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FINAL PROJECT REPORT

LIGHTING CALIFORNIA'S FUTURE: MARKET CONNECTIONS

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Prepared by: Architectural Energy Corporation, California Lighting Technology Center, and New Buildings Institute

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PREFACE

The PIER Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the Commission, annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings Energy Efficiency End Use
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Energy Systems Integration

Lighting California's Future: Market Connections is one of nine final reports for the technical research element of the PIER lighting research program "Lighting California's Future" (Contract Number 500-06-035), managed by Architectural Energy Corporation. New Buildings Institute and the California Lighting Technology Center carried out the market connections project, the purpose of which is to encourage and broaden market adoption of the lighting products developed in the LCF program to ensure that their energy savings potential is realized. This activity contributes to the PIER Buildings End-Use Energy Efficiency Research Program.

For more information on the PIER Program, please visit the Commission's Web Site at http://www.energy.ca.gov/research/index.html or contact the Energy Commission at (916) 327-1551

ABSTRACT

Lighting California's Future was a $3.7 million California Energy Commission Public Interest Energy Research program focused on lighting technologies for buildings. The market connections project carried out activities to encourage and broaden market adoption of Lighting California's Future products to ensure that their energy savings potential is realized. Significant market connection activities included establishing a brand and identity for the Lighting California's Future program; developing a program website; providing technical and market background and business case actions for development of project technologies; arranging feedback and direction to project teams via Program Advisors and program partners; preparing technical briefs on the Lighting California's Future products; participating in trade shows, conferences, and other presentations; and broadening the Energy Commission's relationships while creating demonstration opportunities for the products. Recommendations for future projects include:

- Leverage presence of project partners at trade shows to ensure multiple points of contact with event attendees.
- Ensure ample opportunity to communicate information about research projects in a forum otherwise geared toward commercially available products.
- Investigate use of social networking tools for market connections.
- Ensure web development and information technology is adequately incorporated and funded in projects.
- Provide for working relationships with marketing departments of industry partners.

Keywords: Energy efficiency, energy-efficient lighting, marketing, market research

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EXECUTIVE SUMMARY

Introduction

Lighting California's Future was a $3.7 million California Energy Commission Public Interest Energy Research Program focused on lighting technologies for buildings. The program, which began in May 2007, featured nine technical projects as well as this crosscutting market connections project. The New Buildings Institute and the California Lighting Technology Center carried out market connections activities.

Purpose

The market connections project goal was to encourage and broaden market adoption of products developed as part of the Lighting California's Future program to ensure that their energy savings potential is realized. Market connections activities began early in the program to bring together input and expertise from the multiple stakeholders required for successful technology development throughout the program. These industry relationships were nurtured and were pivotal to the individual projects. Some specific marketing tasks included establishing a brand and identity for the Lighting California's Future program; developing a program website; preparing technical briefs on the Lighting California's Future products; participating in trade shows, conferences, and other presentation opportunities; and creating demonstrations for the products.

Project Objectives

The following were specific project objectives:

- Work with manufacturers and/or product developers to enhance their product business case and market appeal to resolve key market barriers.
- Build alliances with key institutions to support market adoption and expand market opportunities.
- Build relationships with California utility efforts that are aimed at energy efficiency and demand response.
- Support the development of pilot efforts for at least six Lighting California's Future technologies to demonstrate reliability and energy savings.
- Review and establish applicable codes and standards processes for consideration by the research and development teams for each product developed under the Lighting California's Future Program.
- Develop market support strategies for the post-contract period.

Project Outcomes

Highlights of the market connections project were establishing a brand and identity for Lighting California's Future, including developing a website, which will remain in place (maintained by Architectural Energy Corporation) after the close of the project. The market connections team focused on promoting the Lighting California's Future program as a whole and prepared project-specific marketing materials as individual products neared commercialization. For some

products, the industry partners conducted their own marketing campaigns, and California Lighting Technology Center provided support as needed.

For several of the research efforts, products were either ready for commercialization late in the life of the program or were not ready for commercialization by the time the program ended. Therefore, the following products that made the most rapid progress toward commercialization received most marketing attention: the HALO® downlight, the smart light emitting diode fan light kit, and the wireless integrated photosensor and motion sensor. The team worked in partnership with Public Interest Energy Research Program demonstrations to offer information on Lighting California's Future technologies to energy managers, design professionals, and building occupants.

Conclusions

The technologies that reached viable or near-viable market status did so near the end of the project. Throughout the project, the market connections team focused primarily on promoting the Lighting California's Future program as a whole rather than on promoting individual products. Presentations, demonstrations, and media work all aimed at reducing the key market barrier, which was a lack of information among designers and the public about new energy-efficient lighting products. There were some limitations to the collaboration between the Lighting California's Future market connections team and industry partners that made it challenging for the team to ensure that publicity for the product conveyed the message that development of the new technology was supported by public funding.

Demonstration projects were important in this effort, and side-by-side installations of Lighting California's Future technologies and traditional technologies were especially effective, enabling viewers to correct misconceptions about efficient technologies. The perception that light emitting diode products cannot produce a warm color temperature similar to incandescent bulbs, being one example.

Another important addition to the team's marketing efforts was internet-based publicity. The investment in web infrastructure and programming for this project was minimal, and the website was completed in-house using team members' existing knowledge; this is a cost-effective alternative to expensive printed publicity. This use of electronic media was far more extensive than previous Public Interest Energy Research(PIER) projects and is expected to grow as an integral market connection element in future PIER funded lighting projects.

With regard to trade shows as a venue to promote research efforts, the value of attending a trade show can be maximized if there are multiple points of contact with attendees (for example, exhibit booth, speaker, and poster session), which aid in overcoming the difficulty of communicating information about research concepts and products that are not yet available to an audience that is expecting to learn about commercially-available products.

In general, California utilities are already well versed in the energy-efficient products and the types of technologies addressed in this program, so the team did not need to make significant effort in this area. As it is, the products developed by the Lighting California's Future research and development teams are those that fall under the performance criteria of the California Title 24 Code and were designed to meet the U.S. Dept. of Energy-Solid State Lighting specifications for ENERGY STAR® qualifications. Although the Lighting California's Future products did not

push codes, in some cases they were the first products to exceed previously established criteria. The Public Interest Energy Research program works to develop new technologies that provide viable compliance options with better efficacies than the current state of the art.

With regard to pilot efforts, the market connections program supported the technical tasks through publicizing the overall program and the energy-efficient lighting technologies associated with the specific tasks. The market connections successes can be connected to the dissemination of information associated with the product categories, for example light-emitting diode downlights, rather than specific products that emerged from the development efforts.

Recommendations

Recommendations for future projects include leveraging presence of project partners at trade shows to ensure multiple points of contact with event attendees and communicate information about research projects in a forum otherwise geared toward commercially-available products. Another recommendation is to target specific end user audiences by participating in events within trade associations and investigating the use of social networking tools for market connections. Another recommendation is to ensure web development and information technology support are adequately incorporated and funded in projects to provide for collaborative working relationships with marketing departments of industry partners. Finally, a central online file repository that allows multiple contributors should be developed.

Benefits to California

The benefits to California from the Lighting California's Future market connections activities are increased energy savings from expanded awareness and adoption of the new energy-efficient products developed through the program. These benefits extend beyond the lifetime of the products developed during the project as other manufacturers imitate Lighting California's Future products, further broadening the market of efficient technologies. Market connection activities also educate consumers about energy efficient products. The Public Interest Energy Research program aims to influence and support California's Title 24 residential and nonresidential energy-efficiency standards, which create future awareness in consumers to purchase more energy efficient products to save on electricity costs.

Successfully commercialized products in this program meet existing Title 24 standards and Collaborative for High Performance Schools criteria.

1.0 Introduction

Lighting California's Future (LCF) was a $3.7 million California Energy Commission's Public Interest Energy Research (PIER) Program focused on lighting technologies for buildings. The program, which began in May 2007, featured nine technical projects as well as the crosscutting market connections project that this report describes.

1.1. Background

An energy-efficient technology is only as effective at saving energy as the number of users and size of the market that it can command. Given the difficulty for one product or one company to change the direction of the marketplace, the PIER program aims to seed the marketplace with energy efficient technology solutions. Ideally, those solutions lead other companies to address the same energy efficiency needs with different solutions. The more companies offering products to address a similar need or problem results in a higher chance for that energy savings concept to be adopted by the consumer. The market connections project is designed both to build awareness of and markets for the specific technologies developed in the LCF program.

1.2. Project Objectives

The market connections project's specific objectives include the following:

- Work with manufacturers and/or product developers to enhance their product business case and market appeal to resolve key market barriers
- Build alliances with key institutions to support market adoption and expand market opportunities
- Build relationships with the California utility efforts that are aimed at energy efficiency and demand response
- Support the development of pilot efforts for at least six LCF technologies to demonstrate reliability and energy savings
- Review and establish applicable codes and standards processes for consideration by the research and development (R&D) teams for each product developed under the LCF Program
- Develop market support strategies for the post-contract period

1.3. Benefits to California

The benefits to California from the LCF market connections activities are increased energy savings from expanded awareness and adoption of the new energy-efficient products developed through the program. This extends beyond the lifetime of the products developed during the project as other manufacturers imitate LCF products, further broadening the market of efficient technologies. Market connection activities also educate consumers about energy efficient products. Market connections for products developed in the LCF project also support California's Title 24 residential and commercial buildings energy-efficiency standards as all products developed in the project aim to meet Title 24 requirements. The *Title 24 2008 Residential Lighting Guide* developed by California Lighting Technology Center (CLTC) staff serves as a

quick-reference tool to make the code more accessible to a wider audience which is available on the CLTC and LCF web sites. The 2005 version of this guide was a popular download in the California architecture and electrical contractor communities because it summarizes lighting code language in a quick and easy way. The LCF commercially successful products are capable of meeting current Title 24 standards.

1.4. Report Organization

The remainder of this report describes the Project Approach (Section 2.0), the Project Outcomes (Section 3.0), and Conclusions and Recommendations (Section 4.0). Appendices contain marketing documents and information developed through this project.

2.0 Project Approach

The market connections project approach comprised the following activities:

- Project management: Develop and maintain an LCF project management work plan, schedule, and monthly reports; and participating in project meetings
- Program-level technology transfer: Prepare a technology transfer plan and technical briefs on each of the LCF projects
- Partnership development: Develop strategic partnerships to support expansion of market opportunities for the LCF projects
- Pilot efforts and innovator markets: Work with California Emerging Technology (ET) programs and the University of California (UC)/California State University (CSU) Energy Efficiency Partnership
- Market adoption: Develop publications and publicity such as online resource hubs; design, application, and benefits guides; and media story ideas for the LCF projects
- Codes and standards processes: Early assessment of each project provides detailed comments and concerns for the research teams to consider regarding their technologies relationship to state codes and standards
- Production readiness plans and post-contract support strategies: Identify strategies to ensure commercialization of LCF technologies and to stimulate LCF program work beyond the project contract period.

3.0 Project Outcomes

The subsections below describe the outcomes for each of the project tasks.

3.1. Project Management

The market connections team prepared and maintained a work plan for the project, attended program advisory committee meetings, and developed monthly reports for the program activities. Team members were in contact with remote partners via frequent phone calls and e-mail.

As the results of each project became clear, the Project 11 team targeted the most viable projects for the majority of the market connections team effort. The team developed a matrix of potential projects as a guiding tool and addressed the most promising tasks first. Appendix A presents this matrix.

3.2. Technology Transfer

The market connections team developed a program-level technology transfer plan based on product-specific technology transfer plans developed for each LCF project. For each project, the team collected information on the product, its market, and key barriers and opportunities, to enable each project team to anticipate major opportunities and impediments to successful transfer of the technology into the market. These documents were used an internal tools for each project team.

3.3. Partnership Development

As part of this task, the market connections team formed partnerships with Solatube, Finelite, Adura Technologies, Cooper Lighting, Philips Day-Brite, NEV Electronics, Lighting Research Center and Hunter Fan to support expansion of market opportunities for the LCF products. In support of this activity, the team developed specification sheets and technology briefs for each of the viable products that emerged from the nine LCF projects, including specialized briefs for utilities.

The market connections team made numerous presentations to potential project partners, including the following utilities: the Sacramento Municipal Utility District (SMUD), Pacific Gas & Electric Company, and Southern California Edison in California, as well as Duke Energy (NC and region) and the New York State Energy Research and Development Authority. Also, a presentation was made at the E Source Forum, where utility representatives from across the US were in attendance. LCF projects were included in CLTC overview presentations given to visitors to the Center on a weekly basis. See Appendix B for a selected list of presentations.

In late 2008, SMUD installed the Cooper HALO light emitting diode (LED) downlight and the Hunter LED Fan prototype in the SMUD headquarters in Sacramento inside a small "demonstration" home as a part of their residential energy-efficiency home improvements. The market connections team found that, for some projects, such as demand-response technologies which are already familiar to utilities, utilities needed very little marketing support to evaluate the technology.

3.4. Pilot Efforts and Innovator Markets

The subsections below summarize the market connections team's work on pilot efforts and innovator markets.

3.4.1. Improved Daylight Performance of Tubular Daylighting Devices

The manufacturer chose not to commercialize the direct/indirect diffuser for the tubular daylighting device (TDD) designed as part of the LCF project, so the market connections team did not arrange demonstrations for this product. However, the market connections team recommended the inclusion of the Solatube 750 DS (Figure 1), the product that emerged from the Solatube/LCF partnership, in a display on daylighting technologies in the Chevron research office in the Qatar Science and Technology Park in Doha City, Qatar.

The 3D display illustrates how tubular daylighting devices function and what benefits are offered to occupants. This inclusion offered the opportunity to promote TDDs in a new market and the collaboration was made possible by connections made between the Solatube and CLTC marketing teams through the LCF project. Solatube's marketing department did not require support from LCF to launch the 750 DS.

Figure 1. Plans for the Solatube 750 DS tubular daylighting device 3D model and signage, Chevron research office, QSTP, Doha City, Qatar

Source: New Buildings Institute California Lighting Technology Center

3.4.2. Cost-effective Demand Response (CEDR)

The manufacturer decided to seek Underwriters Laboratory (UL) certification for the CEDR system, which significantly delayed the project schedule. The demonstration phase of the CEDR project did not take place during the contract time frame.

3.4.3. Integration of Lighting Controls with Utility Demand-Response Signals

Southern California Edison performed the majority of the work on this project, so there was no need for market connections contributions. In addition, this project did not produce a product that could be showcased.

3.4.4. Retrofit Integrated Classroom Lighting System (R-ICLS)

The Finelite High-Performance Recessed Troffer (Figure 2) entered the marketplace in part as a result of the collaborative work done on the R-ICLS project. The PIER sponsored State Partnership for Energy Efficient Demonstrations (SPEED) program is currently seeking demonstration sites for this recently-released product. The product website is http://www.finelite.com/products/serieshpr-2x4-overview.

Figure 2. The Finelite High-performance Recessed Troffer

Source: New Buildings Institute California Lighting Technology Center

3.4.5. Wireless Integrated Photosensor and Motion Sensor Lighting Control System (WIPAM)

The Adura LightPoint System (ALPS) is the proprietary name for the LCF WIPAM system. Adura Technologies, the commercial partner on this effort, partnered with the PIER Demonstrations program to test the system in several environments: at the CLTC facility in Davis, California; at a UC Santa Barbara (UCSB) parking garage; and, in the near future, at the University Communications Office, Mrak Hall, on the UC Davis campus.

CLTC Demonstration

The WIPAM demonstration at the CLTC (Figure 3) showcases the system in two corridors, one a retrofit application and one a new construction application. The lighting fixtures in the demonstration have dimming capability, allowing the system to remain at a lower light level when the corridors are unoccupied. This installation has demonstrated 60% energy savings compared to energy used by the same fluorescent light fixtures without lighting controls under normal work conditions.

Figure 3. Adura LightPoint System (ALPS) retrofit demonstration installation at CLTC

Source: New Buildings Institute California Lighting Technology Center

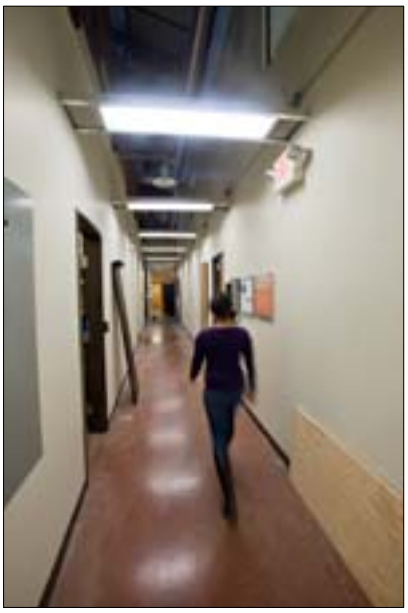


Figure 4. Occupant passing through the CLTC conference room/restroom corridor triggering an increase in light levels in the Adura LightPoint System (ALPS)

Source: New Buildings Institute California Lighting Technology Center

The installation serves as a 3D diagram showing the system components and the energy monitoring interface. Visitors enter the hallway (Figure 4), triggering an increase in light levels. The CLTC hosts an average of 20–30 visitors per week. During weeks with larger events or roundtables, this number increases to 50–60 visitors. Large meetings are held at CLTC approximately twice a month. The installation includes the corridor where the main restrooms are located. This increases the likelihood that CLTC visitors will notice the bi-level functionality. The component installation is located in a hallway that allows access to the classroom and large conference room. An explanation of the system is included on all tours of CLTC. Adura literature is offered next to the display for interested visitors to take. The WIPAM installation was installed just prior to the CLTC Open House held in January 2010. The event drew over 250 people, and Adura staff members were present to demonstrate the system and its features.

UCSB Garage Demonstration

The project team demonstrated the WIPAM system at the 2009 UC/CSU/California Community College Sustainability Conference at UCSB on the second level of a parking structure (Figure 5). The structure previously used 150 W (170 W system wattage) high-pressure sodium canopy luminaires. All luminaires operated 24 hours a day, 365 days a year. The goal of this retrofit project was to demonstrate cost-effective perimeter daylighting controls. Due to the existing circuit configurations at the site, a traditional, wired photosensor controlling all circuits serving the daylighting zone would extinguish too many interior garage luminaries, resulting in dark interior conditions with light levels below standards. To avoid costly rewiring and demonstrate a cost-effective solution that achieved project goals, the demonstration team replaced 10 perimeter high-pressure sodium luminaires with deck-mounted bi-level induction fixtures equipped with Adura wireless daylighting controls.

Figure 5. The WIPAM system in place at UCSB on the second level of a parking structure
Source: New Buildings Institute California Lighting Technology Center

The retrofit reduced energy demand by 900 W and produced annual energy savings of 12,790 kWh, or approximately 80%. This translates to annual energy savings of about $1,600 and a simple payback period of six years. Garage occupants had the opportunity to read about the new system when it was installed through a poster explaining the technology. Facility and energy managers from the UC/CSU/CCC systems were offered a tour of the structure during the 2009 Sustainability Conference held at UCSB on June 21 – June 24, 2009.

The UCSB parking structure demonstration is a collaboration between the California Lighting Technology Center, the State Partnership for Energy Efficient Demonstrations (SPEED) Program, Adura Technologies, the UC Santa Barbara, and EverLast Lighting. The demonstration was funded by the SPEED and cross-promoted through LCF market connections activities. A variety of demonstration materials and activities were developed and conducted with funding from both the LCF and SPEED contracts. These included online materials, the WIPAM tech brief, supporting graphics, and featuring this installation in the LightFair 2010 booth, posters, and presentations at the UCSB Sustainability Conference, subsequent presentations, and case studies.

Mrak Hall, UC Davis: Future Demonstration

At the Mrak Hall demonstration site, the WIPAM system will be installed in 17 private perimeter offices, corridors, and open-space work areas with cubicles.

To obtain the desired energy savings and meet cost goals for this project, CLTC staff devised a solution that integrates Adura's wireless mesh technology to control the overhead lighting with the LED-based Personal Lighting System (PLS) from Finelite to provide task lighting and occupancy sensing. Combining the two technologies offers energy efficiency, better controllability, and reduced system costs to stay within budget.

Figure 6. The University Communications located in UC Davis' Mrak Hall
Source: New Buildings Institute California Lighting Technology Center

Each of the private offices will be provided a task light with an attached occupancy sensor underneath the desk. An Adura sensor interface connected to this sensor will transmit occupancy status information to the two relay Adura Lighting Controllers (LC2R), to allow

bi-level control with the lighting in the overhead fixtures. This lighting control refinement is a cost-effective way to capture energy savings utilizing a single occupancy sensor in the room.

A daylight sensor in the space will dim appropriate fixtures when natural light conditions permit. Stand-alone occupancy sensors in the open office areas will turn on/off shared lighting areas. Wall switches are not included in the project. Instead, occupants will have battery-powered, handheld personal remotes to manually turn on/off relevant fixtures when desired. Industry studies show that personal control with handheld remotes increases occupant satisfaction and lowers energy consumption.

The Adura mesh wireless system will be supported by gateways providing access to the enterprise internet application that facility managers can use for energy management and system control.

The project team will collect feedback from occupants regarding whether the new system improves the work environment. This office houses the UC Davis Media and Communications team. If the project is well received, the team will conduct market connections activities such as installing signage, issuing press releases, or publishing online articles to share information about the project with the campus and the university system. These market connections activities will be conducted in connection with the SPEED program but will be an extension of LCF efforts.

3.4.6. Advanced LED Downlighting System

The Advanced LED Downlighting System prototypes were installed in both CLTC's 1554 Drew Avenue location and in the 633 Peña Drive facility in demonstration kitchen areas (Figure 7). The downlights were consistently popular with visitors for their sleek presentation, unique indirect LED cross-bar design, low can height, and centrally located power supply. An average of 20–30 guests visit the Center on a weekly basis. With the addition of the 2010 Open House guests, roundtable events, and tours, it is estimated that over 2000 CLTC guests will have seen the prototypes by the close of 2010. The prototypes are currently installed with three commercially-available products in an LED downlight comparison. Most guests comment on the unique form and the soft quality of the light due to the indirect configuration. A poster connecting the Advanced LED Downlight and the HALO to LCF is available in the demonstration kitchen. When manufacturers show interest in "adopting" the unit, a summary sheet is offered as a take-away.

Figure 7. Six Advanced LED downlight prototypes installed in the demonstration kitchen at CLTC's former location

Source: New Buildings Institute California Lighting Technology Center

At the 1554 Drew facility, the demonstration kitchen included a Kill-A-Watt monitoring device. The downlights, pendant, over-cabinet, and under-cabinet lighting were all switched separately. Visitors could see first-hand the low energy consumption of the units and the immediate effect of adding layers of lighting to the kitchen. This method of demonstration was very effective and recommended for future residential lighting displays.

Philips Capri, the project partner that was initially interested in bringing this product to market, did produce an LED downlight after evaluating the materials produced from the development phase of this product. Although the Philips Capri 6″ Retrofit Module (Figure 8) resembles the HALO and other downlights where the LED is oriented downward rather than using the indirect technique incorporated into this prototype, Capri indicates that the product was released in part due to the knowledge gained during the collaboration. Six Capri LED downlights are installed over the Outreach area at CLTC and are shown during tours. Six additional downlights will be installed in the side-by-side comparison in the demonstration kitchen in fall 2010 to complete the LCF set.

Figure 8. Philips Capri 6" LED remodel 18 and 19 watt
Source: New Buildings Institute California Lighting Technology Center

3.4.7. HALO (formerly Hybrid) Downlight

The HALO LED downlight (Figure 9), the commercialized product developed under the LCF project originally conceived as a hybrid CFL/LED downlight, has been included in several PIER Demonstration projects: the California State Parks Bidwell Mansion Visitors Center (BMVC), the California Department of Public Health in Richmond, the SMUD E-house, and at CLTC.

Figure 9. Cooper Lighting developed the 6" LED downlight based on input from the CLTC
Source: New Buildings Institute California Lighting Technology Center

For the Bidwell Mansion and Richmond locations, the market connections team produced signage indicating that the product was funded in part by LCF. The SPEED program was responsible for the majority of the costs associated with these two installations. Resulting case studies, web pages, and presentations are used to cross-promote both programs.

Bidwell Mansion Demonstration

The PIER Demonstration program partnered with the Bidwell Mansion State Historic Park, a California state park, to demonstrate the HALO LED downlight at BMVC (Figure 10), which

contains a gift shop, museum, and theater. In addition to hosting general park visitors, BMVC frequently hosts seminars and workshops for the general public, local agencies, and state park personnel. Approximately 35,000 people visit the park each year. The retrofit was divided into two phases: the first phase replaced 16 existing 10-inch recessed downlights in the BMVC foyer, lobby, and lobby restroom, and the second phase retrofitted 11 downlights in the information desk area and audio/visual room. All luminaires were replaced with the HALO LED product. The combination of Phase 1 and Phase 2 retrofits resulted in 49% energy savings and reduced maintenance costs due to the increase in lamp lifetime from 10,000 hours to 50,000 hours.

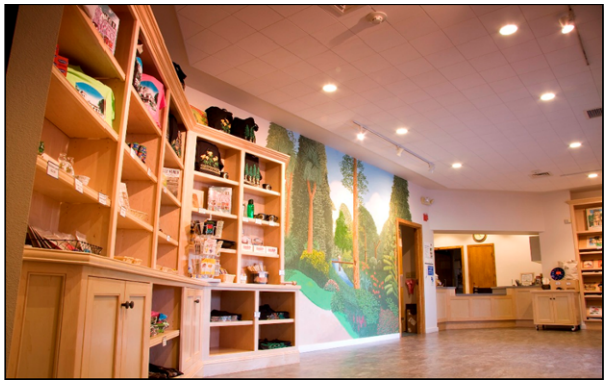


Figure 10. HALO LED downlights at the California State Parks' Bidwell Mansion Visitor Center
Source: New Buildings Institute California Lighting Technology Center

Richmond Department of Public Health

This SPEED-funded demonstration project replaced 12 existing 5" incandescent recessed downlights with the HALO product in a large conference room. Lighting renovations consisted of a one-to-one replacement of existing luminaires with LED luminaires. The LED downlights consumed 75% less energy than the existing luminaires. In addition, lamp lifetime increased from 1,000–50,000 hours, resulting in reduced maintenance costs. Average light levels were maintained, while energy consumption decreased. Signage describing the downlights is installed in the room.

CLTC Demonstrations

The Cooper HALO is installed in the CLTC side-by-side LED downlight comparison in the demonstration kitchen at the 633 Peña facility. In the former location, the HALO was installed in the staff kitchen.

3.4.8. Smart LED Lighting in Residential Fans

The LED ceiling fan prototype (Figure 11) is currently installed in a living room demonstration at the CLTC along with an LED chandelier, LED wall scone, Berkeley Lamp II, and a Seagull GU-24 wall scone. The light board is the CLTC proposed version, rather than the Hunter version. The fan is installed with a dimmer, which appeals to visitors who have switched to non-dimmable CFLs for ceiling fan light kits but prefer dimming capabilities. The ceiling fan is a popular display, and most visitors are disappointed to hear that it is not currently available for sale. Although it would be preferable to answer inquiries with a list of retailers that carry the fan, it serves as an excellent example of a niche that has yet to be filled. The California Energy

Commission Residential Title 24 database currently contains no LED ceiling fans that are certified to the Commission, further indicating that there is a need for this product.

Figure 11. The LED ceiling fan prototype light kit was measured with an efficacy of more than 40 lumens per Watt

Source: New Buildings Institute California Lighting Technology Center

The ceiling fan was installed for several months in 2009 at the 1554 Drew location in a side-by-side comparison with the same fan model with an incandescent light kit. Both units were connected to dimmers so that visitors could compare color and dimming performance between the two light sources. Most commented that they could see the spots of light from the LEDs, but were surprised at the warm quality of the light.

The LED ceiling fan is installed at the SMUD model E-house in the SMUD Sacramento headquarters. Hundreds of visitors from homeowners to business customers view the E-house. According to SMUD lighting specialist Connie Samla, "When I tour E-house with homeowners, they often like the product, didn't realize it was LED, and ask where they can find the product—(and they ask) is it commercially available yet?"

The LED exhaust fan prototype was also installed at the 1554 Drew location along with other prototypes of residential LED fixtures.

3.4.9. Advanced Energy-efficient LED Lighting for Residential & Commercial Applications

The Lighting Research Center (LRC) produced six prototypes for demonstration. However, due to the loss of manufacturer participation, a demonstration was not completed and market connection activities were minimal for this project.

3.5. Market Adoption

The market adoption task was the central focus of the market connections team's activities. For this task, the team developed a program website, signage, and publications, and represented LCF through participation in a number of trade shows and conferences. The team focused its marketing activities on the LCF program as a whole and on education about energy-efficient technologies. Due to time constraints, most of the LCF technologies neared commercialization toward the end of the program term, so the team could not undertake product-specific marketing activities until late in the project. WIPAM, the HALO LED downlight, the advanced

LED downlight, and the LED ceiling fan made the most progress toward commercialization and so were the focus of most of the product-specific marketing efforts.

3.5.1. Branding and Website

Among the team's first tasks was developing an identity and brand for the LCF project, due to the LCF project being large enough to have its own brand identity. The market connections team selected a color palette, typography, and a general style guide elements for consistency across project documents. The team developed the project website (Figure 12) and materials design concurrently with the intent of cross promoting. The team based the website on CLTC's site and created it to match the similar aesthetic. The LCF website is hosted through Architectural Energy Corporation and is cross-linked with the CLTC website to increase exposure. The website launched the project style. The style was also used on printed materials and product samples at LightFair 2008 where CLTC had a large 20x20 booth. The same style was used for signage that accompanied installations of LCF technologies in demonstration spaces and for other publicity. The team observed that there are significant opportunities and cost savings available from use of the internet for promotional activities.

Figure 12. The LCF logo redesign & styles and LCF project website homepage

Source: New Buildings Institute California Lighting Technology Center

3.5.2 Publications and Media

The market connections team produced signage and publications to promote awareness of the LCF technologies and pitched stories about LCF products to the media. Appendix C contains examples of signage, posters, and other marketing materials that the market connections team designed for the project. The team did issue press releases specific to this project, but included LCF technologies in CLTC press releases and media tours. The marketing departments of the manufacturing partners issued releases as needed when new projects were launched.

Signage

Signage at demonstration sites (see Section 3.5.3, Trade Shows, Conferences, and Demonstrations, for more detail on demonstration sites) educated site visitors about the LCF technology, its energy-saving potential, and the organizations that funded its research and demonstration.

Publications

In lieu of a standardized application guide format, the LCF market connections team evaluated potential publications on a case-by-case basis and used the concept of an application guide to shape the design of the document. Although the items produced take various forms, the underlying goal for all of the publications was to publicize energy efficient lighting best practices through the adoption of LCF related technologies. The team produced the following publications for the project:

Title 24 2008 Residential Lighting Guide. The Title 24 2008 *Residential Lighting Guide*, developed by CLTC staff, is a quick-reference tool to make the code accessible to a wide audience. Funded in part by Project 11, Market Connections, this guide is available on the CLTC and LCF web sites.

The 2005 version of this guide was a popular download in the California architecture and electrical contractor communities. A quick read, it supplements the lighting code language, which can be difficult to decode quickly. The intended audience includes contractors, lighting designers, architects, and energy auditors. WattStopper will fund printing of 7,000 copies of the new guide. The guide will also be available as a PDF online from various websites including CLTC, LCF, WattStopper, and possibly also through the utilities and California Energy Commission.

Figure 13. Title 24 Residential Lighting Design Guide
Source: New Buildings Institute California Lighting Technology Center

R-ICLS Guide (produced by Finelite). Industry partner Finelite created a Classroom Retrofit Guide designed to provide school districts with information to enable them to quickly determine the level and type of integrated classroom lighting-system retrofits that are appropriate for their classrooms and payback criteria. The guide includes information on installation costs, energy savings, and teacher preferences.

Technical Briefs. The market connections team prepared a technical brief for select LCF projects. Not all of the products described in technical briefs reached the marketplace by the time the contract ended, but some were close enough that the brief could show a viable "real world" product. Each brief presents a concise overview of the technology designed to attract interest from the emerging technologies teams at the major California utilities and can be used at trade shows, downloaded through the LCF web site, and printed for meetings or events. The technologies described in technical briefs include the following:

- Advanced LED Downlight
- HALO Downlight
- SPE downlight
- LED Fan & Exhaust Fan
- WIPAM

- Solatube 750DS

Advanced LED Downlight Adoption Sheet. For the advanced LED downlight, the market connections team prepared an "adoption sheet," which offered a more robust explanation than the technical brief for that technology. The adoption sheet was designed to secure a manufacturer for the product after Philips Day-Brite declined to pursue the project. The team used the adoption sheet at the CLTC when the product was shown to visitors and at events and sent it as a follow-up to interested parties. Appendix D consists of the technical briefs and adoption sheet.

HALO Rack Card. The CLTC collaborated with Cooper Lighting to produce a bi-fold rack card to be sent to multiple Cooper HALO distribution points throughout the state. The bi-fold presents a mini-case study of the HALO installation at the Bidwell Mansion Visitor Center and includes links to the full case study, the LCF website, and the CLTC website.

The team printed 10,000 copies of the rack card through UC Davis Repro Graphics. Bill Johnson of Cooper Lighting assisted in the distribution of the cards through three hub locations around the state, including CAL Lighting in San Ramon and Sacramento, and Cooper Lighting in Irvine. Product reps will then take the brochure packets with 50 rack cards per holder to retail locations that sell the HALO LED downlight. Once the market connections team receives confirmation that all of the cards have been distributed, team members will follow up on the card distribution by visiting nearby locations where the cards and brochure holders were placed.

The feedback on the rack cards that the team has received from Cooper has been positive, and Cooper plans to post both the rack card and the PIER case study on the Cooper site. Cooper HALO case study rack cards and sales literature are also available in the demonstration kitchen at CLTC.

Case Studies: Tools for PIER lighting technology cross-promotion. The team promoted the WIPAM and HALO through PIER case studies.

A PIER Demonstrations contract funded the creation of these documents, but they served the information distribution needs of both the Demonstrations and LCF contracts.

Figure 14. Images above show the Advanced LED Downlight Adoption Sheet, HALO Rack Card, and WIPAM Case Study, respectively

Source: New Buildings Institute California Lighting Technology Center

Case studies bridge the gap between laboratory and marketplace by informing commercial and residential end users of new energy-efficient lighting technologies. The CLTC website (Figure 15: http://cltc.ucdavis.edu), the PIER Partnership website (Figure 16: http://www.pierpartnershipdemonstrations.com/), and inquiries to CLTC staff serve as the primary modes of distribution for the case studies.

In addition to PIER-managed websites and the CLTC website, PIER Demonstration partners use case studies to share success stories with interested buyers who are looking for an objective opinion of new technologies. PIER Demonstration partner manufacturers appreciate case studies as a valuable "third-party" perspective. Manufacturers that use the case studies on a regular basis include Cooper Lighting and Adura Technologies. The market connections team recommends that finalized case studies be sent to the marketing departments of PIER partners to encourage their use in the broader marketplace.

Hard copies of case studies are typically printed for conferences and trade shows and displayed with tabletop or booth materials. They are also available during events or tours at CLTC. Appendix E presents the case studies prepared for the LCF projects.

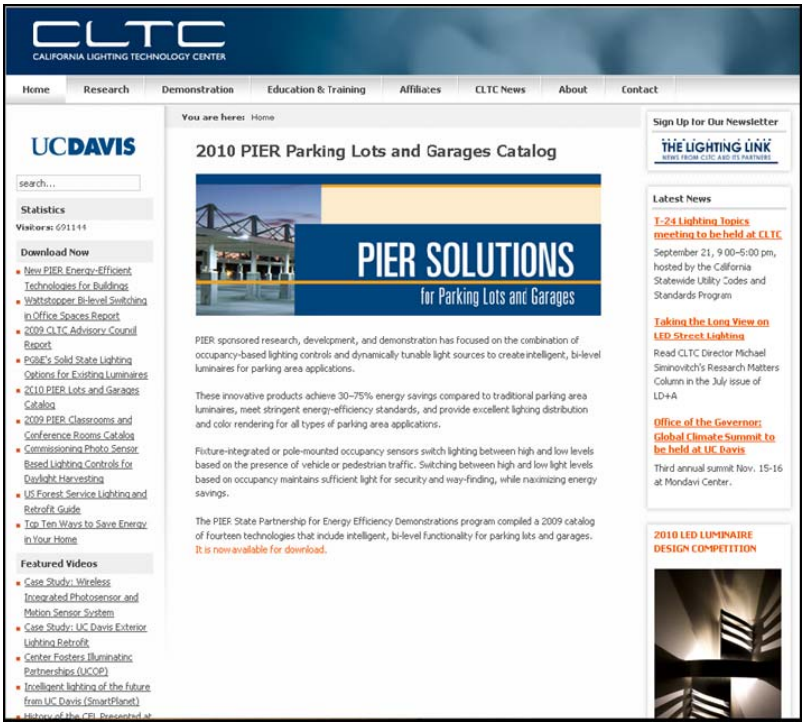


Figure 15. LCF Case Studies and the California Lighting Technology Center website index page

Source: New Buildings Institute California Lighting Technology Center

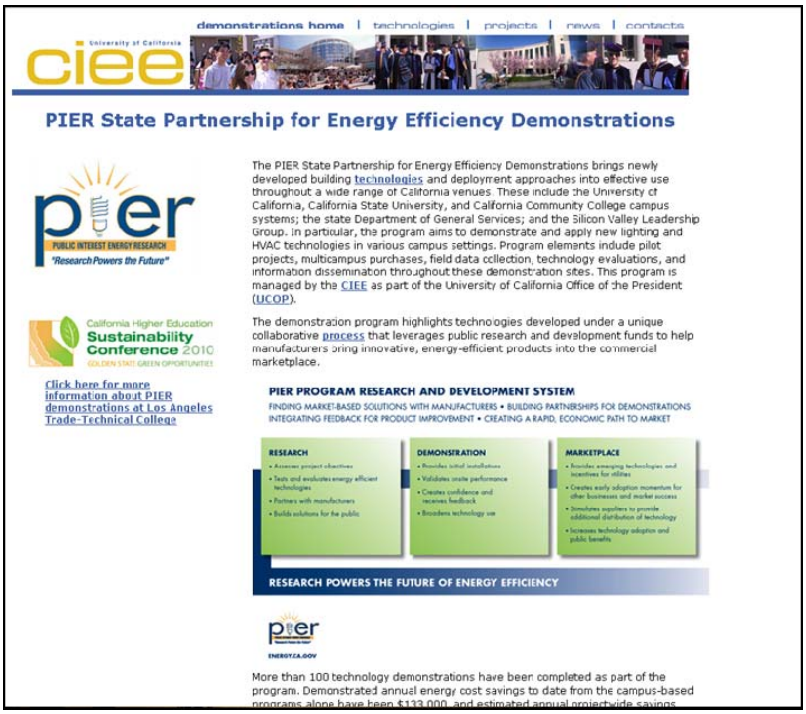


Figure 16. The PIER Partnership website index page

Source: New Buildings Institute California Lighting Technology Center

Advanced Lighting Guidelines: Premiere advanced lighting resource for the commercial lighting industry. Results from the LCF work were adopted into the Advanced Lighting Guidelines new ALG Online Edition (ALG) being released in November 2010. The ALG is widely used by lighting designers, specifiers, contractors and educators as a resource on best practices for energy efficient commercial lighting. Specifically, the ALG section on Radio Frequency style wireless controls integrates information and examples of the Adura LightPoint System and references the CEDR and PIER program. The ALG section on Advanced Lighting Controls demonstrates, explains and promotes applications of control technologies, such as WattStopper. This market accessible content will support the LCF targets to increase the market integration of the most current and highly effective technologies for lighting and daylighting controls.

The ALG is used by the California utilities in training events and as a resource available to their commercial sector architects, lighting designers and engineers.

3.5.2. Trade Shows, Conferences, and Demonstrations

The market connections team showcased LCF technologies at a number of trade shows, conferences, and other similar events, including LightFair 2008, West Coast Green 2008, the 2009 Governor's Climate Change Summit, and LightFair 2010. The team also took advantage of other opportunities to demonstrate LCF technologies with tabletop displays. These other events include UC Davis-related public outreach opportunities like Picnic Day and the Sacramento Area Regional Technology Alliance CleanStart award luncheon.

Larger trade shows and conferences offer the opportunity to showcase the LED downlights installed in a panel that simulates the way the lights would look at typical ceiling height. Booth visitors can turn the units off and on and test the dimming. This type of interaction makes for a memorable experience, especially when paired with printed take-away materials.

Figure 17. CLTC at LightFair 2010, representing LCF
Source: New Buildings Institute California Lighting Technology Center

At the smaller, tabletop events, product presentation often relies on a verbal explanation of its intended use and potential energy savings. For local events that require only incremental labor and travel funds to support, the tabletop presentations are effective ways to raise awareness

about UC Davis, CLTC, LCF, and other PIER-supported programs. However, it is challenging to deliver tabletop presentations that provide audiences with a clear understanding of how the multiple organizations fit together.

For a comprehensive list of the events attended, please see Appendix B.

One of the lessons the market connections team learned was that it is challenging to position research projects at trade shows where the focus is geared toward showcasing commercially available products while meeting the attendees' expectations. The team found this to be particularly true in the exhibit hall where the opportunity to catch an attendee's attention is very brief. Exhibiting at trade shows was more effective when LCF products were also addressed by a speaker and/or presentation (e.g., a poster session) rather than relying solely on a booth. Also, if the booth contained some commercially available products such as at LightFair 2010, the presentation to attendees was more successful.

On a daily basis, demonstration sites hosted visitors who were exposed to and can learned about the various LCF technologies on display (see Section 3.5.2, Media and Publications, regarding the use of signage). Several demonstration sites featured LCF products, including the following:

- The Bidwell Mansion State Historic Park, Chico CA, where the HALO downlight was installed in the lobby and gift shop area with an accompanying sign explaining the technology, the energy savings, and the funding organizations
- SMUD, where the smart LED fan is on display with signage similar to that installed at the Bidwell mansion
- Mrak Hall at UC Davis and a parking garage at UCSB, where the WIPAM system was or will be installed
- The California Department of Public Health, Richmond, which features the HALO downlight in a conference room
- The California Lighting Technology Center, where the advanced LED downlight, the HALO LED downlight, and the smart LED fan are on display, the WIPAM system is installed in two high-traffic corridors. (The LED exhaust fan was also installed in the workshop with several other prototypes at the previous CLTC facility.)

With the CLTC LED downlight installation, the market connections team observed that side-by-side displays of new and conventional technologies are especially effective at demonstration sites, as they give the public an opportunity to see how the technologies compare, and they correct misperceptions about efficient technologies, e.g., the perception that downlights can't create warm lighting like incandescents.

Utility Programs

Some utilities offer rebates for efficient and ENERGY STAR downlights. Pacific Gas and Electric Company (PG&E), for example, lists ENERGY STAR LED surface, pendant, and recessed downlights in its 2010 *Lighting Rebate Catalog*. This rebate applies to the HALO product, which was the first LED downlight to be ENERGY STAR certified.

3.6. Codes and Standards

The PIER-LCF project was established to develop new lighting products – products that would increase energy efficiency of luminaires, systems, and lighting applications. Of the nine LCF projects, there are three commercially-available products in the marketplace. They are the Cooper HALO LED downlight, the Adura LightPoint Wireless Control System (WIPAM), and the Finelite High Performance Recessed (HPR) troffer, which was produced through their R-ICLS project. How these products intersected California's Title 24 and other pertinent codes and standards is reviewed in this section.

3.6.1. Finelite R-ICLS Retrofit Classroom Lighting Systems, Commercialized the HPR (High Performance Recessed) 2x4 Luminaire

The R-ICLS project did demonstrate retrofit lighting solutions for classrooms to integrate luminaires and controls to provide high quality lighting with multi-level settings and teacher control. The goal was to provide schools with "good," "better" or "best" options to combine state-of-the-art technologies into cost-effective retrofit system solutions. Although Finelite is not currently marketing a "system" for retrofitting, they did develop a new high performance 2x4 recessed luminaire as a result of the LCF program. The HPR is now a family of recessed products. The following Codes and Standards to be of interest to this project:

- California High Performance Schools (CHPS) Best Practices Manual, Lighting and Daylighting
- Title 24 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings
- Leadership in Energy and Environmental Design (LEED) for Existing Buildings: Operations and Maintenance
- LEED for Schools for New Construction and Major Renovation

Table 1 provides the review comments the development team members were to consider during R&D and commercialization plans.

Table 1. Project 5 R-ICLS

Code and Standards	Applicable Sections	Review Comments
California Green Building Standards Code	807.1.1.1 Lighting.	Provide individual task lighting and/or daylighting controls for at least 90% of the building occupants.
	807.1.2 Multi-occupant spaces.	Provide lighting and thermal comfort system controls for all shared multi-occupant spaces, such as classrooms and conference rooms.
CHPS Best Practices Manual, Lighting and Daylighting	Guideline LG9: Classroom Lighting- Conventional Teaching	System examples shown appear consistent with CHPS recommendations.[1]

Code and Standards	Applicable Sections	Review Comments
	Guideline LG10: Multi-Scene Classroom Lighting	CHPS recommends use of direct/indirect pendant fixtures. System examples shown appear consistent with CHPS recommendations.[1]
	Guideline LG11: Teaching Board Lighting	CHPS notes that teaching board lighting must be included in W/SF calculations. System examples shown appear consistent with CHPS recommendations.[1]
	Guideline LG12: Lighting Controls for Classroom	CHPS recommends multiple control strategies for classroom lighting designs. System examples shown appear consistent with CHPS recommendations.[1]
Title 24 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings[2]	SECTION 119 – MANDATORY REQUIREMENTS FOR LIGHTING CONTROL DEVICES, BALLASTS, AND LUMINAIRES	See 119 (e) Multi-Level Occupant Sensor; (f) Automatic Daylighting Control Devices; (g) Interior Photosensors; (h) Multi-level Astronomical Time-switch Controls; (k) Dimmers as applicable.
	SECTION 130 – LIGHTING CONTROLS AND EQUIPMENT—GENERAL	See detailed requirements for nonresidential applications as applicable.
	SECTION 131 – INDOOR LIGHTING CONTROLS THAT SHALL BE INSTALLED	See 131 (b) Multi-Level Lighting Controls; (c) Daylit Areas; (d) Shutoff Controls as applicable.
LEED for Existing Buildings: Operations and Maintenance:	EQ Credit 2.2 Occupant Comfort – Occupant Controlled Lighting	Credit requires occupant control of 50% of ambient and task lighting.
LEED for Schools for New Construction and Major Renovation	EQ Credit 6.1: Lighting System Design and Controllability	EQ 6 sets requirements for both general illumination and A/V modes to earn credit. Example designs appear to meet requirements. In some examples average light level is above the 35–50 fc requirement.

Source: New Buildings Institute California Lighting Technology Center

The commercialized HPR fluorescent luminaire uses off-the-shelf fluorescent technologies and the systems that Finelite compiled were purposely meant to use easily available luminaire and control options. As a result the HPR was developed within existing commercial standards and guidelines. As a system, the prototypical combinations of luminaires and controls used in their research installations were and continue to be capable of meeting California's Title 24 and the additional applicable sections outlined in the Codes and Standards Assessment Report table.

3.6.2. Project 6 WIPAM Wireless Sensors, Commercialized as the Adura LightPoint Wireless Control System

Adura Technologies developed and commercialized an easy-to-install lighting control system that combines low power wireless communication, and eliminates the need to be wired into the switchbox or ceiling-mounted near the luminaire. This system offers a less expensive option for remodel/retrofit because the components communicate through radio frequency. The goal is to reduce the total installed cost and improve the reliability of commercial lighting controls by placing sensors in convenient and accessible locations. One goal set within Project 6 for the development of their own branded photosensors and motion sensors has yet to be completed; thus far the systems have used nationally branded sensors available in the marketplace.

The following Codes and Standards to be of interest to this project:

- California Green Building Standards Code
- CHPS Best Practices Manual, Lighting and Daylighting
- Title 24 2008 Building Energy Efficiency Standards for Residential and
- Nonresidential Buildings
- ZigBee Alliance
- National Electrical Code (NEC)
- Underwriter Laboratory (UL)
- Waste Electrical and Electronic Equipment Directive (WEEE)
- LEED for Existing Buildings: Operations and Maintenance:
- LEED for Schools for New Construction and Major Renovation

Table 2 provides the review comments the development team members were to consider during R&D and commercialization plans.

Table 2. Project 6 WIPAM

Code and Standards	Applicable Sections	Review Comments
California Green Building Standards Code	807.3 Daylight 3.	Calls for the use of photosensors to turn off electric lighting when daylight is sufficient.
CHPS Best Practices Manual,	Guideline LG10: Multi-scene Classroom Lighting Guideline	CHPS recommends multiple control strategies in various locations in educational facilities.

Code and Standards	Applicable Sections	Review Comments
Lighting and Daylighting	LG12: Lighting Controls for Classroom Guideline LG13: Gym Lighting Guideline LG14: Corridor Lighting	CHPS recommends daylit zones be separately circuited with multiple levels of illumination provided through dimming or multi-level switching. While Project 6 application is primarily envisioned for the retrofit market, project appears compatible with CHPS recommendations. [1]
Title 24 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings[2]	SECTION 119 – MANDATORY REQUIREMENTS FOR LIGHTING CONTROL DEVICES, BALLASTS, AND LUMINAIRES	Detailed requirements provided in Section119 for (c) Automatic Time Switch Control Devices; (d) Occupant Sensors, Motion Sensors, and Vacancy Sensors; (e) Multi-level Occupant Sensor; (f) Automatic Daylighting Control Devices; (g) Interior Photosensors; (h) Multi-level Astronomical Time-switch Controls;(j) Manual-On Occupant Sensor (Residential) (Vacancy Sensor); (k) Dimmers. Note: Code currently references 21 Code of Federal Regulations, Section 1002.12 (1996) and 47 Code of Federal Regulations, Parts 2 and 15 (1996) respectively.
	SECTION 130 – LIGHTING CONTROLS AND EQUIPMENT—GENERAL	Detailed requirements provided for nonresidential applications.
	SECTION 131 – INDOOR LIGHTING CONTROLS THAT SHALL BE INSTALLED	Detailed requirements provided for (a) Area Controls (b) Multi-level Lighting Controls; (c) Daylit Areas; (d) Shut-off Controls.
	SECTION 150 – MANDATORY FEATURES AND DEVICES (k) Residential Lighting.	While project primary focus is not residential, requirements listed in 150(k) 7. Switching Devices and Controls may be applicable.
ZigBee Alliance[8]	ZigBee Specification I Document 053474r17 ZigBee Smart Energy Profile Specification Document 075356r14	The ZigBee Alliance is an association of companies seeking to enable reliable, cost-effective, low-power, wirelessly networked, monitoring and control products based on an open global standard. Specifications may be helpful for the promotion of interoperability between products and/or systems.
National Electrical Code (NEC)	ANSI/NFPA 70	The NEC6 typically governs all electrical installations.

Code and Standards	Applicable Sections	Review Comments
Underwriter Laboratory (UL)	Underwriter Laboratory Lighting Industry Services9	Underwriters Laboratories tests and certifies Lighting products and accessories. UL can certify a product's Electro Magnetic Compatibility (EMC) and its energy efficiency to qualify for the ENERGY STAR® mark, including specialized photometric testing.
Restriction of Hazardous Substances (RoHS)	DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, Article 4	RoHS is a directive that restricts the use of 6 hazardous materials in electronics imported into the European Union after July 1, 2006. The restricted materials include lead (Pb), cadmium, mercury, hexavalent chromium, PBB (polybrominated biphenal) and PDBE (polybrominated diphenal ethers). While this directive does not directly apply to projects under the PIER program, it is noted here for general knowledge regarding the manufacture of electronic products.[4]
Waste Electrical and Electronic Equipment Directive (WEEE)	Directive 2002/95/EC	This is an EU Directive intended to cover electrical and electronic equipment. Although it does not apply to PIER projects directly, its goal is to promote the prevention of waste and the reuse, recycling and other forms of recovery to reduce the disposal of electronic equipment.
LEED for Existing Buildings: Operations and Maintenance	EQ Credit 2.2 Occupant Comfort-Occupant Controlled Lighting	Credit requires occupant control of 50% of ambient and task lighting.
	ID Credits 1.1–1.4: Innovation in Design	Project lead suggested credit may reward early adopters of technology. In addition, wireless technology is compatible with the intent of LEED to promote resource efficiency.
LEED for Schools for New Construction and Major Renovation	EQ Credit 6.1: Lighting System Design and Controllability	EQ 6 sets requirements for both general illumination and A/V modes for classrooms and task-ambient systems for administrative areas to earn credit. Potential Technologies and Strategies include integrating lighting controllability into overall lighting design.
	EQ Credit 8.1: Daylight & Views: Daylighting	Credit 8 awards credit for various percentages of daylit spaces. Potential Technologies and Strategies include automatic photocell-based

Code and Standards	Applicable Sections	Review Comments
		controls.

Source: New Buildings Institute California Lighting Technology Center

The Adura system is a component based system which communicates using the ZigBee wireless mesh network. Its ability to interface with all types of control hardware allows for many variations in the control scenario. The Codes and Standards table above shows various codes or programs that require lighting control of some type (performance based) while not dictating the specific technology that is used to produce the effects. These include Title 24, LEED, California's Green Building Code, and the CHPS program for schools. Adura is therefore implemented as an acceptable option to traditional wired control systems, pushing the availability and acceptability of lighting controls into the marketplace.

The Adura wireless control system meets California's Title 24 Code specifications and the additional applicable sections outlined in the Codes and Standards Assessment Report table.

3.6.3. Project 8 Novel LED Downlight, Commercialized as HALO LED Downlight

The HALO LED downlight met all the desired criteria set forth in the Project 8 plan, to develop and commercialize a downlight (using LEDs) that is a cost-effective system, has a high overall lumen output while providing continuous dimming control to low output levels. The following Codes and Standards to be of interest to this project:

- California Green Building Standards Code
- CHPS Best Practices Manual, Lighting and Daylighting 10
- ENERGY STAR SSL Solid State Lighting Luminaires Eligibility Criteria version 1.0, 9/12/07
- Title 24 2008 Building Energy Efficiency Standards for Residential and
- Nonresidential Buildings
- Waste Electrical and Electronic Equipment Directive (WEEE)
- LEED for Existing Buildings: Operations and Maintenance: LEED for Homes Rating System
- LEED for Schools for New Construction and Major Renovation

Table 3 provides the review comments the development team members were to consider during R&D and commercialization plans.

Table 3. Project 8 Recessed LED Downlight

Code and Standards	Applicable Sections	Review Comments
California Green Building Standards Code	SECTION 509 LIGHTING (Reserved)	Information may be available in the future regarding lighting requirements in Section 509.

Code and Standards	Applicable Sections	Review Comments
CHPS Best Practices Manual, Lighting and Daylighting	Guideline ES9: Exit and Emergency Lighting Maintenance	CHPS recommends use of LED exit signs.
	Guideline LG10: Multi-Scene Classroom Lighting	CHPS recommends use of direct/indirect pendant fixtures. LED direct and indirect systems may be compatible with recommendations.[1]
ENERGY STAR Solid-State Lighting (SSL) Luminaires Eligibility Criteria version 1.0, 9/12/07	General Requirements: All Luminaires, Modules/Arrays, Power Supplies, Packaging Requirements	General requirement targets apply to all SSL products.
	Category A: Recessed downlights	Targets set in 2007 will rachet every year in September for the next three years (2008, 2009, 2010). See also ENERGY STAR® Program Requirements for Solid State Lighting Luminaires Proposed Category "A" Additions, August XX, 2008 requirements for Ceiling-mounted luminaires with diffusers.
	Category B, includes: IESNA LM-79-08 Electrical and Photometric Measurement of Solid State Lighting Products IESNA-LM-80-XX: Draft IESNA Method for Measuring Depreciation of SSL LightSources ANSI NEMA_ANSLG C78.377-2008 -Specifications for the Chromaticity of Solid State Lighting Products	Defines key standards and test procedures which will apply uniformly to all SSL starting in 2011, if not before. Its intent is to promote substantially increasing future performance requirements. For complete list of referenced documents, existing and under development see Category B.
Title 24 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings2	SECTION 101 – DEFINITIONS AND RULES OF CONSTRUCTION	Includes definitions for LED lighting.
	SECTION 119 – MANDATORY REQUIREMENTS FOR LIGHTING CONTROL DEVICES, BALLASTS, AND LUMINAIRES	Note Title 24 2008 goes into effect in 2009. The current standard, Title 24 2005 does not regulate LED technology. Title 24

Code and Standards	Applicable Sections	Review Comments
	(m) High efficacy LED lighting systems	2008 includes standards on dimming 119 (k); minimum efficacy Table 150-C, and luminaire power Section 130(d).[5]
	SECTION 130 – LIGHTING CONTROLS AND EQUIPMENT—GENERAL	Title 24 2008 Section 130 (d) Luminaire Power references Joint Appendix 8 (JA8) testing method for SSLs. Currently these tests are not consistent with those referenced in *ENERGY STAR SSL Solid-State Lighting Luminaires Eligibility Criteria version 1.0, 9/12/07,* Category B. However, by the time Title 24 2008 goes into effect, these will be closely aligned.
	SECTION 150 – MANDATORY FEATURES AND DEVICES (k) Residential Lighting.	See Table 150-C.
Waste Electrical and Electronic Equipment Directive (WEEE)	Directive 2002/95/EC	This is an EU Directive intended to cover electrical and electronic equipment. Although it does not apply to PIER projects directly, its goal is to promote the prevention of waste and the reuse, recycling and other forms of recovery to reduce the disposal of electronic equipment.
LEED for Existing Buildings: Operations and Maintenance:	MR Credit 4: Sustainable Purchasing: Reduced Mercury in Lamps	Product mercury level assessed in picograms per lumen hours
LEED for Homes Rating System	EA Credit 8: Lighting	EA 8 requires a specified number of ENERGY STAR-labeled lighting fixtures (or ENERGY STAR-labeled CFL lamps) be installed to earn credit.
LEED for Schools for New Construction and Major Renovation	EQ Credit 6.1: Lighting System Design and Controllability	EQ 6 sets requirements for both general illumination and A/V modes for classrooms and task-ambient systems for

Code and Standards	Applicable Sections	Review Comments
		administrative areas to earn credit.

Source: New Buildings Institute California Lighting Technology Center

Footnotes for Tables 1-3:

1 Public review comments welcome. See http://www.chps.net/review/2009edition for more information on review comments procedural requirements.

2 For additional information on changes to title 24 see Rulemaking Proceeding - 2008 Building Energy Efficiency Standards see Appendix A and http://www.energy.ca.gov/title24/2008standards/rulemaking/

3 For additional information on tubular skylights and LEED® see Solatube LEED Application Guide.

4 Note that the Project Leads interviewed for this report reported differing opinions on the safety and advisability of using lead-based solder. The scope of this document is limited to identify, rather than resolving, the issue.

5 For more information see http://www.zigbee.org/en/

6 See http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=70 for information on the NEC revision cycle.

7 For additional information see http://www.ul.com/lighting/

8 For more information see http://www.zigbee.org/en/

9 For additional information see http://www.ul.com/lighting/

Cooper's HALO LED downlight was the first LED downlight on the market to meet the Department of Energy (DOE) SSL ENERGY STAR criteria for downlights. This is an important milestone for an LED downlight, demonstrating that the high lumen output and low wattage needed to be competitive with existing technologies could be provided while dealing with the required heat management for LEDs all in a small fixture package. As with the previous LCF technologies in this section, the Codes and Standards table above provides the list of items of concern to the R&D team, and their performance based limitations that the HALO LED downlight exceeds.

Since there were four LED luminaires included in the LCF program it was determined to retain an outside reviewer to look specifically at how the varied LED downlights and LED Fan Light Kit might affect California's Title 24 energy code. A summary of the review follows:

- LED downlights have applications in both residential and nonresidential applications
- No modifications were required of Title 24 to accommodate the new LCF technologies
- Low rise residential requires "high efficacy luminaires"
- Low rise residential requires recessed units be rated for insulated ceilings
- Nonresidential standards set maximum power consumption not technologies to meet it

- Testing procedures apply to LCF LED technologies as are written in Title 24 Joint Appendix 8

It was deduced that high efficacy downlights that use LED technology will help drive the market to develop additional LED luminaire options and reinforce the technology as a feasible energy efficiency choice. This is reinforced by the ENERGY STAR labeling. LED technologies have been increasing in availability for the residential and commercial lighting markets for 5-plus years but a lack of standards and common understanding of the new source left many specifiers, building owners and home owners with low output blue-light-emitting from an unacceptably early failing luminaire. The DOE-SSL initiative that began in 2006 has provided some guidance for manufacturers and stakeholders. The ENERGY STAR rating for LED downlights, that the HALO LED downlight acquired, is one of those beacons that provide reassurance and extend confidence in the marketplace.

3.6.4. Future Possibilities

In addition to the three commercialized products the market connections team feels that there are two additional products developed under the PIER-LCF program that remain viable if a manufacturing partner is found. The LCF team and potential market adopters were both in support of the commercialization of the CLTC developed LED Ceiling Fan Light Kit prototype and the Advanced LED Downlight prototype. The overall enthusiasm from specifiers and users at conferences and the CLTC display presentations indicates real promise for each product. Although these are both solid state technologies, the way they are treated within codes and standards may vary.

Project 7 Advanced LED Downlight, Indirect LEDs within a cross blade heat sink

The Advanced LED downlight falls under the existing DOE-SSL v1.1 standards for solid state downlights, and was developed to meet the quality and output requirements for an ENERGY STAR rating.

Just like the commercialized HALO LED downlight, this luminaire could meet all the performance based codes and programs (Title 24, LEED, etc.) provided in the Codes and Standards assessment report table.

One item to Note: In the last 12 months the DOE-SSL program has merged with the EPA and relinquished control of the ENERGY STAR program qualifications for solid state lighting. This said the LCF LED downlights were developed to meet the existing SSL Specifications v1.1 provided by the DOE. If the Advanced LED downlight was to be adopted by a manufacturer they would need to reevaluate the ENERGY STAR criteria in place at that moment.

Project 9 Smart LED Lighting in Ceiling Fan Light Kit (CLTC prototype)

The Technology Transfer Plan for this project identified that hundreds of thousands of fans are sold each year in the state of California alone and 90% of those have an incandescent light kit of 120 watts/1350 lumens. The objective of LCF Project 9 was to provide a viable LED solution (aesthetic, color, distribution, energy consumption, installation and cost) for the replacement of those light kits that matched the lumen output. The prototype developed by the CLTC team and displayed at CLTC and the SMUD headquarters has been well received by every audience and was measured to produce more than 40 lumens per Watt, which exceeds current code standards

for SSL products. However, Hunter Fan, the manufacturing partner for this project, does not plan to move forward with manufacturing the CLTC prototype, citing a high price point as one of the reasons. Hunter Fan, the LCF manufacturing partner has a lower lumen output/price point plan for their LED light kit prototype, but the cost structure of producing the 120w incandescent equivalent remains unknown.

The LED Fan Light Kit was included in the assessment of LED technologies by an outside reviewer to look specifically at how the kit might affect California's Title 24 energy code. It was determined that although it can meet the California Title 24 residential requirement of a "high efficiency luminaire" it is currently interchangeable with the incandescent and compact fluorescent kit options. It was thought that devising a method where by the LED light kit cannot be switched out for a less efficient higher wattage technology would help promote the technology application.

3.7. Production Readiness Strategies and Post-contract Support

Of the nine LCF projects, three produced technologies that neared or reached commercial potential early enough in the program for the market connections team to focus specifically on promoting their adoption: the HALO downlight, which is now widely available on the market (see the final report for Project 7, *Advanced LED Downlighting Systems*); the smart LED fan (see the final report for Project 9, *Smart LED Lighting in Residential Fans*); and WIPAM (see the final report for Project 6, *Wireless Integrated Photosensor and Motion Sensor*). Completion of the smart LED fan remains in the hands of the industry partner, Hunter Fan. At the time of this writing, there are no LED fans on the market that meet California Title 24 efficiency standards.

The CEDR project did not produce a viable technology by the end of the program term, although the industry partner is moving through the Underwriters Laboratory certification process and expects to produce a viable technology at the end of that process. Similarly, the project to improve daylight performance of tubular daylighting devices did not produce a viable technology; the industry partner chose not to demonstrate that proposed product outside its own facilities and appears unlikely to pursue the product commercially.

Production Readiness Plans were developed for four categories: LED recessed downlights, retrofit integrated classroom lighting systems, wireless lighting controls, and tubular daylighting devices. The reports have been used internally to provide support information to the LCF Program Manager.

4.0 Conclusions and Recommendations

The subsections below present the market connections team's conclusions and recommendations.

4.1.1. Conclusions

Overall, because of the timing of the project, the market connections team focused primarily on promoting the LCF program as a whole rather than on promoting individual products. Presentations, demonstrations, and media work all aimed at reducing the key market barrier of lack of information among designers and the public about new energy-efficient lighting products. There were some limitations to the collaboration between the LCF market connections team and industry partners. For some LCF products, the manufacturer chose to handle marketing using its in-house team; this proved particularly true once a project neared commercialization. As a result, it was challenging for the market connections team to ensure that publicity for the product conveyed the message that development of the new technology had been supported by public funding. In other cases, assistance with market research (which could, for example, have been obtained for minimal cost through the UC Davis School of Management) would have been helpful. In addition, because team members and project participants were not all at a single location, a robust online central file repository that allows multiple contributors would enhance communications for future projects.

The technologies that reached viable or near-viable market status did so near the end of project—too late for the team to be of much assistance in publicizing these products. As noted above, the team focused primarily on publicizing the program as a whole, promoting awareness and education about energy-efficient lighting among professionals and the public.

Demonstration projects were key to this effort. The market connections team observed that side-by-side installations of LCF technologies were especially effective, allowing consumers and designers to see how the new technology compared to familiar products. Side-by-side displays enabled the public to correct misconceptions about efficient technologies, e.g., the perception that LEDs cannot produce a warm color temperature similar to incandescent bulbs.

Another key to the team's marketing efforts was internet-based publicity. The investment in web infrastructure and programming for this project was minimal, and the website was completed in house using team members' existing knowledge; the team concludes that this is a cost-effective alternative to expensive print publicity and that information technology support is important to consider in the plans and budgets of future efforts (see Recommendations below).

With regard to trade shows as a venue to promote research efforts, the team concluded that the value of attending a trade show can be maximized if there are multiple points of contact with attendees (e.g., exhibit booth, speaker, poster session), which aids in overcoming the difficulty of communicating information about research concepts and products that are not yet available to an audience that is expecting to learn about commercially-available products.

In general, the market connections team found that California utilities are already well versed in energy-efficient products and technologies, so very little effort was needed in this area.

With regard to pilot efforts, the market connections program supported the technical tasks through publicizing the overall program and the energy-efficient lighting technologies associated with the specific tasks. The market connections successes can be connected to the dissemination of information associated with the product categories, e.g. LED downlights, rather than specific products that emerged from the development work.

4.1.2. Recommendations

This section outlines the team's recommendations for future projects.

Future projects could benefit from a central online file system, as noted above in the Conclusions section.

At the time this project was established, the CLTC brand was not fully developed, and PIER has its own style manual and suggestions. With efforts such as LCF, there can be confusion between an "overall" brand (e.g., for PIER projects) and a specific project or "sub" brand (e.g., for LCF). Future branding campaigns should fully examine the need for a hierarchy within all brands being represented and consider how to differentiate individual projects from umbrella organizations in an effective manner. The team recommends that, despite these complexities, a brand be developed for future projects intended to reach a wide audience and especially those intended to appeal to residential products manufacturers or customers.

Marketing efforts can leverage presence at trade shows to ensure multiple points of contact with event attendees to communicate information about research projects in a forum otherwise geared toward products that are already commercially available. For example, a booth in the exhibit hall can be effectively complemented by a speaker and/or presentation (such as a poster session) at the event, so that there is opportunity to explain the research concepts to attendees.

The team recommends that internet-based methods of communicating information about efficiency research projects be explored, including the use of social networking tools. In addition, the team recommends that budgets include subcontractor funding for web development and information technology support, and that project websites be easy to update with only basic knowledge of html required.

Future projects could benefit by conducting market research and planning in advance to secure working relationships with marketing departments of industry partners. This would help tremendously to fulfill future market outreach objectives. For advance market research, programs could take advantage of opportunities to enlist graduate students in research activities.

The market connections team recommends that finalized case studies be sent to the marketing departments of PIER partners to encourage their use in the broader marketplace.

4.1.3. Benefits to California

The benefits to California from the LCF market connections activities are increased energy savings from expanded awareness and adoption of the new energy-efficient products developed through the program. This extends beyond the lifetime of the products developed during the project as other manufacturers imitate LCF products, further broadening the market of efficient technologies. Market connections activities also educate consumers about efficient products. Market connections for products developed in the LCF project also support California's Title 24

residential and commercial buildings energy-efficiency standards as all products developed in the project aim to meet Title 24 requirements.

Glossary

Acronym	Definition
AEC	Architectural Energy Corporation
ALG	Advanced Lighting Guidlines
ALPS	Adura LightPoint System
BMVC	Bidwell Mansion Visitor Center
CCC	California Community College
CEDR	Cost-Effective Demand Response
CHPS	California High Performance Schools
CLTC	California Lighting Technology Center
CSU	California State University
DOE	Department of Energy
ET	Emerging Technologies
FC	Foot Candles
HPR	High Performance Recessed
LCF	Lighting California's Future
LED	Light-Emitting Diode
LEED	Leadership in Energy and Environmental Design
LRC	Lighting Research Center
MC	Market Connections
NEC	National Electric Code
PG&E	Pacific Gas and Electric
PIER	Public Interest Energy Research
PLS	Personal Lighting System
R-ICLS	Retrofit Integrated Classroom Lighting System
SMUD	Sacramento Municipal Utility District
SPEED	State Partnership for Energy Efficient Demonstrations
SSL	Solid State Lighting
TDD	Tubular Daylighting Device
UC	University of California

UCSB	University of California, Santa Barbara
UL	Underwriters Laboratory
WEEE	Waste Electrical and Electronic Equipment Directive
WIPAM	Wireless Integrated Photosensor and Motion Sensor

Appendix A: Potential Marketing Projects Matrix

Project	Audience	Marketing Materials	Press	Events	CLTC Demos
LCF Overview		Final presentation on all the projects	California Energy Commission NBI	E-Source Forum 2010 (9/21) LightFair 2008	
Project 2: Solatube **Daylighting**	Residential homeowners, residential contractors, commercial architects & contractors, lighting designers and engineers, energy integrators	Final presentation Tech Brief	Solatube		
Project 3: CEDR **DR**	ESCOs, UnESCOs, facility managers, energy managers, energy integrators	Final presentation	SCE Universal		
Project 4: Integration of Electric Lighting Controls with Utility DR Signals **DR**	ESCOs, UnESCOs, facility managers, energy managers	Final presentation	SCE (Universal, Convia, Lutron)		
Project 5: R-ICLS **Classroom lighting, daylighting, user controls**	K–12 school systems, universities, education facility managers, architects, lighting designers and engineers	Final presentation	Classroom Retrofit Guide with Finelite, posted to AEC/CLTC websites Manufacturer driven		

Project	Audience	Marketing Materials	Press	Events	CLTC Demos
			CLTC Featured Story: R-ICLS "kit" language to be used for web story and newsletter		
Project 6: WIPAM **Controls**	ESCO and energy integrators, architects, lighting designers and engineers	Final presentation Tech Brief Video (need to continue promotion) PIER: UCSB Case Study, demonstration plaque at UCSB	Manufacturer driven CLTC Featured Story: WIPAM Video	LightFair 2010, as part of PIER	Corridor demonstration
Project 7: Advanced LED Downlight **Downlights**	Residential homeowners, residential contractors, commercial architects and contractors	Final presentation Tech Brief for indirect crossbar downlight	CLTC Featured Story: LCF downlights overview	LightFair 2008 West Coast Green 2008 Governors' Global Climate Change Summit 2009 Demo kit for Title 24 classes and other selected events CLTC Featured Story: LCF downlights overview	CLTC demo kitchen, shown on every tour; Philips Daybrite, Capri, Omega downlights in Outreach
Project 8: Novel LED Downlights	Residential homeowners, residential contractors,	Final presentation Tech Brief	CLTC Featured Story: LCF downlights	LightFair 2008 West Coast Green 2008	Demo kitchen

Project	Audience	Marketing Materials	Press	Events	CLTC Demos
Downlights	commercial architects and contractors		overview 9x4 rack card PIER: Bidwell Mansion case study, general case study, demonstration plaque at Bidwell (potential location at SMUD)	Governors' Global Climate Change Summit 2009 Demo kit for Title 24 classes and other selected events	
9 Project: LED Fan **Ceiling fan light kit**	Residential homeowners, residential contractors, commercial architects and contractors, electrical distributers/ showrooms, big box retailers	Final presentation Tech Brief (either split ceiling and exhaust fan into two separate briefs, or only have ceiling fan)	Potential CLTC featured story PIER: Potential location at SMUD	Demo kit for Title 24 classes and other selected events	Residential lighting demo area
Project 10: Advanced, Energy-efficient LED lighting for residential and commercial applications **Downlights**	Residential homeowners, residential contractors, commercial architects and contractors	Final presentation (LRC needs template)			

Appendix B: Presentations, Demonstrations, and Other Marketing Events

Trade Shows and Conferences Attended

Greenbuild, Chicago IL, Nov. 7–9, 2007

http://2007.greenbuildexpo.org/

LightFair International 2008, May 10–14

http://www.Lightfair.com/Lightfair/V40/index.cvn

West Coast Green 2008, San Jose, CA, September

http://westcoastgreen.com/

Emerging Technologies (ET) Summit, San Diego CA, Oct. 26–28, 2008

http://www.etccconference.com/

Utility Forum, Tahoe City CA, May 6–8, 2009

http://www.utilityexchange.org/archive09.html

Campus Retrofit Forum, University of California Davis, June 30, 2009 and University of California, Irvine, July 13, 2009

http://cltc.ucdavis.edu/content/view/577/

UC, CSU, CCC Sustainability Conference 2009, UC Santa Barbara, June 21–24

http://sustainability.ucsb.edu/conference/

California Energy Commission Climate Change Summit 2009, Sacramento CA, Sept. 8–10

http://www.climatechange.ca.gov/events/2009_symposium/index.html

Governor's Climate Change Summit, Los Angeles 2009, CA,
Sept. 30–Oct. 9

http://www.climatechange.ca.gov/events/2009_governors_summit/index.html

LightFair International 2010, May

http://www.Lightfair.com/Lightfair/V40/index.cvn

Demonstration Sites

Bidwell Mansion State Historic Park, Chico CA (HALO downlight)

http://cltc.ucdavis.edu/content/view/423/316/

California Department of Public Health, Richmond CA (HALO downlight)

http://cltc.ucdavis.edu/content/view/423/316/

California Lighting Technology Center, University of California, Davis (WIPAM, HALO downlight, Advanced LED downlight, LED fan)

http://cltc.ucdavis.edu/content/blogsection/13/157/

Sacramento Municipal Utility District (SMUD), Sacramento CA (LED fan, HALO Downlight)

http://www.energy.ca.gov/2010publications/CEC-500-2010-018/CEC-500-2010-018-CMD.PDF

University of California, Santa Barbara (WIPAM)

http://cltc.ucdavis.edu/content/view/722/383/

MRAK Hall, University of California, Davis (WIPAM)

http://cltc.ucdavis.edu/content/view/722/383/

Educational Events

PG&E Pacific Energy Center Title 24 Design classes, June 5 and Dec. 10, 2009

http://blog.resnet.us/resnet-news/pge-energy-training-center-residentialsmall-business-training-calendar/

Organizations Briefed

New York State Energy Research and Development Authority (NYSERDA), http://www.nyserda.org/

Consortium for Energy Efficiency (CEE), http://www.cee1.org/

Pacific Gas and Electric Company (PG&E), http://www.pge.com/

Duke Energy, http://www.duke-energy.com/residential.asp

E Source Forum, http://www.esource.com

Publications and Media Coverage

KCRA 3, Sacramento, did a Green Living spotlight on green lighting technologies featuring LCF research.

CBS interactive featured an interview with CLTC Research Director Michael Siminovitch in which LCF projects were shown as visuals

http://www.smartplanet.com/people/video/uc-davis-researches-intelligent-light-bulbs-/385995/

Adura Technologies, manufacturers of the WIPAM system, was as also covered by CBS interactive; this was one of the top watched videos in 2009

http://video.techrepublic.com.com/2422-19179_11-407696.html

Appendix C: Marketing Materials

HALO rack card

APPLICATION

More than 800 million recessed downlights are in operation in the United States, with about 83% still using incandescent lamps. Significant energy savings potential exists for long-life LED replacements, which last up to 25 times longer and use significantly less energy.

FEATURES AND BENEFITS

- The Cooper Lighting HALO® LED recessed downlight is the first ENERGY STAR-rated LED downlight and exceeds the high efficacy requirements set by California's Title 24 energy regulations.
- Lasts more than 40 years in residential applications, up to 25 years in commercial applications.
- High color rendering and warm white color temperature: 80 CRI at 3045 K.
- Dimmable to 15% of total light output with standard AC incandescent dimmers, and 5% with low-end trim adjustment.

BIDWELL MANSION VISITOR CENTER CHICO, CALIFORNIA

HALO® LED recessed downlights were demonstrated at the Bidwell Mansion Visitor Center, which hosts approximately 35,000 people annually.

The demonstration was completed in two phases. In the first phase, 14 existing 10-inch CFL recessed downlights and a 3-foot T12 strip light located in the foyer were replaced with 16 HALO® LED recessed downlights. Then, 11 additional downlights located in the audio/visual room and above the information desk were replaced. The combined retrofits resulted in 51% energy savings, which translates to 770 kWh of energy saved annually. The energy savings represent an annual greenhouse gas emissions reduction of 560 pounds. The increased lamp lifetime from 10,000 hours to 50,000 hours reduced maintenance costs.

www.haloltg.com

DEMONSTRATED SAVINGS

Bidwell Mansion Visitor Center

	PREVIOUS		RETROFIT	
LUMINAIRE TYPE	10" fluorescent downlight	3' T12 strip	HALO® LED downlight	
QUANTITY	25	1	27	
WATTS PER LUMINAIRE	28	80	14.8	
TOTAL DELIVERED LUMENS	15,300	1,400	17,500	
ANNUAL ENERGY CONSUMPTION (KWH)*	1,417	162	810	51% SAVINGS
LIFETIME ENERGY COST*	$4,525	$525	$2,600	

*Analysis assumptions:
Cost of electricity ($/kWh) $0.128
Lifetime: 25 years
Hours of operation: 2,025

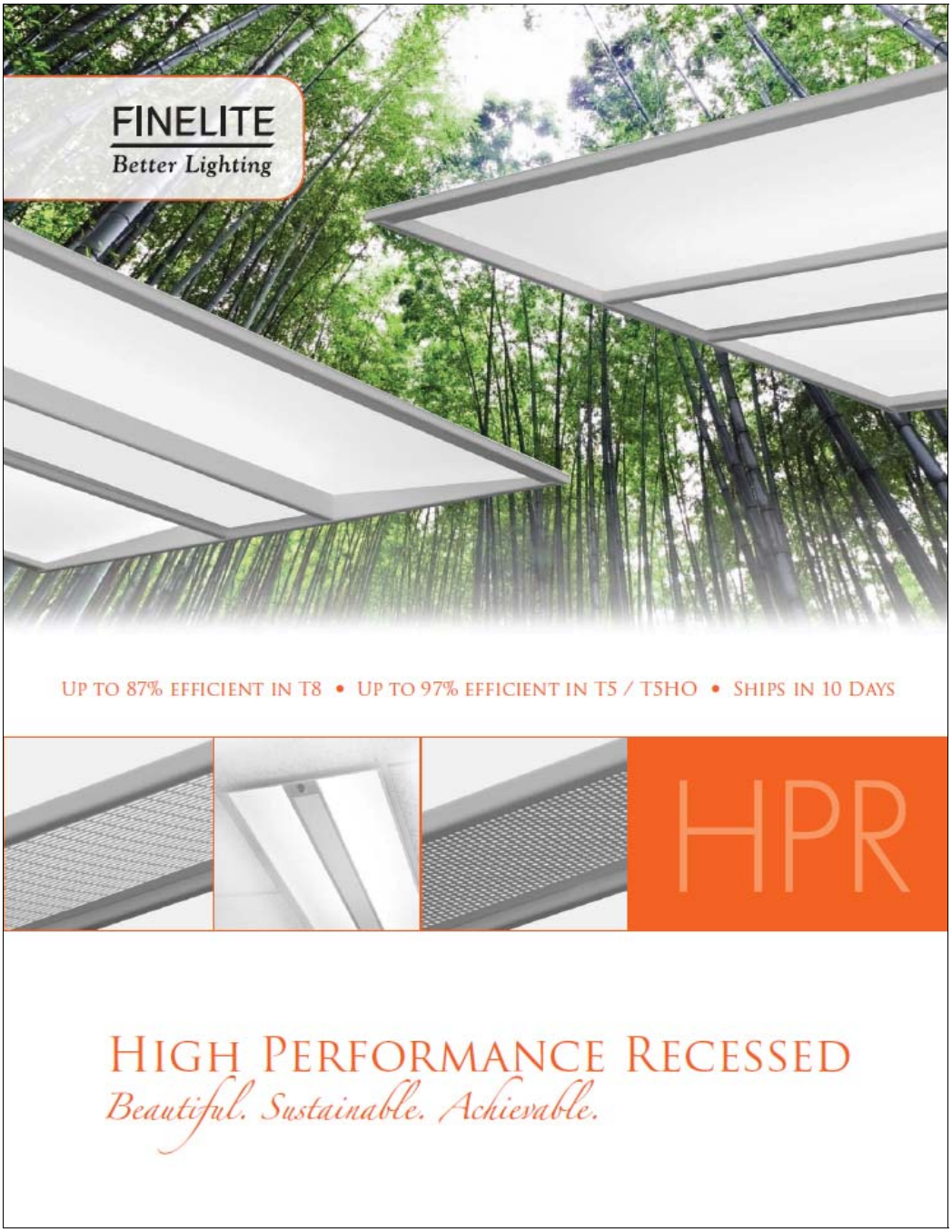
The complete case study is available at cltc.ucdavis.edu/content/view/423/316

WIPAM video

http://www.archenergy.com/lcf/integrated-projects/wipam.html

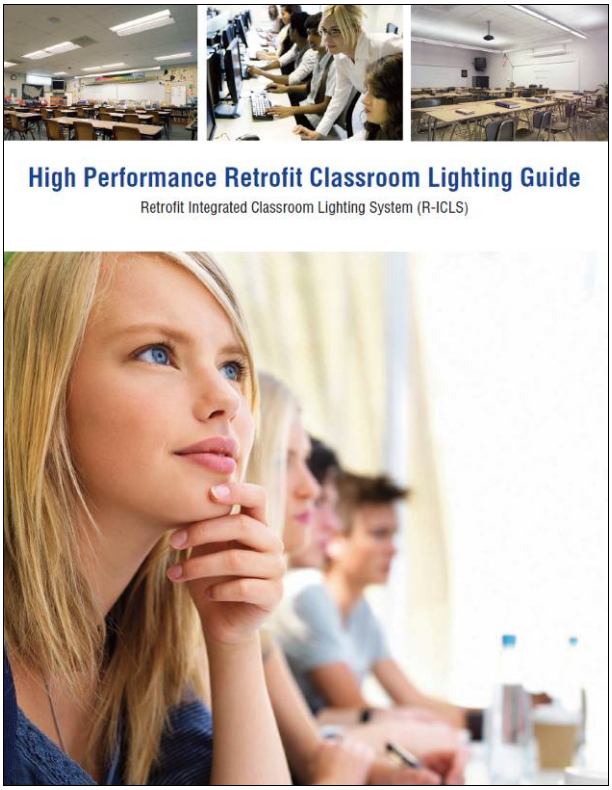
R-ICLS (Finelite) Brochure:

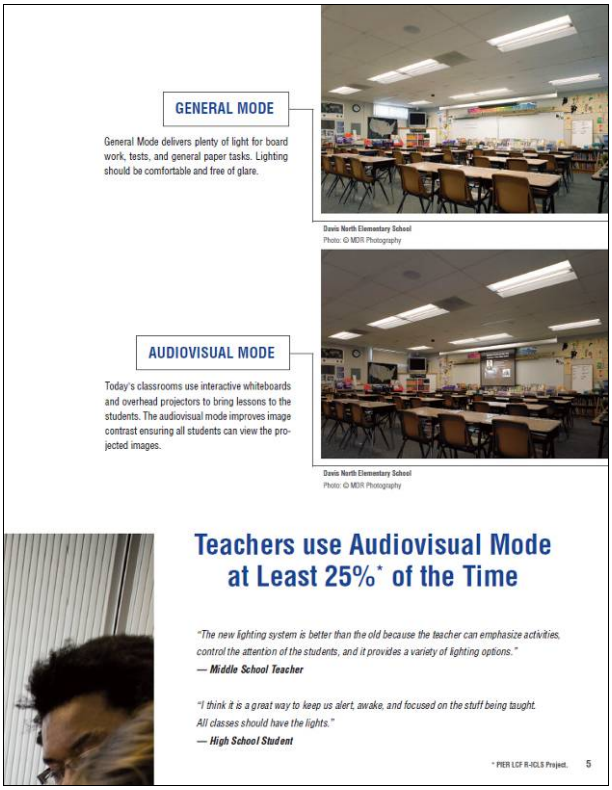
http://www.archenergy.com/lcf/brochures-pdfs/LCF-P5-FL_HPR_Brochure.pdf

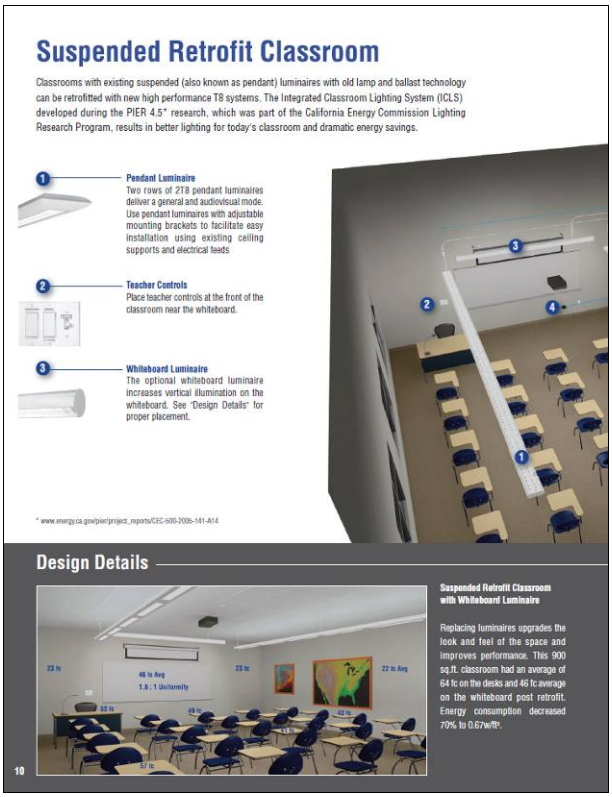


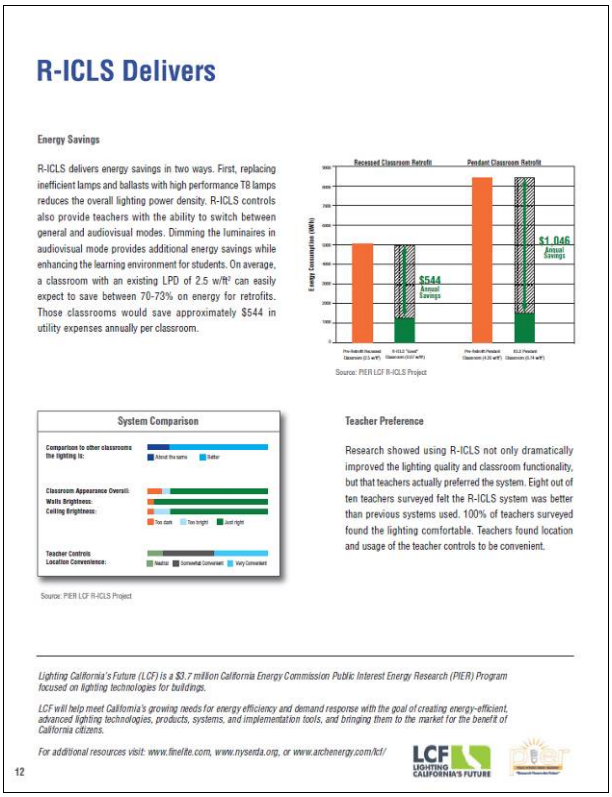
Lighting Guide:

http://www.archenergy.com/lcf/brochures-pdfs/PIER-LCF-P5-Retrofit-Guide_072210_FINAL.pdf









Lighting Portal postcard

LCF
LIGHTING
CALIFORNIA'S FUTURE

Lighting California's Future (LCF) is a $3.7 million California Energy Commission Public Interest Energy Research (PIER) Program focused on lighting technologies for buildings. The program, which is managed by Architectural Energy Corporation, includes nine technical projects with a cross-cutting market connection program.

The goal of LCF is to meet California's growing needs for energy efficiency and demand response by creating and introducing energy-efficient, advanced lighting technologies in 2008 and 2009.

We invite you to learn more about the research at our Web site.

www.archenergy.com/lcf

THE
LIGHTING PORTAL

A NEW RESOURCE FOR THE LIGHTING COMMUNITY

The Lighting Portal is a new online resource to exchange ideas, information, and visions for the future. Lighting enthusiasts are encouraged to register and participate in the Lighting Portal Forum, an online dialogue with links to beneficial resources on pressing topic(s) related to lighting efficiency.

www.thelightingportal.ucdavis.edu

Appendix D: Technical Briefs

Advanced LED Downlight

LCF LIGHTING CALIFORNIA'S FUTURE

ET STAT SHEET

ADVANCED LED DOWNLIGHTS

The objective of the Advanced LED Downlights project is to develop a downlighting system based on indirect optical designs that will reduce glare, decrease installation time, and improve thermal management.

The Advanced LED Downlight has a single central power supply that can control up to ten lights. Each fixture consumes approximately 16 watts. Low voltage CAT-5 cable wiring between the centralized power supply and the downlights allows for simplified wiring, which allows for easier and cheaper installations.

The indirect optic of the Advanced LED downlight increases visual comfort and produces a downlight with uniform brightness and color consistency. The integrated crossblade heatsink and trim places the LED sources in a location where they can be thermally managed, improving LED output and life. The central power supply architecture allows for expandability for additional downlights as well as other LED fixtures, such as under-cabinet lighting.

Lumen Output	640 lumens*
System Efficacy (Lm/W)	40 Lm/W*
CRI	~84
CCT	3000K
Life Hours (L70) Rating	50,000 hrs*
ENERGY STAR Compliant	Yes
Cost Range	$110 per unit
Annual Cost Savings	$50–60
Labor Cost	Lower than average downlight cost

Applications:
Residential: Kitchens, hallways, bathrooms
Commercial: Corridors, conference rooms, break rooms, public areas
Hospitality: Restaurants, corridors, lobbies

Collaborators:
Architectural Energy Corporation
California Lighting Technology Center
Capri Lighting
Samsung

* The numbers listed here are projected specifications for this technology and based on current demonstrations. Specifications may change upon further development of this product.

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Robert Freitag
Capri Lighting
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www.caprilighting.com

Lighting California's Future is a $3.7 million California Energy Commission Public Interest Energy Research (PIER) Program focused on lighting technologies for buildings. The program, which is managed by Architectural Energy Corporation, includes nine technical projects with a cross-cutting market connection program.

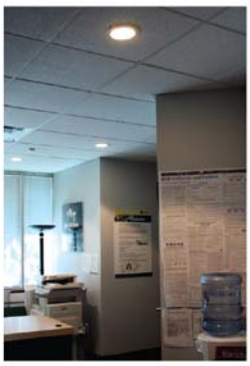
The goal of LCF is to meet California's growing needs for energy efficiency and demand response by creating and introducing energy-efficient, advanced lighting technologies.

www.archenergy.com/lcf

HALO Downlight

LCF LIGHTING CALIFORNIA'S FUTURE

ET STAT SHEET



NOVEL LED DOWNLIGHTS

LEDs are quickly being adopted as an illumination solution for general lighting applications. Energy conscious markets are focusing on high efficiency LED lighting systems to capitalize on the longevity of solid state lighting. Cooper Lighting and California Lighting Technology Center have partnered to develop an energy-efficient, sustainable downlight product that is practical for multiple lighting applications in the home.

The objective of this project is to commercialize a novel LED downlight that is energy efficient and cost effective. The project intends to integrate dimmable LEDs into a recessed downlight to achieve an overall system that has a high lumen output while providing continuous dimming control and low power consumption. The Novel LED Downlights' optical design yields more productive beam lumens and good cut off. The package offers excellent color rendering of 80 CRI and long life of 35,000 hours.

The Novel LED Downlight is now commercially available through HALO, a Cooper Lighting brand, at http://www.haloltg.com.

Lumen Output	650 lumens*
System Efficacy (Lm/W)	54 Lm/W*
CRI	80
CCT	3000K
Life Hours (L70) Rating	35,000+*
ENERGY STAR Compliant	Yes
Cost Range	~$85–90 per unit
Annual Cost Savings	$35–50 per unit
Labor Cost	Standard rate for downlight installation

CONTACT:
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www.cltc.ucdavis.edu

Applications:
Residential: Kitchens, hallways, bathrooms
Commercial: Corridors, conference rooms, break rooms, public areas
Hospitality: Restaurants, corridors, lobbies

Collaborators:
Architectural Energy Corporation
California Lighting Technology Center
Cooper Lighting

* The numbers listed here are projected specifications for this technology and based on current demonstrations. Specifications may change upon further development of this product.

Lighting California's Future is a $3.7 million California Energy Commission Public Interest Energy Research (PIER) Program focused on lighting technologies for buildings. The program, which is managed by Architectural Energy Corporation, includes nine technical projects with a cross-cutting market connection program.

The goal of LCF is to meet California's growing needs for energy efficiency and demand response by creating and introducing energy-efficient, advanced lighting technologies.

pier

www.archenergy.com/lcf

SPE Downlight

LCF LIGHTING CALIFORNIA'S FUTURE

TECHNICAL BRIEF

SPE™ LED DOWNLIGHTS

The objective of the SPE-based LED Downlights project is to develop an advanced, highly energy-efficient LED downlight for commercial and hospitality applications. SPE stands for scattered photon extraction, a technique developed to increase the efficiency of LED systems.

The SPE-based LED downlights have a nominal aperture of 6 inches and produce similar light output to a 75W BR40 downlight with only 9W of input power. The SPE Downlight features an efficient driver with two additional settings if a higher light output is desired.

The correlated color temperature of the SPE LED Downlight is in the range 3500 K to 4000 K, a neutral white suitable for many commercial and hospitality applications.

The design of the SPE LED Downlight affords a sufficiently low LED operating temperature to achieve a target life of 50,000 hours. The one-part reflector and trim is housed in a traditional 6-inch housing that can be installed from below the ceiling (suitable for remodeling jobs; requires a ceiling opening of 7 1/8-inch).

Lumen Output	650 lumens
System Efficacy	72 lm/W
CRI	76
CCT	3500-4000 K
Life Hours (L70) Rating	50,000 h
Light Distribution	General diffuse
ENERGY STAR Compliant	TBD
Cost Range	TBD
Energy Savings Range	Annual savings TBD
Labor Cost	Same as CFL or INC

CONTACT:
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Applications:
Commercial: Lobbies, offices, conference rooms, open areas, etc.
Hospitality: Lobbies, reception areas, corridors, general open areas, etc.

Collaborators: Architectural Energy Corporation, Lighting Research Center

Lighting California's Future is a $3.7 million California Energy Commission Public Interest Energy Research (PIER) Program focused on lighting technologies for buildings. The program, which is managed by Architectural Energy Corporation, includes nine technical projects with a cross-cutting market connection program.

The goal of LCF is to meet California's growing needs for energy efficiency and demand response by creating and introducing energy-efficient, advanced lighting technologies in 2008 and 2009.

www.archenergy.com/lcf

LED Fan and Exhaust Fan

LCF LIGHTING CALIFORNIA'S FUTURE

ET STAT SHEET

LED CEILING AND EXHAUST FANS

The objective of this project is to develop and commercialize LED-based lighting kits for ceiling and exhaust fans in residential applications. Additionally, the project will explore the integration of control systems to the LED fan systems to determine if additional energy savings can be achieved in a cost-effective manner.

The LED ceiling fan will serve as a replacement for ordinary incandescent ceiling fans. The LED ceiling fan is fully dimmable and the LED optic design reduces glare usually associated with LEDs. The LED light kit will be designed to have an output of 40 Lumens per watt (approximately 800 lumens at 20 watts). Typical incandescent kit systems usually produce less than 15 Lm/W.

Lumen Output	800 lumens*
System Efficacy (Lm/W)	40 Lm/W*
CRI	75–80
CCT	3000K
Life Hours (L70) Rating	35,000+*
ENERGY STAR Compliant	Yes
Cost Range	$200 per stand-alone unit
Annual Cost Savings	$58 per year

CONTACT:
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Applications:
Residential retrofit, commercial retrofit, and new construction opportunities

Collaborators:
Architectural Energy Corporation
California Lighting Technology Center
Hunter Fans

Current Status:
A higher performance LED light kit is under development to provide both standard and specialty fans with improved specifications.

* The numbers listed here are projected specifications for this technology and based on current demonstrations. Specifications may change upon further development of this product.

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pier

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WIPAM

LCF
LIGHTING CALIFORNIA'S FUTURE

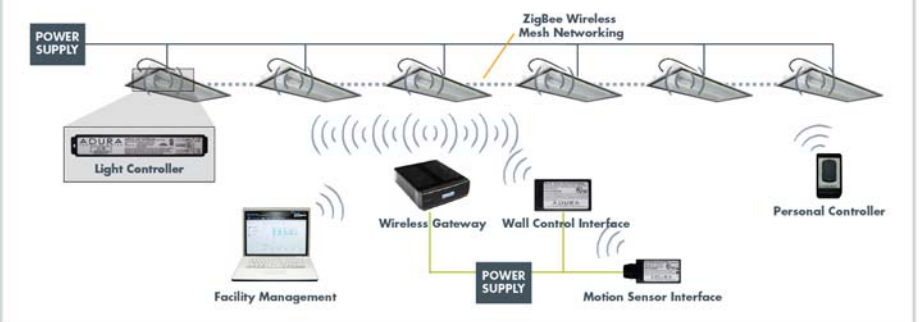
TECHNICAL BRIEF

WIRELESS INTEGRATED PHOTOSENSOR AND MOTION SENSOR

Lighting control systems are readily available in the market that turn lights off when spaces are unoccupied or when sufficient daylight is available. However, installing these systems involves new wiring or rewiring and can be an expensive proposition to retrofit existing buildings.

Adura Technologies, in partnership with the California Lighting Technology Center, developed a wireless integrated photosensor and motion sensor system that communicates wirelessly through radio frequency to circumvent this issue.

Typical Installation



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The goal of LCF is to meet California's growing needs for energy efficiency and demand response by creating and introducing energy-efficient, advanced lighting technologies.

Features:
- Reduces installation costs because most components are wireless
- Multiple possible control scenarios, including intelligent step dimming
- Integrate daylighting and occupancy controls to provide greatest energy savings
- Compatible with any ballast-based or incandescent lighting system
- Individually addressable Light Controllers update data and accept commands in real time
- Web-based application provides monitoring, scheduling, and reporting
- Up to 60% average energy savings in corridor applications

Applications:
Commercial buildings, warehouse facilities, parking garages, schools, and other spaces that could benefit from wireless lighting controls

Collaborators:
Public Interest Energy Research Program
Architectural Energy Corporation
California Lighting Technology Center, UC Davis
Adura Technologies

Current Status:
Commercially available. CLTC continues demonstrations of the system as part of the State Partnership for Energy Efficiency Demonstrations (SPEED) Program. Upcoming demonstration projects are slated for Mrak Hall and Bainer Hall on the UC Davis campus.

www.archenergy.com/lcf

Solatube 750DS

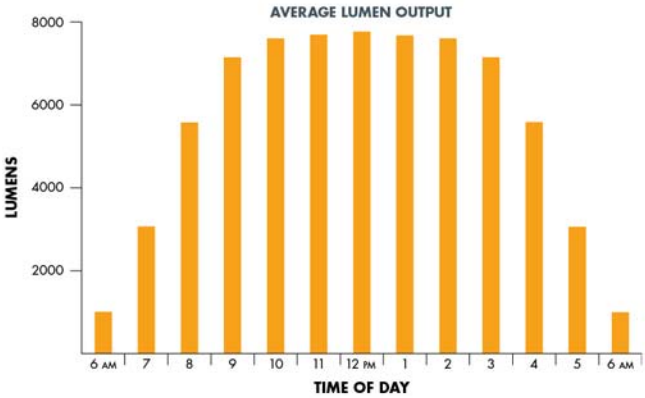
LCF
LIGHTING CALIFORNIA'S FUTURE

TECHNICAL BRIEF

SOLATUBE® 750 DS DAYLIGHTING SYSTEM

Tubular Daylighting Devices (TDDs) have the potential to light building cores that are not reachable by conventional skylights or windows, reducing lighting energy costs and consumption.

The Solatube® 750 DS Daylighting system was engineered to provide the highest and most consistent performance available throughout the day and all year long. This daylighting system is ideal at harvesting low angle sunlight screening intense midday sunlight, reducing heat gain. The higher efficiency tubing increases energy performance and provides better light mixing, improving visual comfort.



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Features:
- ENERGY STAR™ compliant in a closed ceiling application, providing superior thermal performance
- Single 750 DS dome: U-factor 0.52, SHGC 0.23
- Ideal at reducing glare for lower ceiling heights (8 – 15 ft.)
- UV filtering limits the UV impact to interior spaces and occupants
- Perfect color rendering with daylight (CRI 100)

Applications:
Residential, office spaces, schools, and other buildings with lower ceiling heights

Collaborators:
Public Interest Energy Research Program
Architectural Energy Corporation
California Lighting Technology Center, UC Davis
Solatube International, Inc.

Current Status:
The Solatube® 750 DS Daylighting system was installed at the Sierra Vista Elementary School in Upland, CA.

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The goal of LCF is to meet California's growing needs for energy efficiency and demand response by creating and introducing energy-efficient, advanced lighting technologies.

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Appendix E: Case Studies

HALO Downlight

http://cltc.ucdavis.edu/images/documents/case_studies/2010_halo_bidwell_mansion.pdf

California Energy Commission's Public Interest Energy Research Program — *Case Study*

Energy-efficient LED Downlights

Bidwell Mansion Visitor Center
Chico, CA

PIER Buildings Program — *Research Powers the Future* — www.energy.ca.gov/research

The Problem

Recent studies estimate more than 800 million recessed downlights are in operation in the United States, split nearly equally between residential and commercial applications, with about 83% still using incandescent lamps.

Inexpensive compact fluorescent lamp (CFL) downlights are commercially available, but most of these units are not dimmable, which is a desired attribute for many downlight applications. Therefore, energy-saving CFLs often are overlooked in lieu of the functionality of incandescents.

This conflict creates a significant market opportunity for an energy-efficient, dimmable light source designed for the recessed downlight market. Significant energy savings potential exists for long-life LED replacements, as much as 81 trillion watt hours (TWh).[1]

The Solution

Cooper Lighting and the California Lighting Technology Center (CLTC) partnered on this PIER-sponsored project to create an LED recessed downlight suitable for both retrofit or new construction markets that met ENERGY STAR requirements, provided high-quality, broad spectrum light, and could successfully dim on standard analog dimmers. The culmination of this partnership venture was the successful launch of the HALO® LED downlight offered by Cooper Lighting.

Features and Benefits

- The HALO LED recessed downlight is the first ENERGY STAR-rated LED downlight and exceeds the high efficacy requirements set by California's Title 24 energy regulations
- High color rendering and warm white color temperature: 80 CRI at 3045 K
- Delivers light equivalent to many standard incandescent sources used in recessed downlight applications
- Up to 25 times longer lamp life than incandescent lamps, lasting up to 68 years in most residential applications and 15 years in typical commercial applications[2]

[1] DOE, Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications, prepared by Navigant Consulting, September 2008.

[2] Residential applications assume two hours of use per day. Commercial applications assume nine hours of use per day.

FIGURE 1: COOPER HALO® LED DOWNLIGHT
Bidwell Mansion Visitor Center, Chico, CA

- Dimmable to 15% of total light output with standard AC incandescent dimmers, 5% with low-end trim adjustment
- Multiple trim options available designed to minimize glare and increase aesthetic appeal, including those for wet applications

Technology Costs and Incentives

Installation of LED downlights in retrofit and new construction situations is almost identical to typical incandescent or CFL recessed downlights. The exception is that many LED downlight housings—for example, the HALO product by Cooper Lighting—can be in direct contact with insulation. Replacement scenarios generally are one-to-one in retrofit applications. Equipment costs range from $100–300 depending on the manufacturer and distributor, but costs may be offset by maintenance savings and utility rebates.

Demonstration Results

Bidwell Mansion Visitor Center

The Bidwell Mansion Visitor Center (BMVC) in Chico, CA, is the first stop for people visiting Bidwell Mansion, a Victorian mansion built in the late 1800s and operated by the California State Department of Parks and Recreation. The BMVC contains a gift shop, museum, and theater, and is used to host seminars and workshops for the public, local agencies,

WIPAM

http://cltc.ucdavis.edu/images/documents/case_studies/PIER_UCSB_WIPAM.pdf

California Energy Commission's Public Interest Energy Research Program *Case Study*

Wireless Integrated Photosensor and Motion Sensor

University of California, Santa Barbara

PIER Buildings Program *Research Powers the Future* www.energy.ca.gov/research

The Problem

The average commercial building in California spends about 35% of its total electrical use on lighting systems. Lighting control systems are broadly acknowledged as offering large, near-term opportunities for energy savings.

Lighting control systems already exist in the market that turn lights off when spaces are unoccupied or when sufficient daylight is available. However, installing currently available lighting control systems involves wiring and can therefore be an expensive proposition in existing buildings.

The Solution

Adura Technologies in partnership with the California Lighting Technology Center (CLTC) developed a wireless integrated photosensor and motion sensor (WIPAM) system that uses wireless communications to circumvent the complicated wiring issue, thus increasing the pool of buildings that could cost effectively benefit from lighting controls.

The Adura LightPoint System™ allows for the installation of controls components in pre-existing light fixtures as well as luminaires involved in new construction. The system is very robust and offers a large amount of programmability. At the core of the system is the light controller. This light controller communicates wirelessly through radio frequency with system components such as occupancy and photosensors—which have wireless capability through the sensor interface—and then, based on given input, modifies the lighting environment to achieve desired light levels in the most energy-efficient manner.

The system is expected to reduce installation and commissioning time by as much as 50% over standard industry practice for competing technologies. An office retrofit project using this kind of technology, for example, could reduce office lighting energy use by as much as 25%.

Features and Benefits

- Reduces installation costs because most system components are wireless
- Intelligent step-dimming is an option; multiple control scenarios are available
- Layer daylighting and occupancy controls to provide greatest energy savings

FIGURE 1: EVERLAST INDUCTION STEP-DIMMING LUMINAIRES WITH WIRELESS INTEGRATED PHOTOSENSOR AND MOTION SENSOR CONTROLS
Lot 18 parking structure, University of California, Santa Barbara

- Can be used with any ballasted or incandescent lighting system

Technology Costs and Incentives

In a recent field study, a lighting system with no controls was compared to a system implementing daylight harvesting, occupancy sensors, and manual dimming. It showed an estimated 20% energy savings for daylight harvesting, 35% for vacancy/occupancy controls, and about 11% for individual dimming.[1] The LightPoint system costs about $140–$180 per fixture, depending on which components are used.

Few incentives currently exist for this technology, so huge potential exists to increase its market penetration. For example, it is estimated that the broad application of daylight harvesting could have an average energy savings of 40%; however, the current implementation has less than 1–2% market penetration rate.[2]

[1] Galasiu, Anca D et al. Energy Saving Lighting Control Systems for Open-Plan Offices: A Field Study. Leukos. Volume 4. July 2007. Pages 7–29.

[2] Lee, E.S. and S.E. Selkowitz. The New York Times Headquarters Daylighting Mockup: Monitored Performance of the Daylighting Control System. 2005. LBNL-56979.

R-ICLS

http://cltc.ucdavis.edu/images/_projects/demonstration/icls/pier_demo_uc_csu_icls.pdf

http://cltc.ucdavis.edu/images/_projects/demonstration/icls/pier_demo_ccc_iou_icls.pdf

Public Interest Energy Research Program *IOU Partnership Draft-Case Study*

Integrated Classroom Lighting System (ICLS)

"Our instructors and students really enjoy the new systems. We are planning more ICLS installation around campus."
Victor Lai—Energy Manager, San Francisco State University

PIER Buildings Program ***Research Powers the Future*** ***www.energy.ca.gov/research***

Energy and Carbon Savings Opportunity

High lighting quality, flexibility, energy savings, cost-competitive

Many classrooms provide mediocre lighting quality and have high energy costs. Although high-efficiency systems are available, they require a piecemeal approach when including automatic controls for occupancy and dimming. Specifying control components individually greatly increases design time and cost. Additionally, each component carries an individual warranty, causing confusion and potential delayed repair time if performance problems occur.

The Integrated Classroom Lighting System (ICLS) combines high quality lighting, increased flexibility, daylighting, and energy efficiency into an affordable, easy to use, and easy to maintain single-source solution. By increasing lighting quality and distribution with suspended indirect fixtures, the ICLS is able to achieve a lower power density than standard classroom systems. With fewer fixtures, fewer lamps, and fewer ballasts, operational and maintenance costs are reduced. This also means installation costs are often less than costs for traditional classroom fixtures. All this, in addition to improved user controls, means the ICLS can benefit many applications.

Product Overview

Energy Savings:
Typically 30-50% below Title 24 due to reduced lamp quantity, teacher controls, and occupancy sensors
Operation/Maintenance:
Easier access to lamps and ballasts than standard fixtures
Manufacturer is single warranty source
Manufacturer:
Finelite, Inc., www.finelite.com
Market:
K-12 and college classrooms, conference rooms, offices
Project Design Guides:

- New construction product specification available.
- LEED Fact Sheets
- http://pierpartnershipdemonstrations.com/

Public Interest Energy Research ***University of California*** ***California State University***

Page 1 Document #

Integrated Classroom Lighting System (ICLS)

PIER Buildings Program ***Research Powers the Future*** ***www.energy.ca.gov/research***

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Public Interest Energy Research ***California Community Colleges***