California's Advanced Lighting Controls Training Program: Building a Skilled Workforce in the Energy Efficiency Market

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ABSTRACT

Advanced lighting controls are more available and effective than ever, but lacking trained technicians to properly install and commission them, these systems often fail to realize their full energy-saving potential. This means building owners and utilities see disappointing returns on their investments, and occupants are left with underperforming lighting systems. In response to these challenges, stakeholders across California worked together to create the California Advanced Lighting Controls Training Program (CALCTP), a statewide initiative that generates green technology jobs while improving the energy efficiency of commercial buildings.

CALCTP trains and certifies electricians in the proper installation and commissioning of advanced lighting control systems. At the heart of CALCTP's innovative curriculum is an intensive, hands-on laboratory course that allows students to practice the technical skills required to successfully install, commission and verify operation of a wide variety of advanced components, such as photosensors, occupancy sensors, digital dimming networked and wireless control systems, programmable time clocks, and emergency lighting controls. CALCTP has successfully trained more than 1300 electricians, certified 51 contractors, provided its Systems Course to 63 mid-level managers, and instructed 253 senior-level managers in its Business Development Course. The program delivers a sought-after skill set to tradespeople and helps California realize its energy-savings targets.

This work will discuss the CALCTP program, its energy savings potential, the challenges in educating an established trade group in new technology, programs stemming from the initial CALCTP effort, and the immediate need for ongoing support to ensure this model program continues to succeed in the coming years.

Introduction

Education and training have the ability to transform markets. The impact of a technology can be proven, demonstrated and disseminated, but successful market transformation can only come after stakeholders are educated on that technology. By understanding its benefits, people will seek the technology out for their own use. A key stakeholder group, in any building technology success story, is the team responsible for its successful installation and operation. All too often, a technology that is ready for mass adoption fails to succeed due to improper installation. When this occurs, the technology itself is often blamed for the failure, as users only see that the device or system is dysfunctional, without understanding why. To combat this type of market barrier, workforce education is critical.

In the world of energy-efficient buildings, systems are becoming smarter, not just more efficacious. As technology becomes more intelligent, so too must its installation team. In short, smart building systems require smart installers. Emerging, intelligent systems include those

responsible for ventilation, heating and cooling, water distribution, plug loads, and lighting. Lighting is especially sensitive to installation and commissioning procedures. Lighting, by its nature, is also highly visible, and occupants or end-users will quickly, easily perceive even subtle changes in the lighting environment. For this reason, automated controls need to function properly, and smart lighting systems need to adjust properly to occupants' needs, if they are to survive in the marketplace, let alone achieve widespread use.

Workforce education and training, which contribute to a technology's proper installation and performance success, can pave the road toward broad market acceptance. In 2007, stakeholders across California recognized the need for advanced lighting controls training. Well-trained electrical contractors who are able to successfully deploy the technology were identified as key for broad adoption and sustained use of advanced lighting control systems. The California Advanced Lighting Controls Training Program (CALCTP) was established in 2008 in cooperation with the California Energy Commission (CEC), the University of California, Davis, the California Lighting Technology Center (CLTC), the California Community College Chancellor's Office, Advanced Transportation Technology and Energy (ATTE) campuses, California Investor-Owned Utilities (IOUs[1]), Municipal-Owned Utilities (MOUs), the National Electrical Manufacturers Association (NEMA), ICF International, the International Brotherhood of Electrical Workers, and the National Electrical Contractors Association (CA LMCC/IBEW-NECA). The purpose of CALCTP is to increase the number of California state-certified general electricians with the knowledge, skills and abilities necessary to design, install, test, commission, and maintain advanced lighting control systems in commercial facilities.

The CALTCP was formed through industry collaboration. With an eye on the future, leaders at IBEW/NECA recognized the need for green technology training for its tradespeople and partnered with advocates to successfully develop and launch the CALCTP. Seed funding, provided by California IOUs, supported development of the initial course. IBEW contributed funds and provided facilities for beta testing of the newly developed curriculum, inviting electrical instructors and industry experts to attend the training and provide valuable feedback on the curriculum. Following this alpha testing, CLTC and partners revised the curriculum to address many issues identified during the testing, including unclear laboratory instructions and procedures. Additional trainers completed the revised course, and became certified to teach the CALCTP curriculum to students at Joint Apprentice Training Centers (JATC) and Community Colleges statewide. The program has been principally supported through a multimillion-dollar training grant from the U.S. Department of Labor. There are now 28 CALCTP training facilities across the state at 21 JACTs, 6 ATTE community college campuses, and 1 utility energy training center.

This sector strategy, a unique collaboration among utilities, contractors and academia, produced an innovative training program designed to address market barriers and knowledge gaps proliferated by improper installation of lighting control systems, barriers that continued to prevent the broad adoption of advanced lighting controls in the commercial buildings sector. Now entering its fifth year, the CALCTP is viewed as a model for middle skill workforce development and training. At the heart of this successful model, is an intensive, hands-on laboratory course that allows students to practice the technical skills required to successfully install, commission and verify operation of a wide variety of advanced components. These components include: photosensors, occupancy sensors, digital dimming networked and wireless

[1] California IOUs include Pacific Gas & Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric Company (SDG&E).

control systems, programmable time clocks, and emergency lighting controls. The program delivers a sought-after skill set to California tradespeople while making California's economy stronger and more sustainable.

Background

Commercial lighting accounts for 10% of all electricity use in the United States (DOE 2012). In California, the most recent studies indicate this amount is much higher: 35%, more than heating, cooling and ventilation combined (Itron 2006). Lighting controls are key not just for code compliance, but for meeting mandated energy and environmental savings goals. For example, the State of California passed the California Global Warming Solutions Act in 2006, prompting a series of policy actions by the California Energy Commission and California Public Utility Commission (CPUC) mandating stronger energy efficiency standards across all segments of California's economy. It called for increased investment by both the investor-owned utilities and MOUs in strategies to encourage and support energy efficiency programs.

At the federal level, lighting controls are also entering the building code, in some cases as required measures. For example, ASHRAE 90.1 – 2010 now requires all luminaires located in stairwells be controlled by an occupancy sensor, such that light levels are automatically reduced by at least 50% when the stairwell is vacant. Even a simple system, such as a fluorescent strip stairwell luminaire equipped with an integrated occupancy sensor, requires specific installation and commissioning to ensure it operates as intended.

When properly installed, lighting controls reduce commercial buildings' energy use for lighting 24–38%, according to data analysis conducted at Lawrence Berkeley National Laboratory (Williams 2011). Control strategies include personal tuning, institutional tuning, occupancy sensing, photocontrols, and dimming. Table 1 provides conservative estimates of savings by control type. Installation and use of lighting controls could save the U.S. more than 260 terawatt-hours (TWh) of electricity annually.[2] That's enough energy to power the entire world for more than 15 hours each year (DOE 2012).

Table 1. Energy Savings by Control Strategy

Control Strategy	Energy Savings
Personal Tuning	31%
Institutional Tuning	36%
Occupancy Sensing	24%
Daylighting or Photocontrol	28%
Combination of Measures	38%

Still, despite their potential to drastically reduce energy consumption, lighting controls have seen limited use in the commercial sector. A recent study indicated that just 30% of commercial luminaires are controlled by a device other than the standard manual switch (DOE 2012). That small percentage consists of recent commercial new construction. Existing

[2] 1 TWh = one billion kWh.

commercial buildings, which account for nearly 90% of all buildings in the U.S.[3], rarely employ lighting control systems to save energy. The technology exists, today, to transform these existing buildings into energy-efficiency success stories, but only if advanced lighting controls are installed and operated correctly.

The demand for advanced general electricians in California, certified in lighting controls, is driven by the state's unique mix of energy and environmental policy issues. Unfortunately, California has historically had a relative shortage of general electricians with the skills and certifications necessary to support commercial entities in adopting energy-saving advanced lighting controls. This shortage has resulted in installation and acceptance testing of advanced lighting controls by persons without the appropriate level of knowledge, training and experience. The CALCTP program was expressly designed to address this skills gap in California's workforce.

The Program

The California Advanced Lighting Controls Training Program provides contracting companies with skilled, knowledgeable staff who can effectively sell, bid and install lighting controls projects. These objectives are achieved through two separate programs: a business development program for contractor executives, and a technical installation program for electricians. The combination of programs provides education on advanced lighting controls for all levels of the contracting company.

CALCTP-Certified Contractors

A CALCTP-certified contractor is a state licensed C-10 electrical contractor with top management personnel who have successfully completed the CALCTP Business Development Training program. CALCTP contractors employ superintendents and supervisors who have successfully completed the CALCTP Technical Installation program and employ general electricians on staff who have successfully completed the CALCTP Technical Installation program. These requirements ensure the contracting team is proficient in advanced lighting controls. Criteria are based on a company's salaried staff and three-year average gross revenue. The criteria for determining company size are based on existing state and federal designations.

There are two requirements for contractors to become CALCTP certified:

- The contractor must have the criteria-based number of top management personnel who have successfully completed the CALCTP Business Development Course.
- The contractor must employ the criteria-based number of mid-level managers who have successfully completed the CALCTP Systems course (or CALCTP Technical Course).

CALCTP Technical Installation Program

The CALCTP technical installation program is a flexible, 50-hour technical training program that sequences skill building and laboratory instruction in modules that accommodate

[3] Defined as buildings constructed prior to 2000. "Buildings Energy Data Book: 3.2 Commercial Sector Characteristics."

day, evening and/or weekend facility availability. This scheduling flexibility permits CALCTP to serve unemployed, underemployed and incumbent general electricians during day, evening-only, or evening and weekend formats. CALCTP enrollment is available to state-certified general electricians who have completed a ten-hour web-based pre-requisites program that was created by lighting controls manufacturers and is available at: www.lightingcontrolsassociation.org. CALCTP training provides advanced technical training not available through existing JATC curriculum or Cal Labor Fed programs.

The technical installation program is taught by qualified, CALCTP instructors. Instructors must be California state-certified general electricians, who have completed the online prerequisite coursework, completed the 50-hour Train-the-Trainer course, and passed a final exam. Industry experts may also be certified by the CALCTP advisory board as master instructors on an as-needed basis. Currently, there are 85 CALCTP-certified instructors. These certified instructors are teaching the course in 28 CALCTP facilities across the state.

The CALCTP technical installation program currently consists of seven unique training modules. The technical program is designed as 10 hours of lecture and 40 hours of laboratory instruction focused on advanced lighting control systems. In addition to the core CALCTP curriculum, students must complete 10-12 hours of prerequisite, online training through the Lighting Controls Association (LCA) before attending the CALCTP course. Each training module includes a lecture session and a laboratory session. The laboratory training is an innovative method necessary for real understanding than can be transferred to the field. In total, the laboratory session consists of 36 individual lab exercises. A description of each training module is provided in Table 2.

Table 2. CALCTP Modules

Module	Topic	Focus
1	Lamps and Ballasts	Lamps, ballasts, lamp holders, and wiring
2	Line Voltage Controls	Manual switches, timers and emergency lighting control devices
3	Low Voltage Controls	Low-voltage relays and devices
4	Dimming Controls	Dimming systems, components and installation
5	Occupancy Controls	Occupancy sensors, types, use, and installation
6	Photosensors	Optimization of daylight harvesting using photosensors
7	Other Control Systems	Remote control circuit breakers, wireless lighting controls, PLC, centralized and distributed control

Laboratory Instruction

Small class size and hands-on training are important aspects of effective instruction (Monks and Schmidt 2011). CALCTP teaching guidelines require each certified instructor teach no more than 10 participants in one class/lecture portion of the training module. For the laboratory portion of instruction, CALCTP requires one certified instructor per five trainees due to the complexity of the laboratory sequences. This ensures students receive immediate instruction and guidance on each controls exercise, with one-on-one interaction and discussion that reinforces concepts and proper installation procedures. CALCTP instructors must review and approve each laboratory exercise before a student may move on to new topics.

Electricians encounter a wide range of lighting controls and associated components in the field. To ensure CALCTP students are exposed to a significant range of potential controls scenarios, the course was purposely designed to include a wide range of products from multiple manufacturers. Each CALCTP laboratory exercise includes exercise objectives and procedures. Students are given controls and product installation instructions provided by the manufacturers. Following both the lab instructions and the manufacturers' instructions, the participants install the appropriate devices, complete the wiring, and have the wiring checked by an instructor before the system is energized. Students must demonstrate proper operation before moving on to the next lab.

Students are required to achieve a tested competency of 100% for each sequential laboratory module before they may proceed to the next of the seven modules. CALCTP maintains rigorous standards and currently has a 75% certification rate of trainees. The demanding CALCTP curriculum meets the needs of MOUs and lighting control manufacturers for competent design, installation, commissioning, troubleshooting, and maintenance of these systems.

Module 1: Lamps and Ballasts. Energy conservation measures (ECM) often couple source retrofits with new lighting controls. Understanding the light source is absolutely necessary for understanding the lighting controls it should be paired with. In this module, students learn about various types of fluorescent ballasts and their wiring requirements. This set of labs focuses on how to check for compatibility and properly install equipment to avoid the most common mistakes.

Module 2: Line Voltage Controls. While common, line voltage lighting controls are often installed improperly. This set of lab exercises is designed to ensure students understand proper installation of 3-way and 4-way switches, time switches and emergency lighting relays.

Module 3: Low Voltage Controls. Module 3 is focused on low-voltage switching systems. There are several advantages to using low-voltage switching systems; these include cost, flexibility and reduced shock hazards. Students gain experience with low-voltage relays, low-voltage components, and Class II wiring.

Module 4: Dimming. There are several controls choices for dimming ballasts. In each of these labs, the students wire and operate different fluorescent dimming systems to see firsthand the capabilities of each method. Common problems with dimming systems are flickering,

inconsistent dimming, and shortened ballast life. Module 4 provides experience in identifying and troubleshooting these issues.

Module 5: Occupancy Sensors. According to the U.S. EPA, energy savings resulting from the use of occupancy sensors can be as high as 90%. Savings are dependent on the application and unique space characteristics of the control zone. In order to use occupancy sensors to their full potential, the proper type of sensor must be selected, positioned, installed, and commissioned. The understanding gained in this lab allows the students to optimize performance and energy savings provided by occupancy sensor controls.

Module 6: Photosensors. Photosensors are often required by code, and they are a simple and effective way to save energy, provided they operate as designed. There are different types of photosensors for different applications and their location, orientation and commissioning is critical. In this set of labs, the participants learn to position, install and adjust the photosensors for optimal performance.

Module 7: Other Lighting Control Systems. This series of exercises is focused on wireless lighting controls. With nearly 90% of all U.S. building stock consisting of existing buildings, retrofit and renovation projects offer a huge opportunity for energy-efficient upgrades. In these applications, wirelessly controlled lighting systems are often the most economical alternative. This set of labs teaches the electricians how to install, commission, and verify their performance.

CALCTP Business Development Program

The CALCTP business development program is designed for managers, estimators and other administrative personnel who require knowledge and conceptual understanding of advanced lighting controls in order to effectively sell or bid lighting controls projects. The course is designed for top executives and meets one of the two requirements for CALCTP Contractor certification. Executives are required to enroll in and complete the 8-hour CALCTP Business Development Course.

Table 3. CALCTP Contractor Training Requirements

Contractor Category	Minimum Number of Executives Required to Complete Business Course
Micro Small Contractor (1-25)	1
Small Contractor (26-100)	2
Large Contractor (101 or more)	2 in HQ, plus 1 per division or region

This eight-hour course covers marketing, public relations, sales, project development, and financing for advanced lighting controls projects. By providing education to managers as well as electricians, companies can more effectively promote, manage and install advanced lighting controls projects.

Program Impact

The CALCTP program has achieved significant success in training California contractors for work in the energy services market sector. Training opportunities and benefits have allowed contractors to compete on quality terms, and not simply by cost-cutting measures. This results in an educated workforce that is well positioned for the future, more high-quality and energy-efficient projects, and a stronger overall construction economy.

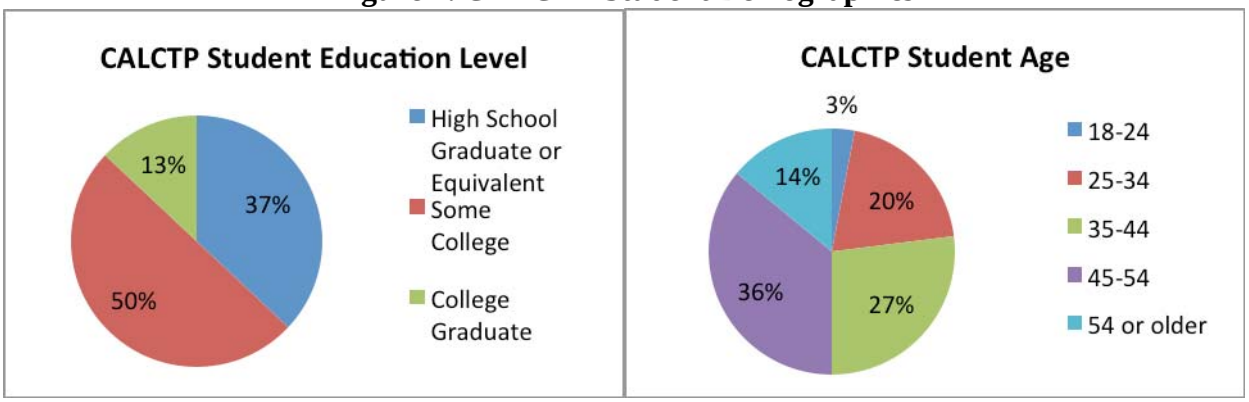
Information collected by participating California IOUs indicates CALCTP contractors and electricians report better understanding of advanced lighting controls concepts, and improved understanding of controls installation, commissioning and operation. The same reports also indicate that CALCTP contactors feel they can better estimate lighting controls project requirements and costs, which translates to reduced costs to the customer. In the past, unnecessary contingencies were often added to project pricing to account for the contractor's lack of knowledge with systems. In addition, contractors report they are now selling a greater number of advanced controls.

Owners report fewer problems, callbacks or improper installation on CALCTP projects. In addition, California utilities expect to see increased energy savings. Projects that previously would not have been captured in annual reporting are now emerging, as contractors begin to take advantage of special incentive programs designed for CALCTP-contracted projects. One contractor states, "CALCTP has taught me how to properly install advanced lighting controls… With this knowledge [we] are more confident bidding advanced lighting controls jobs."

Training Results

The CALTP has been training students since 2008. In the past three years, CALCTP has trained 1,464 electricians, with 1,250 earning certification; 185 electrical contractors have completed at least one certification requirement, and 48 have met both requirements and have been fully certified. CALCTP provides continuing education for the middle skill sector, a sector that requires workers have a high school diploma but not a college degree. Demographics show that a majority of students are male, have some college education, and are between the ages of 35 and 54. A more detailed breakdown of the demographic data on general electricians who have participated in and completed training is provided below.

Figure 1. CALCTP Student Demographics



Success Stories

The California Energy Commission, the California Public Utilities Commission and industry entities have all recognized this highly successful program as a key contributor to reaching statewide energy efficiency goals. Examples of success and broad program adoption are beginning to emerge. CALCTP projects have been promoted by utilities and building owners such as Southern California Edison (SCE), Sacramento Municipal Utility District (SMUD) and Brookfield Properties. Recent projects include office lighting and controls at sites in Long Beach and Los Angeles, CA.

CALCTP has also become a model for effective workforce development both in California and across the nation. CALCTP was included in a Compendium of Promising Practices for Job Placement and Retention prepared by the Technical Assistance Partnership for the ARRA HGEI grant program sector of the U.S. Department of Labor's Employment and Training Administration (ETA) in September of 2011. The collection of abstracts examined select programs across the nation that exhibit specific strategies deemed "immediately relevant" to workforce development, "as they address the many challenges of training and placing people in a difficult economic environment." CALCTP's contextualized, hands-on training was cited as one of four key strategies contributing to the program's success. The compendium abstract includes a CALCTP-trained electrician's statement summarizing the effectiveness of the program's teaching methodology: "The CALCTP program connected the dots for me. It would have taken me six years in the field to cover what I learned. This program is a must for all electricians."

SCE, an early advocate and program developer, recently submitted an incentive program plan to the CPUC. At the core of this program is an increased incentive for lighting controls retrofit, renovation or new construction projects that are installed by a CALCTP-certified contractor. At the time of this writing, the plan was under review by the CPUC. In addition, SMUD has launched a program that provides incentives for many of the advanced lighting controls included in the CALCTP.

Program Challenges

While highly successful, CALCTP has met numerous challenges. Fundamentally, the biggest challenge to the creation of CALCTP was development of the curriculum itself. Stakeholders needed a technically robust, vendor-neutral curriculum that provided the necessary skills required for advanced lighting controls projects. To meet these goals, stakeholders engaged technical experts from the University of California, Davis – California Lighting Technology Center and others to develop, maintain and expand the technical content of the program. CALCTP developers collaborated with a technology-neutral academic institution to ensure the curriculum would successfully address the most important and critical lighting controls concepts and provide a curriculum comprehensive enough to meet certification requirements set by the industry. Curriculum maintenance also continues to be a challenge since the lighting controls sector is characterized by rapidly changing product lines, technologies, device functionality, and system features.

Program organization was also a challenge. The broad collection of training centers required unique training solutions that could be applied to a diverse set of facilities and learning environments. While this diversity is viewed as a strength of the CALCTP, it was also a

challenge to meet the unique needs of multiple training sites. For example, community college programs required a curriculum structure that could easily be subdivided into multiple short sessions to accommodate a traditional higher education class structure. JATC facilities required a curriculum that could be taught continuously over the course of only a short time. To accommodate both needs, the program organization developed around discrete lecture and laboratory modules that could be combined or separated based on the needs of the facility. Efforts also continue to ensure each training facility maintains and teaches the same set of information, which is critical for maintaining the integrity of program certification and realizing the program's overall goals for training and energy savings.

Funding was, and continues to be, a critical issue for the development and continued success of the CALCTP. Because of the collaborative nature of the program, multiple entities required support, and multiple entities were engaged to provide seed funds. Development funding was initially provided by SCE. In 2009, following this initial seed funding, the CALCTP collaboration was awarded a multi-year grant by the U.S. Department of Labor (DOL), to continue training, provide updates to the existing course modules, and develop two new modules on emerging lighting controls concepts. DOL grant funds are set to expire this year. Administration and maintenance funding is needed for continued support of this valuable program.

Conclusion

In the relatively short time that the CALCTP has been training and certifying electricians and contractors in California, the program has proven to be a highly effective and successful means of strengthening the state's workforce while meeting the demand for competent contractors and electricians who are qualified to market, install and maintain advanced lighting controls. This type of cross-cutting, industry collaboration provides an excellent model for future energy efficiency training programs. The tiered training approach, which addresses technology specification, project sales and proper controls installation, is key to achieving significant energy savings. For a middle-skill audience, CALCTP's hands-on laboratory curriculum provides that vital link between conceptual understanding and practical deployment.

As successful installations of advanced lighting controls grow in number and mature through payback periods, demonstrating their capacity to save both money and energy, the CALCTP team expects the demand for skilled technicians will only increase. California's energy policy further supports the growing demand for energy efficiency upgrades in the commercial building sector and beyond. As the 2018 deadline set forth by California Assembly Bill 1109 grows nearer, more skilled electricians will need to be employed in retrofit projects if the state is to succeed in meeting its goals of reducing energy consumption for lighting (25% and 50% for commercial and residential buildings, respectively).[4]

CALCTP will allow California to take advantage of this new demand for a skilled workforce sector, encouraging job creation and potentially reducing unemployment. At the same time, increasing the number of skilled and certified lighting controls technicians and contractors in California will proliferate knowledge about advanced lighting controls in building sectors

[4] Success in meeting AB 1109 goals will also help California hit other legislated targets, including those set forth in AB 32 (aimed at reducing greenhouse gas emissions to 1990 levels by 2020), AB 758 (aimed at achieving energy savings in residential and commercial buildings), AB 2021, and SB 1250. CALCTP is also in alignment with Governor Brown's Clean Energy Job Plan and California's Energy Efficiency Strategic Plan.

throughout the state and across the country. This, in turn, could have a reciprocal effect on demand, increasing interest in retrofits as retrofitting becomes more widespread and commonplace.

The lighting industry is now experiencing unprecedented growth that makes CALCTP all the more relevant. Rapid advances in source technology, as well as controls and network systems, mean new, more energy-efficient lighting products are entering the market all the time. Electricians and contractors will continue to need training and education on these new technologies, both in order to keep current with the growing number of tools and products available for various projects, and in order to take advantage of product improvements that increase energy efficiency and reduce peak loads.

The potential of advanced lighting controls to improve California's environment for current and future generations is one too great to ignore, but the economic opportunity they present must also be appreciated. As previously stated, advanced lighting controls have the potential to reduce electricity use across the U.S. by more than 260 terawatt-hours (TWh) every year, but this savings can only be realized with a workforce that is trained and ready to identify the best technology for the job and install it properly. CALCTP is forging this vital link between potential and real energy savings, savings that could translate into over $32 billion that could be spent in other sectors of the U.S. economy every year.[5]

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[5] Based on a national average rate for electricity of $.125 cents per kWh.