,000	9,000	Complete
Contra Costa County	HVAC	$315,119	50	303,000	8,700	Complete
County of Mendocino	Lighting, HVAC	$96,884	44	130,620	260	Complete
County of Merced	Lighting, HVAC	$1,900,345	353	1,090,000	7,000	Complete
County of Orange	Lighting	$805,117	396	1,747,551	0	Complete
County of Orange	Miscellaneous	$643,408	400	1,527,716	0	Complete
County of Riverside	LED traffic signals	$526,229	268	2,349,562	0	Complete
County of Solano	Lighting, HVAC	$1,027,088	130	1,727,048	0	Complete
Dameron Hospital	HVAC	$348,338	75	599,333	0	In progress
Del Mar Union SD	Lighting, HVAC	$750,000	82	630,000	4,288	Complete
Fuller Theological Seminary	Lighting, HVAC	$250,000	6.3	209,534	0	Complete
Kerman Unified School District	Lighting, HVAC, Misc.	$270,000	25.3	158,794	0	Complete
Latrobe School District	Lighting	$22,300	2.8	13,744	0	In progress
Los Angeles Valley College	Lighting, HVAC	$1,600,000	655.5	1,306,799	0	Complete
Loyola Marymount University	Lighting	$1,125,000	210	1,142,400	0	Complete
Middletown USD	Lighting, Miscellaneous	$131,559	21.7	109,739	0	Complete
Mt. San Antonio College	Lighting	$962,617	335	1,702,393	0	Complete
Mt. San Antonio College	Miscellaneous	$647,134	400	0	0	Complete
O'Connor Medical Center	Lighting, HVAC	$791,200	131	588,560	0	In progress
Piner-Olivet USD	Lighting, HVAC	$261,930	20.9	182,716	0	Complete
Rio Linda USD	Lighting	$730,000	103.2	917,970	0	In progress
San Francisco General Hospital	Lighting	$970,626	311	2,452,988	0	Complete
Sierra College	HVAC	$1,261,583	104	913,403	48,141	Complete
Sierra College (Lighting)	Lighting	$116,727	59	575,092	0	Complete
Sierra View District Hospital	Lighting, HVAC	$140,000	60.5	268,600	0	Complete
Southwestern CCD	Lighting, HVAC, Misc. (2)	$1,210,000	345	767,344	48,154	Complete
State Center CCD	Lighting	$1,308,913	260.5	1,880,317	0	Complete
Sutter Extension Water District	Miscellaneous	$96,300	66	75,600	0	Complete
Torrance Unified School District	Lighting, HVAC	$471,411	43	682,404	4,520	Complete
Town of San Anselmo	LED traffic signals	$82,756	22	190,483	0	Complete
Washington Township Hospital	Miscellaneous	$300,000	120	945,774	24,320	In progress

Loan Recipient	Project Type(s)	Loan Amount	Reported kW Savings	Reported kWh Savings	Reported Therm Savings	Project Status
Totals		**$38,178,494**	**10,567**	**62,215,930**	**946,755**	

4.3 MV&E APPROACH

Nexant's general approach to verifying savings for the ECAA program element involves calculating the difference between the equipment energy use before and after an energy efficiency retrofit. A sample of projects is chosen for analysis, and the findings from that sample are extrapolated to the population as a whole. The sample population must be large and diverse enough to meet the statistical confidence and accuracy levels required by the Energy Commission.

For those projects not already installed before the start of Nexant's evaluation activities, Nexant visits the sample sites to establish baseline conditions by confirming (a) the presence and type of existing equipment, (b) the energy use and/or the load (kW demand) of the existing equipment, and (c) the hours of operation of the existing equipment. Many projects were already installed, however, and for these projects, Nexant was not able to verify baseline equipment and operating conditions.

After a sample project has been reported complete, Nexant visits the site to confirm: (a) the completion of the project, (b) the energy use and/or load of the new equipment, and (c) the hours of operation of the new equipment. Using the baseline and post-installation data, the baseline energy and peak demand and post-installation energy and demand, respectively, are calculated. The difference between the two is the verified energy and peak demand savings.

4.4 PROGRAM ELEMENT MONITORING AND VERIFICATION

To meet the Energy Commission's goal of reporting program savings within an 80 percent confidence interval at a 20 percent precision interval (80/20), Nexant completed M&V activities on 12 randomly selected projects. For sampling purposes, Nexant broke down the 87 projects into four general categories: lighting, HVAC, LED traffic signals, and miscellaneous. Table 4-2 shows the total and sampled populations for these categories.

Table 4-2: Summary of ECAA Projects

Project Type	AB29X Population	Projects for M&V Analysis
Lighting (efficiency & controls)	32	4
HVAC (efficiency & controls)	20	3
LED traffic signals	17	3
Miscellaneous	18	2
Total	**87**	**12**

Nexant has completed its M&V analysis for the 12 sampled projects. M&V plans for each project are located in the Appendix to this report. Results for the sampled projects, which are organized into the four previously defined project types, are discussed in the sections that follow.

4.4.1 M&V Activities for Sampled Lighting Projects

Table 4-3 below shows the results of the four sampled lighting projects. Specific details about each project on which M&V was performed follows after the table.

Table 4-3: Results of Sampled Lighting Projects

Project	Reported kWh Savings	Verified kWh Savings	Realization Rate (kWh)	Reported kW Savings	Verified kW Savings	Realization Rate (kW)
Capistrano USD	549,090	445,574	0.81	52.2	50.6 ± 27.2	0.97
Del Mar USD	135,761	165,158	1.22	28.4	43.0 ± 19.0	1.51
Piner Olivet USD	124,707	128,109	1.03	20.9	20.7 ± 5.6	0.99
SF General Hospital	2,452,988	2,388,054	0.97	311.0	231.5 ± 105.0	0.74
Totals for Lighting	3,262,546	3,126,895	0.96	412.5	345.8	0.84

4.4.1.1 Capistrano Unified School District

The Capistrano Unified School District replaced T-12 fluorescent lamps and magnetic ballasts with high efficiency T-8 fluorescent lamps and electronic ballasts at three schools—R.H. Dana Elementary School, Dana Exceptional Needs Facility, and San Clemente High School. Incandescent fixtures were also replaced with compact fluorescent fixtures. Simultaneously, skylights were installed at the three schools to provide natural lighting and to supplement the existing fixtures in the classrooms, gymnasium, and multipurpose rooms. The daylighting measure is analogous to a lighting controls measure, as it effectively reduces the number of hours the fluorescent lamps operate in the middle of the day.

Nexant's representative visited the Capistrano Unified School District on five separate occasions: August 26, 2002 and November 7, 2002 (discussion of M&V work with facility manager), November 13, 2002 (equipment installation for Dana Elementary), November 18, 2002 (equipment installation for San Clemente High School), and January 14, 2003 (equipment removal). During those site visits, Nexant surveyed and inspected the counts and fixture types of the installed equipment. Time-of-use lighting loggers were also deployed and retrieved to measure the actual lighting usage at the facilities. The data from the lighting loggers were analyzed by Nexant by time-of-use period to determine the estimated electrical energy and peak-period demand savings for the project.

During the post-installation audit inspections, a random sample of retrofitted fixtures were visually inspected to confirm the retrofit work was properly and thoroughly completed. Fixture type and quantity inaccuracies found during the inspections were documented, and the lighting tables were updated to accommodate the modifications. A significant portion of the retrofit work was not performed as originally planned due to a lack of funding for the project, and this is reflected in the energy savings modifications last submitted to Nexant on April 29, 2003.

For combined lighting efficiency and lighting controls projects such as this one, energy savings are calculated using the difference between the pre-installation energy usage and the post-retrofit energy usage. Energy usage is determined by multiplying the wattage of the fixtures by the number of hours the fixtures operate per year. Equation 1 was used to calculate the annual energy savings for the usage groups in which daylighting measures were installed—Classrooms and Gymnasium.

$$(1) \qquad kWh_{saved} = (kW_{pre\text{-}retrofit} * Hours_{pre\text{-}retrofit}) - (kW_{post\text{-}retrofit} * Hours_{post\text{-}retrofit})$$

For the remaining usage groups, in which daylighting measures were not installed, it is assumed that the pre-installation hours of operation are equal to the post-installation hours of operation. Equation 1, upon making this substitution, then simplifies to Equation 2, which is used for all usage groups that do not have savings from daylighting.

$$(2) \qquad kWh_{saved} = (kW_{pre\text{-}retrofit} - kW_{post\text{-}retrofit}) * Hours_{post\text{-}retrofit}$$

The wattages of the pre-retrofit lighting equipment and post-retrofit lighting equipment were taken from the manufacturer ratings, as indicated on the Equipment Data Sheets or listed on the fixtures themselves. Fixture wattages were confirmed during the post-installation inspection, when randomly selected points were verified. Post-installation hours of operation are determined by directly monitoring the run-time of a sample of the fixtures using lighting loggers. Since pre-installation hours of operation could not be obtained for use in Equation 1, the class schedule hours of 8 AM to 4 PM were used for the pre-installation hours of operation.

CMS Viron, the lighting retrofit contractor for this project, submitted lighting survey tables for the three facilities in the project. Of the more than 20 usage groups in the project, only four usage groups were selected for Measurement and Verification, as they provided the majority of the energy savings in the project – Classrooms, Restrooms, Offices, and Other. The "Other" usage group included the gymnasium. Using the 80 percent confidence/20 percent precision statistical guidelines specified by the California Energy Commission, Nexant randomly selected a statistically-valid sample of lines for each M&V usage group, as stated in the project's original M&V plan.

The sample was monitored over a one-month period to accurately assess the actual usage hours of operation by time-of-use period (peak period, part-peak period, and off-peak period). The monitored hours of operation were annualized and applied by usage group to either Equation 1 or Equation 2, depending on whether or not the usage group contained daylighting measures. The resulting energy savings by usage group were then aggregated across the entire project, and the result is the verified energy savings for the project. Both electrical peak demand and energy savings were achieved in this project. Verified peak demand savings are calculated by dividing the verified energy savings in the peak-demand period by the total number of hours in the peak period (1,008 hours – Weekdays, 2-6 PM, excluding 8 main holidays).

The monitoring results gathered by Nexant, given in Table 4-4, indicate that there are some discrepancies in the hours of operation reported by Capistrano Unified School District (CMS Viron) and those monitored by Nexant. Some hours reported by CMS Viron were more than what was monitored by Nexant, so the annual energy savings reported by Capistrano were somewhat aggressive. The actual energy savings are lower than what was expected primarily because part of the original scope of work was removed; originally, an EMS was to automatically open and close louvers based on the time of the day and the amount of sunlight a classroom received. Thus, the daylighting measure would have replaced the use of lights in the classrooms, multipurpose rooms, and gymnasium during the bulk of the operating hours of the schools. However, due to complaints from the occupants of the classrooms, the automated feature was removed from the project scope in favor of manual switches. This has caused the energy savings from the daylighting measure to be reduced, as greater occupant control has allowed for greater use of artificial lighting.

Two sets of realization rates were calculated, one for peak-period demand savings and one for annual energy savings. The peak-period realization rate was calculated by dividing the verified peak demand savings by the reported peak demand savings. Similarly, the energy realization rate was determined by dividing the verified energy savings by the reported energy savings. Table 4-5 lists the project savings and corresponding realization rates for this project. The realization rates indicate that the energy savings calculations submitted by CMS Viron were somewhat aggressive. The reported peak demand savings, however, were very accurate, since the realization rate is 97 percent.

Table 4-4: Capistrano USD Monitoring Results by Facility

School	Reported kWh Savings	Verified kWh Savings	Verified Peak kW Savings
Dana Exceptional Needs	89,840	81,459	8.1
Dana Elementary	138,849	121,265	16.8
San Clemente High	293,293	242,850	25.7
Totals	**549,090**	**445,574**	**50.6**

Table 4-5: Capistrano USD Project Results

Savings	Reported	Verified	Realization Rate
Energy (kWh)	549,090	445,574	0.81
Peak Demand (kW)	52.2	50.6	0.97

Statistical results are presented in Table 4-6. The errors given are reported at an 80 percent confidence level. Measurement error was minimal, but was still included in the evaluation. Measurement uncertainty resulted from errors associated with the lighting loggers, which have an error of a minute per week, or 0.0001 of the collective monitoring time period. Also included in the measurement uncertainty is the equipment “box time,” or the period of time between when the loggers are deployed until when they are installed, and the time between when they are removed until when the data from the logger is downloaded to the computer, which is approximated to be 1 percent.

The largest source of error is from sampling error, which is calculated using the standard deviation of the realization rates of the monitored points, as summarized below. Taking into account the resulting uncertainty of the project, the total verified savings for this project are 445,574 kWh of annual energy, and 50.6 +/- 27.2 kW of peak demand.

Table 4-6: Capistrano USD Statistical Results

Sampled lines	30 of 509 lines
Measurement error	0.0005
Standard deviation	0.4197
Sampling error	0.5379
Total project error	53.8%

4.4.1.2 Del Mar Hills Elementary School

The Del Mar Hills Elementary School replaced T-12 fluorescent lamps and magnetic ballasts with high efficiency T-8 fluorescent lamps and electronic ballasts. The school also replaced incandescent fixtures with compact fluorescent fixtures. Of the original 999 lines of fixtures, 719 lines of fixtures were removed and replaced.

Nexant’s representative visited the Del Mar Hills School District on three separate occasions for the lighting retrofit portion of this project - October 14, 2002 (equipment installation), December 9, 2002 (equipment removal), and December 11, 2002 (equipment verification). During the post-installation audit inspections, a random sample of retrofitted fixtures were visually inspected to confirm the retrofit work was properly and thoroughly completed. Fixture type and quantity inaccuracies found during the inspection were documented, and the lighting tables were updated to accommodate the modifications. No significant errors were found during the inspections. Time-of-use lighting loggers were also deployed and retrieved to measure the actual lighting usage at the facility. The data from the lighting loggers were analyzed by Nexant by time-of-use period to determine the estimated electrical energy and peak-period demand savings for the project.

For projects that contain lighting efficiency measures such as this one, energy savings are calculated using the difference between the baseline lamp wattage and post-retrofit lamp wattage, multiplied by the annual hours of operation.

$$kWh_{saved} = (kW_{pre\text{-}retrofit} - kW_{post\text{-}retrofit}) * \text{Hours of Operation}$$

The wattages of the pre-retrofit lighting equipment and those of the post-retrofit lighting equipment were taken from the manufacturer ratings, as indicated on the Equipment Data Sheets or listed on the fixtures themselves. Fixture wattages were confirmed during the post-installation inspection, when randomly selected points were verified. Post-installation hours of operation are determined by directly monitoring the run-time of a sample of the fixtures. It is assumed that the pre-installation hours of operation will be the same as the post-installation hours for calculating the lighting efficiency savings.

Baker Electric (a subcontractor of Cal-Air), the lighting retrofit contractor for this project, submitted a survey table of 999 fixtures in the pre-retrofit stage and 719 fixtures in the post-retrofit. Only three usage groups were selected for monitoring purposes, because they provided the majority of the project energy savings – Classrooms, Closed Corridors, and Portables. Using the 80% confidence/20% precision statistical guidelines specified by the California Energy Commission, Nexant randomly selected a statistically-valid sample of lines for each M&V usage group, as stated in the project's original M&V plan. The sample was monitored over a one-month period to accurately assess the actual usage hours of operation by time-of-use period (peak period, part-peak period, and off-peak period).

The monitored hours of operation were used to calculate verified energy savings using the lighting efficiency equation. The verified peak-period demand savings were then calculated by dividing the energy savings during the peak-demand period by the total number of hours during the peak-period. Monitoring results are presented in Table 4-7. The monitoring results gathered by Nexant indicates that there are some discrepancies in the hours of operations reported by Del Mar Hills School District and those monitored by Nexant. However, the hours reported by Del Mar Hills were less than what was monitored by Nexant, so the results submitted by Del Mar Hills were conservative.

Two sets of realization rates were calculated, one for peak-period demand savings and one for annual energy savings. The peak-period realization rate was calculated by dividing the verified peak demand savings by the reported peak demand savings. Similarly, the energy realization rate was determined by dividing the verified energy savings by the reported energy savings. Table 4-8 lists the project savings and corresponding realization rates for this project. The high realization rates indicate that the assumptions going into the reported savings calculations (such as estimated hours of operation) are conservative.

Table 4-7: Del Mar USD Monitoring Results

Usage Group	Hours Submitted by Del Mar Hills	Hours Monitored by Nexant	Percentage Difference

Classroom	1,860	2,324	19.97
Closed Corridor	1,860	3,086	39.73
Portables	1,860	1,641	-13.35

Table 4-8: Del Mar USD Project Results

Savings	Reported	Verified	Realization Rate
Energy (kWh)	135,761	165,158	1.22
Demand (kW)	28.4	43.0	1.51

Statistical results are presented in Table 4-9. The errors given are reported at an 80 percent confidence level. Measurement error was minimal, but was still included in the evaluation. Measurement uncertainty resulted from errors found in the lighting data-monitoring device, which has an error of a minute per week, or 0.0001 of the collective monitoring time. Also included in the measurement uncertainty is the equipment "box time," or the period between when the loggers are deployed and when they are installed, and the time between when they are removed and when the data from the logger is downloaded to the computer, which is approximated to be 2 percent.

The largest source of error is from sampling error, which is calculated using the standard deviation of the realization rates of the monitored points, as summarized below. The third source for error resulted from not performing pre-installation monitoring. The pre-installation operating hours was assumed identical to the operating hours of the facility during the post-installation for simplicity, as is usually assumed. However, variations in usage patterns may vary from month to month, which introduces a degree of error into the results. Thus, to add consideration for this error, a 7 percent error was assumed for the variation in hours between pre- and post-installation monitoring. Taking into account the resulting uncertainty of the project, the total verified savings for this project are 165,158 kWh of annual energy and 43.0 +/- 19.0 kW of peak demand.

The uncertainty for this project could be minimized if the lines in the LE table were separated out for each room. A more comprehensive statistical analysis could be performed if a more detailed LE survey table of the pre- and post-retrofit lighting equipment was submitted.

Table 4-9: Del Mar USD Statistical Results

Sampled lines	18 of 72 lines
Measurement error	0.0065
Standard deviation	0.3456
Sampling error	0.4429
Pre-monitoring error	0.00002
Total project error	44.3%

4.4.1.3 Piner Olivet Union School District

The Piner Olivet Union School District replaced T-12 fluorescent lamps and magnetic ballasts with high efficiency T-8 fluorescent lamps and electronic ballasts. Incandescent fixtures were also replaced with compact fluorescent fixtures, and occupancy controls were installed. A total of 135 lines of fixtures in the three schools—Piner, Olivet, and Schaefer—were included in the lighting efficiency and controls project.

Nexant's representative visited the Piner Olivet Union School District on six separate occasions: July 19, August 2, November 7, 2002; January 3, January 8 and February 14, 2003. During the post-installation audit inspections, a random sample of 34 lines (out of 134 total) of retrofitted fixtures were visually inspected by Nexant to confirm the retrofit work was properly and thoroughly completed by Chevron Energy Services. Fixture type and quantity inaccuracies found during the inspection were documented, and the lighting tables were updated. No major errors were found during the inspections.

Time-of-use lighting loggers were also deployed and retrieved for three separate monitoring periods to ensure an accurate assessment of the actual lighting usage at the facilities. The data from the lighting loggers were analyzed by Nexant by time-of-use period to determine the estimated electrical energy and peak-period demand savings for the project.

For projects that contain lighting efficiency and controls measures such as this one, energy savings are calculated by subtracting the post-installation energy usage from the baseline energy usage, as in Equation 1 below:

$$(1)\ kWh_{saved} = (\text{Operating Hours}_{pre\text{-}retrofit} * kW_{pre\text{-}retrofit}) - (\text{Operating Hours}_{post\text{-}retrofit} * kW_{post\text{-}retrofit})$$

For fixtures with only lighting efficiency, Equation 1 simplifies to:

$$(2)\qquad kWh_{saved} = (kW_{pre\text{-}retrofit} - kW_{post\text{-}retrofit}) * \text{Operating Hours}$$

For lighting controls:

$$(3)\qquad kWh_{saved} = (\text{Operating Hours}_{pre\text{-}retrofit} - \text{Operating Hours}_{post\text{-}retrofit}) * kW$$

The wattages of the pre-retrofit lighting equipment and those of the post-retrofit lighting equipment were taken from the manufacturer ratings, as indicated on the Equipment Data Sheets or listed on the fixtures themselves. Nexant confirmed fixture wattages during the pre- and post-installation inspections, when randomly selected points were verified. Monitoring of a sample of fixtures was performed to determine the pre- and post-installation hours of operation. Fixtures were monitored for both the in-session and out-of-session periods for the three usage groups with the highest amount of energy savings and greatest amount of variation in the pre- and post-installation periods: Classrooms, Office, and Restrooms. The usage hours for the other areas are assumed to have similar usage patterns for both in-session and out-of-session periods (i.e. Hallways). For the classroom, office, and restroom usage groups, the annualized hours are proportional to the total number of days during the in-session to out-session days per year. Since the school is in-session for approximately 75 percent of the year and out-of-session for approximately 25 percent of the year, the results are weighted accordingly.

Chevron Energy Services, the lighting retrofit contractor for this project, submitted a survey table of 135 lines of fixtures, organized into 18 usage areas at the campus sites. The six usage groups with the highest amounts of energy savings were monitored during the in-session time period and only the classroom, offices, and restroom usage groups were monitored during the out-of-session time periods. This is because of the low utilization of the other usage groups in the out-of-session period. The results for the three usage groups with low usage hours were pro-rated based on the results of the monitored usage groups. Using the 80 percent confidence/20 percent precision statistical guidelines specified by the California Energy Commission, Nexant randomly selected a statistically valid sample of lines for each M&V usage group. The selected sample was monitored over a one-month period in the in- and out-of-session periods in order to assess accurately the lighting usage of the project.

Table 4-10 summarizes the findings of Nexant's monitoring efforts for this project. The summary compares the monitoring results gathered by Nexant with the energy savings estimates submitted by Piner Olivet.

Table 4-10: Piner Olivet USD Monitoring Results

M&V usage group	Submitted Average (Hrs)	Nexant Measured (Hrs)	Difference (Hrs)	Difference (%)	Project Savings (kWh)	Project Savings (%)*
Classroom	1,985	1,601	383.65	23.96	63,191	53.28
Office	2,376	1,504	872.07	57.99	6,363	5.37
Restroom	2,923	763	2,160.39	283.29	1,135	0.96
Hallway	3,926	1,033	2,892.94	280.04	509	0.43
Kitchen	1,531	1,756	-225.04	-12.81	518	0.44
Multipurpose	3,569	2,358	1,210.92	51.35	20,600	17.37

*The other 12 usage areas, which make up the other 22.15% of the energy savings of this project, were not monitored.

The monitored hours of operation were used to calculate verified energy savings using Equation 1. Verified peak-period demand savings were then calculated by dividing the energy savings during the peak-demand period by the total number of hours during the peak-period. The monitoring results gathered by Nexant indicates that there are some discrepancies in the hours of operations reported by Piner Olivet Union School District and those monitored by Nexant. However, the differences in the usage groups average each other out in yielding a similar total energy savings amount for the entire project. The end result is that the energy savings estimates submitted by Piner Olivet Union School District were close to the true energy savings for the project.

Two sets of realization rates were calculated—one for peak-period demand savings and one for annual energy savings. The peak-period realization rate was calculated by dividing the verified peak demand savings by the reported peak demand savings. Similarly, the energy realization rate was determined by dividing the verified energy savings by the reported energy savings. Table 4-11 lists the project savings and corresponding realization rates for this project. Realization rates were very close to 1.0, indicating that Piner Olivet's assumptions and estimates were extremely accurate.

Table 4-11: Piner Olivet USD Project Results

Savings	Reported	Verified	Realization Rate
Energy (kWh)	124,707	128,109	1.03
Demand (kW)	20.9	20.7	0.99

Statistical results are presented in Table 4-12. The errors given are reported at an 80 percent confidence level. Measurement error was minimal, but was still included in the evaluation. Measurement uncertainty resulted from errors found in the lighting data-monitoring device, which has an error of a minute per week, or 0.0001 of the collective monitoring time period. Also included in the measurement uncertainty is the equipment "box time," or the period between when the loggers are deployed and when they are installed, and the time between when they are removed and when the data from the logger is downloaded to the computer, which is conservatively approximated to be 2 percent.

The largest source of error is from sampling error, which is calculated using the standard deviation of the realization rates of the monitored points, as summarized below. The pre-installation operating hours were assumed identical to the operating hours of the facility during the post-installation for simplicity, as is usually assumed. However, variations in usage patterns may vary from month to month, which introduces a degree of error into the results. Taking into account the resulting uncertainty of the project, the total verified savings for this project are 128,109 kWh of annual energy, and 20.7 +/- 5.6 kW of peak demand.

Table 4-12: Piner Olivet USD Statistical Results

Sampled lines	35 of 134
Measurement error	0.02
Standard deviation	0.2116
Sampling error	0.2712
Pre-monitoring error	0.066
Post-monitoring error	0.066
Total project error	27.2%

4.4.1.4 San Francisco General Hospital

The San Francisco General Hospital replaced T-12 fluorescent lamps and magnetic ballasts with high efficiency T-8 fluorescent lamps and electronic ballasts. Incandescent fixtures were also replaced with compact fluorescent fixtures, and incandescent Exit signs were replaced with light-emitting diode (LED) Exit signs. A total of 5,816 lines of fixtures in 14 buildings were included in the lighting efficiency project.

Nexant's representative visited the S.F. General Hospital facility on four separate occasions – September 9, October 4, November 7 and December 6 2002. During the post-installation audit inspections, a random sample of 140 lines (out of 5,816 total) of retrofitted fixtures were visually inspected to confirm the retrofit work was properly and thoroughly completed by S.F. General Hospital's contractors. Fixture type and quantity inaccuracies found during the inspection were documented, and the lighting tables were updated to accommodate the modifications. During the inspections, 16 errors were found, which is well within the error tolerance for 80% confidence/20% precision.

Time-of-use lighting loggers were also deployed and retrieved for three separate monitoring periods to ensure an accurate assessment of the actual lighting usage at the facility. The data from the lighting loggers were analyzed by Nexant by time-of-use period to determine the estimated electrical energy and peak-period demand savings for the project.

For lighting efficiency projects, such as this one, energy savings are calculated using the difference between the post-retrofit and baseline lamp wattages, multiplied by the monitored hours of operation.

$$kWh_{saved} = (kW_{pre\text{-}retrofit} - kW_{post\text{-}retrofit}) * \text{Hours of Operation}$$

The wattages of the pre-retrofit lighting equipment and those of the post-retrofit lighting equipment were taken from the manufacturer ratings, as indicated on the Equipment Data Sheets or listed on the fixtures themselves. Fixture wattages were confirmed during the post-installation inspection, when randomly selected points were verified. Post-installation hours of operation are determined by directly monitoring the run-time of a sample of the fixtures. It is assumed that the pre-installation hours of operation will be the same as the post-installation hours for the purpose of calculating the lighting efficiency savings.

Digital Energy, the lighting retrofit contractor for this project, submitted a survey table of 5,816 lines of fixtures, organized into 55 usage groups in 14 buildings. As many of the 55 usage groups contained only a few lines and/or represented only a small proportion of the total project savings, Nexant reorganized the usage groups into six manageable M&V usage groups. Using the 80% confidence/20% precision statistical guidelines specified by the California Energy Commission, Nexant randomly selected a statistically-valid sample of lines for each M&V usage group, as given in Table 4-13. The sampling requirements are separated into two monitoring sites—main hospital and other hospital buildings—and are stratified (weighted) based on the projected savings of each M&V usage group. The sample was monitored over a one-month period to accurately assess the actual usage hours of operation by time-of-use period (peak period, part-peak period, and off-peak period).

Table 4-13: San Francisco General Hospital Monitoring Points

Usage Group	Main Hospital	Other Hospital Buildings
Interior Hall, restrooms	8	8
Laboratory, exam rooms	8	8
Office, storage normal	8	8
High	5	5
Medium	5	5
Low	5	5
Totals	**39**	**39**

Table 4-14 summarizes the findings of Nexant's monitoring efforts for this project. The summary compares the monitoring results gathered by Nexant with the energy savings estimates submitted by S.F. General Hospital. The high error percentages in three of the usage groups may be due to Nexant's grouping of the many S.F. General Hospital usage groups.

Table 4-14: San Francisco General Hospital Monitoring Results

M&V Usage Groups	Submitted Average (Hrs)	Nexant Measured (Hrs)	Difference (Hrs)	Difference (%)	Project Savings (%)
High	8,482	6,547	1,935	-29.6	22.2
Interior Hall, Restroom	6,388	5,972	416	-7.0	23.6
Laboratory, Exam	3,200	5,244	2,044	39.0	18.1
Low	1,777	1,696	81	-4.8	9.7
Medium	3,470	1,732	1,738	-100.3	3.3
Office, Storage Normal	2,499	2,854	355	12.4	21.4
Exit Signs (unmonitored)	8,760	8,760	0	0	1.7

The monitored hours of operation were used to calculate verified energy savings using the lighting efficiency equation. Verified peak-period demand savings were then calculated by dividing the energy savings during the peak-demand period by the total number of hours during the peak-period. The monitoring results gathered by Nexant indicates that there are some discrepancies in the hours of operations reported by San Francisco General Hospital and those monitored by Nexant. However, the differences in the usage groups average each other out in yielding a similar total energy savings amount for the entire project. Thus, the energy savings estimates submitted by San Francisco General Hospital were close to the measured energy savings for the project.

Two sets of realization rates were calculated—one for peak-period demand savings and one for annual energy savings. The peak-period realization rate was calculated by dividing the verified peak demand savings by the reported peak demand savings. Similarly, the energy realization rate was determined by dividing the verified energy savings by the reported energy savings. Table 4-15 lists the project savings and corresponding realization rates for this project. The high realization rate for energy savings indicates that the assumptions going into the reported savings calculations (such as estimated hours of operation) are accurate. The lower realization rate for demand savings indicates that the estimated peak-period hours of operation were somewhat aggressive.

Table 4-15: San Francisco General Hospital Project Results

Savings	Reported	Verified	Realization Rate
Energy (kWh)	2,452,988	2,388,054	0.97
Demand (kW)	311.0	231.5	0.74

Statistical results are presented in Table 4-16. The errors given are reported at an 80 percent confidence level. Measurement error was minimal, but was still included in the evaluation. Measurement uncertainty resulted from errors found in the lighting monitoring device, which has an error of a minute per week, or 0.0001 of the collective monitoring time period. Also included in the measurement uncertainty is the equipment "box time" or the period between when the loggers are deployed to when they are installed, and the period between when they are removed to when the data from the logger is downloaded to the computer, which is approximated to be 2 percent.

The largest source of error is from sampling error, which is calculated using the standard deviation of the realization rates of the monitored points, as summarized below. The third source of error resulted from not performing pre-installation monitoring. The operating hours of the pre-installation lamps was assumed identical to the operating hours of the facility during the post-installation for simplicity, as is usually assumed. However, variations in usage patterns may vary from month to month, which introduces a degree of error into the results. Thus, to add consideration for this error, a 7 percent error was assumed for the variation in hours between pre- and post-installation monitoring. Taking into account the resulting uncertainty of the project, the total verified savings for this project are 2,388,054 kWh of annual energy, and 231.5 +/- 105.0 kW of peak demand.

The uncertainty for this project could be minimized if the monitoring sample is increased. However, considering that this project contained 5,844 rooms/lines of fixtures, selecting a representative random sample of fixtures is the only cost-effective way to estimate the energy savings for the project.

Table 4-16: San Francisco General Hospital Statistical Results

Sampled lines	78 of 5,844
Measurement error	0.0201
Standard deviation	0.3492
Sampling error	0.4475
Pre-monitoring error	0.07
Total project error	45.3%

4.4.2 M&V Activities for Sampled HVAC Projects

Table 4-17 below shows the results of the three sampled HVAC projects. Specific details about each project on which M&V was performed follows after the table.

Table 4-17: Results of Sampled HVAC Projects

Project	Reported Savings (kWh)	Verified Savings (kWh)	Realization Rate (kWh)	Reported Savings (kW)	Verified Savings (kW)	Realization Rate (kW)
Contra Costa County	303,000	149,193	0.49	50.0	40.0 ± 23.2	0.80
Del Mar USD	494,239	568,598	1.15	53.6	89.5 ± 29.1	1.67
Piner Olivet USD	58,009	54,876	0.95	0	92.5 ± 50.0*	--
Totals for HVAC	**855,248**	**772,667**	**0.90**	**103.6**	**129.5**	**1.25**

*Savings for this project are not counted in verified savings results

4.4.2.1 Contra Costa County

Contra Costa County (CCC) installed similar energy saving HVAC measures in four buildings. The measures include removing pneumatic controls equipment (Alerton DDC controls system); controlling hot water pumping via Alerton DDC; replacing variable inlet vanes on air-handling unit (AHU) fans with variable frequency drives (VFDs); decreasing chiller usage due to the VFDs and other energy savings control algorithms; and reducing heating gas usage due to VFD control and OSA temperature reset. All measures were installed before the start of the M&V activities. Since the enhanced DDC control system and the decreased chiller usage measures required pre-installation monitoring to establish an accurate baseline, these could not be included in the M&V activities. Only the hot water pumping controls and the replacement of the variable inlet vanes with VFDs were included in the M&V analysis since these did not require pre-retrofit monitoring to establish the baseline.

Nexant staff visited the four CCC facilities on August 8, 2002, to conduct a post-installation site visit. At each facility, information was gathered, power draw measurements were made, and equipment installation was verified. Information collected includes equipment nameplate data and pre-retrofit time-of-use schedules. Power draw measurements were made with a Powersite Energy Analyzer. Equipment installation was visually verified. In addition, Nexant requested that the CCC use their energy management system to trend a number of parameters. The trending period began September 3, 2002, and lasted for one month. The energy management system collected data every 10 minutes during the trending period. Nexant used the trend data to complete its analysis and determine the estimated electrical energy and peak-period demand savings resulting from the two measures.

The M&V process focused on two energy conservation measures at each facility: (1) the control of hot water pumps with Alerton energy management system and (2) the replacement of variable inlet vanes on air-handling unit fans with VFDs. For the pump controls measures, Nexant calculated energy and peak demand savings using Equation 1 below; for the VFD measures, Nexant used Equation 2 below. The equations relate energy usage to the hours of operation of the equipment multiplied by the power consumption of the equipment. Efficiency savings are the result of a reduction in equipment power consumption, with hours of operation remaining constant (Equation 2). Control savings result from a reduction in the hours of operation, with the equipment power consumption remaining constant (Equation 1). Peak demand savings are calculated by dividing the energy savings during the peak-demand time-of-use period by the total number of hours in the peak-demand period. For the peak demand savings calculation, the analysis was conducted only for weekdays between the hours of 2 pm and 6 pm.

(1) $\text{Savings (kWh)} = (\text{Hours}_{\text{pre-retrofit}} - \text{Hours}_{\text{post-retrofit}}) * \text{kW}_{\text{post-retrofit}}$

(2) $\text{Savings (kWh)} = \Sigma(\text{kW}_{\text{pre-retrofit}} - \text{kW}_{\text{post-retrofit}})_i * \text{Hours}_{\text{post-retrofit, i}}$

Where:
- Savings — are energy savings, expressed in units of kWh
- $\text{Hours}_{\text{pre-retrofit}}$ — are pre-installation hours of operation
- $\text{Hours}_{\text{post-retrofit}}$ — are post-installation hours of operation
- $\text{kW}_{\text{pre-retrofit}}$ — is pre-installation power consumption in units of kW
- $\text{kW}_{\text{post-retrofit}}$ — is post-installation power consumption in units of kW
- i — refers to a specific temperature bin

The hours of operation in Equation 1 come from trended data, and the power consumption of the water pumps was measured during the site visit. The efficiency savings in Equation 2 are calculated using a temperature bin analysis, where the average fan power after installation is subtracted from the average fan power before installation for each temperature bin *i*. The difference in power consumption is multiplied by the number of operating hours from weather data within each temperature bin *i*. Then the energy savings from all the temperature bins are added to result in the savings over the entire range of operating temperatures.

The savings estimated from the M&V analysis (verified savings) were divided by the savings reported on the ECAA loan application (reported savings) to arrive at the realization rates, reported by building for each of the two analyzed measures. The loan recipient's calculation spreadsheet, which was broken down building-by-building, indicated a total peak-demand savings of 128 kW, while the reported aggregate demand savings from the loan application was reduced to 50 kW. Thus, Nexant normalized the peak-demand savings attributed to each building by a ratio of 50/128. These results are presented in Table 4-18 and Table 4-19 for electrical energy savings and peak-period demand savings, respectively.

Low realization rates for the VFD measure are due to: (1) low on-site power measurements when VFD was at full speed; (2) low VFD speed variability in trend data; and (3) assumption that VAV system was properly commissioned in the pre-retrofit condition. This last assumption means that, in order to approximate the baseline conditions of the project, Nexant had to assume that the HVAC equipment, such as the inlet vanes, was operating at the original design conditions. Some of these assumptions may be in error due to degradation of the equipment. For example, according to observations made by the Energy Commission, the HVAC equipment controlled by the existing pneumatic control was experiencing problems prior to the energy management system retrofit. These included: (1) building air pressure imbalance caused by uneven ventilation and (2) inlet vane malfunction in the air handling units. As a result, the HVAC equipment would operate more than needed to keep the building occupants comfortable.

The strengths of the M&V process include: (1) separate analysis for each piece of equipment; (2) power draw based on site visit measurements; and (3) time-of-use analysis (in the post) based on temperature-binned trend data. The M&V analysis weaknesses include: (1) baseline schedule based on interview and not directly verifiable; and (2) trend data only captured part of outside air temperature operating range. For outside air temperature bins not covered by the trend data, a correlation between pump duty cycle and outside air temperature had to be made. In some cases, this correlation was difficult to estimate and may be a significant cause of error.

Table 4-18: Contra Costa County Summary of M&V Results—Energy Savings

Building	Pump Controls			VFDs			Total Realization Rate
	Reported Savings (kWh)	Verified Savings (kWh)	Realization Rate	Reported Savings (kWh)	Verified Savings (kWh)	Realization Rate	
10 Douglas	1,371	1,239	0.90	24,327	10,336	0.42	0.45
50 Douglas	1,904	1,961	1.03	56,143	29,623	0.53	0.54
1980 Muir	4,114	1,849	0.45	26,556	8,660	0.33	0.34
597 Center	1,143	4,855	4.25	40,832	18,481	0.45	0.56
Totals	**8,532**	**9,904**	**1.16**	**147,858**	**67,100**	**0.45**	**0.49**

Table 4-19: Contra Costa County Summary of M&V Results—Peak-Demand Savings

Building	Pump Controls			VFDs			Total Realization Rate
	Reported Savings (kW)	Verified Savings (kW)	Realization Rate	Reported Savings (kW)	Verified Savings (kW)	Realization Rate	
10 Douglas	0.19	1.43	7.48	3.39	2.36	0.70	1.06
50 Douglas	0.48	0.78	1.64	9.38	5.66	0.60	0.65
1980 Muir	0.57	1.13	1.99	3.70	2.06	0.56	0.75
597 Center	0.16	0.58	3.65	5.97	4.95	0.83	0.90
Totals	**1.40**	**3.93**	**2.81**	**22.44**	**15.03**	**0.67**	**0.80**

Using the results from the two analyzed measures, the total project savings are then estimated. The overall project results are given in Table 4-20. The total verified project savings are 149,193 kWh of annual energy, and 40.0 +/- 23.2 kW of peak-period demand.

Table 4-20: Contra Costa County Project Results

Savings	Reported	Verified	Realization Rate
Energy (kWh)	303,000	149,193	0.49
Demand (kW)	50.0	40.0	0.80

Statistical results are shown in Table 4-21. The errors in the tables are reported at an 80 percent confidence level. The standard deviations reported were calculated using realization rates for the four pumps and 14 fans, respectively. The sampling error for both measures is equal to zero because the entire population was sampled. The measurement error is a combination of equipment measurement error and calculation error. A 2 percent measurement error is associated with the one-time equipment power draw measurement. Another source of error common to both analyses results from correlating pump duty cycle and average VFD speed to outside air temperature and then using the correlation to extrapolate to outside air temperature bins that were not captured by the trend. The other significant error in estimating energy and demand savings for the pump's controls was an assumed 10 percent error associated with the pre-retrofit operating schedule filled out by building staff. This error component is the driving error for the project, and ultimately contributes 35 percent to the project uncertainty. Other sources of error for the VFD measures include the standard error associated with averaging VFD speeds for each temperature bin and the error, assumed to be 2 percent, associated with using ASHRAE curves to correlate percent flow to percent power draw for both pre (inlet guide vanes) and post (VFD) retrofit conditions.

Table 4-21: Contra Costa County Statistical Results

Equipment Measured	Statistical Measure	Result
Pump Controls	Sampled pumps	4 of 4
	Standard deviation	0.31
	Sampling error	0.00
	Measurement error	0.44
	Total error	44%
VFDs	Sampled fans	14 of 14
	Standard deviation	0.083
	Sampling error	0.00
	Measurement error	0.38
	Total error	38%
Total project error		**58%**

4.4.2.2 Del Mar Hills Elementary School

The original design of the Del Mar Hills (DMH) elementary school facility was very inefficient in terms of energy usage and, according to district records, the school once held the distinction of having the highest energy usage per pupil in the state of California. Cognizant of this situation, the school's facility manager manually deactivated many of the HVAC components affected by the upgrade project. Time clocks originally intended to regulate the AC systems were disabled and electric heating elements would frequently operate simultaneously with cooling equipment. The AC unit serving the administrative office area would operate continuously and a lack of walls separating zones served by the original AC systems contributed to the excessive HVAC energy usage. Baseline HVAC equipment included seven rooftop AC units that provided a total of 165.5 tons of cooling with an accompanying 288.5 kW of electric heating elements.

Included with the ECAA loan application was an analysis performed by Cal Air, the project's vendor, wherein the baseline HVAC consumption was identified as 1,165,530 kWh per year. Assisted by Del Mar Hills Union School District staff, Nexant researched the specifications of the original equipment and enhanced the model developed by Cal Air. Based on the refined HVAC component data, Nexant developed a baseline estimate of 764,968 kWh per year including Cal Air's original estimate of 299,252 kWh attributable to electric heating.

Nexant staff visited the school several times beginning on December 9, 2002 to conduct a post-installation site visit. During a site visit on December 11, 2002, Nexant identified the priorities and instrumentation required to perform the M&V analysis for the project. After the seven original AC units were removed, 29 new units were installed to provide a total of 141 tons of cooling and gas-fired heat to the facility. True power measurements were recorded for a statistically valid sample of the new units based on the tonnage rating for each system. Furthermore, these measurements were recorded when the units were in full cooling mode and economizer mode. A total of 24 data loggers were installed in 19 of the units starting on January 8, 2003 and were removed on February 20 in an effort to record operational characteristics for the systems during active academic sessions. The following table summarizes the populations and sample sizes for each category of AC unit monitored.

Table 4-22: Del Mar USD HVAC Equipment

Manufacturer & Model No.	Quantity	Tons Each.	Sample Size
Carrier 48HJD004	7	4	5
Carrier 48HJD005	13	5	6
Carrier 48HJD006	4	6	3
Carrier 48HJD007	3	7	3
Carrier 40QKB024	2	1.5	2
Totals	**29**	**141**	**19**

As indicated in the M&V Plan, Nexant relied upon monitoring data collected from the new AC units in comparison with the modeled baseline in order to derive a savings estimate for the project. Continuous monitoring of the 19 sampled units was performed for 42 days and an average consumption profile for each size of AC unit was developed from the data. While the monitoring was performed in January and February, unseasonably high temperatures were experienced for two weeks of the session and provided significant opportunities to monitor heavy AC operations during the academic year. Of the 24 total data loggers deployed at the site, 14 units were able to record variable load data at 1-minute increments. This load data was calibrated by referring to the true power measurements recorded for each unit at the time of the logger installation. Pursuant to the M&V Plan, the following formula was used to calculate the savings attributable to the project.

Verified Savings (kWh/year) = Modeled Baseline (kWh/year) – Post-Installation Usage (kWh/year)

Where: Post-Installation Usage = (Fan-only demand [kW] x Annualized fan-only operational hours) + (Fan and cooling demand [kW] x Annualized fan and cooling operational hours) + (Fan and heating demand [kW] x Annualized fan and heating operational hours)

The savings estimate derived from the M&V analysis (verified savings) was divided by the savings reported on the ECAA loan application (reported savings) to arrive at the realization rate. The following table summarizes these values for both the energy and demand components of the project.

Table 4-23: Del Mar USD Project Results

Savings	Reported	Verified	Realization Rate
Energy (kWh)	494,239	568,598	1.15
Demand (kW)	53.6	89.5	1.67

Factors affecting the realization rates include the modifications to the baseline that were enabled by Nexant's research into the detailed performance specifications of the original AC systems and the exclusion of demand savings attributable to the decommissioning of the electric heating system. Interviews with Del Mar Hills staff indicated that the heating elements had been disconnected for two to three years before the project's implementation and, subsequently, did not contribute to the current savings values. Furthermore, the vendor's original estimate of post-installation energy consumption identified in the ECAA loan application was higher than the actual consumption determined from the monitoring process. The verified energy savings for this project is 568,598 kWh, and the peak-demand savings is 89.5 ± 29.1 kW.

The strengths of the M&V process include: (1) statistically valid sampling and detailed monitoring of each type of affected AC unit in the post-installation period; (2) post-installation demand values are based on detailed true power measurements; and (3) access to site-based facilities personnel with hands-on familiarity of all pre- and post-installation equipment affected by the project. The M&V analysis weaknesses include: (1) baseline was developed prior to Nexant's presence at the site and was not verified via monitoring or measurements; (2) monitoring data was not collected during all seasons of facility operation and only captured brief periods of high ambient air temperature operating characteristics; and (3) several original HVAC components were either disabled or not functioning properly during the baseline and resulted in artificially low utility consumption data. Ultimately, uncertainties with the baseline will function as the most significant cause of error in the analysis.

With the transition of seven AC systems to 29 new AC systems of differing sizes, the development of a conventional standard deviation of pre-and post-installation consumption values is challenging. Subsequently, a standard deviation reported for the project was calculated using data obtained from the monitoring session wherein performance data from similar-sized units is compared for consistency. This standard deviation value of 0.112 was further used to calculate the standard error. The sampling error for the project is based on a sample size (n) of 19 out of a population (N) of 24 and is adjusted with the finite population multiplier. A measurement error of 1.02 percent for the project is based on the manufacturer's specifications for the Fluke Model 41B true power meter used to record the demand measurements for the selected AC units. Furthermore, all of the Onset data loggers have a 5 percent error factor for the measurement of amperages versus time. This error factor was added as a separate item in addition to the measurement error for the demand samples. Modeling error is based on assumptions indicated in the baseline consumption estimate submitted with the loan application that were further modified during the M&V process using original equipment specifications.

Table 4-24: Del Mar USD Statistical Results

Statistical Measure	Results
Sampled AC units	19 of 29
Standard deviation	0.112
Sampling error	0.0257
Modeling error – baseline	0.300
Measurement error – demand	0.0102
Measurement error – amps vs. time	0.050
Total project error	32.5%

4.4.2.3 Piner Olivet Union School District

Chevron installed three HVAC measures at the Piner Olivet Union School District for the ECAA Loan Program. The measures include: installing 23 new gas-pack units on the school buildings (11 of which were funded by the program), replacing the manual thermostats controlled by six-hour timers with programmable thermostats throughout the classrooms; and the installation of a new HVAC control system at Schaefer Elementary.

Nexant staff visited the three schools in the Piner Olivet Union School District on six occasions – July 19, August 2, November 7, 2002; January 3, January 8 and February 14, 2003. At each facility, nameplate information was gathered, power draw measurements were made, equipment installation was verified, and data loggers were installed to measure the performance of the equipment before and after the retrofit. Information collected includes equipment nameplate data and pre-retrofit time-of-use schedules. Power draw measurements were made with a Powersite Energy Analyzer. Nexant staff verified equipment installation visually. In addition, current data loggers were also installed to monitor the performance of the HVAC equipment for a 1-month period in the summer and winter (due to the different usage patterns of the units based on the climate at the facility). The data was taken in 2- to 5-minute increments to monitor the cycling patterns of the gas-packs in various times during the year. Nexant used the trend data to complete its analysis and to determine the estimated electrical energy and peak-period demand savings resulting from the programmable thermostat and gas-pack replacement measures.

The M&V process focused on two major energy conservation measures (ECMs) at each facility: (1) control of the new gas-packs using programmable thermostats with preset schedules, and (2) replacement of the old gas-packs with new high-efficiency Bard gas-packs. An additional HVAC control measure was also installed at Schaefer Elementary, but because of the low energy savings resulting from the project, no M&V activities were performed for that measure.

Information collected during the site visits and trend weather data for the Santa Rosa area were used to calculate energy and peak demand savings with Equation 1 below for HVAC controls, and with Equation 2 below for HVAC efficiency. The equations relate energy usage to the hours of operation of the equipment multiplied by the energy consumption of the equipment.

Efficiency savings are the result of a reduction in equipment power consumption, with hours of operation remaining constant (Equation 2). Control savings result from a reduction in the hours of operation, with the equipment power consumption remaining unchanged (Equation 1). Peak demand savings are calculated by dividing the energy savings during the peak-demand time-of-use period by the total number of hours in the peak-demand period. For the peak demand savings calculation, the analysis was conducted only for weekdays between the hours of 2 PM through 6 PM.

(1) $\text{Savings (kWh)} = (\text{Hours}_{\text{pre-installation}} - \text{Hours}_{\text{post-installation}}) * \text{kW}_{\text{post-installation}}$

(2) $\text{Savings (kWh)} = \Sigma(\text{kW}_{\text{pre-installation}} - \text{kW}_{\text{post-installation}})_i * \text{Hours}_{\text{post-installation, i}}$

The pre-installation hours of operation in Equation 1 is calculated from the monitoring data, the post-installation hours of operation is calculated from the monitoring data and supported by the time schedules programmed into the thermostats by the Piner Olivet staff. The difference in hours is multiplied by the average power consumption of the unit at each temperature bin interval taken during the post-installation measurements. The energy savings at each temperature interval is totaled over the range of temperature between 50 to 90 degrees for the HVAC controls measure. The efficiency savings in Equation 2 are calculated using a temperature bin analysis, where the average power drawn by the gas-pack after installation is subtracted from the average power drawn by the gas-pack for each temperature bin i. The difference in power consumption is multiplied by the number of annual hours within each temperature bin (i) extracted from the weather data, and from the duty cycle of the units within those temperature bins. The energy savings from all the temperature bins are added to result in the total savings over the temperature range of 50 to 90 degrees for the HVAC efficiency measure.

The savings estimated from the M&V analysis (verified savings) were divided by the savings reported on the ECAA loan application (reported savings) to arrive at the realization rates, given in Table 4-25. The strengths of the M&V process include: (1) separate analysis for each piece of equipment; (2) power draw based on site visit measurements; and (3) time-of-use (in the post) based on temperature-binned trend data. The M&V analysis weaknesses include a small monitoring sample selection, which resulted in a large fluctuation in data.

Table 4-25: Piner Olivet USD Project Results

Savings	Reported	Verified	Realization Rate
Energy (kWh)	58,009	54,876	0.95
Demand (kW)	0	92.5	--

Statistical results are shown in Table 4-26. The errors in the tables are reported at an 80 percent confidence level. The total verified project savings are 54,876 kWh of annual energy, and 92.5 ± 50.0 kW of peak-period demand. Since, for this project, the loan recipient claimed no peak-period demand savings, the savings are ignored for the purposes of calculating a program element realization rate.

The standard deviations reported for HVAC efficiency and controls were calculated using realization rates from three of the sampled heat pumps in the population of 11 funded by the CEC. The sampling error is slightly high for the measures due to the small sample size and the high variation in the data results. For HVAC efficiency and controls, a 2 percent measurement error is associated with the one-time equipment-power-draw-measurement. Another source of error common to both analyses results from the gas-pack duty cycle, since measurements were taken at 5-minute intervals and the cycling behavior of the gas packs operate at unknown intervals.

Table 4-26: Piner Olivet USD Statistical Results

	HVAC Efficiency	HVAC Controls	HVAC Combined
Sample size	3 of 11	3 of 11	3 of 11
Standard deviation	0.4656	0.4407	0.4282
Sampling error	0.5968	0.5560	0.5403
Measurement error	0.0002	0.0003	0.0003
Total project error	59.7%	55.6%	54.0%

4.4.3 M&V Activities for Sampled LED Traffic Signals Projects

Table 4-27 below shows the results of the three sampled LED Traffic Signal projects. Specific details about each project on which M&V was performed follows after the table.

Table 4-27: Results of Sampled LED Traffic Signals Projects

Project	Reported Savings (kWh)	Verified Savings (kWh)	Realization Rate	Reported Savings (kW)	Verified Savings (kW)	Realization Rate
City of Redlands	851,981	765,937	0.90	97.0*	87.4 ± 63.2	0.90
County of Riverside	2,349,562	2,091,110	0.89	268.0	241.0 ± 46.2	0.90
City of Westlake Village	295,976	249,668	0.84	34.0	28.5 ± 2.6	0.84
Totals for LED Traffic Signals	**3,497,519**	**3,106,715**	**0.89**	**399.0**	**356.9**	**0.89**

* Corrected value (refer to project description below)

4.4.3.1 City of Redlands

The City of Redlands replaced red, amber, and green main signals and turn signals, as well as pedestrian "Walk/Don't Walk" signals with LED traffic signal modules at 49 intersections. Nexant staff visited a randomly selected sample of 13 intersections within the City of Redlands during the post-installation site visit on July 3, 2002. During the inspection, it was verified that the signals had been replaced with LED traffic signal modules. Lamps at each intersection were counted by type (main signal, turn signal, pedestrian signal) and color (red, amber, green, pedestrian orange, pedestrian white). The counts were compared to the Intersection Inventory Spreadsheet submitted to the Energy Commission by the loan recipient. No errors were observed during the inspection. Utility bill results were submitted to Nexant by the City of Redlands for the same 13 randomly selected intersections to complete the billing analysis specified in the approved M&V plan.

For each of the 13 intersections in the sample, utility bill results for several months before the retrofit and for several months following the retrofit were submitted. Nexant performed a billing analysis to compare the savings expected—based on the Intersection Inventory Spreadsheet and using assumed use factors—to the savings actually achieved based on the utility bill analysis. Table 4-28 lists the incandescent wattages, LED traffic signal module wattages, and assumed use factor used by the loan recipient for each lamp type in the project. The loan recipient estimated the use factors. These values are used, along with the counts of the lamps, to calculate the expected energy and demand savings for each of the 13 sampled intersections. For LED traffic signals projects, demand savings and peak demand savings are synonymous, since usage does not vary by time of day. Nexant discovered an error in the loan recipient's demand savings calculation methodology. The loan recipient had not included the use factors in their calculations. As Nexant does not believe this error is common within projects of this type, the calculation was corrected using the use factors. The energy saving calculations were correct as submitted.

Table 4-28: City of Redlands Signal Specifications

Signal Type	Pre-installation Wattage	Post-installation Wattage	Assumed Use Factor
Red 12" Main Signal	135	11	0.5
Red 8" Main Signal	60	7	0.5
Red 12" Turn Signal	135	7.5	0.5
Amber 12" Main Signal	135	15	0.07
Amber 8" Main Signal	60	10	0.07
Amber 12" Turn Signal	135	8	0.07
Green 12" Main Signal	135	12	0.43
Green 8" Main Signal	60	7	0.43
Green 12" Turn Signal	135	7	0.43
Pedestrian Signal–Orange	135	14	0.8
Pedestrian Signal—White	135	10	0.2

The average energy usage of each intersection *after* the retrofit, as indicated by the utility bill results, is subtracted from the average energy usage of the intersection *prior to* the retrofit, as indicated by the utility bill results, to calculate verified energy savings for the intersection. Energy savings are calculated on a per-day basis, to account for differences in billing periods. The expected energy savings for the 13 intersections are compared to the verified energy savings from the billing analysis to calculate the realization rate for each intersection. Two realization rates are calculated—one for demand savings and one for energy savings.

The savings resulting from the M&V utility billing analysis (verified savings) were divided by the savings reported on the ECAA loan application (reported savings) to arrive at the realization rates shown in Table 4-29. The energy and demand realization rates, both 90 percent, are typical for LED traffic signals projects.

Errors in the calculated expected savings might be due to the use factors assumed by the loan recipient. In particular, typical use factors for red turn signals are usually much higher than 0.5, and typical use factors for green turn signals are usually much lower than the value of 0.43 assumed by the loan recipient. Assumed use factors that are significantly different from the actual use factors (which have not been measured for this project) can result in large errors due to the propagation of small errors over large numbers of intersections. In this project there were 115 red arrow LED modules (for which reported savings were probably under-predicted, resulting in increased realization rates), and 154 green arrow LED modules (for which reported savings were probably over-predicted, resulting in decreased realization rates). It is likely that any errors from green turn signals will propagate since there are 33 percent more green turn signals than red turn signals.

Table 4-29: City of Redlands Project Results

Savings	Reported	Verified	Realization Rate
Energy (kWh)	851,981	765,937	0.90
Demand (kW)	97.0 (corrected)	87.4	0.90

Statistical results are presented in Table 4-30. The errors given are reported at an 80 percent confidence level. Measurement error was minimal, but was still included in the evaluation. Measurement uncertainty resulted from errors in the utility revenue meters from which the utility bills are obtained, and are conservatively estimated to be 1 percent for the purpose of the calculations. The largest source of error is sampling error, which is calculated using the standard deviation of the realization rates of the 13 intersections. For this project, three of the intersections had large variations between the expected savings and the verified savings, resulting in a large standard deviation in the intersection realization rates. The large standard deviation is the cause of the high uncertainty value of 72 percent for this project. Taking into account the resulting uncertainty of the project, the total verified savings for this project are 765,937 kWh of annual energy, and 87.4 +/- 63.2 kW of peak demand.

Table 4-30: City of Redlands Statistical Results

Statistical Measure	Results
Sampled intersections	13 of 49
Standard deviation	0.5639
Sampling error	0.7228
Measurement error	0.0271
Total project error	72.3%

4.4.3.2 County of Riverside

The County of Riverside replaced red, amber, and green main signals and turn signals, as well as pedestrian "Walk/Don't Walk" signals with LED traffic signal modules at 128 intersections. Nexant staff visited a randomly selected sample of 13 intersections within the County of Riverside during the post-installation site visit on July 3, 2002. During the inspection, it was verified that the signals had been replaced with LED traffic signal modules. Lamps at each intersection were counted by type (main signal, turn signal, pedestrian signal) and color (red, amber, green, pedestrian). The counts were compared to the Intersection Inventory Spreadsheet submitted to the Energy Commission by the loan recipient. No errors were observed during the inspection. Utility bills were submitted to Nexant by the County of Riverside for the same 13 randomly selected intersections to complete the billing analysis specified in the approved M&V plan.

For each of the 13 intersections in the sample, utility bill results for several months before the retrofit and for several months following the retrofit were submitted. For three intersections, only one bill was received either before or subsequent to the retrofit. These three intersections were excluded from the billing analysis due to a lack of confidence in results from a single utility bill. For the remaining 10 intersections, Nexant performed a billing analysis to compare the savings expected—based on the Intersection Inventory Spreadsheet and using assumed use factors—to the savings actually achieved based on the utility bill analysis. Table 4-31 lists the incandescent wattages, LED traffic signal module wattages, and assumed use factor for each lamp type in the project. The loan recipient estimated the use factors. These values are used, along with the counts of the lamps, to calculate the expected energy and demand savings for each of the 10 sampled intersections. The loan recipient did not retrofit any amber turn signals, and all of the retrofit amber main signals were in flashing intersections (where amber and red flash on and off). For LED traffic signals projects, demand savings and peak demand savings are synonymous, since usage does not vary by time of day.

Table 4-31: County of Riverside Signal Specifications

Signal type	Pre-installation Wattage	Post-installation Wattage	Assumed Use Factor
Red 12" Main Signal	150	11	0.59
Red 8" Main Signal	116	8	0.59
Red 12" Turn Signal	150	9	0.81
Amber 12" Main Signal	150	22	0.5
Amber 8" Main Signal	116	13	0.5
Amber 12" Turn Signal	N/A	N/A	N/A
Green 12" Main Signal	150	15	0.38
Green 8" Main Signal	116	12	0.38
Green 12" Turn Signal	150	13	0.16
Pedestrian Signal	69	10	0.9

The average energy usage of each intersection after the retrofit, as indicated by the utility bills, is subtracted from the average energy usage of the intersection prior to the retrofit, as indicated by the utility bills, to calculate verified energy savings for the intersection. Energy savings are calculated on a per-day basis, to account for differences in billing periods. The expected energy savings for the 10 intersections are compared to the verified energy savings from the billing analysis to calculate the realization rate for each intersection. Two realization rates are calculated—one for demand savings and one for energy savings.

The savings resulting from the M&V utility billing analysis (verified savings) were divided by the savings reported on the ECAA loan application (reported savings) to arrive at the realization rates shown in Table 4-32. The energy and demand realization rates, 89 and 90 percent respectively, indicate that the assumptions going into the reported savings calculations (such as use factors) are accurate.

Table 4-32: County of Riverside Project Results

Savings	Reported	Verified	Realization Rate
Energy (kWh)	2,349,562	2,091,110	0.89
Demand (kW)	268.0	241.0	0.90

Statistical results are presented in Table 4-33. The errors given are reported at an 80 percent confidence level. Measurement error was minimal, but was still included in the evaluation. Measurement uncertainty resulted from errors in the utility revenue meters from which the utility bills are obtained, and are conservatively estimated to be 1 percent for the purpose of the calculations. The largest source of error is sampling error, which is calculated using the standard deviation of the realization rates of the 10 intersections. Taking into account the resulting uncertainty value of 19.2 percent, the total verified savings for this project are 2,091,110 kWh of annual energy, and 241.0 +/- 46.2 kW of peak demand.

Table 4-33: County of Riverside Statistical Results

Statistical Measure	Results
Sampled intersections	10 of 128
Standard deviation	0.1477
Sampling error	0.1893
Measurement error	0.0293
Total project error	19.2%

4.4.3.3 City of Westlake Village

The City of Westlake Village replaced red, amber, and green main signals and turn signals, as well as pedestrian "Walk/Don't Walk" signals with LED traffic signal modules at 15 intersections, which included two intersections operated by CalTrans. Nexant staff visited a randomly selected sample of eight intersections within the City of Westlake Village during the post-installation site visit on June 27, 2002. During the inspection, it was verified that the signals had been replaced with LED traffic signal modules. Lamps at each intersection were counted by type (main signal, turn signal, pedestrian signal) and color (red, amber, green, pedestrian). The counts were compared to the Intersection Inventory Spreadsheet submitted to the Energy Commission by the loan recipient. One error was found during the inspection, three modules were missed at one intersection. Nexant does not believed the error to be a global error, nor is it a significant error. Therefore, the results will not be adjusted to account for it. Utility bills were submitted to Nexant by the City for all 13 intersections controlled by Westlake Village to complete the billing analysis specified in the approved M&V plan. One intersection, Agoura Road and Terrace Avenue, was found to have a problem with the utility meter, and the results were excluded from the analysis.

For each of the 12 intersections analyzed, utility bill results for several months before the retrofit and for several months following the retrofit were submitted. Nexant performed a billing analysis to compare the savings expected—based on the Intersection Inventory Spreadsheet and using assumed use factors—to the savings actually achieved based on the utility bill analysis. Table 4-34 lists the incandescent wattages, LED traffic signal module wattages, and assumed use factor for each lamp type in the project. These values are used, along with the counts of the lamps, to calculate the expected energy and demand savings for each of the 12 intersections. The loan recipient did not have any eight-inch signals to retrofit. For LED traffic signals projects, demand savings and peak demand savings are synonymous, since usage does not vary by time of day.

Table 4-34: City of Westlake Village Signal Specifications

Signal Type	Pre-installation Wattage	Post-installation Wattage	Assumed Use Factor
Red 12” Main Signal	135	10.5	0.59
Red 8” Main Signal	N/A	N/A	N/A
Red 12” Turn Signal	135	9.3	0.81
Amber 12” Main Signal	135	15	0.03
Amber 8” Main Signal	N/A	N/A	N/A
Amber 12” Turn Signal	135	9	0.03
Green 12” Main Signal	135	11.8	0.38
Green 8” Main Signal	N/A	N/A	N/A
Green 12” Turn Signal	135	9	0.16
Pedestrian Signal	135	9.4	0.9

The average energy usage of each intersection *after* the retrofit, as indicated by the utility bills, is subtracted from the average energy usage of the intersection *prior to* the retrofit, as indicated by the utility bills, to calculate verified energy savings for the intersection. Energy savings are calculated on a per-day basis, to account for differences in billing periods. The expected energy savings for the 12 intersections are compared to the verified energy savings from the billing analysis to calculate the realization rate for each intersection. Two realization rates are calculated—one for demand savings and one for energy savings.

The savings resulting from the M&V utility billing analysis (verified savings) were divided by the savings reported on the ECAA loan application (reported savings) to arrive at the realization rates shown in Table 4-35. The energy and demand realization rates, both 84 percent, are reasonable for a typical LED traffic signals project.

The realization rates may be less than 1.0 because of errors in the calculated expected savings that come about as a result of the use factors assumed by the loan recipient. The use factors used in the calculations are standard values and do not appear to be inaccurate. However, large variations in use factors can be found from city to city, and even from intersection to intersection within the same city. Without actually measuring the real use- factors, it is impossible to know how accurate the assumed use-factors are. Moreover, any small error in use factor can propagate into a large error over a population of intersections.

Table 4-35: City of Westlake Village Project Results

Savings	Reported	Verified	Realization Rate
Energy (kWh)	295,976	249,668	0.84
Demand (kW)	34.0	28.5	0.84

Statistical results are presented in Table 4-36. The errors given are reported at an 80 percent confidence level. Measurement error was minimal, but was still included in the evaluation. Measurement uncertainty resulted from errors in the utility revenue meters from which the utility bills are obtained, and are conservatively estimated to be 1 percent for the purpose of the calculations. The largest source of error is sampling error, which is calculated using the standard deviation of the realization rates of the 12 intersections. Taking into account the resulting uncertainty value of 9.3 percent, the total verified savings for this project are 249,668 kWh of annual energy, and 28.5 +/- 2.6 kW of peak demand.

Table 4-36: City of Westlake Village Statistical Results

Statistical Measure	Results
Sampled intersections	12 of 15
Standard deviation	0.0680
Sampling error	0.0872
Measurement error	0.0309
Total project error	9.3%

4.4.4 M&V Activities for Sampled Miscellaneous Projects

Table 4-37 below shows the results of the two sampled Miscellaneous ECAA projects. Specific details about each project on which M&V was performed follows after the table.

Table 4-37: Results of Sampled Miscellaneous Projects

Project	Reported Savings (kWh)	Verified Savings (kWh)	Realization Rate	Reported kW Savings	Verified kW Savings	Realization Rate
Antelope Valley College – Solar Heating	12,700 Therms	11,814 Therms	0.93	0	0	--
Mount San Antonio – Thermal Energy Storage	0	0	--	400.0	218.9 ± 41.6	0.55
Totals for 12 Sampled Projects	7,615,313 kWh	7,006,277 kWh	0.92	1,315.1 kW	1,051.1 kW	0.80

4.4.4.1 Antelope Valley College – Solar Heating

The AVCC project has one energy conservation measure (ECM), which adds solar heating capacity to an existing pool boiler system. The modified boiler pipe distribution system has valves and piping added to direct pool water flow to 64 solar panels. It is anticipated that the solar heating system will provide all needed pool heating from April to September. However, due to changes in the sun's position throughout the year, the solar panels will not be able to provide sufficient heating at all times, and the boiler will often need to supplement the solar panels. Savings will result from the reduced operation of the existing boiler. The existing boiler will be used as backup heating for times of the year when the heat generated by the solar collectors is not adequate to maintain pool water at 86 degrees, the temperature desired by the school. As reported in the approved ECAA loan application, this project is expected to save 12,700 therms/year.

The loan recipient to calculate the boiler energy offset by the solar panels used an analysis program called "Heliocol Commercial Pool Energy Savings Analysis". Before installation of this measure, the boiler contributed 100 percent of the heating requirement of the pool water. After the solar panels were installed, the boiler can contribute anywhere from zero to 100 percent of the heating requirement, with the rest of the heating requirement met by the solar panels. The energy savings are determined from that portion of the heating requirement that is met by the solar panels. The heating contribution of the solar panels effectively offsets the heating requirement of the boiler, saving natural gas energy, expressed in units of therms.

A post-installation inspection was conducted on September 9, 2002 to confirm the installation of the solar panels and associated valves and piping. Nameplate information of the boiler was recorded, and the pump was verified as a constant-flow system. The pre- and post-installation control methodology for system operation was also confirmed by interviewing site staff.

Monitoring during a three-month period was completed to provide an operational profile of the solar collectors and to characterize periods when the boiler is needed and when it is not needed to maintain 86-degree pool water. Temperature loggers recorded temperatures in 5-minute intervals at two locations: pool water leaving temperature, and solar collector water leaving temperature. The system controller engages the pump motor whenever it estimates, based on measurements from a rooftop light intensity meter, that the collectors can contribute at least six degrees to the pool water. The collectors are in four parallel arrays of sixteen panels to reduce the total flow and increase the temperature change, which is on average eight to 15 degrees. The flow rate was balanced across the system at 200 GPM during system commissioning.

The change in water temperature from the pool exit to the solar collector exit, along with the known constant flow rate of the water, was sufficient to determine the energy savings of the boiler. Results are reported in one-hour intervals. The following equation was used to compute the project energy savings for each hour of operation:

Equation 1:

$$\text{Energy Saving (Therms)} = \frac{(200\ \text{GPM})(8.34)(\text{SPWLT-PWL})(60)}{100{,}000 * (\text{Boiler Efficiency})}$$

Where:	PWLT	Pool Water Leaving Temperature (°F)
	SPWLT	Solar Panel Water Leaving Temperature (°F)
	8.34	Conversion from gallons to pounds
	60	1 Btu per pound-degree Fahrenheit * 60 minutes/hour conversion
	100,000	Btu per therm conversion

The monitoring occurred during January, February, and March of 2003. Monitoring was to occur during the summer months; however, problems with sensor installation prevented the monitoring until the winter-spring period. As per the approved M&V plan, the data was analyzed and results recorded to yield the hourly therm savings, calculated from Equation 1, and aggregated for the entire month. When the pump was not operating, the temperature difference was minimal, so the hourly savings were automatically assigned zero therm savings. The monthly results were compared to the program-predicted results.

Several variables were tested to determine the effect on energy consumption at AVCC. Nexant reviewed national weather data records, the utility bill data, and enrollment to demonstrate what, if any, correlation exists. Enrollment records show that winter-spring sessions, which began and ended about the same time each year, had similar number of students during the performance period as in the summer session, so these are not major factors and can be ignored in the analysis. The last major variable tested for effect on energy consumption is the normal and actual weather used by the Heliocol program during the actual performance period.

The monthly results were compared to the program-predicted results. The calculated energy savings for the three months of collected data were compared to the energy savings for the same three months as reported by the Heliocol program. The Heliocol program uses average monthly temperature values and solar angles of incidence, as well as engineering assumptions, to estimate the baseline. The Heliocol program is not adjusted based on actual results; therefore, the baseline is constant, and no adjustments need to be made for weather or other variables. The results from the three monitored months were used to extrapolate the results for the remainder of the year.

Savings estimated from the M&V analysis (verified savings) were divided by the savings reported on the ECAA loan application (reported savings) to arrive at the realization rate, shown in Table 4-38. The realization rate for the solar pool heating system may be affected by: (1) abnormal weather patterns, such as less sun, during the performance period; (2) possible changes in operation, such as maintaining the pool to a higher tolerance around the desired 86 degree target during the performance period, thus requiring more boiler heating and; (3) the assumption that the boiler/solar heating control system was properly commissioned in the post-retrofit period. Additionally, Nexant suspects that much of the heating occurred early in the morning, during the coldest part of the day and before there is much daylight. If this is the case, the boiler will provide the majority of the heating before the sun rises, after which the solar collectors are needed only to maintain the 86-degree water temperature throughout the remainder of the day.

The strengths of the M&V process include: (1) use of actual measured temperature data and results; (2) verification of how the solar panel usage depends on solar conditions. The M&V analysis weaknesses include: (1) the assumption that sensors were placed in the best location for measurement; and (2) the ability of sensors to respond quickly enough to the cycling water flow. This would have a direct effect on the recorded volume of water flow. It was anticipated that the pumps would not short-cycle in response to transition times of clouds to sunny periods. The boiler delay and solar controller delay will be adjusted to correct for these transient conditions. It is still anticipated that these conditions will not exist in the summer periods.

Using the results from the analysis, the total project savings were estimated. The overall project results are given in Table 4-38. Statistical results are shown in Table 4-39. The errors in the tables are reported at an 80 percent confidence level. The total verified project savings are 11,814 +/- 2,975 therms.

Table 4-38: AVCC Solar Heating Project Results

Savings	Reported	Verified	Realization Rate
Therms	12,700	11,814	0.93

The sampling error for the solar heating project is equal to zero because the entire population was sampled. The error associated with the utility billing meters is set at three percent. The measurement error reported is actually a combination of measurement error and calculation error. There is an assumed 15 percent measurement error—a conservative value—associated with the flow meters. Another significant error in estimating therm savings for the project is an assumed 20 percent error associated with the monthly insolation (sun) data for the stations closest to AVCC.

Table 4-39: AVCC Solar Heating Statistical Results

Sampling error	0.00
Billing error	0.03
GPM flow error	0.15
Insolation	0.20
Project error (percent)	25.20

4.4.4.2 Mount San Antonio College – Thermal Energy Storage

Mt. San Antonio College (Mt. SAC) replaced two eutectic salt thermal energy storage (TES) systems with ice-storage TES systems. For the two years before project installation, the thermal energy capacity of the existing system was zero, as it was not operational. Instead, chilled water was simply pumped into the holding tanks and distributed to the buildings with no additional benefit of energy storage. This required the chillers to run during peak operational periods. The new TES system relies on air-cooled chillers to charge the holding tanks nightly from 11 PM to approximately 8 AM, depending on cooling needs.

Thermal energy storage systems are effective at reducing or eliminating peak-period demand usage. The TES system allows a facility to generate cooling capacity—generally cold water—during the off-peak nighttime hours, and then circulate this stored cooling capacity during the on-peak daytime hours. Electrical energy usage may increase or decrease, depending on the system chosen. For example, since the cold water produced during the night will continuously increase in temperature as the day goes by, it is usually necessary to produce more cold water, or to chill it to lower temperatures, than would be necessary if the water was immediately circulated after leaving the chiller. This has the effect of requiring additional energy usage. However, chilling water at night, when the ambient temperature is lower, rather than during the day may increase equipment efficiencies. This has the effect of reducing the electrical energy consumption. Mt. SAC chose not to claim electrical energy savings, and Nexant did not investigate changes in energy consumption for this project.

The new TES systems utilize the existing pipe distribution network, storage tanks (with new heat exchangers), existing building pumps, and air-distribution and control systems. As reported in the approved ECAA loan application, this project was expected to save 400 kW peak-demand with no energy (kWh) savings. The measure was installed before the start of M&V activities, so analysis focused on available post-installation data.

A post-installation inspection was conducted on September 9, 2002. The chillers, pumps, glycol storage tanks, energy management system, and chilled water distribution systems are all installed and operational. In the baseline configuration, each building, except Building 11, had its own water-cooled chiller. Building 11 had swamp coolers previously and this is additional cooling capacity; however, the space is nominal (approximately 500 square feet) and offset by the removal of the swamp coolers. The existing chillers remain as back-ups to the central plant, and are connected with three-way valves.

The M&V process focused on comparing actual measured results to the results predicted by the engineering calculations contained in the loan recipient's spreadsheet. An analysis spreadsheet was used by the loan recipient to calculate the peak kW savings resulting from installation of the new TES systems. The spreadsheet relies on engineering calculations, projected hours of operation, adjusted chiller efficiencies, and average yearly weather data to estimate savings. It is based on average values, rather than actual results; thus, the baseline is fixed. Nexant compared the actual energy use, from the monthly utility bills, to the predicted energy use supplied by the project sponsor, so the methodology amounts to verifying the peak kW reduction that was achieved by installation of the TES system. A reality check indicated that the 400 kW reported peak-demand savings is greater than twenty percent of the average peak-hourly demand at Mt. SAC, so it appeared that a billing analysis methodology is appropriate. It is generally accepted that billing analyses should not be performed if the expected project savings are less than 20 percent of the average energy usage.

Nexant carried out the methodology to estimate the actual energy demand saved by using the TES systems during representative periods and compared to the spreadsheet results. The TES plant performance evaluation consists of two subtasks: (1) choose weather correction parameters, and (2) evaluate user-defined variables such as campus population changes.

As reported in the approved ECAA loan application, this measure is primarily to shift kW demand from the peak-demand time-of-use (TOU) period, (weekdays 12 PM to 6 PM), to the off-peak TOU period, (weekdays 11 PM to 8 PM). Utilities provide monthly billing data segmented for on-peak usage during the summer months only; therefore the representative periods are baseline, summer 2000, and performance summer 2002. Enron Energy Marketing Corporation serviced Mt. SAC during the summer of 2000 with rate schedule I-6-DA (direct access), and for summer 2002 Southern California Edison serviced Mt. SAC with rate schedule TOU – DA. The billing month starts approximately on the twenty-first for Enron and the ninth for Edison, so a direct monthly comparison is not possible. Instead, Nexant compared the summer seasonal usage for baseline to performance period with correction parameters to account for influences by other variables on energy usage.

To calculate the average hourly demand during peak periods, Nexant used Equation 1 to normalize the billing data. First, the energy usage is adjusted to count only non-holiday weekdays, and the seasonal usage is normalized by day. Next, Nexant divided the daily usage by the six hours during the peak period to yield the average peak-hourly demand.

Equation 1:

$$\text{Savings } (kW_{\text{peak-period}}) = \Sigma(kWh_{\text{pre-installation}} - kWh_{\text{post-installation}})_i \,/\, (\text{Days}_{\text{summer peak}} * \text{Hours}_{\text{summer peak}})$$

Several variables were tested to determine their effect on energy consumption at Mt. SAC. Nexant reviewed school records, national weather data records, and the utility bill data to demonstrate what, if any, correlation exists. Enrollment records show that summer sessions, which began and ended about the same time each year, had seven percent more students during the performance period, so these are not major factors and can be ignored in the analysis. In addition, the campus buildings affected by the retrofit are not significantly changed in size, class usage and schedule, or population; therefore, these are also not major factors and can be ignored in the analysis. The last major variable tested for effect on energy consumption is the normal and actual weather during both the baseline and performance periods.

Weather effects were characterized by cooling-degree days (CDD) for local stations to best approximate the actual weather experienced by the campus during monitoring periods. A CDD is defined as the cumulative number of degrees in a month or year by which the mean temperature is above the balance-point temperature of a building (generally around 65°F). The National Climatic Data Center (NCDC) publishes CDD figures for both the current monthly averages and the historical monthly averages (1971 to 2000). Analysis of these figures and the utility billing data surprisingly shows no strong correlation between the monthly CDD data and the energy consumption during the baseline or performance periods; however, the summer season has fourteen percent fewer CDDs during the performance period indicating a potential for reduced demand savings. Due to there being no data correlation, it is not possible to quantify this variable. Thus, the billing analysis was performed by directly comparing the per-day average energy usage during the baseline peak-period to the per-day average energy usage during the performance peak-period.

Nexant arrived at the realization rate by estimating savings from the M&V analysis (verified savings), which were then divided by the savings reported on the ECAA loan application (reported savings). These results are in Table 4-40 below.

Low realization rates for the TES project may be due to: (1) fourteen percent fewer CDDs during the performance period; (2) possible changes in operation, such as lowering the average room temperature during the performance period, thus requiring more peak cooling; and (3) assumption that the TES system was properly commissioned in the post-retrofit period.

The strengths of the M&V process include: (1) use of actual billing data and results; (2) consideration of measured CDD data for local stations; and (3) examination of published campus records for enrollment and class schedules. The M&V analysis weaknesses include: (1) the assumption that plug-loads (e.g. computers, toasters, etc.) are constant; and (2) actual room temperatures, baseline and performance period, are not verifiable. This would have a direct effect on the required cooling.

Using the results from the billing analysis, the total project savings were estimated. The overall project results are given in Table 4-40. The statistical results are in Table 4-41. The errors in the tables are reported at an 80 percent confidence level. The total verified project savings are 218.9 +/- 41.6 kW of peak-period demand.

Table 4-40: Mount San Antonio College TES Project Savings

Savings	Reported	Verified	Realization Rate
Demand (kW)	400	218.9	0.55

The sampling error for the TES measure is equal to zero because the entire population was sampled. The measurement error reported is actually a combination of measurement error and calculation error. There is a 1 percent measurement error—a conservative value—associated with the utility revenue meter. Other significant errors in estimating demand savings for the TES are an assumed 5 percent error associated with the monthly CDD data for the stations closest to Mt. SAC, and a 15 percent plug-load error associated with undocumented equipment added to

Table 4-41: Mount San Antonio College TES Statistical Results

Sampling error	0.00
Measurement error	0.11
Plug-load error	0.15
CDD error	0.05
Project error (percent)	**19.0**

4.5 PROGRAM ELEMENT EVALUATION

Table 4-42 summarizes the status of the program element as of July 31, 2003.

Table 4-42: ECAA Loan Program Summary

Statistical Measure	Results
Number of current projects (loans)	65
Number of sampled projects for M&V	12
Reported savings from sampled projects	1.32 MW
Verified savings from sampled projects	1.05 MW
Realization rate (kW) from sampled projects	0.80

The results from the 12 sampled projects were applied to all 87 projects in the ECAA Loan Program. The realization rates determined through the M&V efforts were applied to the reported savings for each of the four project types. Results were then aggregated for the entire program element. Table 4-43 gives the results of the ECAA Loan Program element evaluation.

Table 4-43: Results of ECAA Loan Program Element Evaluation

Population category	Reported Savings (kWh)	Verified Savings (kWh)	Realization Rate	Reported Savings (kW)	Verified Savings (kW)	Realization Rate
Lighting	19,437,991	18,655,322	0.96	3,543	2,975	0.84
HVAC	7,712,263	6,943,980	0.90	1,689	2,203	1.25
LED traffic signals	14,139,988	12,578,513	0.89	1,609	1,434	0.89
Miscellaneous	20,925,689	19,251,634	0.92	3,726	2,880	0.80
ECAA program element	**62,215,930**	**57,429,449**	**0.92**	**10,567**	**9,492**	**0.90**

4.6 PROGRAM ELEMENT COST-EFFECTIVENESS

Cost-effectiveness for the ECAA program element is calculated from the levelized costs of the state's 2001 program investments, as explained below. The ECAA program element cost effectiveness is determined to be $32.65/kW-year. Final results are given by project in the

Appendix for two different indicators of levelized costs—both peak power and electrical energy impacts are calculated, and are expressed in units of dollars per kilowatt-year ($/kW-year) and dollars per kilowatt-hour ($/kWh), respectively. The program element cost effectiveness for energy impacts is $0.0056/kWh.

The general equation for calculating levelized cost of impacts is taken from the Energy Commission's Standard Practice Manual: Economic Analysis of Demand-Side Management Programs, (1987). The terms are modified slightly to reflect Energy Commission, rather than utility, implementation, but otherwise remain unchanged. The formula for levelized cost at the project level is:

$$LC_{CEC} = LC/IMP$$

Where: LC = total Energy Commission costs used for levelizing

IMP = total discounted demand and energy impacts of the project

These terms are further defined as follows:

$$LC = \sum_{t=1}^{N} \frac{Principal_t - Payments_t + Grants_t}{(1 + d)^{t-1}}$$

$$IMP = \sum_{t=1}^{N} \frac{(\Delta kW_t) \text{ or } (\Delta kWh_t) \text{ or } (\Delta therm_t)}{(1 + d)^{t-1}}$$

Where: Principal = amount of project loan from CEC to project host in year *t*

$Payment_t$ = amount of loan repayment from project host to CEC in year *t*

Grants = amount of ECAA service contract in year *t*

ΔkW_t = summer peak demand impact in year *t*, measured in kW

ΔkWh_t = electrical energy impact in year *t*, measured in kWh

d = State Pool Money Investment Account (PMIA) rate of 4.1 percent. (The 4.1 percent interest rate was in effect in 2001 when the CEC made its decision to fund AB29X.)

N = loan repayment period including principal and interest

Loan repayments are discounted over the lifetime of the project loans, which vary in duration, and are limited to no more than eleven years. Energy and peak demand impacts are levelized over equipment lifetimes, which is an estimate of the median number of years that installed measures are still in place and operable. The September 25, 2000, CALMAC report, Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management (DSM) Programs (MA&E Protocols), will be used to identify average equipment lifetimes. By discounting to the common denominators noted above, the overall cost effectiveness can be derived by weighting and combining project impacts.

The Appendix contains the cost-effectiveness indicators for each project within the ECAA Loan Program. The effective subsidy represents the present value of the difference between payments on the below-market loan at 3 percent and baseline financing at the April 2001 PMIA rate. It includes the service contract payment for projects completed before May 1, 2002, and any technical assistance cost spent to date. Projects analyzed in the sample all have attractive cost-effectiveness metrics from the perspective of the magnitude of demand and energy savings achieved per dollar of loan subsidy delivered through the program.

4.7 PARTICIPANT AUDITS

Nexant conducted participant audits for the ECAA program to evaluate participants' compliance with the program rules and requirements such as program eligibility, the application process, program reporting, and repayment of loans. As an adjunct, the audits also provided some indication of the level of satisfaction with the program process and design. All participant audits for the ECAA program were conducted by telephone from December 2002 to mid-January 2003.

Nexant selected to perform participant audits on the 10 participants that constituted the 12 projects that were randomly chosen for the M&V activates. Of the original 10 telephone surveys, seven participants were reached while three were not, even after repeated attempts over a one-month time period. Due to the nature of the ECAA program, it was not necessary for Nexant to perform any administrator audits because of the maturity of the program, now in its 24 year of implementation under Energy Commission administration.

Table 4-44: Audit Participants

Number	Participant Sampled	Loan Project
1	Capistrano USD	Lighting
2	City of Westlake Village	LED Traffic Signals
3	San Francisco General Hospital	Lighting
4	Contra Costa County	HVAC
5	County of Riverside	LED Traffic Signal
6	Piner-Olivet USD	Lighting and HVAC
7	City of Redlands	LED Traffic signals

Nexant developed a collection of 20 structured interview questions to ask program participants. The survey questionnaire was designed to fully cover the necessary research questions while at the same time not unduly keep respondents on the telephone. Of the 20 questions, participants responded to all of them, except for Questions 4, 6, 10, 14, and 17, which one respondent declined to answer, and Question 13, which two respondents declined to answer. Participants did not answer these questions because they either felt the questions were not relevant to their project or they could not recall enough detail to feel confident about their response.

The questions were broken down into specific categories, each covering a different aspect of the program and/or a participant's experience. Questions 1 through 8 ask participants about various aspects of the program such as program marketing, communication, reporting, and verification of results. Table 4-45 lists questions and survey responses regarding program communications. Responses indicate effective outreach and marketing, as well as the importance of the financial assistance. Table 4-46 provides additional detail that highlights the influence of the financial assistance among factors motivating program participation.

Table 4-45: Participant Responses to Program Communication Questions

Questions 1—8 focus on program aspects such as marketing, communication, reporting and verification		
Question Number	**Question**	**Response**
1	How did you find out about the ECAA program element?	4 respondents found out through the Energy Commission; 2 mention the website. 1 answered for each: word of mouth, consultant, and the utility
2*	Why did you participate in the program?	Financial incentives was the most frequent response Second highest responses were between (a) energy savings and (b) the financial benefit of obtaining low-interest rate loans to perform previously scheduled retrofits. One participant answered because of local political pressure.
3	Did you participate in any other similar peak load reduction programs?	4 said no, 3 said yes. Yes answers included: (a) a program with PG&E, (b) ECAA Loan Program battery backup system with the LED traffic signals project, and (c) installation of occupancy sensors.
4	Rate the overall quality of communication with the Energy Commission (5=thorough; 3=sufficient; 1=inadequate)	The average was 4.3 with three responding with 5, two with 4 and one with 1. The frequency of communication between the Energy Commission and participants varied from once, to weekly, to whenever a question arose.
5	By what means did you most often communicate?	Phone and e-mail were the most frequent responses. The only different response was in-person meetings in conjunction with e-mail.
6	Rate the reasonableness of the required reporting requirements (5=very reasonable; 3=somewhat reasonable; 1=very unreasonable)	The average was 4.7 with five responses of 5 and one response of 3. One said there were no reporting requirements; others mentioned progress reports that were due throughout the project implementation.
7	How long did it take for you to be notified about the status of your application after submittal?	Two said two weeks; 1 said four weeks; 2 said one to two months; 1 said less than a week; 1 did not remember
8	Did anyone from the Energy Commission visit your project to verify project completion?	Four said yes, 2 said an auditor visited and 1 could not remember

* More than one answer available for this question

Table 4-46: Participant Motives

Source	No. of Responses
Save energy	2
Rebate	4
Retrofit	2
Political pressure	1
Total	**9**

Questions 9 through 14 ask about how the program went over time and what effects the program had on participants' willingness to undertake efficiency upgrades. Responses listed in Table 4-47 indicate that program procedures pose no significant obstacles to participation, with all participants indicating that they would apply to the same or a similar program in the future.

Table 4-47: Participant Responses to Project Application and Development Process

Questions 9—14 are about the application process and what effect the program had on participants' willingness to undertake energy efficiency upgrades		
Question Number	**Question**	**Response**
9	Did you achieve your peak demand savings goals?	Five said yes; 2 were not sure because final savings numbers were not yet available
10	Rate how significant the obstacles were that you encountered implementing the project (5=no significant obstacles; 3=obstacles were significant, but would do project again; 1=obstacles were prohibitive).	The average was 4.2, with four 5s, one 4, and one 1 (Redlands). Two respondents noted "hang-ups", one with CalTrans and one with a part of the project that never got completed
11	Did you need approvals before project implementation? If yes, did this interfere with or delay the application?	All respondents had to get approval: three from a city/county council and two from a school board. No delays were noted.
12	Do you anticipate having any difficulties in repaying the loan within the time period?	All answered no
13	What is the likelihood that you would have performed peak load-reducing actions without the ECAA program? (5=definitely yes, 3=yes but under different circumstances; 1=definitely no)	The average was 2.7 with five participants responding.
14	From your experience, would you participate again in a similar program? (5=definitely yes; 3 =yes, though under different circumstances; 1=definitely no)	The average was 4.8 with five participants responding with a rating of 5 and one responding with a 4.

Questions 15 through 20 are questions with quantifiable responses offering the respondent a range of 1 to 5 to describe the level of satisfaction around the various program aspects such as about the administrator, the application, and the timeline. Table 4-48 tabulates the survey results. Responses indicated a high level of satisfaction with all program attributes, averaging 4 or higher to each question. Contra Costa County was the only respondent that gave consistently low ratings to program components. It rated the overall program and the Energy Commission both 3, the application and verification processes both 2, and the payment process a 1. Piner-Olivet Unified School District also rated the program a three, attributing that to the different people they had to deal with at Chevron. Riverside County rated the implementation timeline a three.

Table 4-48: Program Attribute Satisfaction Rankings (frequency of response)

Question No.	Question Focus	Low	Ranking			High	Average
		1	2	3	4	5	
15	Overall program	0	0	2	2	3	4.1
16	Administrator	0	0	1	2	4	4.4
17	Application process	0	1	0	3	2	4.0
18	Payment process	1	0	0	3	3	4.0
19	Verification process	0	1	0	1	5	4.4
20	Timeline	0	0	1	2	4	4.4

4.7.1 Non-participant Audits

Nexant performed non-participant audits on those program participants that had not finished either their application or their project after starting the process. The purpose of these audits was to try to discover why participants left the program, if they continued with their energy retrofit projects, and how the program might be altered to accommodate their participation in the future. The audit was composed of five questions:

1. How did you find out about the program?
2. At what point in the application or participation process did you choose to withdraw your application?
3. Why did you withdraw your participation in the CEC Peak Load Reduction Program?
4. Did you perform peak load-reducing actions without this program?
5. Would you participate in a similar program if it met your needs?

Question 1 was open-ended, two and three were multiple choice, and four and five were yes/no questions with room for explanation.

Of the 11 non-participants contacted by Nexant, only one completed the non-participant audit. The San Jose Unified School District withdrew its application because: (1) the process appeared more involved than expected; (2) there was a belief that cheaper money was available elsewhere; (3) and it could participate in a similar program if it found a no-interest loan program.

4.8 CONCLUSIONS

Most of the AB29X-funded projects in the ECAA Loan Program element have been installed and are saving energy and/or peak-demand. At this time, loan recipients have reported 9.8 MW of installed demand savings. Since its inception in 1979, the ECAA Loan Program element has funded energy efficiency projects, load reduction projects, and projects with both energy and demand savings. Since the program is not exclusively focused on peak-demand savings, Nexant has examined results for both peak-demand and energy savings. For this program element, Nexant reports two sets of realization rates—one for peak-demand and one for energy.

Nexant completed M&V activities on 12 randomly selected projects with the AB29X-funded projects. Projects were selected randomly to ensure a diverse range of projects was examined. The results of the M&V analyses indicate that most of the loan recipients have been accurate in reporting energy savings and, to a slightly lesser degree, peak-period demand savings. Nexant's results indicate a program element realization rate of 92 percent for energy savings, and a realization rate of 90 percent for peak-period electrical demand savings. Nexant has verified an ECAA program element annual energy savings of 57,429,449 kWh. Additionally, the verified peak demand savings for the ECAA Loan Program is 9,492 kW ± 1,905 kW. The error analysis for this program element, given in the Appendix, indicates that Nexant's analysis resulted in an 80 percent confidence at a 20 percent precision level, which is the exact level that was specified by the California Energy Commission.

Nexant believes that, at least in some cases, the loan recipients have not been advised of the correct way to calculate peak demand savings. Nexant has reviewed several project applications where the loan recipient has simply subtracted the total demand of the new equipment from the total demand of the old equipment to calculate demand savings. For projects where the equipment does not operate continuously, such as typical lighting projects, this is not reporting peak-demand savings, but rather the maximum-possible coincidental demand savings. As these calculations do not take into account the actual operating schedules of the equipment, the demand savings may be greatly overstated. Compounding this is the fact that, in general, peak-demand savings are more difficult for the loan recipient to accurately predict, and more difficult for the Energy Commission's loan application reviewers to fully and accurately assess. Nexant believes that the ECAA Loan Program is an important and cost-effective means of achieving peak-demand savings, but greater emphasis should be placed on ensuring that loan applications have accurately reported peak-demand savings.

The ECAA program element cost effectiveness has been determined for two indicators—peak-period demand and electrical energy. The program element results are $32.65/kW-year and

$0.0056/kWh, respectively. Cost effectiveness at the project level varied from $2.14/kW-year to over $500/kW-year for peak demand savings.

The participant audits have been completed, and the results are positive for the ECAA Loan Program element. Seven participants were contacted, and the results indicate that they are generally satisfied with the ECAA Loans and Grants Program. Results from the participants were almost all positive, including their experience with Energy Commission staff, the application process, the invoicing process, and the MV&E process. When asked if they would participate in a similar program based on their experience with the ECAA Loan Program, the response was overwhelmingly positive, indicating strong satisfaction with the ECAA program element and a desire to participate in similar programs. Most did not think they would have performed peak-load reduction actions if it were not for the ECAA Loan Program.