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Sustainable Office Lighting Control Pilot Program Evaluation

VOLUME 1

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Prepared for:

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Executive Summary

This report presents methods and findings for an evaluation of Southern California Edison's (SCE) Sustainable Office Lighting Control Pilot Program.

Background

SCE's Sustainable Office Lighting Control Pilot Program (the pilot) was designed to study the energy impacts of Advanced Lighting Control Systems (ALCS) and to collect data to support the California Public Utilities Commission's (CPUC) Decision 12-05-15, which directs California's investor owned utilities (IOU) to collect information on installation costs, participation impacts, and short- and long-term benefits associated with California Advanced Lighting Controls Training Program (CALCTP) certification.[1] In 2016, ASWB Engineering and the Opinion Dynamics Corporation (ODC) completed a *Lighting Controls Training Assessment*, which helped define work quality from the perspective of lighting control projects.[2]

SCE launched the pilot in 2015 and, to investigate potential differences in ALCS work quality or performance, sought to recruit projects designed and implemented by contractors representing three different groups:

Group 1: General electrical contractors who did not receive specialized training in lighting controls.

Group 2: Manufacturer-trained contractors or electricians trained by ALCS manufacturers.

Group 3: CALCTP-certified contractors with any other specialized training. [3]

To allow this comparison, SCE originally planned to implement and evaluate at least 80 projects from contractor groups 2 and 3 (with equal distribution across these two contractor groups), and as many projects as possible from contractor Group 1. However, given subsequent budget cuts to the program in 2015, the pilot completed only 31 projects, with eight of these projects completed by the same contractor,more than one-half of the projects completed by CALCTP-trained contractors (Group 3), and only two projects completed by a general electrical contractor (Group 1).

Between 2015 and 2017, SCE provided incentives to 31 ALCS projects that were implemented at a variety of nonresidential customer facilities—including offices, warehouses, and manufacturing and retail spaces. SCE offered enhanced financial incentives to encourage customers to implement ALCS with

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[1] Decision 12-05-15, issued on May 18, 2012, is available online at: http://www.calmac.org/events/Decision_12-05-15.pdf

[2] ASWB Engineering and Opinion Dynamics Corporation. *Lighting Controls Training Assessment.* Prepared for Southern California Edison, San Diego Gas & Electric, and Pacific Gas and Electric Company. CALMAC Study ID: SCE0392.01. April 8, 2016.

[3] CALCTP requires CALCTP-certified Projects to be conducted by CALCTP-certified contractors using a CALCTP-certified project manager and CALCTP-certified installers. This study did not determine whether projects performed by CALCTP -certified contractors met these requirements and if the persons actually installing the ALCS received CALCTP training or certifications.

dimming ballasts or dimmable LED drivers, occupancy or vacancy sensors, photocells for daylighting (where feasible), and automated demand response capability. Twenty-eight of the 31 projects elected to retrofit lighting with LED fixtures. One project had existing LED fixtures installed. Another changed out ballasts for existing linear fluorescent fixtures, relamping with linear fluorescent lamps, and still another site was a new construction LED installation.

The pilot program offered $0.48 per kWh saved (approximately double the incentive offered to similar lighting controls projects through SCE's nonresidential express or customized solutions programs). SCE limited the incentives to the lesser of $50,000 per project or 50% of project costs (whichever came first). The pilot incentive amount was designed to encourage customers to participate and to agree to extensive project assessment and monitoring by SCE and its quality control (QC) contractor.

In 2016, Cadmus was selected to evaluate the pilot program. While the evaluation was originally intended to assess potential differences in ALCS work quality or performance across the three contractor groups, due to the limited number of completed projects and the unbalanced distribution of projects among contractor groups, the pilot program evaluation shifted focus from comparing contractor group performance to reviewing ALCS project performance and savings. Cadmus also examined pilot program savings attribution. Due to the specific pilot program design, the evaluated net-to-gross (NTG) ratio may not be applicable to other ALCS programs.

The shift in study objectives, the small number of participants, and the unequal distribution across the three groups required this study to follow a case study approach. Consequently, findings should be considered exploratory and indicative of potential trends and relationships rather than statistically valid conclusions that could be extrapolated to larger populations.

Research Objectives

The evaluation sought to answer the following questions:

- What can we learn from previous studies of ALCS projects?
- What are the energy and demand impacts of ALCS projects?
- Does the current pilot delivery influence customers to install ALCS?
- What energy savings can be attributed to the pilot?
- Are customers and end users satisfied with the performance of the ALCS?
- Are end users familiar with their ALCS and do their actions impact savings?
- How did the pilot projects perform against the work quality criteria established in the *Lighting Controls Training Assessment* study?[4]

[4] ASWB Engineering and Opinion Dynamics Corporation. *Lighting Controls Training Assessment*. Prepared for Southern California Edison, San Diego Gas & Electric, and Pacific Gas and Electric Company. CALMAC Study ID: SCE0392.01. April 8, 2016.

Methods

Cadmus collected pilot- and project-specific data through the following activities:

- **Literature review** to examine best practices for lighting controls, controls training, installation, and optimization of ALCS performance.
- **Program and evaluation manager interviews** to gather additional information about the program.
- **Project implementation and inspection data review** (for a census of projects) to examine ALCS project details and to verify original energy and demand savings calculations.
- **Assessment of work quality** (for a census of projects). For this assessment, Cadmus referred to the description of work quality completed in the *Lighting Controls Training Assessment* study for its description of work quality completed by ASWB Engineering and ODC in 2016.
- **Surveys** with key decision-makers (representing 13 projects), contractors (representing 15 projects), and end users (representing seven projects) to solicit feedback about participation motivations, participation experiences, changes in business practices, and satisfaction with the ALCS system.
- **NTG assessment** (based on 11 key decision-maker interviews representing 13 projects) to examine net energy and demand impacts attributable to the pilot.
- **Analysis of advanced metering infrastructure (AMI) data** (for seven projects) before and after ALCS installations to assess whether energy savings could be detected through billing analysis.

For all projects, SCE's QC contractor, Richard Heath and Associates (RHA), performed desktop reviews, site inspections, functional testing, metering, and savings estimate analysis using engineering analysis methods. RHA also collected work quality parameters for each project. Pre-inspections were conducted by RHA and members of SCE's third-party review team. Cadmus reviewed RHA's findings and verified the engineering savings, in addition to conducting the activities listed above.

Challenges engaging decision-makers, contractors, and end users limited survey responses, with results representing less than one-half of the pilot's projects, and—combined with the small population size—limited the number of sample points used for net savings evaluation.

Key Findings, Conclusions, and Recommendations

Due to limited pilot program participation, the evaluation produced qualitative findings that are necessarily limited in nature for the reasons described above. Key findings should be viewed as insights into customer and contractor decision-making regarding lighting controls and the experiences of stakeholders that participated in the pilot program; the quantitative findings should not be considered definitive with regard to ALCS effects.

Review of existing ALCS-related studies indicated that ALCS projects face similar challenges to building management system projects in achieving optimal performance.

Successful implementation of ALCS systems (similar to building management systems) relies on the performance of many parties, including system designers, installers, building managers, code officials, and building owners. Communication, documentation, and diligence by all parties prove critical to proper installation and operation of ALCS.

Twenty-eight of 30 retrofit projects replaced their legacy lighting fixtures with LED fixtures at the time they upgraded to an ALCS. The replacement of legacy lighting with LED constituted the bulk of the lighting energy savings (approximately two thirds of total lighting savings).

Any future ALCS program should include the consideration that lighting fixtures are likely to be upgraded at the same time in the majority of projects. Upgrading lighting to LEDs provided the majority of energy savings for participants that replaced their legacy lighting; however, the one project that kept its legacy linear fluorescent lighting also produced significant energy savings when it implemented ALCS (47% reduction in usage). Another project had already upgraded their lighting to LED and later found they needed a new control system for it to function correctly.

Compared to existing conditions, pilot projects achieved, on average, a 68% reduction in lighting energy consumption from combined ALCS and fixture upgrades, based on load monitoring. Across all projects, fixture upgrades and ALCS each accounted for a 44% reduction in lighting energy consumption.

Reduction in energy usage from lighting fixture upgrades varied between 12% and 82% across projects with an average reduction of 44%. Reduction in energy usage from ALCS varied between 6% and 95% across projects with an average reduction of 44%. For example, if a typical building used 100,000 kWh per year for lighting, LED fixture upgrades reduced annual consumption by 44% (down to 56,000 kwh per year). The addition of ALCS reduced annual consumption by another 44%, decreasing annual usage to 31,360 kWh, resulting in a total reduction of 68%.[5]

> **Recommendation** Due to the large variance in observed savings, a larger study of ALCS would help refine savings estimates for forecasting and planning.

All decision-makers who responded to the survey (11 of 28) cited saving money on energy bills as their primary reason for participating in the pilot. Survey results, however, suggested decision-makers would have installed similar measures for a smaller incentive or without the pilot.

The pilot provided incentives at $0.48 per kWh of savings, and limited incentives to the lesser of $50,000 per project or 50% of the project cost. Eight of 11 surveyed decision-makers indicated they would have installed the same project for 25% of the incentive. The NTG finding also suggests that all decision-makers interviewed would have pursued at least some aspects of their project without the pilot (and financial incentives). This finding should be considered when accounting for the pilot program's

[5] The example calculation results in 69% savings due to rounding.

design, which relied on a large incentive to encourage study participation and included an extensive project assessment and QC process.

The NTG analysis (based on 11 responses from 28 decision-makers) estimated that 44% of gross above-code savings achieved by ALCS installations were attributable to the pilot program. This result, however, should be viewed in context with the pilot's high incentive amount, which was designed to recruit projects for this study.

Pilot design and marketing through distributor channels and contractors focused on recruiting customers to participate in the pilot to demonstrate savings potential with ALCS technology. Slightly more than one-third of customers (4 of 11 respondents, representing 5 of 13 surveyed projects) indicated they would not have done anything to their lighting in the pilot's absence; the remaining seven survey respondents indicated they would have at least upgraded to code. Given the specific design of the pilot program, the attributable savings ratio may not be applicable to other ALCS programs.

RHA, upon conducting site inspections and assessing contractor work quality, found many ALCS projects did not achieve optimal savings due to project quality issues.

Site inspections conducted by RHA included functional testing of the system, load monitoring, light logging, and trending data analysis to identify both unique and systematic problems with ALCS performance. Across the 31 projects, RHA found 11 projects failed to correctly program the ALCS, thus causing reporting errors; nine projects experienced communication problems with the networked devices; and five projects experienced occupancy sensor connection issues, malfunctions, or defects. Additional training or emphasis on installation quality would alleviate some of these issues. RHA did not attempt to determine which faults were due to work quality or equipment quality.

Some projects did not comply with daylight harvesting or occupancy sensor aspects of the energy lighting code, leading to reduced energy savings from ALCS. Among code requirements, daylight harvesting had the highest noncompliance rate.

All projects complied with the lighting power density requirements of Title 24, Part 6, which also mandated automatic daylight harvesting features for 20 of the 31 projects. Thirteen of these 20 met the daylight harvesting requirement; the other seven did not. Although all projects required occupancy sensors, four of the 31 projects did not install occupancy sensors, or, according to customers, the sensors were disabled due to health and safety reasons.

> **Recommendation** Provide additional training on Title 24 daylighting requirements to designers and installing contractors.

Though the program required task tuning, scheduling, daylight harvesting when required, and occupancy controls for all pilot projects, at least one of these strategies was not implemented in 16 of 31 projects.

Three of 31 projects did not implement task tuning, three did not implement scheduling, seven did not implement daylight harvesting, and four did not implement occupancy controls. Pilot participants cited issues such as reliability, uncertainty of system capabilities, and customer preferences as reasons for not implementing these strategies.

Decision-makers and contractors that responded to the survey were satisfied with their pilot experiences, but they recommended that SCE improve pre- and post-installation inspection processes and the clarity of pilot requirements.

Ten of 11 decision-makers who responded rated themselves as *very satisfied* with the performance of their new lighting system, and all 11 rated themselves as *somewhat* or *very satisfied* with the pilot overall.

All end users that responded were satisfied with the new lighting system and indicated they would recommend the system to others.

Only seven end-users responded to the survey, representing seven projects. Five respondents were *very satisfied* with the new lighting and control system, and one was *somewhat satisfied*. One did not respond to this question. Only one end user reported experiencing an issue with the new lighting system (which was quickly resolved).

Introduction

Through its Sustainable Office Lighting Control Pilot Program, Southern California Edison (SCE) provided incentives to 31 advanced lighting control system (ALCS) projects at nonresidential customer facilities between 2015 and 2017. This document is Volume I of the pilot program evaluation and it reports on trends found across projects. Volume II (Project Results) contains project-specific evaluation results in a case study format.

Background

In early 2008, California investor-owned utilities (IOU), labor organizations, and other interested parties created the California Advanced Lighting Controls Training Program (CALCTP), aimed at increasing the use of lighting controls in commercial buildings. The CALCTP program educates, trains, and certifies electricians and licensed electrical contractors to design, install, and maintain ALCS projects. A CALCTP-certified installer contractor has the required number of top-level to mid-level management personnel who have successfully completed the CALCTP Systems Course as well as the required number of electricians who have successfully completed the CALCTP Installation Course (or an equivalent course). CALCTP determined the required number of personnel in each category based on the contractor company's size.

In May 2012, the California Public Utilities Commission (CPUC) published Decision 12-05-15,[6] directing IOUs to collect information on installation costs, participation impacts, and short- and long-term benefits associated with CALCTP certification.

In April 2016, ASWB Engineering and Opinion Dynamics Corporation (ODC) completed a *Lighting Controls Training Assessment*, designed to review the effectiveness of various ALCS training opportunities for installers, including CALCTP and lighting manufacturers' training.[7] That report defined work quality for ALCS installations, including the following elements:

- Design: Design meets the customer's requirements and complies with applicable codes. Construction documents communicate effectively to the installer.
- Installation: Installation follows general electrical work quality standards (e.g., basic wiring techniques, grounding) and responds to specific limitations and obstacles found in a space.
- Code Compliance: The project meets all relevant code requirements, including Title 24, Part 6, mandatory measures and prescriptive requirements for nonresidential indoor lighting.
- Commissioning: New construction work (which does not require commissioning under Title 24, Part 6) is commissioned to ensure that the system meets the owner's requirements and the designer's basis of design. Alterations and retrofits (which do not require commissioning under

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6 Decision 12-05-15 is available online: http://www.calmac.org/events/Decision_12-05-15.pdf

7 ASWB Engineering and Opinion Dynamics Corporation. *Lighting Controls Training Assessment.* Prepared for Southern California Edison, San Diego Gas & Electric, and Pacific Gas and Electric Company. CALMAC Study ID: SCE0392.01. April 8, 2016.

Title 24, Part 6) are checked, inspected, and tested to verify that the installed system performs as intended and is ready to hand off to occupants.

- Functionality (Acceptance Testing): The system operates as intended, responding to "triggers" (e.g., occupancy/vacancy, outdoor lighting levels, time of day, day of week) as specified and not responding to "false triggers" (e.g., noise from vents, people walking outside the controlled area). Typically, a lighting control system's function is verified through the Title 24, Part 6, Acceptance Testing Procedures.
- Persistence: The system maintains functionality over the equipment's life.
- Occupant Satisfaction: The system improves occupants' experiences with the lighting system and does not hinder occupants' ability to use the space.

Sustainable Office Lighting Control Pilot Program Design

SCE designed its original Sustainable Office Lighting Control Pilot Program to study ALCS installations and to collect data in response to Decision 12-05-15. SCE offered enhanced incentives for nonresidential customers to install ALCS projects, and tracked participating customers and their contractors, from rebate reservations to project completions and post-installation inspections. SCE targeted commercial office spaces with a high potential for energy savings from ALCS projects, and required that ALCS projects include the following:[8]

- Dimming ballasts or dimmable LED drivers
- Occupancy or vacancy sensors
- Photocells for daylighting (where feasible)
- Automated demand response capability

The pilot also required that ALCS software include the following capabilities:

- A display in near-real-time mode that overlaps onto a floor plan or controlled space on a monitor screen (with the near-real-time mode defined as updated in no more than three-minute intervals)
- Modify lighting controls' operating schedules by lighting zone, either internally or remotely via software or communication protocols
- Measure and track (by lighting control zones) kWh consumption and kW demand for a defined duration
- Estimate energy usage, compared to the prior lighting system or prior period
- Estimate energy bill savings, compared to the prior lighting system or prior period

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[8] *Southern California Edison Company's (U 338-E) Statewide Lighting Market Transformation Program Report*. June 1, 2015. Filed November 14, 2013. Available online: http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/5F24A62D8874DD2488257E570074B196/$FILE/R 13-11-005_EE Rolling Portfolios OIR_SCE Statewide LMT Report.pdf

- Maximize lighting operation limits (i.e., tuning) through lighting control zones that use software and communication protocols
- Fine-tune time delays, occupancy sensors, and vacancy sensors by lighting control zones using software and communication protocols
- Daylight harvesting by lighting control zones via software and communication protocols
- Automated demand response via software and Internet communications

As shown in Table 1, pilot participants and contractors could choose between two participation options: Path A included all requirements shown for projects where daylighting was not possible; and Path B included all requirements shown in Table 1 for projects where daylighting was possible. SCE offered the same incentives for either path. The pilot provided incentives at $0.48/kWh of energy savings calculated by Richard Heath and Associates (RHA) and limited incentives to the lesser of $50,000 per project or 50% of project costs (whichever came first).

Table 1. Pilot Participation Paths

Capability	Path A	Path B
Daylight harvesting	n/a	✓
Demand and real-time pricing signal response	✓	✓
Individual control where feasible	✓	✓
Occupancy or vacancy controls	✓	✓
Remote access to the controls dashboard	✓	✓
Scheduling	✓	✓
Tuning of ballasts	✓	✓
User-friendly interface	✓	✓

An original pilot objective sought to collect quantifiable project data from lighting control installations conducted by CALCTP-certified and non-CALCTP-certified contractors; this supported CPUC Decision 12-05-015 and future program design data needs. For the pilot, SCE identified three lighting contractor groups:

Group 1: General electrical contractors who did not receive specialized training in lighting controls.

Group 2: Manufacturer-trained contractors or electricians trained by ALCS manufacturers.

Group 3: CALCTP-certified contractors with any other specialized training. [9]

To allow for this comparison, as shown in Table 2, SCE originally planned to implement at least 80 projects from Groups 2 and 3 (with equal distribution across both groups), and as many projects as possible from Group 1. However, given subsequent budget cuts to the program in 2015, the pilot

[9] CALCTP requires CALCTP-certified Projects to be conducted by CALCTP-certified contractors using a CALCTP-certified project manager and CALCTP-certified installers. This study did not determine whether projects performed by CALCTP -certified contractors met these requirements and if the persons actually installing the ALCS received CALCTP training or certifications.

completed only 31 projects with eight of these projects completed by the same contractor, more than one-half of the projects completed by CALCTP-trained contractors (Group 3), and only two projects completed by a general electrical contractor without any defined training (Group 1).

In 2015, SCE initiated discussions with the CPUC regarding the budget limitations and recruitment difficulties affecting the pilot program. Pilot staff and stakeholders identified low participation as a significant limitation in obtaining representative and statistically significant evaluation results regarding the relative performance of contractor groups or the performance of ALCS installed by different contractor groups. Additionally, contractors pursuing CALCTP training could exhibit self-selection bias, making it impossible to determine a causal link between CALCTP training and contractor performance.

Table 2. Contractor Group Definitions and Number of Projects

Contractor Group	Contractor Group Definition	Maximum Number of Projects Allowed in Program	Number of Projects Completed	Number of Unique Contractors
Group 1: General Electrical Contractors	Contractors without specialized training in lighting controls	No limit	2	1
Group 2: Manufacturer-Trained Contractors	General electricians trained by lighting manufacturers on ALCS	40	12	11
Group 3: CALCTP-Certified Contractors	CALCTP-certified contractors with a combination of any other specialized training	40	17	8
Total		**More than 80[a]**	**31**	**20**

[a]Given budget and recruitment difficulties, the total project quota was reduced to 40 in early 2016.

In 2016, SCE contracted with Cadmus to evaluate the pilot program. During the 2016 evaluation kickoff meeting, given the limited ability to draw comparisons between contractor groups, SCE and CPUC's Energy Division staff determined that the evaluation should focus on reviewing project performance, work quality, energy savings, and attribution. The targeted project participation quota fell to 40 projects from the original target of more than 80 projects. Although the pilot was designed to encourage customer participation (given the extensive project monitoring and quality control requirements), the pilot provided an opportunity to gather insights about attribution for the ALCS technology and the pilot incentive levels. To recognize the pilot's limitations and not overgeneralize the pilot's outcomes, the evaluation plan framed this pilot study as qualitative, with case-study findings.

Pilot Program Projects

Between 2015 and November 2017, pilot participants completed 31 out 40 planned pilot ALCS projects (30 retrofit projects and one new construction project). One general electrical contractor completed two projects, and eleven manufacturer-trained contractors completed 12 projects. Eight CALCTP contractors completed 17 projects, as shown in Table 2.

Pilot participants included a variety of businesses and organizations. Retrofitted spaces included offices, warehouses, manufacturers, retail outlets' distribution facilities, universities, restaurants, and a convention center. As shown in Table 3, the 31 ALCS projects covered approximately 2.8 million square feet.

Table 3. Project Summary

Space Types	Number of Projects	Total Area Impacted (sq. ft.)
Offices	7	780,325
Warehouse	6	514,038
Manufacturing	4	508,175
Mixed Warehouse and Office	4	215,000
Retail	3	20,900
University	3	122,239
Refrigerated Warehouse	2	581,529
Convention Center	1	52,924
Mechanical Tunnel[a]	1	20,174
Total	**31**	**2,815,304**

[a] This project consisted of retrofitting an underground mechanical tunnel serving multiple campus buildings.

While legacy linear fluorescent fixtures (such as T8 lamps) could be controlled with ALCS-compatible ballasts, 28 of the 31 projects elected to retrofit lighting with LED fixtures. One site was a new construction LED installation. Another changed out ballasts for existing linear fluorescent fixtures and relamped with linear fluorescents, and still another purchased LED fixtures prior to hearing about the pilot and later found they were not compatible with their existing control system.

Table 4 details the number of projects that replaced each type of lighting, with nine projects replacing multiple lighting types. A majority of projects (23 of 31) replaced linear fluorescent T8 lighting with LED fixtures. Installed lighting fixtures included integrated sensors with photocells for daylight harvesting and with passive infrared (PIR) or combined PIR and ultrasonic for occupancy controls.

Table 4. Legacy Lighting Types Replaced in the Pilot Program with LED

	Number of Projects Replacing Legacy Lighting with LED Lighting[a]
T8	23
Metal Halide	8
T5	7
CFL	3
T12	1
Halogen	1
Incandescent	1

[a] Nine projects replaced more than one legacy lighting type.

The contractors installed sensors to provide feedback to ALCS-networked controls and programmed the networked ALCS to provide sufficient lighting to each zone, depending on ambient lighting, occupancy status, and time of day. Not all systems utilized all available ALCS system features.

Using a central control system that can balance inputs from multiple sensors and parameters to achieve maximum energy savings, while maintaining occupant comfort, ALCS systems can provide significant energy savings over non-networked lighting controls. For the pilot, each project employed unique ALCS programming strategies, based on space requirements, safety requirements, occupancy patterns, and

other factors. Contractors and customers determined specific strategies and setpoints to balance comfort and energy savings:

- Task tuning was employed to keep the lighting fixture's maximum output below 100%.
- Occupancy controls were employed to sense when a room was occupied and adjusted lighting levels accordingly.
- Scheduling was employed to change a system's operation strategy, based on the time of day; often, during nighttime or unoccupied hours, systems were programmed to use more aggressive tuning strategies. Shorter occupancy delays further reduced a system's energy consumption.
- Daylight harvesting was employed to dim or turn off fixtures in response to ambient lighting.

The pilot required employment of all these strategies (where feasible) for every project. Table 5 shows the number of projects included each control strategy. Most ALCS projects employed multiple control strategies, but, as discussed in the report's work quality reviews, RHA found through post-installation visits that some projects did not employ all the required controls. Table 5 shows the number of projects employing each pilot program required strategy.

Table 5. Lighting Controls Strategies Required and Employed in Pilot Program Participants

	Task Tuning	Occupancy Controls	Scheduling	Daylight Harvesting
Number of ALCS projects that employed control strategy	28	27	28	15
Number of ALCS projects that were required to employ control strategy per program requirements	31	31	31	20
Percentage of ALCS projects complying with program requirements	90%	87%	90%	83%[a]

[a] Eleven projects were not required to install daylight harvesting.

Twenty-nine projects (94%) employed task tuning, which typically provides savings proportional to the maximum tuning level. ALCS strategies often tuned all fixtures to 90% or less of maximum output, providing, in most cases, control savings of 10%.

Additionally, all installed ALCS had the capability to provide real-time price signal responses, remote access to control systems, and user-friendly graphical user interfaces. Though all systems included automated demand response capabilities, data were not collected to determine if this feature was enabled.

The pilot implemented QC reviews, utilizing RHA and other members of SCE's third-party verification team. Further, the pilot attempted to conduct pre-installation and post-installation inspection visits for every project, including fixture verification, monitoring, and functional testing, but this was not always possible. Table 6 details QC activities conducted at each project.

Table 6. Pilot Program Quality Control Activities[a]

Project Number	Pre-Installation Site Inspection Conducted	Pre-Installation Site Metering Conducted (>7days)	Post-Installation Inspection Conducted	Post-Installation Monitoring Conducted (>7days)
ALCS-001	Yes, SCE Third Party Review	No	Yes, RHA	Yes

Project Number	Pre-Installation Site Inspection Conducted	Pre-Installation Site Metering Conducted (>7days)	Post-Installation Inspection Conducted	Post-Installation Monitoring Conducted (>7days)
ALCS-002	No	No	Yes, RHA	Yes
ALCS-003	Yes, SCE Third Party Review	No	Yes, RHA	Yes
ALCS-004	Yes, SCE Third Party Review	No	Yes, RHA	Yes
ALCS-005	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-006	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-007	Yes, SCE Third Party Review	Yes	Yes, RHA	Yes
ALCS-008	Yes, SCE Third Party Review	Yes	Yes, RHA	Yes
ALCS-009	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-010	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-011	Yes, SCE Third Party Review	No	Yes, RHA	Yes
ALCS-012	Yes, SCE Third Party Review	No	Yes, RHA	Yes
ALCS-013	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-016	No	No	Yes, RHA	Yes
ALCS-017	Yes, SCE Third Party Review	Yes	Yes, RHA	Yes
ALCS-018	Design Review (New Construction)	N/A	Yes, RHA	Yes
ALCS-020	Yes, by RHA	Yes	Yes, RHA [b]	Yes
ALCS-021	Yes, SCE Third Party Review	No	Yes, RHA	Yes
ALCS-023	Yes, SCE Third Party Review	No	Yes, RHA	Yes
ALCS-024	Yes, SCE Third Party Review	Yes	Yes, RHA	Yes
ALCS-025	No	Yes	Yes, RHA	Yes
ALCS-028	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-029	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-030	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-034	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-035	Yes, SCE Third Party Review	Yes	Yes, RHA	Yes
ALCS-036	Yes, SCE Third Party Review	Yes	Yes, RHA	Yes
ALCS-037	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-038	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-039	Yes, by RHA	Yes	Yes, RHA	Yes
ALCS-040	Yes, by RHA	Yes	Yes, RHA	Yes
Completed	**27**	**21**	**31**	**31**

[a] ALCS project numbering in this table skips due to ALCS project numbers assigned to projects that expressed interest in the program during the planning stage, but ultimately did not participate in the program or complete the installation.

[b] Cadmus visited ALCS-20 during the post-inspection to verify QC activities.

Every project included a post-installation inspection, with monitoring conducted by RHA. For 20 of the 31 projects, pre/post-installation verification was conducted, including load metering. A pre-installation site inspection was not possible for one project, but the installing contractor monitored the lighting system with their own lighting loggers; these data were passed to RHA, which reanalyzed them. One project (new construction) did not prove applicable for a pre-installation inspection and monitoring. RHA, however, analyzed the planning data to determine system baseline information.

Research Objectives

In August 2016, Cadmus, SCE staff, and stakeholders developed the following study objectives during an evaluation kickoff meeting. Objectives included those added to reflect the shift in pilot program evaluation focus, as discussed earlier.

To evaluate SCE's Sustainable Office Lighting Control Pilot Program, Cadmus sought to answer the following research questions:

1. What can we learn from previous studies of ALCS projects?
2. What are the energy and demand impacts of ALCS projects?
3. Does the current pilot delivery influence customers to install ALCS?
4. What energy savings can be attributed to the pilot?
5. Are customers and end users satisfied with the performance of the ALCS?
6. Are end users familiar with their ALCS, and do their actions impact savings?
7. How did the pilot projects perform against work quality criteria established in the *Lighting Controls Training Assessment* study?

Methods

In addressing each research question, Cadmus conducted a variety of activities to collect information, including a literature review, program manager interviews, a project documentation review, surveys with customers and contractors, and data analysis. This section describes methods used for each activity and presents specific challenges that limit key data analysis aspects.

Literature Review

Cadmus reviewed the following documents to examine best practices for lighting controls, controls training, installation, and optimization:

- ASWB Engineering and Opinion Dynamics. *Lighting Controls Training Assessment*. February 2016.
- Northwest Energy Efficiency Alliance (NEEA). *Luminaire Level Lighting Controls Market Characterization and Baseline Report*. December 2016.
- Lawrence Berkeley National Laboratory. *Wireless Advanced Lighting Controls Retrofit Demonstration*. April 2015.
- Emerging Technology Associates. *Veterans Administration Medical Center Assessment Report.* 2010.

Cadmus also reviewed estimates of technical savings (based on literature, a review of similar projects in other territories, and Cadmus controls and commissioning experts' direct installation experience, with particular attention paid to the way differences in installations and customer training affect savings.

Program Manager Interview

Cadmus developed an interview guide and interviewed the SCE pilot program manager and evaluation manager by phone, examining the following topics to assist in development of the program evaluation plan:

- Pilot processes, including contractor training and QC processes
- Challenges in implementing the pilot or tracking metrics
- Customers' perceived participation barriers

Project Implementation and Inspection Data Review

SCE's pilot included an extensive QC process to track and verify customers, from the initial reservation of funds through project completion. RHA, the pilot's QC contractor, performed this QC process for all pilot projects. The effort included verifying the following:

- Capabilities of ALCS installed through the pilot
- Existing baseline conditions prior to controls project installation
- Control strategy of the installed equipment
- Ability of the control system to monitor performance

- Elements of work quality (specifically: installation, code compliance, commissioning, and functionality)
- Energy savings (documented after final QC)
- Project cost and scope
- Building type and size

Cadmus reviewed RHA's QC documents for all completed projects, then visited one site to conduct a final inspection, designed to observe RHA's data collection and metering processes and to confirm Cadmus' understanding of the data available in the QC project documents.

Surveys

To address specific research objectives, Cadmus conducted surveys with three stakeholder groups: key decision-makers, contractors, and end users. Table 7 shows the sample frame size, the number of survey completes, and the survey objectives for each activity.

Table 7. Interviews and Surveys

Activity	Sample Frame Size (All Representing 31 Projects)	Completed Surveys	Objectives
Contractor Surveys	20 contacts	6 respondents representing 15 projects	Training Participation motivations
Key Decision-Maker Surveys	28 contacts	11 respondents representing 13 projects	Attribution Participation motivations Satisfaction
End-User Surveys	200 [a]	7 respondents representing 7 projects	Satisfaction with system Training on system Modifications of system

[a] Cadmus reached end-users through decision-makers who responded to the survey.

Cadmus attempted to reach contractors and decision-makers up to seven times, both by email and phone, over the course of six months. In five cases, contractors or decision-makers no longer were with the company. In all other cases of non-completes, contractors and decision-makers did not respond to efforts to reach them. Contractors were offered a $100 incentive for their time.

Upon completion of each decision-maker survey, Cadmus asked the decision-makers to distribute the End-User Survey to their tenants via email (as the team had no other way of obtaining contact information for building tenants). Initially, no incentive was offered for completing the End-User Survey, but, after an initial low response rate, Cadmus added an option for responding tenants to enter a drawing for a $100 gift card. Table 8 shows the disposition results of Key Decision-Maker and Contractor surveys.

Table 8. Survey Disposition Status by Project

Survey Status by Project	Contractor	Decision-Maker	End-User
Completed	15	13	7
Participating staff no longer at business	2	3	0
Nonresponsive	13	15	6
No contact information	1	0	N/A
Total	**31**	**31**	**N/A**

Contractor Surveys

As the pilot emphasized workforce development and training contractors on ALCS, Cadmus conducted telephone surveys with contractors participating in the pilot. This included asking contractors to outline training they received, their motivations for receiving such training, and reviewing respondents' current skills, experience, or awareness that might influence their involvement in SCE's pilot. Cadmus also asked contractors about the pilot processes, participation barriers for their customers, the QC process, and what they would advise customers to do in the pilot's absence.

Similar to decision-maker surveys, Cadmus asked contractors a set of attribution questions, and compared the contractors' responses with customer responses, weighting the findings into a final attribution or baseline value. For contractors completing multiple projects, Cadmus asked the attribution questions for each project.

Appendix C presents the contractor survey guide.

Key Decision-Maker Surveys

Cadmus surveyed key decision-makers—customer contacts listed in program applications that represented building owners and/or facility managers. This included asking respondents about their experiences with the pilot and their contractors. Cadmus used the surveys to assess participant satisfaction with the pilot and to assess net energy and demand benefits by asking questions to understand each customer's likelihood of participation at different incentive levels.

Appendix B provides the key decision-maker survey guide.

End-User Surveys

While building owners decided whether to participate in the pilot, tenants were the lighting controls' end users. Tenants' understanding of how to use and work with the new lighting controls could affect the energy-savings amounts resulting from completed projects. While verified ALCS impacts were captured during the time of the post-installation QC inspection (performed shortly after system installation), energy savings performance would likely change over time due to end-user interactions with the systems.

Cadmus' brief online surveys of end users sought to provide insights into users' issues or their concerns with the new system, their training and understanding of how to use the controls, and their comfort

with the new controls. Cadmus also asked whether they changed the programmed schedules and why they did so.

It proved difficult, however, to reach end users, as Cadmus' could only access them through the key decision-maker, and only seven responses came from tenants representing seven of the 13 completed decision-maker surveys.

Appendix D provides the end-user survey guide.

Savings Impact Methodology

For this evaluation, Cadmus reviewed RHA's calculated gross savings (according to IPMVP Option A) for all 31 projects. Verified savings are based on this review. Additionally, Cadmus conducted an exploratory analysis using normalized annual consumption analysis (according to IPMVP Option C) to estimate savings for seven projects.

Engineering Analysis Methodology

For each project, the implementation contractor estimated project energy savings prior to implementation. These projected values served as *ex ante* estimates, against which verified savings could be compared.

RHA estimated achieved savings based on measures installed, the number of installations, operating hours, and other key characteristics, using IPMVP Option A. Cadmus calculated verified (*ex post*) total gross energy and demand savings for each pilot project by reviewing RHA's analysis and adjusting for fixtures documented during post-installation site visits and for pre-installation documentation with verified wattages from the Design Lighting Consortium's qualified products list and Appendix B's tables of standard fixture wattages. Cadmus applied DEER 2014 interactive effects and coincidence factors to the results, as this fell outside of RHA's scope.

Cadmus calculated *total verified gross savings* as the overall difference between a project's existing baseline and verified retrofit conditions. Cadmus also calculated *fixture savings* where applicable, and determined ALCS system *controls savings* as the difference between *total savings* and *fixture savings*. After calculating verified gross savings, Cadmus analyzed attribution and net savings, as discussed in the Net Savings Methodology section.

Normalized Annual Consumption Analysis Methodology

Cadmus analyzed Advanced Metering Infrastructure (AMI) data for a subset of projects, seeking to explore the viability of using a normalized annual consumption analysis method to estimate savings from ALCS projects.

As this was an exploratory analysis, Cadmus requested that SCE provide AMI data for a random sample of 10 sites. Cadmus received two years of hourly energy consumption data (November 2015 through November 2017), along with corresponding ALCS installation dates, facility street addresses, and preliminary savings estimates. With these data, Cadmus estimated annual energy savings that each

project should achieve during a "typical" year. (Typical year energy savings—also called "normalized" savings—refer specifically to savings expected under typical-weather conditions at a geographic location.)

Of 10 sites where SCE provided AMI data, Cadmus excluded three sites from analysis:

- For ALCS-017, the documented project installation date was September 2015, but provided AMI data did not begin until November 2015. Therefore, data from the baseline period were unavailable for this facility.
- For ALCS-029, AMI data did not derive from correct meters as they did not represent building energy consumption.
- For ALCS-036, AMI data contained multiple meters, but it remained unclear which meters corresponded to areas with lighting upgrades.

Of seven sites included in the analysis, five were industrial facilities without production data available. Production serves as a large energy-use driver at industrial facilities. Another facility was a warehouse, and the last facility was a convention center. The convention center's occupancy schedule (or calendar of events) was unavailable for analysis.

Cadmus used ALCS installation dates to split AMI data into a baseline period before a project began and into a reporting period after the project finished, and used site addresses to search for nearby weather stations and to download historical weather data.

Cadmus sourced local climatological data (LCD) from a National Oceanic and Atmospheric Administration application programmer interface. These data contained hourly, historical records of temperature and relative humidity coincident with AMI data. Weather stations were selected for each facility by geolocating the nearest station to the provided street address.

Annual energy savings, often reported for a "typical" year, are meant to represent expected energy savings under a set of normal and standardized weather conditions. The National Renewable Energy Laboratory (NREL) develops these sets of hypothetical weather data, referring to the construct as a typical meteorological year. Cadmus downloaded these data from NREL's website for the same set of LCD weather stations.

During the baseline and performance periods, Cadmus used statistical analytic models to estimate "normalized" energy consumption at each of the seven facilities. Cadmus developed models by iteratively testing combinations of independent variables and reviewing the performance of each model. The testing sought to select the best set of independent variables, model type and parameters, and sampling frequency for making reliable predictions. Cadmus selected independent variables from a set that included heating degree days and cooling degree days, temperature, relative humidity, hour of day, day of week, holiday, and business hours. The evaluation tested multi-variable linear and random forest regression models, considering both hourly and daily sampling frequencies.

All tested variable combinations resulted in a very low R-squared value, indicating that weather was not a significant energy driver at these facilities. As discussed, five of the seven sites were industrial facilities with unavailable production data. One site was a convention center, with an unavailable occupancy schedule. Without these additional data, energy savings could not be estimated accurately. Therefore, this report does not present the analysis results.

Net Savings Methodology

Project net savings represent savings above the counterfactual scenario of what the customer would have done in the pilot's absence. With input from SCE, Energy Division, and IOUs, Cadmus developed an approach to calculate the net-to-gross ratio (NTGR) following established protocols to provide comparable results to other evaluated nonresidential programs in California. The NTGR methodology followed the nonresidential self-report framework, relying on responses to Program Attribution Index (PAI) questions, described in the CPUC's *Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers*.[10] The pilot's unique requirements and characteristics influenced Cadmus' development of key decision-maker survey and calculation metrics used to assess attribution. Self-report surveys were most appropriate due to the small population.

Cadmus asked key decision-makers about the pilot's influence on their decision to implement an ALCS project, using PAI questions about the timing of their decisions, the influences on their decisions, their financial ability to sponsor the project independently, and the likely path they would have taken without the pilot. Appendix A provides the PAI questions, responses, and analysis. Appendix B provides the key decision-maker survey instrument.

The PAI used three equally weighted indices to score attribution:

- First (PAI-1), the decision-maker rated the influence of multiple factors, on a 0- to 10-point scale, including factors attributed to the pilot and to external factors outside of the pilot's influence. The PAI-1 score was calculated by dividing the highest pilot influence score by the sum of the highest pilot influence, plus the highest non-pilot influence score.
- Second (PAI-2), the decision-maker stated whether they made the decision to implement the project before knowing about the pilot, and stated whether the pilot had greater influence than non-pilot influences. The PAI-2 score was calculated as the maximum importance rating of any pilot elements, divided by 10, on a 0- to 10-point scale. The PAI-2 score was reduced by one-half if the respondent learned about the pilot after making their decision.
- Third (PAI-3), the decision-maker rated, on a 0- to 10-point scale, whether they would have been likely to incorporate each required measure into their project had the pilot not existed and had they not received the pilot incentives. The PAI-3 score was calculated for each pilot site as the weighted rating for each measure, divided by that measure's percentage of the total pilot

[10] Nonresidential Net-To-Gross Ratio Working Group. *Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers*. Prepared for the Energy Division, California Public Utilities Commission. October 2012.

savings, then subtracting that value from 10, and dividing the resulting estimate by 10 to convert it to a percentage.

Averaging the three PAI scores determined the NTGR.

Cadmus also included consistency checks, based on actions decision-makers would have taken in the pilot's absence, when they would have completed any project, that project's scope, and whether they had funding to pay for the project (see the decision-maker survey instrument in Appendix B). These consistency-check questions allowed Cadmus to establish a range of attribution scores to expect from PAI questions.

This method provided good estimates of partial freeridership, but, as the method weighted all three PAIs equally, it might not have accurately assessed those projects 100% influenced by the pilot or those projects that the pilot did not influence. Additionally, as customers' decisions about the ALCS were made in conjunction with decisions about the lighting upgrade, responses may not necessarily reflect the program's influence on the ALCS alone.

Eleven key decision-makers responded to the survey, representing 13 projects. After determining the NTGR for each of the 13 projects, Cadmus calculated net savings as the product of the project's above-code savings and the project's NTGR. To develop the pilot's overall NTGR, total net savings for the 13 projects were divided by above code gross savings for those projects. By applying the overall NTGR to the total pilot, above-code gross savings, Cadmus determined the pilot's net savings.

Evaluation Limitations

As this research addressed a pilot program, limited by a small number of participants and data gaps, the effort could not provide the rich evidence required to provide statistically defensible answers to some of the original research questions. Consequently, Cadmus approached the research as a case study, preparing questions that addressed how processes worked and why certain outcomes occurred, while providing initial insights into causal relationships and effects, based on observations from a small number of cases. Several challenges, discussed below, limited this evaluation's ability to answer some study questions in detail.

Net Energy Impacts

Though the evaluation determined net impacts for SCE pilot participants, due to the pilot's participant recruitment strategy, the results should be viewed with caution; they may not apply to similar projects implemented through other programs. As the pilot's original intent was to examine the technical performance of ALCS technology and the influence of contractor training on ALCS installation and performance, the pilot recruitment efforts focused on customers who were willing to implement ALCS through the pilot's comprehensive implementation and documentation procedures, with less regard for what customers would have done in the program's absence.

Above Code Savings

The complexities of detailing above-code energy savings pose unique analytic challenges. Title 24, Part 6, allows for application of the complete building method when the same occupancy type takes up 90% or more of the building floor area. However, the pilot did not gather specific data that verified space occupancy types for each project (per Title 24, Part 6).

To address above-code savings, RHA assumed projects met this 90% occupancy-type requirement and classified them accordingly. To avoid a regressive baseline, RHA assumed the minimum lighting power density (LPD) requirements for Title 24, Part 6, applied to new construction projects and to existing building lighting systems that did not meet the code's minimum LPD requirements for retrofits.

Contractor Training

This study does not assign individual faults to designer, contractor, installer, or manufacturer. Due to limitations of the pilot scope and small sample size, the evaluation could not link contractor training to improved savings or work quality.

Evaluation Results

This section summarizes the results of the following evaluation activities:

- Literature Review
- Work Quality Reviews
- Customer (Decision-Maker) Feedback
- Contractor Feedback
- End-User Feedback
- Savings Impact

Literature Review

Cadmus reviewed available literature to inform the evaluation about ALCS best practices and to provide an understanding of participation barriers. Though ALCS projects differed in scope across reviewed studies, all studies outlined similar system capabilities and design elements. These design elements serve a central system, which controls fixtures in zones capable of variable lighting (by receiving feedback from occupancy sensors and ambient light sensors, and by programming each space to provide minimum lighting required for each time of day). In providing minimum lighting, dimming and shutting down fixtures serve as the primary mechanisms for achieving energy savings.

Building Applicability

Based on a market characterization report prepared for NEEA, ALCS projects are commonly implemented at commercial office buildings, manufacturing facilities, warehouses and distribution centers, and educational facilities. In addition to reviewing secondary sources, the market characterization relied on interviews with market actors—manufacturers, distributors, regional lighting experts, and building owners with in-depth knowledge about ALCS.

Market actors interviewed for the NEEA study identified commercial offices as the building type where ALCS have gained the most traction and offer the greatest potential. Market actors also cited manufacturing facilities and warehouses as showing promise due to typically low occupancy rates and historic use of high-wattage fixtures. Typically, these facilities have fewer fixtures, lowering per-square-foot installation costs. The low occupancy rates allow for deep energy savings through ALCS aggressive vacancy settings, particularly in storage areas. Additionally, the open ceiling design of most warehouses and manufacturing facilities simplifies installation and allows a facility to operate during the retrofit process.

Market actors also cited educational facilities as prime ALCS locations due to predictable operation hours. Other building types (such as retail, hospitals, parking garages, cold storage facilities, stadiums, and convention centers) may be good ALCS candidates in concert with careful design and planning.[11]

[11] Research Into Action and Energy 350. *Luminaire Level Lighting Controls Market Characterization and Baseline Report.* Prepared for NEEA. Report #E16-343. December 14, 2016.

The Sustainable Office Lighting Pilot program addressed most of these building types, except for hospitals and stadiums.

Design and Installation Challenges

ALCS face similar challenges to building management systems, with energy savings dependent on the equipment's performance and on system designers, installers, building operators, and end users. The following sections address additional, specific challenges discussed in the literature.

Sensor or Driver Failures

Similar to building management systems widely used with HVAC equipment, ALCS' savings potential is not represented well by proper installation of any individual part of the system; rather, these parts are integral to the system as a whole. Consequently, breakdowns of individual parts can have a crippling effect on an ALCS' energy performance. If left unchecked, fixture sensor failures or driver failures can force an ALCS to operate in "safe mode" (as the space conditions remain unknown), thus decreasing energy savings. A recommended strategy for mitigating such failures employs two-way communication between light fixtures and the ALCS server, allowing building operators to more easily identify nonfunctional parts and troubleshoot effectively.[12]

Typically, ALCS sensors are integrated into fixtures, providing feedback to every fixture, or are installed remotely to control fixture zones. The reviewed literature commonly cited sensor placement and sensor quality as installation issues.[13, 14, 15] Installing too few sensors or installing them in improper locations forces a system commissioning agent to program overly conservative strategies to meet an occupants' needs, diminishing the system's possible energy savings.

Experience and training, however, play a key role in sensor installation as system designers cannot foresee all sensor placement contingencies. The installation contractor must properly place and network sensors, requiring a deeper understanding of the technology than that possessed by typical electrical contractors. Helping contractors understand the impacts of poor sensor placement on an entire system can motivate them to take greater care when installing sensors.

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12 Joy Wei, Francis Rubinstein, Jordan Shackelford and Alastair Robinson. Wireless Advanced Lighting Controls Retrofit Demonstration. Lawrence Berkeley National Laboratory. Prepared for the General Services Administration. April 2015.

13 Emerging Technology Associates. Advanced Lighitng Controls System Assessment. Veterans Administration Medical Center, Prepared for San Diego Gas & Electric. December 15 2010

14 EMCOR Energy Services. *Advanced Lighting Control System in an Office Building*. Prepared for Pacific Gas and Electric Company. ET12PGE1031. April 5, 2013

15 ASWB Engineering and Opinion Dynamics Corporation. *Lighting Controls Training Assessment*. Prepared for Southern California Edison, San Diego Gas & Electric, Pacific Gas and Electric Company. CALMAC Study ID: SCE0392.01. April 8, 2016.

Installation Timeline and Costs

The literature cited the installation process timeline as a common issue, deterring customers from installing an ALCS if it necessitates long-term closure of a facility or parts of a facility.[16,17,18] Installers commonly overestimate ALCS installation costs due to their wariness about the time required to correctly commission the system. Wireless communication systems can reduce installation times and costs, but these systems are more likely to experience communication issues and interference from other systems. While wireless systems communication issues can be identified and mitigated during system commissioning, the reliability of these systems over time remains unknown as they present a relatively new technology.

Acceptance Testing

Under Title 24, Part 6, nearly all ALCS are subject to acceptance testing. Lighting installers often cite a perception that designers and engineers do not adequately understand code requirements to produce designs that meet the ALCS requirements. This can cause issues during post-installation inspections if system designs do not originally meet code requirements. Additionally, a general perception exists that code is "difficult to understand and comply with" and has "room for interpretation"—ideas that lead to frustration and misunderstandings between designers and installers regarding parties responsible for code compliance, with each party blaming the other for "poor design" or "poor installation" that fails code. This significant market barrier to ALCS adoption may discourage market actors' desire to pursue ALCS projects.[19]

Potential Energy Savings

ALCS include many capabilities to display and report energy usage and savings. Throughout the literature review, Cadmus found energy-savings estimates associated with ALCS ranged from 32% to 43% of existing lighting energy use, not including fixture savings. In the literature reviewed, all systems relied on users to provide accurate information on fixture wattages installed. Other studies have shown differences between savings reported by an ALCS and verified performance. Though such differences are typically small (between 2% and 5% of reported savings), improper programming can significantly impact these differences.[20,21]

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16 ASWB Engineering and Opinion Dynamics Corporation. *Lighting Controls Training Assessment*. Prepared for Southern California Edison, San Diego Gas & Electric, Pacific Gas and Electric Company. CALMAC Study ID: SCE0392.01. April 8, 2016.

17 EMCOR Energy Services. 2013.

18 Research Into Action and Energy 350. 2016.

19 ASWB Engineering and Opinion Dynamics Corporation. 2016.

20 EMCOR Energy Services, 2013.

21 Joy Wei, et al. 2015.

Best Practices

The *Lighting Controls Training Assessment* reported that an ALCS design-intent document—a written explanation of how the design meets a customer's project requirements—can ensure proper installation and operation of an ALCS. Written with input from the customer and referencing appropriate codes and standards, this document serves as a reference point for comparing the system's designed performance with its verified performance. Maintaining this document also provides a history of the project's process, both immediately after completion and after time has passed, thus aiding assessment of the system's ability to maintain its performance (i.e., persistence) and to sustain occupant comfort. As part of commissioning,[22] Title 24 Part 6, requires providing documentation to the customer that includes key information about system operations and maintenance.

Based on the literature review and the framework listed in *The Lighting Controls Training Assessment*, Cadmus determined the following best practices to ensure ALCS project quality:

1. Design: Ensure communication between designers and customers, which proves critical for properly scoping and setting project expectations (as discussed above).
2. Installation: Employ a well-trained and experienced installer to ensure critical placement of sensors and networking of ALCS components.
3. Code compliance: Provide system designers and installers with an adequate understanding of Title 24, Part 6.
4. Commissioning: Provide designers and installers with design and commissioning guidelines to help mitigate any uncertainty when scoping projects and estimating costs. Commissioning design reviews also help identify design problems before the installation process begins, avoiding project failures.
5. Functionality: Ensure that building operators understand ALCS functionality and have sufficient documentation and training to effectively operate the systems.

Work Quality Reviews

For this evaluation, Cadmus reviewed each lighting project's work quality in regard to the following work aspects:

- Installation quality
- Compliance with code and pilot requirements
- Commissioning
- Functionality (acceptance testing)
- Customer and end-user satisfaction

The *Lighting Controls Training Assessment* report's work-quality definition includes design and persistence, but assessing these factors fell outside of this evaluation's scope and timeframe.

[22] ASWB Engineering and the ODC, 2016.

To assess work quality, RHA conducted post-installation inspections for each of the 31 projects. These inspections included the following:

- Functional testing of the control system, load monitoring, or light logging
- Collected trending data from the ALCS

Cadmus reviewed RHA's site visit findings, where it assessed installation quality, code compliance, commissioning, and functionality.

Installation Quality

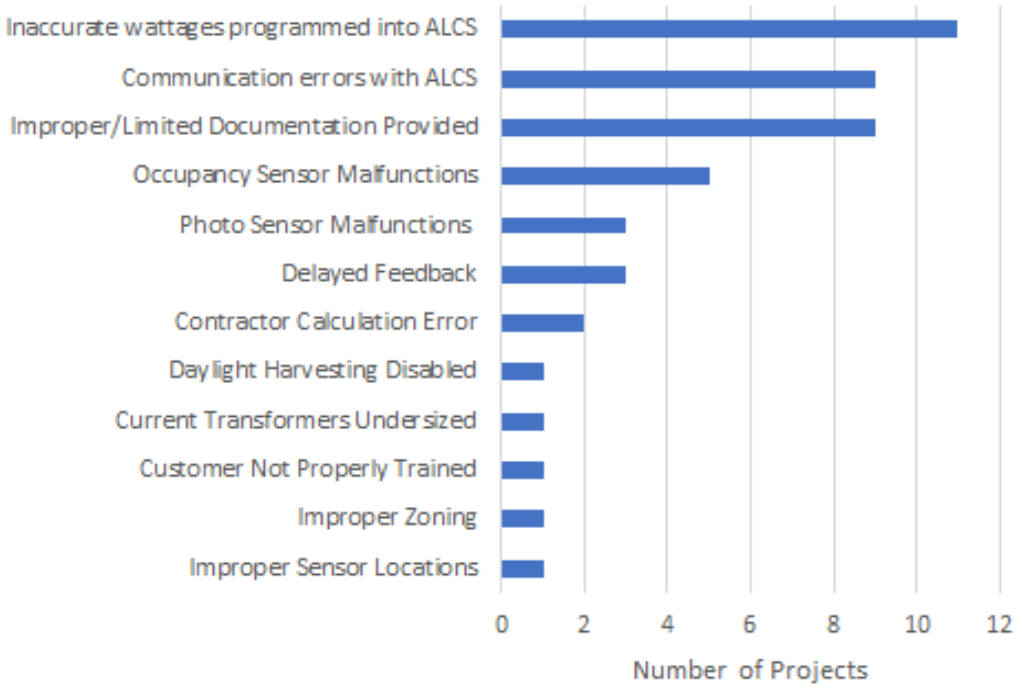
Examining inspection reports provided by RHA, Cadmus compiled installation errors as well as system errors in the ALCS's systems data reporting:

- Eleven projects failed to correctly enter fixture wattage information into the ALCS, causing it to report erroneous power usage. Though these errors were not specifically detrimental to the ALCS's actual performance, they limited the user's ability to correctly tune the system.
- Nine projects experienced communication issues between the main control computer and the fixtures or sensors, causing no connections or delayed connections across the control system.
- Five projects had occupancy sensor connection issues, malfunctions, or defects, which caused sensors to not behave as designed. In one case, a sensor exceeded its allowed connection limit (per its specification).
- Three projects had photo-sensor malfunctions, where fixtures were incapable of dimming in response to the daylight. While equipment failure may be unavoidable it is unknown if these malfunctions occurred after the equipment was installed or during installation.
- Three projects exhibited a slower-than-required connection speed, resulting in delayed system responses. The pilot required an ALCS to provide nearly real-time feedback, defined by a less than three-minute delay. These projects operated at an observed connection speed between 12 and 27 minutes.
- One project had sensitivity issues with the installed current transformers and were unable to detect the electrical load of the installed fixtures while dimming. It is unknown if this issue was known by the installing contractor.
- One project had the daylight harvesting feature disabled, consequently savings for daylight harvesting could not be known

RHA noted an additional 12 errors, including data collection errors (when the contractor could not provide complete trending data and specifications) or logger readings discarded due to incomplete or inaccurate data.

Figure 1 details error rates for the types of installation issues found. As the literature suggested, programming inaccurate wattages posed a frequent problem; improper sensor locations, however, were infrequent, contrary to the findings of past studies.

Figure 1. Project Issues



Compliance with Code and Pilot Requirements

Table 9 summarizes the number of projects meeting the Title 24, Part 6, (2013) lighting control requirements. All projects met or exceeded LPD requirements by staying below allowable LPDs. Four of the 31 projects did not install occupancy sensors, or sensors were disabled (reportedly due to health and safety reasons). In 20 projects for which Title 24 mandated automatic daylight harvesting, 13 met the requirement, but seven projects did not comply with the code. Contractors and RHA cited various reasons for failing to implement daylight harvesting, including sensor compatibility issues, failing to identify daylighting zones, and failing to activate daylight harvesting features in the controls software.

Table 9. Number of Projects that Met Title 24 Requirements

Title 24 Requirement	Installed (# projects)		Did Not Install (# projects)	Total Where Requirements Applied (# projects)
	Met / Exceeded Code	Did Not Meet Code	Did Not Meet Code	
Occupancy Controls	27	1	3	31
Daylight Harvesting	13	2	5	20

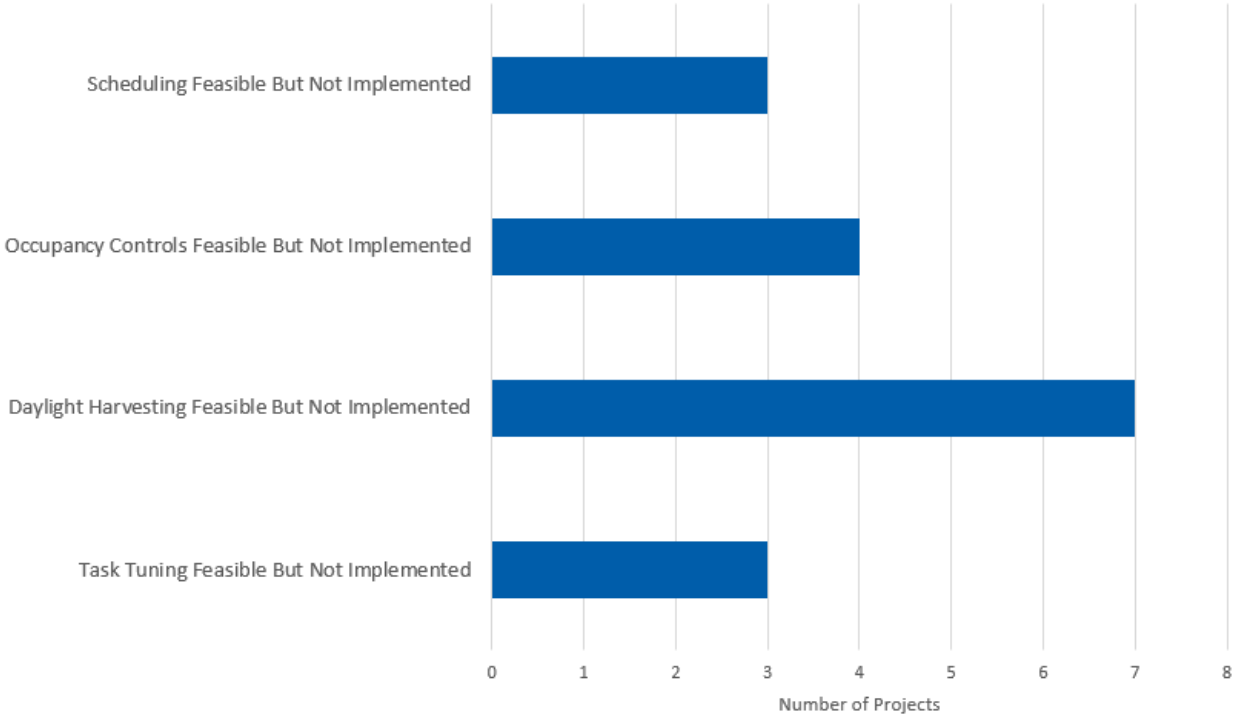
The pilot program required employing, where feasible, the following:

- Task tuning
- Occupancy controls
- Scheduling

- Daylight harvesting where feasible

Cadmus examined the feasibility of control strategies that contractors did not implement with ALCS installations. Figure 2 summarizes the number of projects where a control strategy was feasible but not implemented. At least one of these strategies was not implemented for the majority of projects (16 of 31). Two additional projects were identified as not requiring daylight harvesting under Title 24.

Figure 2. Number of Projects Where Features Were Feasible But Not Installed



Pilot contractors and RHA provided the following notes regarding control strategies not employed:

- Sensors were unreliable, necessitating control feature overrides
- Contractors misunderstood the capabilities of equipment they installed
- Sensor were not compatible with the ALCS central control system
- Contractors failed to identify all daylighting zones where controls should be employed
- Health and safety reasons necessitated disabling occupancy sensors
- Employees were dissatisfied with lower lighting levels that occurred when systems were tuned to lower energy consumption

Commissioning

Title 24, Part 6, (2013) requires commissioning of all newly constructed buildings or additions. Thirty of the 31 projects did not require commissioning as they were alterations, not new construction or additions. The pilot required that applicable projects submit their Certificate of Compliance

Commissioning Construction Documents (NRCC-CXR-02-E). Though the one new construction project required commissioning, the certificate was not provided to RHA.

Functionality

The *Lighting Controls Training Assessment* study defined functionality as the quality of an ALCS, operating as intended, by appropriately responding to "triggers" and not responding to "false triggers." A lighting control system's functionality was verified through Title 24, Part 6, Acceptance Testing Procedures. Title 24 mandates that certified Acceptance Testing Technicians verify performance functionality of newly installed lighting control systems. All 31 projects were required to submit their Certificate of Acceptance Documents for Lighting Controls (NRCA-LTI-02-A) and Daylight Controls (NRCA-LTI-03-A). Three projects met this requirement by submitting their documents to the California Energy Commission (CEC); six projects submitted their documents to SCE, but not to the CEC. The remaining 22 projects submitted their contractor's internal commissioning report to SCE rather than the Acceptance Testing documents.

Customer (Decision-Maker) Feedback

SCE customers who completed ALCS projects through the pilot provided feedback about their program experiences and their reasons for participation. The following sections summarize feedback from phone surveys with 11 of 28 decision-makers, representing 13 of the 31 total projects in the ALCS pilot.

Awareness

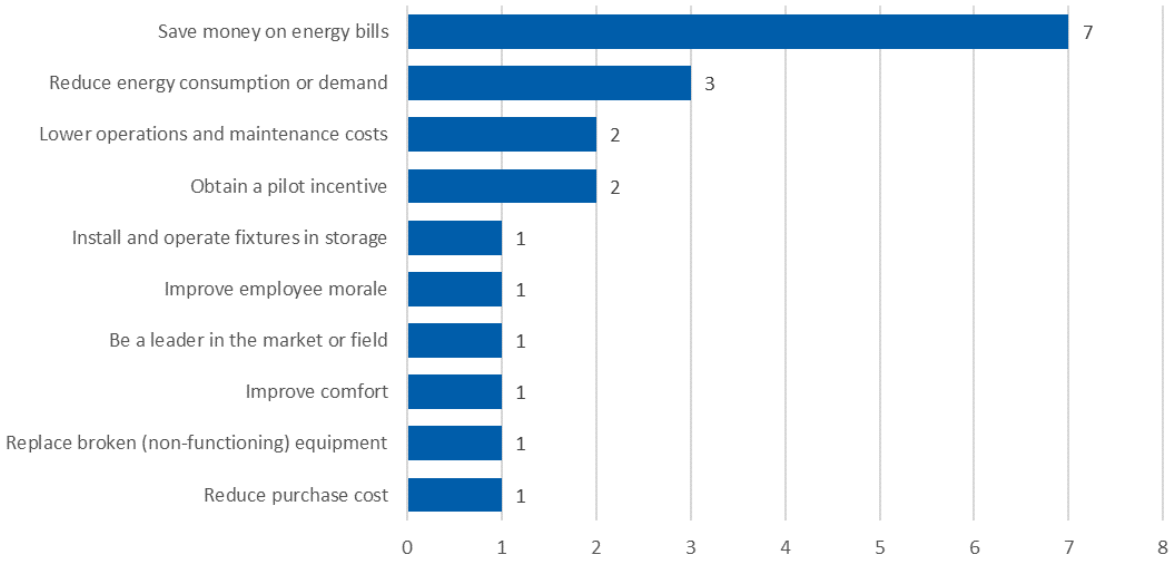
Project decision-makers learned about the Sustainable Office Lighting Control Pilot Program from various sources, predominantly contractors. Of 11 unique respondents, one could not recall how he learned about the pilot. The remaining 10 specified the following ways in which they learned of the pilot:

- Contractor (five respondents).
- SCE account manager (two respondents)
- SCE program manager (one respondent)
- Someone at their company or parent company (one respondent)
- Internet research on rebates (one respondent)

Reasons for Participation

Seven of 10 decision-makers reported reducing energy usage, lowering operational costs, and saving money on energy bills as their most important reasons for participating in the pilot. Figure shows all responses cited by decision-makers regarding their participation reasons.

Figure 3. Customer Reasons for Participation (n=10)[a]



[a] Multiple responses allowed.

Participation Challenges

Five of 11 respondents cited high initial costs as their biggest challenge in making energy-efficient improvements to their facilities. However, when it came to program participation, respondents specifically noted the following challenges:

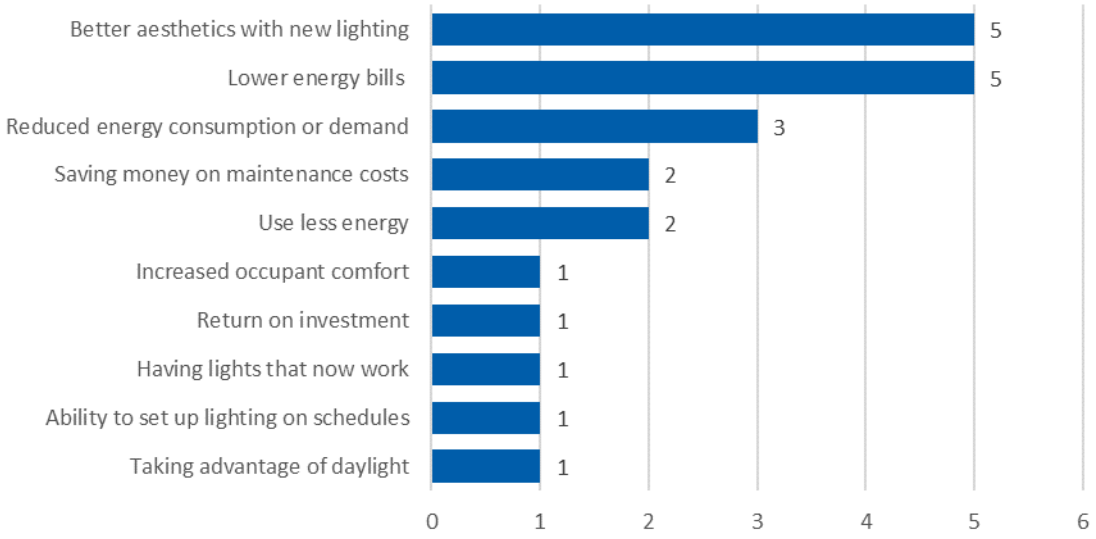
- Lack of awareness about available incentives for energy-efficient equipment
- Custom facility features that were difficult to retrofit
- Long payback periods for energy-efficient equipment
- Difficulty finding time to install the new lighting system (as affected areas had to be shut down)
- Scheduling contractors around tight timelines
- The pilot application process
- Understanding potential areas for improvements, and demonstrating cost savings and benefits from those improvements to administrative staff

Participation Benefits

Respondents described a variety of benefits from pilot participation. Five of 11 respondents said they experienced better aesthetics. Five of 11 respondents also cited lower energy bills due to the new

lighting. Better aesthetics with new lighting did not serve as a significant reason for participation, but it was cited as a significant benefit. Figure 4 shows benefits described by survey respondents.

Figure 4. Benefits of Pilot Participation (n=11)[a]



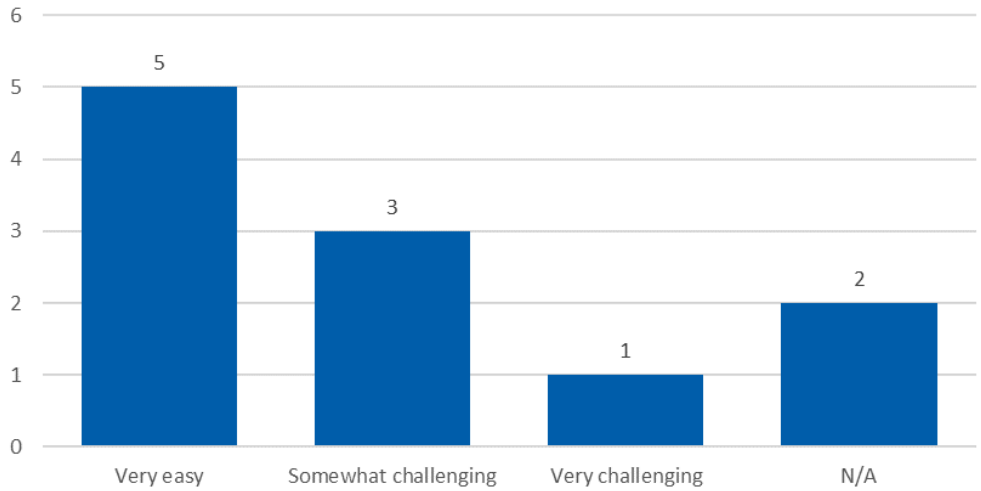
[a]Multiple responses allowed.

Customer Satisfaction

Cadmus asked decision-makers about their satisfaction with various ALCS pilot elements, including paperwork, new ALCS equipment, overall pilot experiences, and contractors.

Of 11 respondents, five rated the application paperwork as *very easy* to complete; three rated it as *somewhat challenging;* and one rated it as *very challenging*. The remaining two respondents indicated that they did not complete the application paperwork themselves. Figure 5 illustrates the results.

Figure 5. Ease of Completing Application Paperwork (n=11)[a]

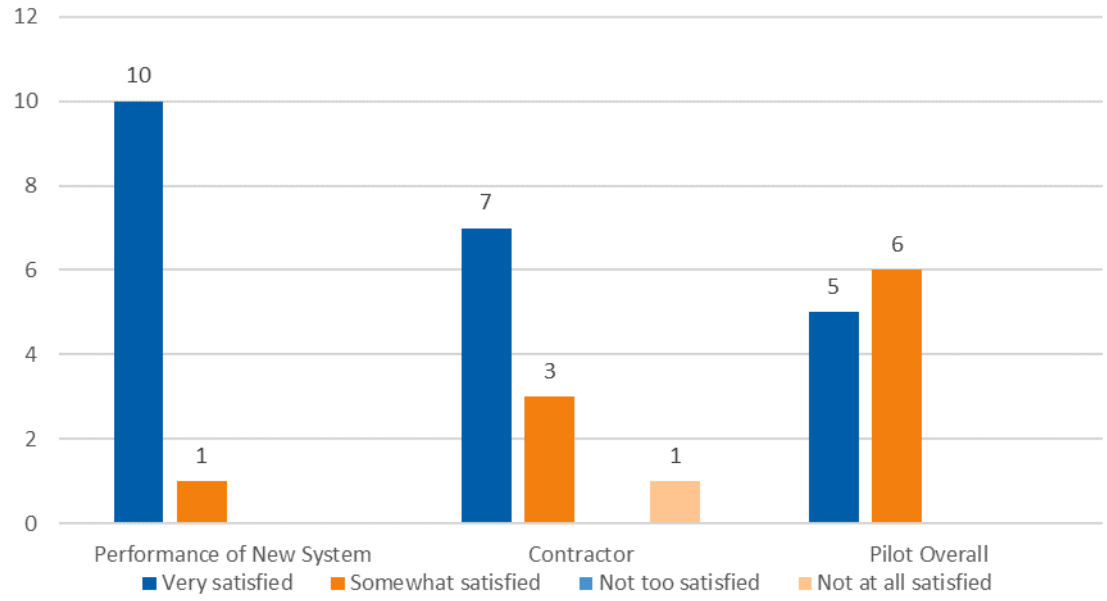


[a] N/A responses represent customers whose contractors completed the paperwork on their behalf.

Respondents expressed high satisfaction levels with their new ALCS' performance and with their general satisfaction with the pilot. Of 11 respondents, 10 respondents said they were *very satisfied* with performance of the new system; five said they were *very satisfied* with the pilot overall; and no respondents provided an unsatisfactory rating.

Decision-makers also expressed satisfaction with their primary ALCS contractors. Of 11 respondents, seven said they were *very satisfied* with their contractors; three were *somewhat satisfied;* and one was *not at all satisfied*. Respondents' reasons for dissatisfaction included off-schedule projects, communication gaps, and issues during installation. Satisfied respondents reported having very proactive, involved, and accommodating contractors.

Figure 6. Satisfaction with New System, Contractor, and Pilot Overall (n=11)



When asked what SCE could have done to improve the pilot, six of 11 decision-maker respondents provided suggestions that included the following:

- Provide a larger incentive
- Improve the organization of paperwork and of the verification process
- Extend the incentives through 2018
- Provide an SCE point person for small accounts without an SCE account manager
- When offering an incentive, make it easy for the customer to obtain that incentive
- Ensure that the QC contractor takes more proactive steps before and after the project *(this suggestion appears to request that the QC contractor perform project commissioning support, which was never intended for the pilot program's QC process)*

Table 10 shows decision-makers' satisfaction with their contractor. Most (7 of 11 respondents) were *very satisfied* with their contractors. Only one was *not at all satisfied,* stating that the contractor began the project later than expected and the project ran longer than expected.

Table 10. Decision-Maker Satisfaction with Contractor

Satisfaction Rating	Total
Very satisfied	7
Somewhat satisfied	3
Not too satisfied	0
Not at all satisfied	1
Total	**11**

Willingness to Pay

Cadmus asked decision-makers whether they would have pursued the project for a different incentive. All respondents (representing 13 of 31 total projects) indicated they would have completed the project with a smaller incentive, with eight of 11 saying they would have pursued the project for 25% of the incentive. One customer would have pursued the project for 50% of the incentive, and two would have completed the project for 75% of the incentive.

Contractor Feedback

Contractors who completed ALCS projects through the pilot provided feedback about their program experiences and reasons for participation. Additionally, contractors provided insights into specific training they received regarding lighting and lighting controls, and the effect program participation had on their sales.

The following sections summarize feedback from phone surveys with six contractors, representing 15 of 31 total projects in the ALCS pilot. Contractors responding to the survey represented contractor Groups 2 and 3.

Pilot Awareness and Influence on Sales Practices

Contractors reported that they primarily learned about the Sustainable Office Lighting Control Pilot Program directly from SCE. Five of six contractors learned about the pilot through an SCE representative, and one contractor learned of it by attending an information session conducted by SCE.

When asked for their preferred method of staying informed about programs such as the Sustainable Office Lighting Control Pilot Program, four of six contractors preferred SCE's website, and two of six preferred emails.

Contractors reported that pilot participation produced little influence on their sales practices, and they reported no changes in ALCS sales after participation. Only one of six contractors reported increasing how often they recommended an ALCS to customers after knowing about the pilot program. Before knowing about the pilot program, the one contractor recommended an ALCS to customers 30% of the time; after participation, the contractor recommended the systems 100% of the time.

Participation Reasons

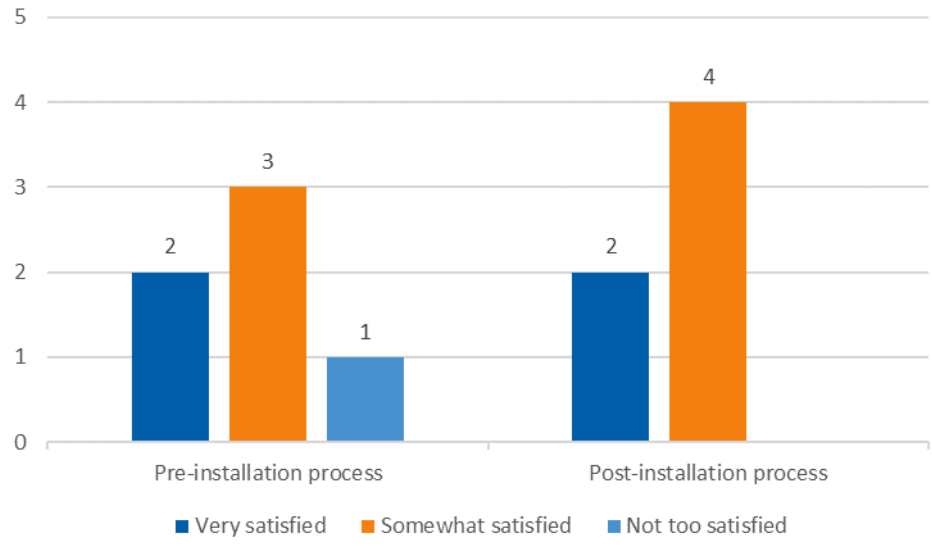
All six contractors reported recommending the pilot to customers due to cost savings, and two of the six cited the importance of the pilot incentives. One contractor indicated a desire to gain a competitive advantage in the marketplace, noting "the work needed to meet the program standards wasn't a massive undertaking…and when we crunched the numbers ahead of time, we realized we could be better off through the program."

Contractors reported that their knowledge of the pilot modestly impacted their decisions to recommend ALCS projects to their customers. On a scale of 0 to 10, where 0 is *no influence at all* and 10 is *very influential*, contractors rated the pilot an average of 6.8 in terms of its influence on their decisions to recommend ALCS projects to customers. Responses varied considerably, from 0 to 10.

Satisfaction

Cadmus asked contractors about their experience and satisfaction with a range of pilot elements. As shown in Figure 7, the contractors expressed mixed views regarding pre- and post-installation processes, which involved multiple site visits from SCE and third-party vendors to verify installations. For the pre-installation process, two of six contractors said they were *very satisfied*, three of six were *somewhat satisfied,* and one of six was *not too satisfied*. For the post-installation process, two of six contractors said they were *very satisfied;* the remainder were *somewhat satisfied*.

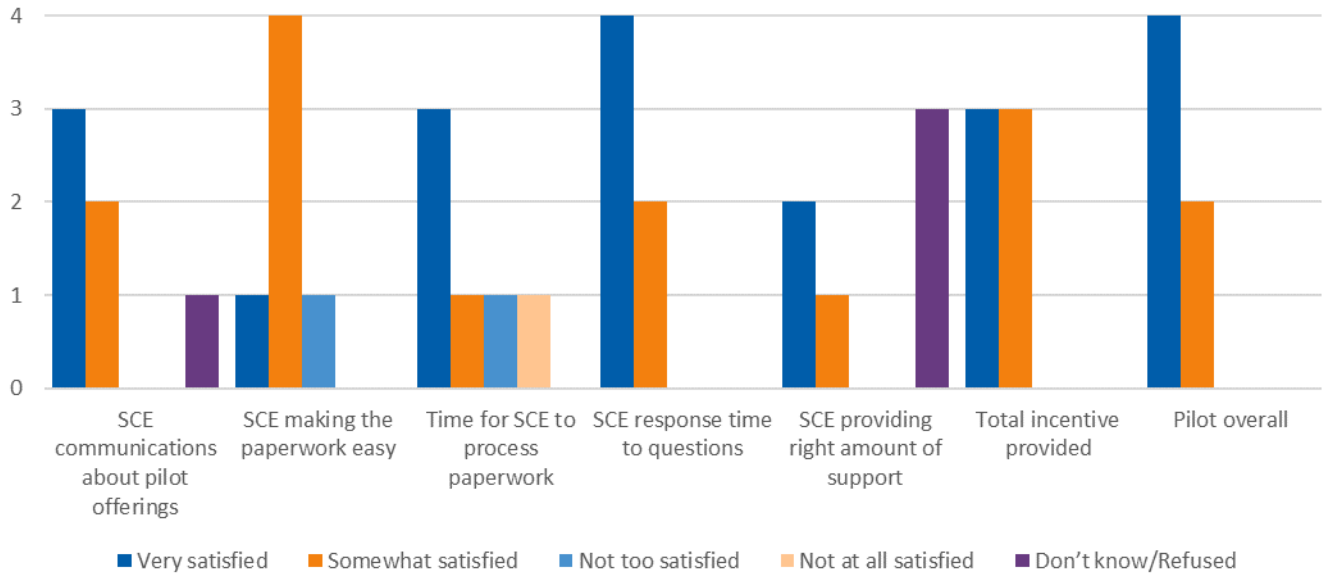
Figure 7. Satisfaction with Pre- and Post-Installation Processes



In other categories, contractors reported mixed satisfaction, with the highest satisfaction ratings for the pilot overall and for SCE's response time to questions or inquiries. As shown in Figure 8, four of six contractors said they were *very satisfied* with the pilot overall and with response times to questions or inquiries, while two of said they were *somewhat satisfied* in those categories. Contractors also expressed satisfaction with SCE communications about pilot offerings and with final incentives provided.

Ratings divided more regarding the ease of paperwork, paperwork processing times, and SCE's ability to sufficiently support pilot delivery to customers.

Figure 8. Satisfaction with Pilot Elements



Four of six contractors provided suggestions for ways the pilot could be improved; these included the following:

- Clarifying the pilot requirements
- Ensuring consistency in requirements throughout the pilot's duration
- Speeding up the pre- and post-inspection process

Contractors also provided the following verbatim comments:

- "Make the requirements as plain as possible from the beginning."
- "Create something better than the current SCE log-in page, like a Dropbox account where all of the documents could be stored and shared."
- "Make currently available program offerings on the SCE website clearer and easier to identify. Also, people who are going to do controls are going to do them anyways. The financial aspect is less promising due to the availability of LED lamps. LED lamps are already highly efficient. The savings for controls on top of LEDs makes the energy savings less attractive."
- "The process of the post-inspection by RHA was cumbersome, and the clients weren't happy with the way the process intruded into their business."

It should be noted that the pilot program was designed to include a comprehensive QC process and provided an increased incentive to encourage participation, given program requirements.

End-User Feedback

Seven tenants (end users) of buildings receiving ALCS systems through the pilot responded to a survey addressing their knowledge of, training in, and experience with the ALCS system.

All seven end-user respondents indicated knowing of the lighting control upgrades made to their facilities. Five of seven end users received training on how to use the lighting system, either from the installation contractor or from a building manager. All five of the trained end users also considered the training *very effective* in helping them understand how to operate the system, and four of five said they could *very effectively* operate the lighting system; the fifth said they could *somewhat effectively* operate the lighting system.

Only three of seven end-user respondents answered a question addressing whether they had administrator access to the ALCS: two indicated they had access, and one indicated they did not. One end user with administrator access modified settings (e.g., hours of operation) about once a month to adjust for days requiring longer shifts or overtime. The other end user with administrator access modified brightness, working hours, and sensor detection timers only once since the system's installation.

End-user respondents expressed satisfaction with the new lighting system, with six respondents saying they would recommend the system to others. Five of six respondents said they were *very satisfied* with the new lighting and control system, and one said he was *somewhat satisfied*. Only one end user reported experiencing an issue with the new lighting system, saying a few fixtures initially failed, but "everything has worked perfectly" since that incident. One respondent did not answer questions about satisfaction with the new lighting system and whether they would recommend the system to others.

Savings Impact

This section summarizes the pilot projects' energy and demand savings. As described earlier, implementation contractors forecasted *ex ante* savings estimations, and Cadmus evaluated project energy savings using an engineering analysis (based on RHA's pre/post-installation data analysis and IPMVP Option A). Cadmus also explored normalized annual energy consumption analysis (based on AMI data and IPMVP Option C) for seven projects to determine whether this offered a feasible method for determining savings in the future. Due to the low coefficient of determination, these results were not incorporated into the pilot's verified savings. This section first discusses gross savings results and then examines net savings results.

Engineering Analysis Results

Cadmus verified each project's energy savings by reviewing RHA's data including inspection reports, load monitoring, light logging, and ALCS trending data. Total pilot savings included two components: fixture upgrades and ALCS controls. RHA calculated total energy savings as the difference between energy use for a building's baseline operating conditions (including old fixtures and original controls) and new operating conditions with upgraded fixtures and ALCS controls.

RHA calculated ALCS controls savings as the difference between energy use under baseline operating conditions with the new fixtures and under new operating conditions with new fixtures *and* ALCS controls using site visit findings, logging data, and trending data from the ALCS. Measure interaction RHA also calculated above-code savings using code-minimum requirements, unless existing conditions exceeded code. In the latter case, the existing condition was used in lieu of a code-minimum baseline. Above-code savings were used in estimating the pilot's net savings. Table 11 details the baseline and efficient conditions used in this analysis.

Table 11. Saving Calculation Baselines

Conditions for Savings	Fixture Savings		ALCS Savings		Project Savings		Above Code Savings	
Baseline Condition	Existing Hours of Operation	Existing Lighting Fixtures	Existing Hours Of Operation	Upgraded Lighting Fixtures	Existing Hours of Operation	Existing Lighting Fixtures	Title 24 - Controls[a]	Title 24 - LPD[b]
Efficient Condition	Existing Hours of Operation	Upgraded Lighting Fixtures (if applicable)	Upgraded Hours of Operation	Upgraded Lighting Fixtures (if applicable)	Upgraded Hours of Operation	Upgraded Lighting Fixtures (if applicable)	Upgraded Hours of Operation	Upgraded Lighting Fixtures (if applicable)

[b]Required controls were estimated in the baseline by applying DEER 2014 hours of use reductions to required occupancy zones and daylighting areas.
[a]Where code lighting power density (LPD) exceeded original conditions, original conditions were used to avoid a regressive baseline

A majority of projects (28 of 31) involved normal replacements of existing equipment; two projects purchased the lighting fixture upgrade prior to pilot participation (and thus were considered add-on equipment); and one project was new construction. The appropriate gross savings baseline for normal replacements and new construction would be code or pre-existing conditions if above code; and the appropriate baseline for add-on equipment would be the new fixture baseline, as fixtures were replaced prior to pilot participation.

Cadmus reviewed each project's documentation and conducted a ride along with RHA staff to verify that site visits were conducted as established in the quality assurance plan. After adjusting for fixture counts reported by contractors and verifying ALCS' achieved performance, Cadmus verified 31 documented projects as completed and verified project savings by updating existing fixture wattages to the Appendix B table of standard fixture wattages and by updating the upgraded LED fixture wattage to the Design Lights Consortium's qualified products list wattage values. Cadmus applied DEER 2014 interactive effects and demand coincidence factors, resulting in a verified energy realization rate of 121% and demand realization rate of 83%. RHA had not applied interactive effects because early projects were warehouses and manufacturers. Upon completion of the pilot, projects included two refrigerated warehouses, three retail stores and seven office buildings, and three university buildings. Cadmus determined that interactive effects were applicable in 30 of the 31 projects. Table 12 and Table 13 show projects' reported and verified energy savings and demand reduction.

Table 12. Verified Project Energy Savings (kWh/year)

Project Number	RHA Reported Energy Savings for ALCS Only (Excludes Energy Savings for Fixture)	Cadmus Verified Energy Savings for ALCS Only (Excludes Energy Savings for Fixture)	Realization Rate	Cadmus Verified Energy Savings for Project (Existing Baseline)	Cadmus Verified Energy Savings for Project (Code Baseline)
ALCS-001	31,534	49,508	157%	648,749	526,881
ALCS-002	7,058	8,033	114%	47,987	14,856
ALCS-003	23,360	26,852	115%	65,297	15,563
ALCS-004	69,176	69,176	100%	83,805	81,466
ALCS-005	312,634	345,179	110%	504,683	N/A [a]
ALCS-006	37,323	41,208	110%	154,276	12,785
ALCS-007	42,136	46,522	110%	296,897	217,684
ALCS-008	88,518	97,733	110%	198,121	40,730
ALCS-009	240,711	382,129	159%	1,049,454	656,911
ALCS-010	36,739	41,816	114%	121,323	62,608
ALCS-011	29,091	33,111	114%	62,718	29,607
ALCS-012	2,653	2,929	110%	100,556	72,356
ALCS-013	58,172	66,211	114%	134,712	50,174
ALCS-016	19,643	21,841	111%	74,736	38,995
ALCS-017	24,286	26,814	110%	245,775	108,911
ALCS-018	281,566	419,449	149%	947,503	947,503
ALCS-020	14,051	15,514	110%	179,852	85,095
ALCS-021	62,202	68,677	110%	299,468	185,964
ALCS-023	24,487	25,599	105%	58,174	35,340
ALCS-024	94,072	98,343	105%	500,827	167,585
ALCS-025	74,368	84,646	114%	171,497	34,492
ALCS-028	27,423	30,278	110%	159,939	143,968
ALCS-029	3,927	4,470	114%	30,820	N/A [a]
ALCS-030	302,966	334,505	110%	408,795	225,746
ALCS-034	26,274	29,272	111%	168,441	21,689
ALCS-035	124,350	137,295	110%	328,199	255,031
ALCS-036	197,581	228,680	116%	870,641	399,426
ALCS-037	50,050	57,532	115%	75,381	N/A [a]
ALCS-038	39,390	45,279	115%	165,201	N/A [a]
ALCS-039	2,150	2,391	111%	17,760	15,110
ALCS-040	1,343	1,468	109%	14,881	11,625
Total	**2,349,234**	**2,842,460**	**121%**	**8,186,468**	**4,458,100**

[a] Savings above code not available for these projects and could not be calculated due to lack of data.

Table 13. Project Demand Reduction (kW)

Project Number	Reported Demand Reduction For ALCS (Fixture Baseline)	Verified Demand Reduction for ALCS Only (Excludes Demand Reduction for Fixture)	Realization Rate	Verified Demand Reduction for Project (Existing Baseline)	Verified Demand Reduction for Project (Code Baseline)
ALCS-001	1.2	0.8	69%	31.0	31.0
ALCS-002	3.0	2.7	90%	12.8	10.0
ALCS-003	5.7	6.0	104%	18.3	10.5
ALCS-004	4.1	1.9	45%	2.6	2.6
ALCS-005	31.7	22.2	70%	37.0	N/A [a]
ALCS-006	5	3.5	70%	14.5	12.2
ALCS-007	0	0.0	N/A	9.0	9.0
ALCS-008	8.3	5.8	70%	13.1	13.1
ALCS-009	0	0.0	N/A	38.9	38.9
ALCS-010	5.5	4.9	90%	20.0	20.0
ALCS-011	6.4	5.8	90%	11.6	11.6
ALCS-012	0	0.0	N/A	14.6	14.6
ALCS-013	3.3	3.0	90%	20.1	12.4
ALCS-016	3.2	2.6	81%	10.2	8.3
ALCS-017	0	0.0	N/A	32.1	18.4
ALCS-018	0	0.0	N/A	41.6	41.6
ALCS-020	6.4	4.5	70%	19.1	19.1
ALCS-021	5.4	3.8	70%	22.1	22.1
ALCS-023	3.5	2.3	67%	8.5	8.5
ALCS-024	12.0	8.0	67%	57.7	22.1
ALCS-025	6.7	6.0	90%	18.3	13.8
ALCS-028	1.1	0.8	70%	10.1	10.1
ALCS-029	1.1	1.0	90%	7.6	N/A [a]
ALCS-030	5.0	3.5	70%	8.9	8.9
ALCS-034	0	0.0	N/A	42.1	N/A
ALCS-035	5.7	4.0	70%	17.8	17.8
ALCS-036	62.1	60.1	97%	197.9	197.9
ALCS-037	7.2	7.5	104%	14.0	N/A [a]
ALCS-038	3.2	3.3	104%	30.0	N/A [a]
ALCS-039	0.8	0.6	81%	3.7	3.7
ALCS-040	0.09	0.1	76%	1.1	1.1
Total	**198**	**164.6**	**83%**	**786.6**	**579.4**

[a] Reductions above code were not available for these projects.

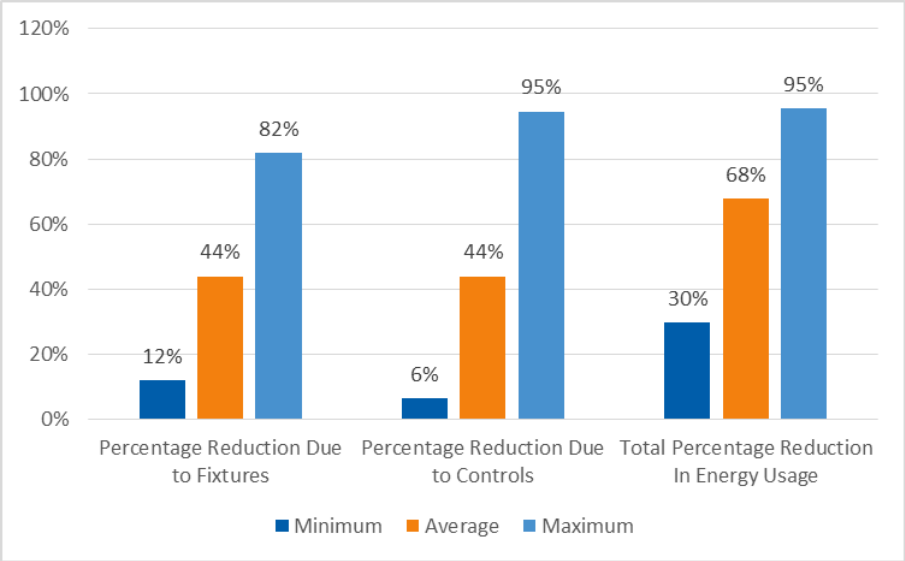
Table 14 details ALCS pilot verified savings for fixture upgrades and ALCS upgrades using the existing baseline. Although the fixture upgrades accounted for two-thirds (65%) of total energy savings, verified savings for ALCS provided significant additional energy savings on top of fixture upgrades. Similarly, fixture upgrades accounted for 79% of demand reduction, with the ALCS providing an additional 21% reduction in demand over fixture upgrades alone.

Table 14. Fixture, Controls, and Total Verified Savings and Demand Reduction for Pilot Participants

Savings Source	Project Energy Savings (kWh)	Project Demand Reduction (kW)	Percentage of Project Energy Savings	Percentage of Project Demand Reduction
Fixture Upgrade	5,344,008	621.9	65%	79%
Controls Upgrade	2,842,460	164.6	35%	21%
Total Savings	**8,186,468**	**786.6**	**100%**	**100%**

Figure 9 compares the percentage of energy-usage reduction achieved by fixtures alone, controls alone, and combined fixtures and controls on average, across the 31 pilot projects, in addition to minimum and maximum reductions achieved. The fixture upgrades alone provide the same average reduction in energy use as would controls implemented without upgrading the fixtures.

Figure 9. Percentage Reduction in Lighting Energy Usage for Pilot Projects



When combining fixture upgrades and controls, pilot participants experienced an overall 68% average reduction in lighting energy usage. Fixture upgrades provided a maximum of 82% reduction in energy usage, while one ALCS provided a maximum of 95% reduction in lighting energy usage. The largest ALCS savings occurred for a mechanical tunnel where lights previously operated 8760 hours annually.

Realization Rates for Contractor-Provided Savings Estimates

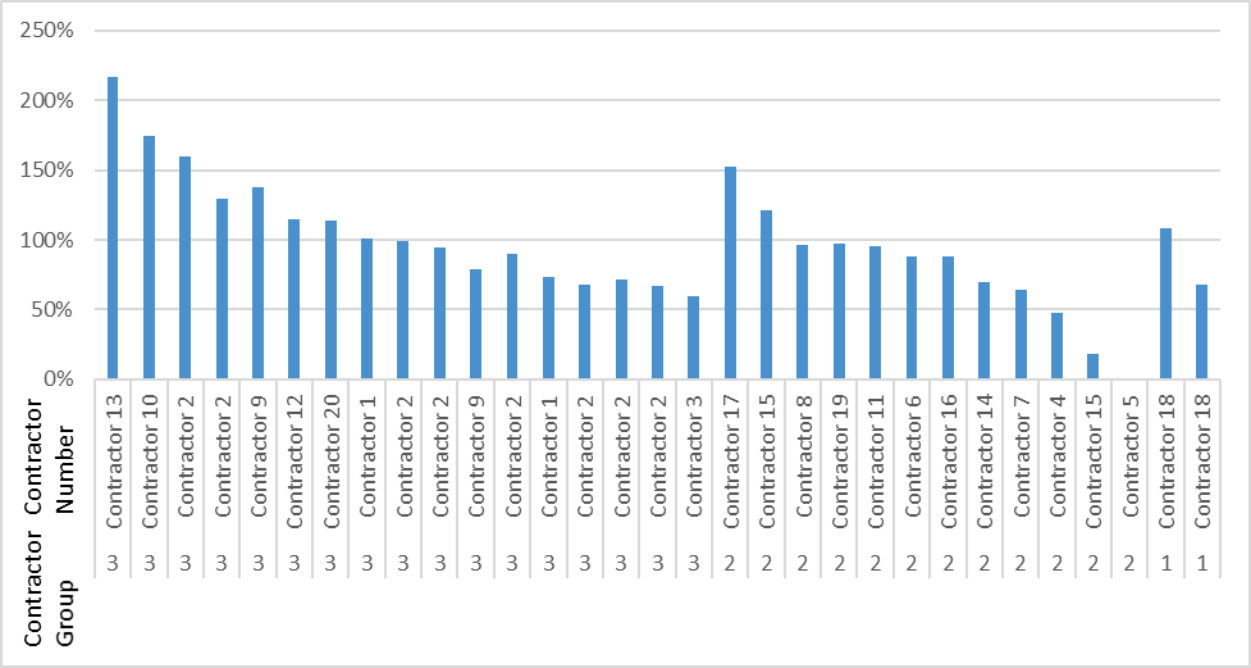
This section examines the energy savings estimates that contractors provided to verify savings. Savings and realization rates are measured from existing conditions in this section.

Many factors—including building types, customer needs, and space needs—influenced ALCS performance and savings. Prior to installation, contractors also estimated energy savings for each project as their *ex ante* savings. These savings were documented in the ALCS systems' trending data. Contractors forecasted energy savings that were both higher and lower for some projects than those verified. For example, one contractor completed seven projects, with realization rates between 160% and 68%. At one extreme, one contractor forecasted energy savings more than 400% higher than those

verified, achieving an 18% realization rate. This difference resulted from the contractor incorrectly calculating baseline fixture wattages and significantly overestimating hours of operation.

Figure 10 shows the realization rate of projected savings (estimated by the contractor) and verified savings (estimated by RHA and verified by Cadmus) for each project, along with the associated contractor.

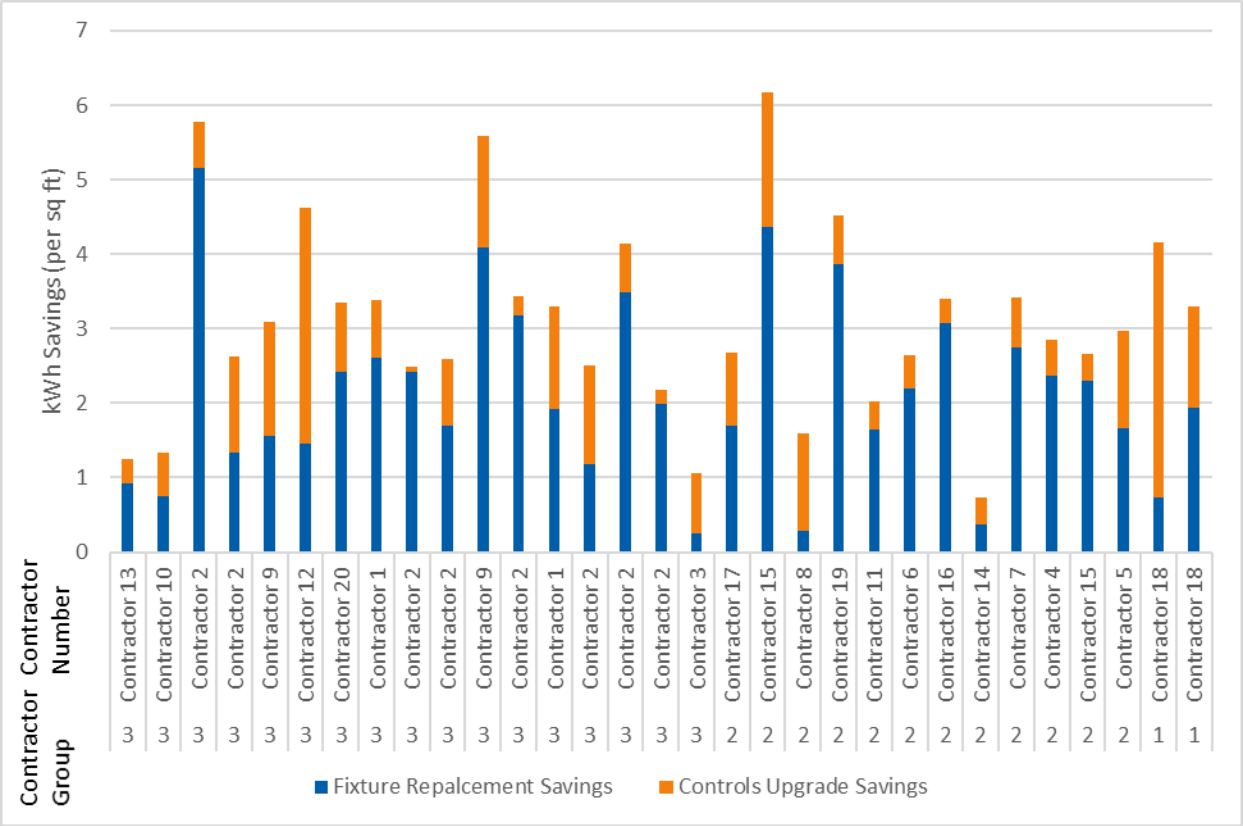
Figure 10. Contractor Realization Rate Comparison [a]



[a]As contractors completed several projects, they are displayed multiple times. Contractor 5 could not provide trending data from the ALCS, precluding calculation of a realization rate.

Figure 11 details all projects' combined energy savings and ALCS savings by contractor and grouping.

Figure 11. Verified Project Savings by Contractor and Group (per sq. ft) [a]



[a] As some contractors completed several projects, they are displayed multiple times.

Net Savings Results

Table 15 presents the results for the three PAI components, the resulting NTGR (calculated by averaging the three PAI scores), and the consistency check results for each surveyed pilot project.

Table 15. PAI Attribution Score Results

Project ID	PAI-1	PAI-2	PAI-3	NTGR	Consistency Check Below 60%	Consistency Check Above 40%
ALCS-003	47%	80%	23%	50%	Pass	Pass
ALCS-004	44%	20%	32%	32%	Pass	NA
ALCS-011	53%	100%	100%	84%	NA	Pass
ALCS-012	44%	20%	100%	55%	Pass	Pass
ALCS-013	44%	75%	16%	45%	Pass	Pass
ALCS-018	50%	50%	50%	50%	Pass	Pass
ALCS-021	44%	50%	0%	31%	Pass	NA
ALCS-024	41%	40%	0%	27%	Pass	NA
ALCS-025	47%	38%	17%	34%	Pass	NA
ALCS-034	44%	20%	45%	36%	Pass	NA
ALCS-035	50%	50%	32%	44%	Pass	Pass
ALCS-037	50%	30%	21%	34%	Pass	NA

ALCS-038	50%	30%	21%	34%	Pass	NA

Table 16 shows net savings for each surveyed project. The overall NTGR was 44%.

Table 16. Project Net Energy Savings (kWh/year)

Project ID	Verified Gross Savings (Code Baseline)	NTGR	Net Savings
ALCS-003	15,563	50%	7,804
ALCS-004	81,466	32%	26,250
ALCS-011	29,607	84%	24,932
ALCS-012	72,356	55%	39,662
ALCS-013	50,174	45%	22,597
ALCS-018	947,503	50%	473,751
ALCS-021	185,964	31%	58,544
ALCS-024	167,585	27%	45,347
ALCS-025	34,492	34%	11,763
ALCS-034	29,272	36%	10,649
ALCS-035	255,031	44%	111,897
ALCS-037	57,532	34%	19,373
ALCS-038	45,279	34%	15,247
Total	**1,971,823**	**44%**	**867,816**

As shown in Table 12 and Table 13, Cadmus verified total energy and demand savings using the code baseline as 4,436,411 kWh and 579 kW. As shown in Table 17, applying an estimated 44% NTGR resulted in pilot net savings of 1,952,021 kWh and demand reductions of 255 kW.

Table 17. Pilot Program Gross and Net Energy Savings and Demand Reduction

Savings	Energy Savings (kWh)	Demand Savings (kW)
Gross Savings	4,436,411	579
NTGR	44%	44%
Net Savings	1,952,021	255

Key Findings, Conclusions, and Recommendations

Due to limited pilot program participation, the evaluation produced qualitative findings that are necessarily limited in nature for the reasons described above. Key findings should be viewed as insights into customer and contractor decision-making regarding lighting controls and the experiences of stakeholders that participated in the pilot program; the quantitative findings should not be considered definitive with regard to ALCS effects.

Review of existing ALCS-related studies indicated that ALCS projects face similar challenges to building management system projects in achieving optimal performance.
Successful implementation of ALCS systems (similar to building management systems) relies on the performance of many parties, including system designers, installers, building managers, code officials, and building owners. Communication, documentation, and diligence by all parties prove critical to proper installation and operation of ALCS.

Twenty-eight of 30 retrofit projects replaced their legacy lighting fixtures with LED fixtures at the time they upgraded to an ALCS. The replacement of legacy lighting with LED constituted the bulk of the lighting energy savings (approximately two thirds of total lighting savings).
Any future ALCS program should include the consideration that lighting fixtures are likely to be upgraded at the same time in the majority of projects. Upgrading lighting to LEDs provided the majority of energy savings for participants that replaced their legacy lighting; however, the one project that kept its legacy linear fluorescent lighting also produced significant energy savings when it implemented ALCS (47% reduction in usage). Another project had already upgraded their lighting to LED and later found they needed a new control system for it to function correctly.

Compared to existing conditions, pilot projects achieved, on average, a 68% reduction in lighting energy consumption from combined ALCS and fixture upgrades, based on load monitoring. Across all projects, fixture upgrades and ALCS each accounted for a 44% reduction in lighting energy consumption.
Reduction in energy usage from lighting fixture upgrades varied between 12% and 82% across projects with an average reduction of 44%. Reduction in energy usage from ALCS varied between 6% and 95% across projects with an average reduction of 44%. For example, if a typical building used 100,000 kWh per year for lighting, LED fixture upgrades reduced annual consumption by 44% (down to 56,000 kwh per year). The addition of ALCS reduced annual consumption by another 44%, decreasing annual usage to 31,360 kWh, resulting in a total reduction of 68%.[23]

> **Recommendation** Due to the large variance in observed savings, a larger study of ALCS would help refine savings estimates for forecasting and planning.

[23] The example calculation results in 69% savings due to rounding.

All decision-makers who responded to the survey (11 of 28) cited saving money on energy bills as their primary reason for participating in the pilot. Survey results, however, suggested decision-makers would have installed similar measures for a smaller incentive or without the pilot.

The pilot provided incentives at $0.48 per kWh of savings, and limited incentives to the lesser of $50,000 per project or 50% of the project cost. Eight of 11 surveyed decision-makers indicated they would have installed the same project for 25% of the incentive. The NTG finding also suggests that all decision-makers interviewed would have pursued at least some aspects of their project without the pilot (and financial incentives). This finding should be considered when accounting for the pilot program's design, which relied on a large incentive to encourage study participation and included an extensive project assessment and QC process.

The NTG analysis (based on 11 responses from 28 decision-makers) estimated that 44% of gross above-code savings achieved by ALCS installations were attributable to the pilot program. This result, however, should be viewed in context with the pilot's high incentive amount, which was designed to recruit projects for this study.

Pilot design and marketing through distributor channels and contractors focused on recruiting customers to participate in the pilot to demonstrate savings potential with ALCS technology. Slightly more than one-third of customers (4 of 11 respondents, representing 5 of 13 surveyed projects) indicated they would not have done anything to their lighting in the pilot's absence; the remaining seven survey respondents indicated they would have at least upgraded to code. Given the specific design of the pilot program, the attributable savings ratio may not be applicable to other ALCS programs.

RHA, upon conducting site inspections and assessing contractor work quality, found many ALCS projects did not achieve optimal savings due to project quality issues.

Site inspections conducted by RHA included functional testing of the system, load monitoring, light logging, and trending data analysis to identify both unique and systematic problems with ALCS performance. Across the 31 projects, RHA found 11 projects failed to correctly program the ALCS, thus causing reporting errors; nine projects experienced communication problems with the networked devices; and five projects experienced occupancy sensor connection issues, malfunctions, or defects. Additional training or emphasis on installation quality would alleviate some of these issues. RHA did not attempt to determine which faults were due to work quality or equipment quality.

Some projects did not comply with daylight harvesting or occupancy sensor aspects of the energy lighting code, leading to reduced energy savings from ALCS. Among code requirements, daylight harvesting had the highest noncompliance rate.

All projects complied with the lighting power density requirements of Title 24, Part 6, which also mandated automatic daylight harvesting features for 20 of the 31 projects. Thirteen of these 20 met the daylight harvesting requirement; the other seven did not. Although all projects required occupancy sensors, four of the 31 projects did not install occupancy sensors, or, according to customers, the sensors were disabled due to health and safety reasons.

> **Recommendation** Provide additional training on Title 24 daylighting requirements to designers and installing contractors.

Though the program required task tuning, scheduling, daylight harvesting when required, and occupancy controls for all pilot projects, at least one of these strategies was not implemented in 16 of 31 projects.

Three of 31 projects did not implement task tuning, three did not implement scheduling, seven did not implement daylight harvesting, and four did not implement occupancy controls. Pilot participants cited issues such as reliability, uncertainty of system capabilities, and customer preferences as reasons for not implementing these strategies.

Decision-makers and contractors that responded to the survey were satisfied with their pilot experiences, but they recommended that SCE improve pre- and post-installation inspection processes and the clarity of pilot requirements.

Ten of 11 decision-makers who responded rated themselves as *very satisfied* with the performance of their new lighting system, and all 11 rated themselves as *somewhat* or *very satisfied* with the pilot overall.

All end users that responded were satisfied with the new lighting system and indicated they would recommend the system to others.

Only seven end-users responded to the survey, representing seven projects. Five respondents were *very satisfied* with the new lighting and control system, and one was *somewhat satisfied*. One did not respond to this question. Only one end user reported experiencing an issue with the new lighting system (which was quickly resolved).

Appendix A: Net Savings Analysis Questions and Results

PAI-1 Question

E8. Using a 0 to 10 rating scale, where 0 means *not at all important* and 10 means *very important*, please rate the importance of each of the following in your decision to complete the advanced lighting control project.

Pilot Factors

1. The availability of the pilot incentive or discount
6. Recommendations or suggestions from SCE pilot staff
7. Recommendations or suggestions from SCE account representative
8. Recommendations or suggestions from a contractor or vendor

Non-Pilot Factors

1. Internal policy or requirements inside your company or organization?
9. Concerns about environmental effects or global warming?
10. Your desire to install a control system improve employee morale?
11. Your desire to save money on your monthly energy bill?
12. Your interest in the lighting control technology?
13. Your desire to install a control system reduce operations and maintenance costs?
14. Your desire to install a control system that automated lighting decisions?

PAI-1 Scoring

The highest pilot influence rating, divided by the sum of the highest pilot influence rating plus the highest non-pilot influence rating.

PAI-1 Results

Table 18 shows the responses and final scoring, by project, for the first component of the program attribution index.

Table 18. PAI-1 Results

Site ID	Pilot Factors				Max Pilot Rating	Other Factors							Max Non-Pilot Rating	PAI-1 Score
	Pilot incentive	Suggestion from SCE pilot staff	Suggestion from SCE account representative	Suggestion from contractor		Internal policy or requirements	Concerns about environmental effects or global warming	To improve employee morale	To save money on energy bill	Interest in the technology	To reduce operation and maintenance costs	To automated lighting decisions		
ALCS-003	4	5	8	9	9	9	8	7	7	9	7	10	10	47%
ALCS-004	8	0	0	0	8	3	6	5	10	10	7	8	10	44%
ALCS-011	10	7	8	8	10	5	3	2	9	6	7	6	9	53%
ALCS-012	8	8	7	6	8	10	10	10	10	10	10	8	10	44%
ALCS-013	8	0	0	8	8	0	9	10	9	7	9	8	10	44%
ALCS-018	8	5	0	9	9	5	5	5	9	7	9	7	9	50%
ALCS-021	8	0	0	8	8	9	5	Refused	10	10	9	9	10	44%
ALCS-024	7	4	2	0	7	10	10	7	8	6	8	6	10	41%
ALCS-025	8	0	0	9	9	10	10	10	10	8	10	5	10	47%
ALCS-034	6	4	4	8	8	0	7	0	10	7	10	10	10	44%
ALCS-035	10	10	10	8	10	10	5	3	10	10	10	10	10	50%
ALCS-037	9	0	0	0	9	9	8	0	8	0	5	9	9	50%
ALCS-038	9	0	0	0	9	9	8	0	8	0	5	9	9	50%

PAI-2 Questions

E9. Did your organization learn about the SCE Advanced Lighting Control pilot program before or after you decided to implement the advanced lighting control system that was eventually installed?

1. Before
2. After
98. Don't know
99. Refused

E10. Now I would like to ask you about the importance of the pilot in your decision to install the lighting control system, as opposed to other factors. Using a 0 to 10 rating scale, where 0 means *not at all important* and 10 means *very important*, please rate the overall importance of the pilot factors versus the most importance of the other factors you identified in an earlier question (E8) in your decision to install the advanced lighting control system. This time I would like you to have the two ratings total 10.

1. Record pilot factors score
2. Record non-pilot factors score
98. Don't know
99. Refused

PAI-2 Scoring

The importance of the pilot, on the 0 to 10 scale to question E10, divided by 10. This score is reduced by half if the respondent learned about the pilot after the decision had been made (E9).

PAI-2 Results

Table 19 (next page) shows the responses and final scoring, by project, for the second component of the program attribution index.

Table 19. PAI-2 Results

Site ID	Did your organization learn about the SCE Advanced Lighting Control Pilot Program before or after you decided to implement the advanced lighting control system that was eventually adopted or installed?	Using a 0 to 10 rating scale, where 0 means *not at all important* and 10 means *very important*, please rate the overall importance of the pilot factors versus the most importance of the other factors you identified in an earlier question (E8) in your decision to install the advanced lighting control system.		PAI-2 Score
		Pilot Factors Score	Non-Pilot Factors Score	
ALCS-003	Before	8	2	80%
ALCS-004	After	4	6	20%
ALCS-011	Before	10	0	100%
ALCS-012	After	4	6	20%
ALCS-013	Don't know	10	0	75%
ALCS-018	Before	5	10	50%
ALCS-021	Before	5	5	50%
ALCS-024	Before	4	6	40%
ALCS-025	Don't know	5	5	38%
ALCS-034	Before	2	8	20%
ALCS-035	Before	5	5	50%
ALCS-037	Before	3	7	30%
ALCS-038	Before	3	7	30%

PAI-3 Questions

Now I would like you to think about the action you would have taken with regard to the installation of certain equipment and controls if the pilot and incentives had not been available.

E11. Using a 0 to 10 rating scale, where 0 means *not at all likely* and 10 means *extremely likely*, please rate the likelihood that your company would have integrated each of the following features into your lighting control system.

1. Graphical User Interface (GUI Dashboard)
2. Fixtures using task tuning, where fixtures can be tuned to optimize the lighting in that space
3. Installed a daylight harvesting system that dims lighting fixtures in response to natural light [Skip if daylight harvesting was not employed]
4. Installed occupancy or vacancy controls that turn off lighting in rooms that are not occupied
5. Installed a lighting automation system that turns lighting on and off, depending on the time of day and need for lighting
6. Installed a control system allowing for automatic demand response that allows the utility to dim lighting in response to high demand for electricity
7. Incorporated a control system into the entire area of the building that was part of the final project

PAI-3 Scoring

The rating for each measure weighted by that measure's percentage of the total pilot savings, then subtracting that value from 10. The resulting estimate is then divided by 10 to convert it to a percentage.

PAI-3 Results

Table 20 shows the responses and final scoring, by project, for the third component of the program attribution index.

Table 20. PAI-3 Results

Site ID	Graphical User Interface	Task Tuning	Daylight Harvesting	Occupancy or Vacancy Controls	Lighting Automation System	Control System for Automatic Demand Response	Control System Incorporated to Entire Area	PAI-3 Score
ALCS-003	8	9	6	9	5	9	9	23%
ALCS-004	Refused or Did not answer / PAI-3 Score is average of PAI-1 & PAI-2 Scores							32%
ALCS-011	0	0	0	0	0	0	0	100%
ALCS-012	0	0	NA	0	0	0	0	100%
ALCS-013	9	7	8	9	8	2	10	16%
ALCS-018	Refused or Did not answer / PAI-3 Score is average of PAI-1 & PAI-2 Scores							50%
ALCS-021	10	10	10	10	10	10	10	0%
ALCS-024	10	10	NA	10	10	4	10	0%
ALCS-025	10	10	0	10	2	10	10	17%
ALCS-034	8	8	NA	NA	NA	NA	0	45%
ALCS-035	2	8	NA	8	8	0	8	32%
ALCS-037	10	5	9	10	7	NA	7	21%
ALCS-038	10	5	9	10	7	NA	7	21%
Savings	**16%**	**20%**	**18%**	**15%**	**15%**	**0%**	**16%**	

Net-to-Gross Scoring

The net-to-gross (NTG) value for each project is the simple average of the PAI-1, PAI-2, and PAI-3 scores.

Consistency Check

If the NTG value is below 60%, respondent **fails** consistency check if they responded:

> "Would have done nothing" to question E1. "Which of the following best describes what your company would have done had the Advanced Lighting Controls Pilot Program not existed?"

and

> "No" to question E4. "Prior to learning about Advanced Lighting Control Pilot Program, was the purchase of the advanced lighting control system included in your organization's capital budget?

and

> "No" to question E6. "Did a comparison of energy bill savings and the project cost inform your decision to go forward with the lighting control system installation?"

If the NTG value is above 40%, respondent **fails** consistency check if they responded:

> "Would have installed the same lighting system we did" to question E1. "Which of the following best describes what your company would have done had the Advanced Lighting Controls Pilot Program not existed?"

and

> "At the same time" or "Later but within the one year" to question E3. "If the Advanced Lighting Control Pilot Program did not exist, when would you have installed the lighting control system?

Net-to-Gross Results

Table 21 shows the PAI scoring results for each project with a completed decision-maker survey.

Table 21. NTG Results

Site ID	PAI-1	PAI-2	PAI-3	PAI Score	Consistency Check Below 60% NTG	Consistency Check above 40% NTG
ALCS-003	47%	80%	23%	50%	Pass	Pass
ALCS-004	44%	20%	32%	32%	Pass	NA
ALCS-011	53%	100%	100%	84%	NA	Pass
ALCS-012	44%	20%	100%	55%	Pass	Pass
ALCS-013	44%	75%	16%	45%	Pass	Pass
ALCS-018	50%	50%	50%	50%	Pass	Pass
ALCS-021	44%	50%	0%	31%	Pass	NA
ALCS-024	41%	40%	0%	27%	Pass	NA
ALCS-025	47%	38%	17%	34%	Pass	NA
ALCS-034	44%	20%	45%	36%	Pass	NA
ALCS-035	50%	50%	32%	44%	Pass	Pass
ALCS-037	50%	30%	21%	34%	Pass	NA
ALCS-038	50%	30%	21%	34%	Pass	NA

Appendix B: Key Decision-Maker Survey

Cadmus staff members will survey the key decision-maker (identified by SCE) for each completed pilot ALCS project sampled for evaluation. We will conduct surveys using contact information provided by SCE for all completed projects at the end of the pilot phase. Cadmus staff will perform the survey over the phone but will use Qualtrics as a data gathering tool. Table 22 shows the relevant Research Questions for this survey.

Table 22. Research Questions for Key Decision-Maker Survey

Key Research Topics	Areas of Investigation	Related Questions
Screening	Project initiation process	B4
Marketing and Outreach	Program Awareness	C1
	How customers would like to be contacted about opportunities from SCE	G3
	Key factors influencing customers' decision to participate in program	C3, C5, C7-C9
Barriers	Obstacles to installing high-efficiency equipment	C4, D5
Satisfaction	Assess satisfaction with various program components and reasons for dissatisfaction among participants	C6, D3, D4, F1-F4, H1
Firmographics	Determine building and company characteristics of participants	B3, G1, G2
Contractor involvement	Level of involvement of contractor/designer in project scope	C2, D1, D2
Attribution	Determine likely baseline in absence of program	E1-E9

Green text indicates instructions for the interviewer.
Red text indicates instructions for Qualtrics programming.
Answers in parenthesis should not be read.

SAMPLE VARIABLES
[Contact Name]
[LOCATION ADDRESS]
[MEASURE 1]
[MEASURE 2]
[MEASURE 3]
[INCENTIVE]
[MONTH]
[CONTRACTOR NAME]

A. Introduction

A1. Hello, my name is [INTERVIEWER NAME], and I'm calling on behalf of Southern California Edison regarding the Advanced Lighting Control Systems Pilot Program. I'm with Cadmus, an independent research firm. May I speak with [Contact Name]? [IF NOT AT THIS LOCATION, ASK FOR PHONE NUMBER AND NAME AT CORRECT LOCATION AND CALL RESPONDENT]

1. (Yes) [CONTINUE WITH RESPONDENT ON PHONE]
99. (REFUSED) [THANK AND TERMINATE]

Back-up information, not to be programmed:

[If "No – Not available," ask if Respondent would like to arrange a more convenient time for us to call them back or if you can leave a message for that person.]

[IF RESPONDENT ASKS HOW LONG, SAY: "APPROXIMATELY 15 MINUTES."]

[IF NEEDED:] We'd appreciate your input. By participating in the program, you have an obligation to support this survey effort as it is a condition of the program participation and rebate.

[IF NEEDED:] This survey is for research purposes only and this is not a marketing call. Your participation in this study is important so that Southern California Edison can improve the energy efficiency programs it offers to businesses and other organizations.

[**Only if asked** for a SCE contact to verify the survey authenticity, offer Dario Moreno with SCE at 626-302-0306.]

B. Screeners

B1. Southern California Edison hired Cadmus to follow up with customers who participated in the Advanced Lighting Control Pilot Program and identify any areas in which the program could be improved. We will keep your responses confidential.

B2. Our records show that you upgraded your lighting equipment including [MEASURE1], [MEASURE 2], and [MEASURE3] at [LOCATION ADDRESS] in [MONTH]. [To ensure our records are correct, can you confirm that you received an incentive for this/these upgrades recently?

1. (Yes)
2. (No, wrong address/measure/other) [Record correct information, if possible]
3. (No, I did not install any measures) [THANK AND TERMINATE]
4. (Don't know) Is there someone we could speak with that would know this? [Record name and contact information:_____]

99. (Refused) [THANK AND TERMINATE]

B3. What industry is your company in? [Do not read; select one.]

1. (Agriculture)
2. (Auto repair shop)
3. (Construction)
4. (Education/schools/university)
5. (Finance and Insurance)
6. (Food Processing)
7. (Government)
8. (Grocery/food stores/convenience stores)
9. (Healthcare/hospital)
10. (Hotel/motel)
11. (Industrial Electron & Machinery)
12. (Industrial Mining, Metals, Stone, Glass, Concrete)

13. (Industrial Petroleum, Plastic, Rubber and Chemicals)
14. (Manufacturing)
15. (Media – TV, radio, newspaper, etc.)
16. (Mining)
17. (Non-profit)
18. (Office, professional services)
19. (Real estate and property management)
20. (Religious – house of worship/community service)
21. (Restaurant/food service)
22. (Retail/wholesale)
23. (Transportation)
24. (Other [RECORD_____])
98. (Don't know)
99. (Refused)

B4. Can you take a moment to think back to the project and all the different people involved. I'm going to read you a short list. Please tell me who, if anyone, initiated the project. By initiated, I mean who came up with the idea to do the lighting control project.? [READ LIST AND MARK 1= YES, 2=NO, 99=DON'T KNOW; 88 REFUSED FOR EACH]

1. Myself or someone in my organization
2. Your primary contractor or vendor
3. Lighting control system manufacturer
4. A designer or other vendor associated with your primary contractor
5. Your SCE account manager
6. SCE ALCS Pilot program manager
7. (Other [SPECIFY:_____])
98. (Don't know)
99. (Refused)

C. Decision-Making

C1. How did your organization learn about SCE's ALCS Pilot? [Do not read; select all that apply]

1. SCE account manager
2. SCE ALCS Pilot program manager
3. Other SCE staff
4. Email from SCE
5. Contractor
6. Brochure / direct mail from SCE
7. Business partners / colleagues
8. Advanced Lighting Controls Systems Kick off meeting at the Irwindale Energy Center in January 2015
9. Other meetings or events [SPECIFY]
10. Other [SPECIFY]

98. (Don't know)
99. (Refused)

C2. What factor(s) were important to your company's decision to make the lighting system upgrades through SCE's Advanced Lighting Control Pilot Program? [DO NOT READ LIST; RECORD UP TO 3 RESPONSES MAXIMUM]

1. To save money on energy bills
2. To reduce energy consumption or energy demand
3. To obtain a program incentive
4. To replace old (but still functioning) equipment
5. To replace broken (not-functioning) equipment
6. To enhance performance/programmability of our system(s)
7. To improve comfort
8. To improve employee morale
9. To lower operations and maintenance costs
10. Other [SPECIFY_____]
98. (Don't know)
99. (Refused)

C3. Of the factors you mentioned in the previous question, which was most important in your decision to make the lighting upgrades?

1. To save money on energy bills
2. To reduce energy consumption or energy demand
3. To obtain a program incentive
4. To replace old (but still functioning) equipment
5. To replace broken (not-functioning) equipment
6. To enhance performance/programmability of our system(s)
7. To improve comfort
8. To improve employee morale
9. To lower operations and maintenance costs
10. Other [SPECIFY_____]
98. (Don't know)
99. (Refused)

C4. What do you see as the biggest challenges your company has in making energy-efficient improvements? [DO NOT READ LIST; RECORD UP TO 3; PROBE FOR MULTIPLE RESPONSES]

1. High initial costs
2. Budget limitations
3. Long payback period
4. Funding competition for other investments/improvements
5. Replacing equipment without affecting operations
6. Understanding potential areas for improvement
7. Lack of awareness about available incentives for energy efficient equipment
8. Understanding equipment eligibility
9. Issues with program application process

10. Finding a contractor with which to work
11. Inadequate incentive/incentive was only available through 2016
12. Other [SPECIFY:_____]
98. (Don't know)
99. (Refused)

C5. Did you experience any challenges when deciding whether to participate in the Advanced Lighting Controls pilot program? If so, please describe those challenges. [Do not read; select all that apply]

1. High initial costs
2. Budget limitations
3. Long payback period
4. Funding competition for other investments/improvements
5. Replacing equipment without affecting operations
6. Understanding potential areas for improvement
7. Lack of awareness about available incentives for energy efficient equipment
8. Understanding equipment eligibility
9. Issues with program application process
10. Finding a contractor with which to work
11. Inadequate incentive/incentive was only available through 2016)
12. Other [SPECIFY:_____]
98. (Don't know)
99. (Refused)

C6. What would you say are the main benefits your company is experiencing as a result of the advanced lighting controls you installed through the Advanced Lighting Control Pilot Program? [DO NOT READ LIST; RECORD UP TO 3; PROBE FOR MULTIPLE RESPONSES]

1. The incentive payment
2. Using less energy, reducing energy consumption or energy demand
3. Saving money on our utility bills; lower energy bills
4. Increased occupant comfort
5. Better aesthetics
6. Saving money on maintenance costs
7. Other [SPECIFY:_____]
8. NO BENEFITS
98. (Don't know)
99. (Refused)

Instructions to Interviewee: I understand you may have received multiple incentives for this project and related activates however these following questions refer to the incentive you had received from the Advanced Lighting Control Systems Pilot Program to install the lighting controls with a graphical user interface. Your responses do not affect the incentive you have already received or are entitled by the program to receive.

C7. Would you have installed the same advanced lighting control system if the pilot program incentive were half of the [INCENTIVE] that you already received? (Record full response)

1. Yes (Ask Question C8)
2. No (Ask Question C9)
3. Maybe (Ask Question C8)

98. (Don't know) (Ask Question C9)

99. (Refused) (Skip to Section C9)

C8. Would you have installed the same advanced lighting control system if the [INCENTIVE] you had received was one quarter or 25% of the[INCENTIVE] you received? (Record full response)

1. Yes (skip to C10)
2. No (skip to C10)
3. Maybe (skip to C10)

98. (Don't know)

99. (Refused)

C9. (Skip if C7= Yes or Don't Know) Would you have installed the same advanced lighting control system if the rebate you had received was three quarters or 75% of the [INCENTIVE] you received? (Record full response)

1. Yes
2. No
3. Maybe

98. (Don't know)

99. (Refused)

C10. Did you receive an incentive check in the mail for the control system from SCE, or did your contractor provide an instant discount on the cost of the project? [Do not read]

1. Incentive check in the mail from SCE.
2. Instant discount from Contractor.
3. Other [SPECIFY:_____]

98. (Don't know)

99. (Refused)

D. Involvement with Contractor

D1. Our records show that you worked with [CONTRACTOR NAME] Is that correct?

89. Yes

90. No (Record contractor name)

98. Don't know (Skip to E1)

D2. Why did you choose to work with [CONTRACTOR NAME] you selected for this project? [MULTIPLE RESPONSES ALLOWED]

1. Worked with them on previous projects
2. They sought us out
3. CALCTP certified
4. Other certification [SPECIFY]
5. Other training or experience [SPECIFY]
6. Other reason [SPECIFY]

98. (Don't know)
99. (Refused)

D3. Did [CONTRACTOR NAME] involve other contractors or designers to complete the project? If so, please describe those involved and their roles.
1. [RECORD ANSWER]

D4. Can you provide contact information for that person?
1. [RECORD contact information readily available but follow up for those not readily available]

D5. Did your [CONTRACTOR NAME] have to correct issues found either during commissioning, code inspection, SCE quality assurance or by anyone else?
1. Yes[Ask D6 to D8)
2. No[Skip to D9]
98. (Don't Know)[Skip to D9]
99. (Refused)[Skip to D9]

D6. What were those issues?
1. [RECORD ANSWER]

D7. Do you believe [CONTRACTOR NAME]'s lack of knowledge caused the issue?
1. Yes
2. No
98. (Don't Know)
99. (Refused)

D8. Did these issues get resolved in a way you are satisfied with?
1. Yes
2. No
98. (Don't Know)
99. (Refused)

D9. How satisfied are you with your experience with the contractor that designed and/or installed the lighting control equipment? [COLLECT SATISFACTION FOR BOTH CONTRACTORS]
1. Very satisfied
2. Somewhat satisfied
3. Not very satisfied
4. Not at all satisfied
98. (Don't know)
99. (Refused)

D10. Can you share more about this rating?
1. [RECORD ANSWER]

D11. Do you have any plans to install other energy-efficient equipment in the future?

1. Yes [SPECIFY_____]
2. No

98. (Don't know)
98. (Refused)

E. Attribution

Next I'm going to ask you a few questions now about your company's decision making.

E1. Which of the following best describes what your company would have done had the advanced lighting controls pilot program not existed?(Read list)

1. We would have installed the same lighting control system we did[SKIP TO E3]
2. Would have done nothing to the lighting [SKIP TO E4]
3. Would have only done a basic lighting retrofit project following Title 24 code requirements. [SKIP TO E3]
4. Would have done a less ambitious lighting controls project[SKIP TO E3]
5. None of these options[Ask E2]

98. (Don't know) [SKIP TO E4]
99. (Refused) [SKIP TO E4]

E2. How would you describe what your company would have done had the advanced lighting controls pilot program not existed? (open ended)

1. [RECORD ANSWER]
2. (Refused)

E3. If the Advanced Lighting Controls pilot program did not exist, when would you have installed the lighting control system?

1. At the same time?
2. Later but within one year?
3. Later than one year but within two years?
4. More than two years?
5. No, would not have installed the system?

98. (Don't know)
99. (Refused)

E4. Prior to learning about Advanced Lighting Controls pilot program, was the purchase of the advanced lighting control system included in your organization's capital budget?

1. Yes
2. No

98. (Don't know)
99. (Refused)

E5. What is your company's process for comparing costs and benefits of potential energy efficiency projects? [RECORD VERBATIM]

E6. Had you considered the energy savings in relation to the project cost as a metric in your decision to go forward with installing the lighting control system that you did?

1. Yes (Ask Question E7)
2. No (Skip to Question E8)

98. (Don't know) (Skip to Question E8)
99. (Refused) (Skip to Question E8)

E7. Had you not received the rebate on the controls system would the return on investment (ROI) have been high enough to install the same controls system?

1. Yes
2. No

98. (Don't know)
99. (Refused)

PAI-1

The following questions refer to the entire advanced lighting control project you completed. I'm going to ask you to rate the importance of the ALCS Pilot and other factors that may have had an effect on your decision to install advanced lighting controls with a graphical user interface. Think of the degree of importance as being shown on a scale from 0 to 10 where 0 means not at all important and 10 means very important.

E8. Using this 0 to 10 rating scale, please rate the importance of each of the following in your decision to implement the advanced lighting controls with a graphical user interface.

Program Factors

1. The availability of the program incentive or discount
2. Recommendations or suggestions from SCE program staff
3. Recommendations or suggestions from your SCE account representative
4. Recommendations or suggestions from a contractor or vendor.

Other Factors

5. Internal policy or requirements inside your company or organization?
6. Concerns about environmental effects or global warming?
7. Your desire to install a control system improve employee morale?
8. Your desire to save money on your monthly energy bill?
9. Your interest in the lighting control technology?
10. Your desire to install a control system reduce O&M costs?
11. Your desire to install a control system that automated lighting decisions?

PAI-2

E9. Did your organization learn about the SCE Advanced Lighting Control Program BEFORE or AFTER you decided to implement the advanced lighting control system that was eventually adopted or installed?

1. Before
2. After
98. (Don't know)
99. (Refused)

Now I would like to ask you about the importance of the pilot program in your decision to install the lighting control system, as opposed to other factors. Using the 0 to 10 rating scale we used earlier, where 0 means not at all important and 10 means very important, please rate the overall importance of the program factors versus the most importance of the other factors you identified in an earlier question (E8) in your decision to install the advanced lighting control system. This time I would like you to have the two ratings total 10.

3. Record Program Factors Score
4. Record Non-Program Score
98. (Don't know)
99. (Refused)

PAI-3

Now I would like you to think about the action you would have taken with regard to the installation of certain equipment and controls if the pilot program and incentives had not been available.

E10. Please rate what the likelihood is that you would have integrated each of the following features into your lighting control system where 0 is not at all likely and 10 is extremely likely.

1. Graphical user interface (aka Dashboard)
2. Fixtures utilizing task tuning, where fixtures can be tuned to optimize the lighting in that space
3. Install a daylight harvesting system that dims lighting fixtures in response to natural light [Skip if daylight harvesting was not employed]
4. Installed occupancy or vacancy controls that turn off lighting in rooms that are not occupied
5. Installed a lighting automation system that turns lighting on and off depending on the time of day and need for lighting
6. Installed a control system allowing for automatic demand response that allows the utility to dim lighting in response to high demand for electricity
7. Incorporated a control system into the entire area of the building that was part of the final project

E11. Overall, what benefits have you experienced as a result of your participation in this program? [Probe for noneconomic, non-energy related benefits]

F. *Satisfaction*

Now I have a few questions about your satisfaction with different aspects of the Advanced Lighting Control Pilot Program.

F1. Thinking about the application you submitted in [MONTH], how easy would you say this paperwork was to complete? Would you say: [READ LIST]

1. Very easy
2. Easy
3. Somewhat challenging
4. Very challenging

98. (Don't know)
99. (Refused)

F2. How satisfied are you with the performance of your new lighting control system?

1. Very satisfied
2. Somewhat satisfied
3. Not very satisfied
4. Not at all satisfied

98. (Don't know)
99. (Refused)

F3. How satisfied are you with the SCE Advanced Lighting Controls Pilot Program overall?

1. Very satisfied
2. Somewhat satisfied
3. Not very satisfied
4. Not at all satisfied

98. (Don't know)
99. (Refused)

F4. Is there anything that SCE could have done to improve your overall experience with the Advanced Lighting Controls Pilot Program? [DO NOT READ THE LIST, RECORD ALL THAT APPLY]

1. Better/more communication [SPECIFY: Who would you like more communication from?_____]
2. Quicker response time on questions from SCE [SPECIFY: Who would you like a quicker response time from?__]
3. Larger selection of eligible equipment [ASK: What energy-efficient equipment?_____]
4. Increasing the incentive amount
5. Simplify the application process [ASK: In what way?_____]
6. Provide quicker approval on applications
7. Send incentive check out faster
8. Other [SPECIFY:_____]
9. No, nothing

98. (Don't know)
99. (Refused)

G. Firmographics

I have just a few more questions about your business.

G1. Does your organization lease or own the facility? [DO NOT READ]

1. Lease – I am the tenant
2. Lease – I am the owner
3. Own
4. Other [SPECIFY:_____]

98. (Don't know)
99. (Refused)

G2. How many people are employed at this location?

1. [RECORD ANSWER]

G3. For upcoming energy efficiency opportunities sponsored by SCE, what are the best ways for them to reach people at your company such as yourself? [ALLOW MULTIPLE SELECTIONS]

1. (Phone call)
2. (Email)
3. (Bill insert)
4. (Contractor)
5. (Letter/flyer)
6. (Local event)
7. (Post it on website)
8. (Other [SPECIFY:_____])

98. (Don't know)

H. Closing

Thank you for your participation in this survey and in SCE's Advanced Lighting Controls Pilot Program

H1. We are conducting surveys to find out how the employees/occupants who are working in the building like the new lighting systems. We have quick 5 minute online survey we would like to send to them. Would you be willing to forward this 5-minute online survey to the tenants or staff who work in these spaces?

1. [RECORD RESPONSE]

H2. Do you have any final comments about the Advanced Lighting Control Pilot Program? [TEXT, NO FORCED RESPONSE]

Appendix C: Contractor Survey

Cadmus staff members will survey the lead contractor (as described in the pilot tracking data provided by SCE) for each completed pilot ALCS project sampled for evaluation. We will conduct surveys using contact information provided by SCE for all completed projects at the end of the pilot phase. Cadmus staff will perform the survey over the phone, but will use Qualtrics as a data gathering tool. Table 23 shows the relevant Research Questions for this survey.

Table 23. Research Questions – Contractor Survey

Key Research Topics	Areas of Investigation	Related Questions
Screening	Ensure we are conducting survey with the appropriate person	A2, I2
Firmographics	Contractor company background	J1, J2, J6, J7,
Participation	Previous SCE program participation	J5
Training	Trainings the contractor has received Contractor motivations for training	K1, K2, K3, K4
Program Experience	Contractor feedback on program processes, barriers to participation, and the QA/QC process	J3, J4, N1, N2, N3,O4, O5, O6, O7, O8, O9
Satisfaction	Satisfaction with the program and its processes	L1, L2, L3, O8
Attribution	What the contractor would have advised customers to have done in the absence of the program	N4, N5, N6, O1, O2, O3, O5, O6

Interviewer instructions are in green.
Qualtrics programming instructions are in red.
Answers in parenthesis should not be read.

SAMPLE Variables:

[COMPANY] = Name of contractor's company
[PARTICIPATING COMPANY1] = Name of participating company that contractor did work for
[PARTICIPATING COMPANY2] = Name of participating company that contractor did work for
[PARTICIPATING COMPANY3] = Name of participating company that contractor did work for
[FIRST NAME] = Contractor's first name
[LAST NAME] = Contractor's last name
[MEASURE CATEGORY1]
[MEASURE CATEGORY2]
[MEASURE CATEGORY3]

I. Introduction

A2. Hello, my name is [INTERVIEWER NAME] and I'm calling on behalf of Southern California Edison regarding the Advanced Lighting Control Systems Pilot Program. I'm with Cadmus, an independent research firm. May I speak with [Contactor Name]? [IF NOT AT THIS LOCATION, ASK FOR PHONE NUMBER AND NAME AT CORRECT LOCATION AND CALL RESPONDENT]

1. (Yes) [CONTINUE WITH RESPONDENT ON PHONE]
99. (REFUSED) [THANK AND TERMINATE]

Back-up information, not to be programmed:

[If "No – Not available," ask if Respondent would like to arrange a more convenient time for us to call them back or if you can leave a message for that person.]

[IF RESPONDENT ASKS HOW LONG, SAY: "APPROXIMATELY 30 MINUTES."]

[IF NEEDED:] This survey is for research purposes only and this is not a marketing call. Your participation in this study is important so that Southern California Edison can improve the energy efficiency programs it offers to businesses and other organizations. We also appreciate your time and will provide a $100 Visa prepaid gift card in appreciation of your time.

[**Only if asked** for a SCE contact to verify the survey authenticity, offer Dario Moreno with SCE, Manager of the ALCS Pilot Program, 626.302.0306.]

Screeners

Southern California Edison (SCE) is conducting a study to understand the experience of contractors who participated in the Advanced Lighting Control Systems Pilot Program in order to identify any areas in which the program could be improved. Your responses will be kept confidential. We are offering a $100 visa prepaid card in appreciation of your time for helping us with this study.

I2. Our records show that you installed lighting and controls at [PACTICIPATING COMPANY], [PACTICIPATING COMPANY], [PACTICIPATING COMPANY]. To ensure our records are correct, can you confirm that you installed these upgrades recently at that company? [IF YES, CONTINUE]

J. Firmographics and Participation

First off, I'd like to ask a couple questions about the company that you work for to get a better idea of the work that you do.

J1. What does your company specialize in? (Select all that apply)

1. Commissioning services
2. Electrical/lighting
3. Controls(Mechanical, electrical, lighting, energy management)
4. Energy assessments, diagnostics, or ratings
5. HVAC equipment
6. Other mechanical systems
7. Insulation/building envelope
8. New building construction
9. Refrigeration
10. Renewable energy
11. Renovations
12. Training/consulting
13. Other (Specify_____)

98. (Don't know)

J2. How many employees work at your company?
(Record response)

J3. How did you learn about the opportunity to participate in the SCE ALCS Lighting program? (Select all that apply)

1. (Contact with SCE representative through phone, email, or in person)
2. (SCE newsletter)
3. (SCE website)
4. (SCE sponsored workshop or event)
5. (SCE printed program materials)
6. (Contact with SCE representative / SCE authorized agents)
7. (Utility mailing, bill insert, or utility Website)
8. (Word of mouth (family, friend, or business colleague))
9. (I contacted my contractor/vendor to ask)
10. (My contractor/vendor let me know about them)
11. (Previously participated in an SCE program/received an incentive [SPECIFY: _____])
12. (Through a trade association or professional organization [SPECIFY: _____])
13. (Through a training course I attended [SPECIFY: _____])
14. (Other [SPECIFY: _____])

98. (Don't know)
99. (Refused)

J4. Why did you choose to recommend the SCE Advanced Lighting Control Systems Pilot Program to your customers? (Select all that apply)

1. Cost savings / incentive provided
2. Being able to receive the incentive on my customer's behalf
3. To work with SCE
4. Wanting to learn more about SCE programs
5. To gain a competitive advantage in the marketplace
6. To be help advertise my business
7. Other (Specify_____)

98. Don't know

J5. Has your company participated in other SCE energy efficiency programs? Mark all that apply

1. Yes (Customized)
2. Yes (Express)
3. Other (Specify_____)
4. No

98. (Don't know)

J6. Do you work with any lighting control system manufacturers?

1. (if yes) Which manufacturer?
2. No

J7. Do you work with any lighting control system designers?

1. (if yes) Which lighting control system designer?
2. No

K. Training

This next section will ask you about your experience and training as lighting and controls contractor.

K1. How many years of experience do you have working as a lighting and controls contractor? [Record Response]

K2. What are the trainings or certificates (if any) you have in lighting and controls? [SPECIFY: _____] [COMMON TRAININGS AND CERTIFICATIONS MAY BE THE FOLLOWING:

1. CALCTP (California Advanced Lighting Control Training Program)
2. Lighting and controls training from manufacturer (Specify manufacturer_____)
3. Journeyman or Master electrician training
4. CLEP (Certified Lighting Efficiency Professional)
5. ATTCP (Acceptance Test Technician Certification Provider Program)
6. LED Certification Program through Philips Lighting
7. LCI (Lighting Control Institute)
8. CLCATTs (Certified Lighting Controls Acceptance Testing Technician)]
9. Other[Record]
10. Other[Record]
11. Other[Record]

K3. [FOR EACH CERTIFICATION OR TRAINING] Why did you choose to pursue that training / certification? [SPECIFY: _____]

K4. [IF CALCTP MENTIONED IN K2] What were some of your reasons for choosing the CALCTP Training Program? [SPECIFY: _____]

K5. [IF CALCTP MENTIONED IN K2] How effective was the CALCTP training in preparing you for designing the project? Would you say the training was… [READ LIST]

1. Very effective
2. Somewhat effective
3. Not too effective
4. Not at all effective

98. Not applicable

K6. [IF CALCTP MENTIONED IN K2] How effective was the CALCTP training in preparing you for installation? Would you say the training was… [READ LIST]

1. Very effective
2. Somewhat effective

3. Not too effective
4. Not at all effective
98. Not applicable

K7. [IF CALCTP MENTIONED IN K2] How effective was the CALCTP training in preparing you for the post-installation QA/QC process? Would you say the training was… [READ LIST]

1. Very effective
2. Somewhat effective
3. Not too effective
4. Not at all effective
98. Not applicable

L. Satisfaction

L1. The next questions ask about your experience with the SCE Advanced Lighting Control Systems Pilot Program performance. Please answer each question with the response choices very satisfied, somewhat satisfied, not very satisfied, or not at all satisfied. Record verbatim.

A. Reaching out to you and keeping you informed about the program and offerings
B. The pre-installation process
C. The post-installation process with Richard Heath & Associates
D. Making the paperwork easy
E. The time it took for paperwork to be processed
F. Response time to questions or inquiries that you had
G. Providing the right amount of support so you can confidently sell and install energy efficiency equipment
H. The financial incentives provided
I. Your satisfaction with SCE's Advanced Lighting Control program overall

L2. We're also interested in your experience with code officials. Did your project have to get acceptance testing ? [Note: All required lighting controls and devices must be certified as properly installed & operational, prior to the issuance of occupancy permits. Acceptance testing is required by code officials.]

L3. [If L2 = yes] What did you think about the acceptance testing process? [SPECIFY: _____]

L4. When the project was completed did you receive acceptance testing documentation?

1. Yes
2. No
3. Not yet, but will be receiving
4. Other [Specify]
5. (Don't know)

M. Market Barriers and Financing

M1. Have you worked with any customers that did not pursue a project that may have been a candidate for the Advanced Lighting Controls Program?

1. (If yes) Did that company end up doing a project?
2. (If yes) Would that project have been applicable for the Advanced Lighting Controls program?
   (If yes) Do you know any of the reasons that the company did not pursue the project under the Advanced Lighting Controls Program?

N. Program Experience

Next I want to ask you about your experience with the SCE pilot.

N1. Did you fill out the rebate application or did the customer?
1. Contractor
2. Customer
3. (Don't know or don't recall)

N2. [IF N1=1] How frequently do you / did you run into challenges with the rebate application process?
1. Very frequently
2. Often
3. Not very often
4. Almost never

98. (Don't know)

N3. Based on your experience, are there aspects of the pilot program process that could be improved? If so, what? [Select all that apply]
1. Pre-application [SPECIFY]
2. [IF N1=1] Application
3. Pre-and post-installation inspection [process is cumbersome to schedule--what do about.
4. Too many requirements for eligible equipment
5. Difficult to get a hold of program staff when I had questions
6. Took too long for approval
7. The financial incentive provided
8. Other

98. (Don't know)

Next I'm going to ask you a few questions about your role on each of the projects that you have worked on through the SCE program.

[REPEAT 0 , 0, N6, O1, and O2 FOR EACH PROJECT ON RECORD – A MAXIMUM NUMBER OF THREE PROJECTS]

IF MULTIPLE PROJECTS: First we would like to discuss your role and decision making regarding [Project]. Please consider your responses in the context of the work you preformed with [Project].

N4. Can you please describe your role in the [PROJECT]?

1. How involved were you in determining the scope of work involved with this project?
2. At what point did you first become involved with the project?

N5. Did you design the plan for the new or upgraded lighting system for this [PROJECT]?

N6. Were there other firms or professionals involved in the [PROJECT]? [Probe: architect, engineer or other professional involved]

1. If yes, how involved were they? [If a significant role, ask for name, company, and any contact information that they may have.]

O. PAI 1

Skip O1 & O2 if customer survey PAI1 contractor influence score is lower than 5.

This next section will ask you to rate the importance of the SCE's Advanced Lighting Control Systems Pilot Program in influencing your decisions to recommend installing the advanced lighting control system with a graphical user interface at [PARTICIPATING COMPANY].

O1. Using a scale from 0 to 10, where 0 is "Not at all important" and 10 is "Very Important," how important was the ALCS Pilot program in influencing your decision to recommend that [PARTICIPATING COMPANY] install the advanced lighting control system with a graphical user interface?

O2. Now I would like you to think about the actions you would have taken with regard to recommending this equipment if the program and incentives had not been available. We will use a likelihood scale from 0 to 10, where 0 is "not at all likely" and 10 is "very likely." Please rate what the likelihood is that you would have recommended installing the following features if the Advanced Lighting and Control program had not been available.

1. Graphical user interface
2. Fixtures utilizing task tuning, where fixtures can be tuned to optimize the lighting in that space
3. Install a daylight harvesting system that dims lighting fixtures in response to natural light [Skip if daylight harvesting was not employed]
4. Occupancy or vacancy controls that turn off lighting in rooms that are not occupied
5. A lighting automation system that turns lighting on and off depending on the time of day and need for lighting
6. A control system allowing for automatic demand response that allows your utility to dim the lights in response to high demand for electricity
7. Incorporated the control system into the entire area of the building that was part of the final project

O3. In general, approximately what percentage of sales situations have you been recommending installing advanced lighting control systems **before you knew** about SCE's Advanced Lighting Controls Pilot program?

1. Record %

O4. To confirm, are you saying that [XX% from O3] of the time you recommend your customer install an advanced lighting control system that would incorporate all the features required SCE's advanced lighting controls pilot program?

1. Open ended response

O5. And after you have worked with SCE's Advanced Lighting Control Systems Pilot Program, what percentage of sales situations are you **now** recommending an advanced lighting control system.

1. Record %

O6. Using a scale from 0 to 10, where 0 is "Not at all important" and 10 is "Very Important," how important in your recommendation to potential customers was:

1. Information provided by SCE's website?
2. Training and seminars provided by SCE?
3. You company's past participation in a rebated program sponsored by SCE?
4. Training outside of the program (If yes, which ones)

O7. What is your preferred source for staying informed about SCE's programs? [Select all that apply] [DO NOT READ ANSWER OPTIONS]

1. SCE website
2. E-mails
3. Meetings
4. Newsletters
5. My SCE program or utility representative
6. My colleagues / contracting peers
7. Trainings
8. Personal calls from the program representatives
9. Other (Specify_____)
10. Nothing/I don't look for any information

98. (Don't know)

O8. What is/was the greatest benefit of promoting SCE's Advanced Lighting Control Systems Pilot Program? [ALLOW ONLY ONE RESPONSE]

1. The rebates for my customer
2. Increased business
3. Affiliation with SCE
4. Doing something good for the environment
5. Other (Specify_____)

98. (Don't know)

O9. We have just one final question. The hope with the ALCS program was to achieve deep energy savings that would not have been possible without a properly designed control system. In the projects you completed, how often was this an explicitly stated project goal of the clients?

1. RECORD ANSWER.

Thank you for taking the time to complete our survey. Again, we are offering a $100 Visa prepaid card in appreciation of your time today. If you would like this incentive, what is the best address to send it to?

Name:
Street:
City:
State:
Zip:

Appendix D: End User Survey

The purpose of the End User Survey is to learn about the experiences of individuals who occupy and use the offices in which program measures were installed. While building owners make the decision to participate in the pilot program, end users live or work with the lighting control systems. Cadmus staff members will issue an online survey the end users for each completed Sustainable Office Lighting Control Pilot Program project sampled for evaluation. During the Key Decision-Maker surveys, Cadmus staff will ask key decision-makers to provide contact information for staff/end-users who work in the buildings that received advanced lighting control systems. Cadmus will invite end users to participate in the survey via email with a link to an online survey. If the key decision-maker prefers not to distribute end user contact information, Cadmus will send the survey link to the key decision-maker for them to distribute to their staff. Table 24 shows the relevant Research Questions for this survey.

Table 24. Research Questions

Researchable Questions	Item
Have end users been trained to use the controls?	Section C
Do end users know how to use the controls?	Section C
Have end users altered the programmed scheduled or settings?	Section C
Have end users experienced any issues or concerns with the new system?	Section D
Have the new systems provided increased comfort, productivity, or safety to the end users?	Section D

Target Quota = [200 online completes]

P. Email Invitation

[UPDATED TEXT AS OF 4/26] ----------

Subject: Please tell us about your new lighting and win $100

Hi,

A lighting control system was recently completed in the building in which you work. The upgrade was part of a program offered by your utility, SCE. Cadmus, a research firm, has been hired by SCE to evaluate the program and we would like to know more about how the lighting upgrade has affected you.

Please take a moment to answer a few short questions about the lighting upgrades installed at your workplace. Your feedback will help SCE offer better programs and your responses will be confidential.

Click the link below to take this brief survey. If you take the survey by May 5th, enter your email address upon completion for a drawing for a $100 VISA gift card. The survey should take less than 5 minutes.

[TAKE THE SURVEY]

Thank you in advance for your thoughts and time. If you have questions about this survey, contact me or the survey administrator Emily at Emily.Miller@cadmusgroup.com.

Sincerely,

Dario Moreno
Program Manager,
Lighting Market Transformation & Lighting Innovation
Southern California Edison
Joseph.D.Moreno@sce.com

[ORIGINAL TEXT] ----------

Subject: Please tell us about your new lighting

Hi,

A lighting control system was recently completed in the building in which you work. The upgrade was part of a program offered by your utility, SCE. Cadmus, a research firm, has been hired by SCE to evaluate the program and we would like to know more about how the lighting upgrade has affected you.

Please take a moment to answer a few short questions about the lighting upgrades installed at your workplace. Your feedback will help SCE offer better programs and your responses will be confidential.

Click the link below to take this brief survey. The survey should take less than 5 minutes.

[TAKE THE SURVEY]

Thank you in advance for your thoughts and time. If you have questions about this survey, contact me or the survey administrator Emily at Emily.Miller@cadmusgroup.com.

Sincerely,

Dario Moreno
Program Manager,
Lighting Market Transformation & Lighting Innovation
Southern California Edison
Joseph.D.Moreno@sce.com

Q. Introduction and Screener

Thank you for taking a moment to fill out this survey. Your feedback will help SCE offer more programs like the Sustainable Office Lighting Control Pilot Program in the future.

Q1. Just to confirm, what is the address of the building in which you primarily work?

1. **SPECIFY: _____**

Q2. Our records show that your building received a significant upgrade to your lighting system recently. The upgrade probably involved new types of switches and sensors. Are you aware of these lighting upgrades?

1. Yes, I am aware of the lighting upgrades.
2. No, I am not aware of the lighting upgrades. **[TERMINATE]**

Q3. Do you work in the area where the new lighting upgrades were installed?

1. Yes, I work in the area with the new lighting upgrades.
2. I sometimes work in the area with the new lighting upgrades.
3. No, I do not work in the area with the new lighting upgrades. **[TERMINATE]**

Q4. When you are at work, where do you spend most of your time? **[Select one]**

1. At my desk
2. All around the building
3. In a conference room
4. Out of the office (in the field)
5. I work from home
6. Other **SPECIFY: _____**

Q5. What is your job title? **SPECIFY: _____**

R. User Experience

R1. Did you receive any training on how to use the new lighting system?

1. Yes
2. No **[SKIP TO R12]**
3. I taught myself with no training **[MAKE MUTUALLY EXCLUSIVE - SKIP TO R5]**

R2. Who taught you how to use the lighting controls systems? **[RANDOMIZE – MARK ALL THAT APPLY]**

1. **[MAKE MUTUALLY EXCLUSIVE - SKIP TO R5]**Installation contractor
2. Building manager
3. Building owner
4. A consultant
5. SCE staff [SPECIFY]
6. SCE account manager
7. SCE ALCS Pilot program manager
8. Other **[SPECIFY]**

R3. How effective was the lighting control system training that you received? (Carry forward choices in a matrix)

1. Very effective
2. Somewhat effective
3. Not too effective
4. Not at all effective
98. (Don't know)
99. (Refused)

R4. [IF R3 = 3 OR 4] How could the training be improved?

1. **SPECIFY: _____**

R5. How effectively are you able to operate the lighting control system?

1. Very effectively
2. Somewhat effectively
3. Not too effectively
4. Not at all effectively

R6. **[IF R5 = 3 or 4]** You said you were not able to effectively operate the lighting system controls. Why?

1. **SPECIFY: _____**

R7. Do you have administrator access to the lighting control system? This means you have the ability to modify lighting operation in the entire area where the lighting controls were installed.

1. Yes, I have administrator access
2. No, I do not have administrator access
3. (Don't know)

R8. Have you updated any of the control programming (schedule or settings) since the new controls were installed?

1. Yes
2. No

R9. **[IF R8 = 1]** How often are you updating the control programming (scheduling or settings)?

1. Only once
2. Once a month or less
3. Weekly
4. Daily
5. Don't know

R10. [IF R8 = 1] What settings are you changing? SPECIFY: _____

R11. [IF R8 = 1] Why are you changing the settings? SPECIFY: _____

R12. Have you experienced any issues or do you have any concerns with the new lighting control system?

1. Yes **SPECIFY: _____**
2. No

R13. Would you recommend this lighting control system to others?

1. Yes
2. No **SPECIFY: _____**

S. Satisfaction

S1. Please indicate your agreement with the following statements. The new lighting control system has… **[MATRIX WITH STRONGLY AGREE, SOMEWHAT AGREE, SOMEWHAT DISAGREE, AND STRONGLY DISAGREE, DON'T KNOW, NOT APPLICABLE]**

1. Made my workplace more comfortable
2. Made my workplace safer
3. Improved the aesthetics of my workplace
4. Improved the quality of my work/ my productivity
5. Saved the company money/reduced utility bills

S2. How satisfied are you overall with the new lighting control system?

1. Very satisfied
2. Somewhat satisfied
3. Not very satisfied
4. Not at all satisfied

[IF S2 = 3,4]

S3. Why are you less than satisfied?
[OPEN RESPONSE] _____

S4. Do you have any final comments about your new lighting control system? [TEXT, NO FORCED RESPONSE]

This completes the survey. Your responses are very important to SCE. We appreciate your participation and thank you for your time.

Appendix E: Response to Public Comments

sItem #	Commenter	Page-# or Report-section in Report the Comment Pertains To	Comments	Comment Disposition
1	Michael Siminovitch, University of California, Davis Cori Jackson University of California, Davis	On pages 1 and 9	In the description of Group 3 ("CALCTP-certified contractors with any other specialized training") should be modified with a footnote stating: "CALCTP requires CALCTP-Certified Projects to be conducted by CALCTP-certified contractors using a CACLTP-certified project manager and CALCTP-certified installers.This study did not determine whether projects performed by CALCTP - certified contractors met these requirements or if the persons actually installing the ALCS had CALCTP training or certifications." In addition, the sentence: "However, given subsequent program budget cuts in 2015, the pilot completed only 31 projects, with more than one-half of the projects completed by CALCTP-trained contractors (Group 3) and only two projects completed by general electrical contractors (Group 1)." should be changed to: "However, given subsequent budget cuts to the program in 2015, the pilot completed only 31 projects with over 25% of these project completed by the same contractor, with more than one-half of the projects completed by CALCTP-trained contractors (Group 3) and only two projects completed by general electrical contractors without any defined training." and a description should be added of how many contractors participated in the study with a breakdown of how many projects were performed by each contractor.	We accept this change and have revised the report.
2	Michael Siminovitch, University of California, Davis Cori Jackson University of California, Davis	On page 10, Table 2	should be modified to provide the number of contractors within each group. In addition, the sentence: "General electrical contractors completed two projects, and manufacturer-trained contractors completed 12 projects. CALCTP contractors completed 17 projects, as shown in Table 2." should be changed to identify the number of contractors involved, e.g.,: "Two (?) General electrical contractors completed two projects, and twelve (?) manufacturer-trained contractors completed 12 projects. Eight (?) CALCTP	We accept this change and have revised the report.

			contractors completed 17 projects (but 8 of these projects were completed by the same contractor)., as shown in Table 2."	
3	Michael Siminovitch, University of California, Davis Cori Jackson University of California, Davis	Volume II	Finally, Appendix II should be amended to specify which projects were performed by the same contractor. Where project summaries identify the contractor as a CALCTP-contractor, Appendix II should specify whether the study determined if the installation was a CALCTP Project – e.g., met the requirements to ensure at least half of the workers who actually installed the project were CALCTP-certified electricians. If it did not, each summary should include the statement: "CALCTP requires CALCTP-Certified Projects to be conducted by CALCTP-certified contractors using a CACLTP-certified project manager and CALCTP-certified installers.This study did not determine whether projects performed by CALCTP - certified contractors met these requirements or if the persons actually installing the ALCS had CALCTP training or certifications."	We accept this change and have revised the report.