PIER Lighting Research Program

California Energy Commission
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Design Information Development Plans For Project 6.2 Design Tools

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Table of Contents

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Design Information Development Plan

Abstract

Fifteen Lighting Research Program (LRP) projects are candidates for the development of design tools. Multiple factors influence whether or not a technology is a viable candidate. The following discussion outlines the various LRP projects and identifies their strengths and weaknesses as candidates for design tools.

In general, characteristics deemed favorable to the development of design tools are:

- **Highly variable applications**. Designs with a high degree of variability require numerous decisions on the part of the designer. In these cases, design tools can prove invaluable to select and to shape the technology as it is applied.

- **Performance Impact.** The energy saving performance (and occupant satisfaction) of certain technologies is more dependent on their design and implementation than others. It is those technologies, which are highly affected by the design and resulting user interaction, where a design tool can be the most effective. An example of a project with low design impact is the Project 3.2 Energy Efficient Load Shedding Technology. Because the energy savings depends solely on the number of fixtures equipped with the technology, the calculation is relatively straightforward and, as such, only merits a relatively simple design tool.

Preliminary characteristics of various LRP technologies noted as discouraging to the creation of LRP design tools within the project term are:

- **Portability**. The portability of task light or portable lighting systems limits the control of the designer over performance and reduces the effectiveness of design tools. For example, Project 4.2 Energy Star Residential Portable Fixtures does not merit the creation of a design tool.

- **Scheduling.** In some cases, the project schedules are not conducive to this project's integrated development of design tools in coordination with product development.

- **Standardization.** If product application is standard and highly specific, a design tool has little effectiveness in selecting whether or not and in what manner the technology should be applied. An example would be LRP Project 4.1 Hotel Bathroom Lighting.

Table 1 summarizes preliminary recommendations for design tools to be further investigated and developed in coordination with the various project teams. Together with Project Leads, the Project Team will prioritize and determine the precise number of design tools to be created on the basis of total funds available.

The strongest candidate and the one whose design tool could have the most far-reaching market impact is the Project 3.3 Classroom Photocell and Control System. The potential and need for such a design tool was identified not only by the LRP 3.3 Project Team, and the LRP 6.2 Project Team, but also by lighting design professionals in surveys and personal interviews. LRP 3.3 will be targeted as the

technology to receive the most development work in creating a functional design tool. However, the LRP 6.2 Project Team will also individually assess the scope of work for other potential design tools listed in **Table 1** pending available funding. In this way, the project team believes efforts will be the most effective in adding and increasing market acceptance of the PIER program as a whole.

Table 1: Summary of Design Information Development Plan Recommendations

Pier LRP Technology	Potential Design Tool / Information Development	Recommended for Possible Case Study Development
LRP Project 2.1 Exterior LED Luminaires	**Cutsheet, IES files**	
LRP Project 2.2 LED Task Lights	**Unknown at this time**	
LRP Project 2.3 Low Profile LEDs	**Cutsheet, IES files**	**YES**
LRP Project 3.1 Retrofit Fluorescent Dimming	**User Guide, Energy Savings Estimator (Calculator)**	
LRP Project 3.2 Load-shedding Technology	**Utility Incentive Estimator (Calculator)**	
LRP Project 3.3 Classroom Photosensor	**Computer Software Design Tool for Photosensor placement, LEED / CHPS energy savings calculator**	
LRP Project 4.1 Hotel Bathroom Lighting		**YES**
LRP Project 4.2 ENERGY STAR Residential Fixtures		
LRP Project 4.3 Retrofit Downlights		
LRP Project 4.4 Portable Office Lighting	**Cutsheet, IES files**	
LRP Project 4.5 Integrated Classroom Lighting	**Computer Modeling of Representative Spaces**	**YES**
LRP Project 5.1 Bi-level Stairway Fixtures		**YES**
LRP Project 5.2 HID Electronic Ballasts		
LRP Project 5.3 Low Glare Outdoor Luminaires		
LRP Project 5.4 DALI	**User Guide**	**YES**

It should be noted that in **Table 1** AEC is recommending the development of various design tools and information. However, AEC's work will focus primarily on the development of the software tool, comprised of two components, for Project 3.3 and four total case studies that are detailed in the next sections of this report.

Discussion

The discussion in this section reviews each of the LRP projects and outlines some of the background information and reasoning, which supports the recommendations summarized in **Table 1**.

LRP Project 2.1- LED Luminaires for Exterior, Porch, and Perimeter Building Lighting

This project addresses the potential of LEDs to work as exterior illumination devices. Project 2.1 project leads have stated that, "the best near term opportunities for LEDs in illumination applications will be those applications with lower lumen output requirements, highly directional output characteristics, colored illumination, or critical performance applications where maintenance is difficult or expensive." Outdoor lighting is a good application for LEDs since outdoor applications generally require lower light levels, and lighting designers and engineers are more willing to build systems that produce less light than indoor systems. However, as exterior luminaires, LEDs will function as illumination devices (as opposed to indicator lights – LEDs' function in traffic signals and elsewhere), and will, therefore, be in direct competition with other commercially available exterior lighting fixtures.

As such, and at the very least, LED luminaires proponents will need to provide industry standard information in order to evaluate LEDs against existing technologies and gain any type of market penetration. For this reason, AEC suggests that cutsheets and IES files are requisite design information for developing the new technology. At a minimum, cutsheets should include such information as:

- Lumen output
- Candela plots
- Coefficient of Utilization
- CRI
- Maintenance data

Project organizers have stated in early reports that, "reliable light output data for state-of-the-art LEDs can be difficult to obtain. Although manufacturer specification sheets for their products are very detailed, small variations in packaging and individual chip performance can have large effects on total system performance." However they go on to state that, "it is possible to infer some useful data from spec sheets and, coupled with actual measurements performed at the Lawrence Berkeley National Laboratory, develop legitimate parameters for LED illumination systems." AEC may work with the project team and further consider what design information would be best and most useful to a designer wishing to integrate an LED luminaire into one of their exterior designs.

Recommendation: While IES files and/or cutsheets may be useful to support Project 2.1, given limited time and budget for LRP Project 6.2, AEC recommends that no design tools or case studies be developed under LRP Project 6.2 for this project. The manufacturing partner may want to provide IES files and cutsheets as part of their commercialization efforts.

LRP Project 2.2- LED Task Lights

LRP Project 2.2 is evaluating the technical potential of LED task lights in residential applications. Certain technical obstacles still exist to creating market ready, high performing

LEDs. The LRP 2.2 Project team is currently investigating certain material substrates for their thermal properties and thermal management capabilities.

Recommendation: Given the state of product development and the fact that once developed, the product will be portable and residential in nature, AEC is not recommending a design tool or case study be developed for LRP Project 2.2 at this time.

LRP Project 2.3- LED Low Profile Fixture

Project 2.3 has performed extensive research evaluating which LED is most appropriate for which low profile application. Preliminary research concluded that power illuminator LEDs are the most appropriate source for the low profile luminaire applications. In addition, the project has identified the following as potential applications for optical modeling and prototyping of the low profile luminaires.

- Under-cabinet lighting fixture
- Downlight for elevators
- Museum display lighting fixture
- Jewelry display lighting fixture

As low profile luminaires, it will be essential that the emerging technologies provide cutsheets and IES files to potential clients. In addition to information typical to cutsheets, the project team is studying attributes such as efficacy, color rendering, color consistency, distribution, lumen maintenance, thermal controllability, cost, and reliability and may wish to make this information available to interested designers as a sheet of addition product information.

Recommendation: While IES files and/or cutsheets may be useful to support Project 2.3, given limited time and budget for LRP Project 6.2, AEC recommends that no design tools be created under LRP Project 6.2 for this project. LRC or the manufacturing partner may want to provide IES files and cutsheets as part of their commercialization efforts.

- AEC recommends that a Case Study may be created for LRP Project 6.2 highlighting the findings of the extensive research being performed. The development of a Case Study is dependent on how successful LRC is on developing the specific low profile LED applications.

LRP Project 3.1- Retrofit Fluorescent Dimming with Integrated Lighting Controls

The goal of LRP project 3.1 is to develop and test a dimmable, fluorescent lighting system that is suited for easy retrofit into existing commercial buildings and dimmable down to 25 percent output using “phase-cut” technology primarily controlled by utility-triggered load shedding signals transmitted via Intranet-connected PC. This unique lighting solution will be well suited to retrofit applications since the installation requires no added wiring.

It is difficult to conceive of design tools that would directly assist the “designer” in such a retrofit application. As a replacement or direct “fit-out” technology, project 3.1 will not require "design work" per se, but rather decisions about where and when to implement the technology. As such, the most useful design aid would be a source of information to aid in the decision of whether or not to implement the technology. Information regarding potential energy savings and energy cost savings would be useful to a potential client. It may be useful to develop information resources or tools which inform the user of energy saving and energy cost savings potential. In particular, such information could be developed in cooperation with local utilities to estimate savings and establish economic incentives programs.

Recommendation: While a User Guide and an Energy Savings Estimator (Calculator) might provide valuable information to aid in the decision making process of whether or not to implement this technology, given limited time and budget for LRP Project 6.2, AEC recommends that no design tool or case study be developed under LRP Project 6.2 for this project. LBNL may want to provide a guide or energy savings estimator as part of their commercialization efforts.

LRP Project 3.2- Energy Efficient Load Shedding Technology

Two products were initially evaluated for the load shedding technology, a load shed ballast and a retrofit load shed device. These devices are intended to reduce fluorescent lighting power requirements by a fixed percentage during times of high electric demand. A load shed ballast is made up of an instant start ballast and circuitry which receives a signal from external sources and can reduce lamp output and power input on command. A retrofit load shed device is a device that receives an outside signal and tells the ballast to lower the lamp output during times of utility peak electric usage. Since both devices can be housed within fluorescent light fixtures, the technology allows the customer to choose which lights to control on an individual basis. It does not control area lighting at the panel nor does it require the lighting to be separately circuited from other building loads.

As a retrofit technology implemented on the individual fixture level, it is difficult to conceive of a design tool, which would be useful or capable of selecting candidate fixtures on a room by room basis. More likely, a tool could be developed which would calculate the optimum number of fixtures that should be dimmed on a building level. Such a tool might project the potential energy savings, which would occur as a result of using such a technology. Furthermore, it could be developed in conjunction with the local utility to calculate possible rebates or incentives available to clients should they implement the load shedding technology. Such a tool would likely be spreadsheet based and would most effective only if developed in collaboration with local utilities.

Recommendation: While a Utility Incentive Estimator (Calculator) would aid in informing both the potential client and the local utility about the potential benefits of this technology and advance market penetration, given limited time and budget for LRP Project 6.2, AEC recommends that no design tool or case study be developed under LRP Project 6.2 for this project. LRC may want to provide a savings estimator as part of their commercialization efforts.

LRP Project 3.3- Classroom Photocell and Control System

Preliminary research identified the photosensor system technology of LRP 3.3 - classroom photosensor system as the leading candidate for the creation of a design tool. The potential and need for such a design tool has been identified by the LRP 3.3 Project Team, the LRP 6.2 Project Team, and by numerous lighting design experts and professionals through surveys, interviews and industry trends. The goal of Project 3.3 is to develop a photosensor lighting control system that is optimized for common classroom electric lighting solutions (recessed and pendant lighting) and daylighting configurations (side-lighting only, top-lighting only, side- and top-lighting). The optimization involves maximizing energy savings while ensuring adequate light levels are provided at all times. In addition, an optimized system would be one that can be simply and easily commissioned and that effectively operates in conjunction with manual controls and occupancy sensors.

According to research being done by the LRP 3.3 Project Team, the use of photosensor controls appears to be quite limited in current classroom construction practices. In many of the schools in which daylight is being addressed, photosensor controls are often value-engineered out of the design near the end of the project. The ready acceptance of this value-engineering decision to eliminate the photosensors is due, in part, to the general perception of the industry that photosensors are difficult to successfully integrate into a project. Several generations of photosensors with spotty performance records along with poor photosensor system design have left many design professionals as well as building owners with little confidence in the effectiveness of these systems, and worse yet, with the feeling that the performance might be problematic for the occupants.

Recent strides have been made by the industry to improve the reliability and effectiveness of photosensor performance. Current obstacles to their acceptance and application have more to do with the challenge of proper implementation (and cost) rather than unreliable performance. For this reason, a user-friendly tool that could help diagnose and optimize photosensor selection and placement could prove extremely valuable in furthering market acceptance. Furthermore, earlier surveys of design professional documented a strong sentiment that the industry has a real need for a design tool that could analyze lighting controls. The LRP 6.2 Project Team highly recommends the development of a design tool(s) that would assist in the implementation of photosensors by providing analysis and recommendations for classroom specific photosensor system design. Building on prior work by and in conjunction with Dr. Richard G. Mistrick, Associate Professor of Architectural Engineering, Pennsylvania State University and Dorene Maniccia, Manager, Market Segment Development, The Watt Stopper, the LRP 6.2 project would like to develop an interactive analysis tool which would assist designers in designing a photosensor system for their project.

The following is a preliminary outline of potential inputs and outputs for a photosensor design and analysis tool. As currently conceived, there will be two separate but integrated components of this tool: one component will focus on design and assist in the selection and layout of photosensor systems, and one component will provide performance analysis of an already selected photosensor system.

Inputs

1) Space Characteristics (allow advanced users to define these characteristics through a CAD program either with a plugin similar to Desktop Radiance or Rayfront, or through a dxf converter program)
    a. Room Dimensions
        i. Width

      ii. Length (limit to rectangular floorplans)
      iii. Height 1, Height 2 etc. to allow for sloped ceilings
      iv. Orientation
   b. Room Surface Characteristics
      i. Ceiling reflectance
      ii. Wall reflectance
      iii. Floor reflectance
      iv. Furniture reflectance -> area of furniture (or % of area)
      v. White board location, size and reflectance (defines whiteboard illuminance calculation grid)
      vi. Workplane height (defines with room width and height workplane calculation grid)
   c. Daylight Apertures
      i. Window X
         1. Width
         2. Height
         3. Sill Height
         4. Location on walls (S, E, W, or N walls, allow spacing of windows as optional input)
         5. Daylight/view window break height
         6. Daylight window visible transmission (T_{vis})
         7. View window T_{vis}
         8. Daylight system (choose from predefined or custom lists)
      ii. Skylight X
         1. Width
         2. Length
         3. Chase height
         4. Chase reflectance
         5. Skylight Tvis
         6. Location in ceiling (array spacing as optional input)
   d. Electric Lighting Characteristics
      i. Fixture type - IES file (choose from variety of predefined fixtures or allow for custom definition of fixtures which would require IES file input)
      ii. Location (array spacing as optional input)
      iii. Suspension height for pendant fixtures
2) Lighting Control Characteristics (**a separate but integrated Design Tool will be created to assist in optimizing and running parametric studies for these inputs**)
   a. Photosensor type (choose from variety of predefined photosensor sensitivity files or allow custom input)
   b. Photosensor control zoning - allowing for multiple zones
   c. Zone setpoints (or specific settings depending on type of photosensor)
   d. Photosensor location
   e. Photosensor aiming
3) Occupancy Schedules
   a. Daily
   b. Weekly
   c. Annually
4) Location and Climate
   a. Geographic Location

        i. City (choose from predefined list or allow custom definition)
        ii. Climate Data (automatically gathered from database for predefined list)
        iii. Latitude and Longitude (automatically gathered from database for predefined list)
    b. Utility Information (tied into database for predefined list but allow user to override)
        i. Natural gas rate
        ii. Electrical consumption rate
        iii. Electrical demand rate

Outputs

1) Annual Performance Data (with sorting abilities to refine results to look at time of day, daily averages, monthly averages, annual extremes etc.)
    a. Illuminance for workplane and whiteboard
    b. Energy consumption and savings compared to base case (identical but with no photosensor system)
    c. Energy costs and cost savings (consumption and demand) compared to base case
    d. Pollution reductions and cost implications
    e. Heating and Cooling load impacts
    f. Relative glare levels
    g. Direct Sunlight penetration location and duration
    h. Hours below critical illuminance thresholds
    i. Photosensor vs. workplane correlation graphs
2) Refinement recommendations
3) Renderings (based on predefined views - 2 corners of room, side view, top view, and photosensor bugeye views - perhaps allow for manual input of viewpoints)
4) LEED Calculation and documentation - does the design meet the LEED IEQ 8.1 - Daylight availability requirement?
5) CHPS Calculation and documentation

Previous market analysis and research has suggested that a photosensor design tool will be most useful if it provides energy saving results and analysis which are compatible with the requirements of industry standards or guidelines such as LEED or CHPS. Details will be further developed as the design of tool(s) progresses, nevertheless, it is worth noting that the lighting professionals consulted requested that the energy savings reports be compliant with LEED and CHPS formatting and requirements.

<u>Recommendation</u>: The goal of LRP Project 6.2 is to create software tools that will aid the newly developed energy-efficient lighting equipment in getting accepted into general lighting practices and penetrate the market. The technology being developed LRP Project 3.3 is the leading candidate for the development of such design tools. Market need and usefulness has been confirmed by numerous industry sources.

- AEC recommends that design tools be created to assist in the proper implementation of photosensor electric lighting control systems by providing guidance and analysis for classroom specific photosensor system design.

LRP Project 4.1- Hotel and Institutional Bathroom Lighting Project

The Lighting Control System (LCS) being developed for project 4.1 is a wall switch occupancy sensor designed specifically for hotel bathrooms to save energy. The LCS has two key features. The first feature is that the LCS is preprogrammed with a timeout setpoint that is significantly longer than what is typically used by occupancy sensors. The one-hour setpoint will presumably turn off the bathroom lights if the occupant has no need for the light while greatly minimizing the chances of generating "false offs" when the lights turn off while a guest is in the bathroom. The second key feature is a built-in LED nightlight that automatically turns on whenever the bathroom luminaire is turned off. Prior research suggested that a small but significant amount of the extended period usage of the bathroom luminaires occurred during nighttime hours. It is thought that some hotel guests purposely leave bathroom luminaires on as a nightlight. The nightlight feature of the LCS has the potential to provide adequate illumination for guests at night while using only a fraction of the energy.

The LSC being developed in LRP Project 4.1 has very specific applications. In either retrofit or new construction, the LSC is intended for use in a hotel bathroom. While there may be other applications (hospital, campgrounds, motels etc.) where this technology is appropriate and beneficial, in all cases the use is very similar and well defined. In this way, the particular function rather than other design considerations determine whether or not the product should be installed. A design tool would not be particularly useful since there are few variables regarding the installation, which could be determined. Energy savings estimates ("a LCS is estimated to save X watts/year") would be helpful in marketing the product. A designer could simply multiply the number of fixtures by the estimated savings to predict overall cost savings and justify initial first costs by means of simple payback. Nevertheless, it is not likely that a design tool would bring any additional information to the table nor would a design tool be helpful in specifying or installing the product for a given project.

<u>Recommendation</u>: The technology being developed under LRP Project 4.1 is not conducive to the development of a design tool or case studies. AEC recommends that no design tools or case studies be created under LRP Project 6.2 for this project.

LRP Project 4.2- Energy Star Residential Fixture Project

The Energy Star Residential Light Fixture Project is intended to encourage lighting fixture manufacturers to develop higher-end portable indoor residential light fixtures. The lamps in these fixtures will utilize a pin-based configuration that will not allow screw-based lamps. While there is no question that this new line of fixtures will produce high end table and floor lamps that are attractive and use less energy than traditional lamps, there is some question about whether or not a design tool could assist in their implementation. Particularly due to their portable high-end nature, it seems that commercial success will depend primarily on individual homeowners, consumers, and possibility high-end residential designers' personal preference rather than a more traditional design team specifications. LRP Project 6.2 does not see great potential for effective design tools for these residential fixtures unless LRP Project 4.2 would like assistance in developing marketing (energy-star compliant labels, cutsheets, etc.) materials targeting the individual consumer. As with any product competing with existing fixtures, cost will be of major concern.

Recommendation: The technology being developed under LRP Project 4.2 particularly given its portable nature, is not conducive to the development of a design tool or case studies. AEC recommends that no design tools or case studies be created under LRP Project 6.2 for this project.

LRP Project 4.3- Development of Energy Efficient Retrofit/Remodel Alternatives to Incandescent Downlights

This project focuses on providing alternatives to inefficient incandescent downlights. These retrofit systems from this project are envisioned as "out of the box" lighting systems that can go into residential or commercial applications that currently have incandescent downlighting as well as areas with no downlighting at all. This system has the potential to greatly reduce the wiring requirements for installation of a downlight system, which can be significant given the difficulties often encountered when working in confined attic spaces. High-quality, high-output electronically ballasted CFLs will be utilized in the retrofit systems.

It is difficult to conceive of design tools that would directly assist the "designer" in such a retrofit application. As a replacement technology, project 4.3 will not require "design work" per se, but rather decisions about where and when to implement the technology. As such, the most useful design aid would be a source of information, which aid in the decision of whether or not to implement the technology.

Recommendation: As a retrofit technology, LRP Project 4.3 is not conducive to the development of a design tool. AEC recommends that no design tools or case studies be created under LRP Project 6.2 for this project.

LRP Project 4.4- Portable Office Lighting Systems

The Portable Workstation (PWS) is a CFL based, floor-standing fixture boasting a broad scope of user and space management controls. The fixture seeks to replace multiple lamps by using a source that efficiently provides sufficient high-quality, useable light to supply simultaneous ambient (uplight) and task (downlight) illumination and offer the user the flexibility to choose the proportions of each. Optional office-level controls allow office supervisors to easily choreograph motion/occupancy sensors and monitor usage in a modular way; that is, the system offers procurement officers the ability to purchase exactly the number of units needed and customize them to meet the specific needs of the business and the individual user.

Similar to the LRP Project 4.2, it at first appears that the portable nature of the PWS, would make it difficult for design tools to be effective since user behavior and preference will determine the success of the lighting design. However, since the PWS boasts an efficacious lamp designed to fill the need for multiple lamps to accomplish a single task, it is very conceivable that such a fixture will be an attractive option to many lighting designers given the proper application. While the portability and flexibility of the PWS fixtures will make analytical design tools complicated and ineffective, it is conceivable that cutsheets and/or IES files would be useful to design teams. In general, however, corporate office managers, small business owners, and contractors are the targeted audience for marketing. These individuals are less likely to use cutsheets and IES files. It may be useful to develop detailed and technical marketing material (and, perhaps, cutsheets) to assist the consumer to understand how the product they are purchasing will perform. Again, cost will be a major factor in determining market acceptance.

Recommendation: While IES files and/or cutsheets may be useful to support Project 4.4, given limited time and budget for LRP Project 6.2, AEC recommends that no design tools or case studies be developed under LRP Project 6.2 for this project. The manufacturing partner may want to provide IES files and cutsheets as part of their commercialization efforts.

LRP Project 4.5- Integrated Classroom Lighting System

The product for LRP 4.5 is an integrated classroom lighting system that combines a high performance, direct – indirect light fixture with high efficiency, Super T8 lamps, and electronic ballasts together with sensors, controls, and plug and play interconnection cables to provide excellent quality lighting, more teacher control of the lighting mode, and cut energy usage by 30 to 50 percent from current Title 24 levels. In general, every time light reflects off of a surface, a portion is absorbed or “lost.” Since light often bounces multiple times within a fixture, the amount of light that is lost becomes substantial quickly. Increasing surface reflectivity of the reflector from 86 to 97 percent, for example, generates 62 percent more light output after only four bounces. The lighting system proposed under LRP Project 4.5 delivers 25 percent more light due to a new 96 percent reflective coating combined with Super T8 lamp and ballast technology.

As LRP 4.5 Project Team notes, one of the most effective ways to encourage use of their product will be to have the manufacturer provide assistance to specifiers and engineers with respect to how to properly specify this new system. There may be some opportunities to assist with characterizing the Integrated Classroom Lighting Systems performance through computer modeling. At the very least, cutsheets and IES files could be developed to assist the specifiers to understand how this new system will perform in a given space. LRP 6.2 team members may further consult with LRP Project 4.5 project leads to see if generic modeling (modeling of “typical” or representatives space types) would provide useful information to interested specifiers as well.

Recommendation: While computer modeling of representative spaces would be useful in assisting specifier specify the system, given limited time and budget for LRP Project 6.2, AEC recommends that no such design tool be developed under LRP Project 6.2 for this project. Finelite may want to provide IES files and computer modeling as part of their commercialization efforts.

- AEC recommends that a Case Study be created under LRP Project 6.2 summarizing the energy performance and findings of the installations of the technology being advanced by LRP Project 4.5.

LRP Project 5.1- Bi-Level Stairwell Fixture Performance

Bi-level stairwell fixtures are two-lamp T8 fluorescent fixtures manufactured by LaMar Lighting. These fixtures use newly-developed dimmable ballasts capable of step-dimming the fixture from (nominal) 64W at full power to a 13 watt “standby” level, based on the response of the occupancy sensor built into each fixture. The occupancy sensors used are capable, to some degree, of detecting occupancy from floor to floor, so the sensors may detect a person entering the stairwell on the floor above and/or below depending on the stairwell configuration. Current monitoring and testing are being performed to calculate the potential energy savings of these fixtures.

Similar to the LCS being developed in LRP Project 4.1, the bi-level stairwell fixture has a very specific application. In both retrofit or new construction applications, the use of a bi-level stairwell fixture will be limited to stairwells. In this case, the function and effectiveness of the fixture (it's ability to provide sufficient light on demand while saving energy the rest of the time) will trump other design considerations. Monitored performance data will be invaluable in convincing specifiers whether or not to use the project. A design tool, however, would only have limited usefulness since installation and application of the fixture are largely pre-defined.

Recommendation: AEC recommends that no design tools be developed under LRP Project 6.2 for this project.

- AEC recommends that a Case Study be created under LRP Project 6.2 summarizing the energy performance and findings of the installations of the technology being advanced by LRP Project 5.1.

LRP Project 5.2- Electronic HID Ballasts and Controls

LRP Project 5.2 is testing and evaluating various manufactures of HID electronic ballast to assess performance. As such, this exercise is research based. Since no new technology is being developed, rather existing products are being analyzed, evaluated, and compared.

Recommendation: AEC recommends that no design tools or case studies be developed under LRP Project 6.2 for this project.

LRP Project 5.3- Low Glare Outdoor Retrofit Luminaire

LRP Project 5.3 is charged with researching, analyzing, and recommending appropriate retrofit strategies and code recommendations for lighting of parking lots in California. To this end three main energy saving strategies were addressed as potential upgrades to parking lot lighting: 1) light source efficacy improvements and lamp replacements; 2) reduced power densities; and 3) application of lighting controls (curfews). As a result of such an analysis as well as information regarding current outdoor lighting use in California, and review of the European specification to establish performance standards, the following additional energy saving strategies were suggested:

1) Light source efficacy improvements
    a) Savings from increased efficacy standards
    b) Savings from replacement of mercury vapor lamps
    c) Savings from replacement of high pressure sodium lamps
    d) Impact of standards on other lamp types
2) Power and light levels
    a) Maximum power requirements for California environmental lighting zones
    b) Comparison of existing power densities and lighting zone designations

c) Feasibility of meeting illuminance requirements under specified power densities

3) Proposed curfew requirements and potential implications

4) Glare, light pollution, and light trespass issues

In general, such discussion and research will prove invaluable in revamping the current California code for exterior lighting and greatly improving energy efficiency in this arena statewide. However, this does not seem like the proper application or project for the development of a design tool, and LRP Project 6.2 is not recommending a design tool be developed for this project.

It is important to note that in previous surveys polling design professionals, they noted the importance of vertical illuminance. Leadership in Energy and Environmental Design (LEED™) Rating System references the Illuminating Engineering Society of North America (IESNA) Recommended Practice Manual: Lighting for Exterior Environments, which includes maximum ratios for vertical illuminance.

Finally, scheduling of LRP Project 5.3 is not conducive to working with LRP Project 6.2.

Recommendation: AEC recommends that no design tools or case studies be developed under LRP Project 6.2 for this project.

LRP Project 5.4- DALI Lighting Control Device Standard Development

The DALI is a non-proprietary digital communication protocol that allows communications between a DALI ballast and the lighting system. The key features of the DALI ballast enable:

- Two-way communications for obtaining operating status and performance of luminaires.
- Individual fixture control which allows users to re-configure space lighting groups without changing the wiring, easily implement load-shedding functions, and integrate a fixture into multiple control zones.
- The user to mix and match ballasts from multiple suppliers and obtain consistent control operation.
- The elimination of costly installation errors due to reversing control wiring at ballast or control terminals.
- The easy addition of DALI-based wall controls and other devices because a two-wire communications bus is used. This feature greatly reduces labor and installation costs.

The goal of Project 5.4 is to create industry consensus among the different control manufacturers to allow for the creation of predefined messages and commands that would be embedded in the controller intelligence and allow for seamless communication between control devices and between the control device and the ballast. As such, DALI is a protocol, not a product, and industry consensus based on standardization does not require a design tool. Nevertheless, manufacturer willingness to abide by the proposed protocol will rely, somewhat, on consumer satisfaction with the product. The LRP 5.4 Project Team performed an in-depth survey polling customers about features critical to DALI market acceptance. The survey showed that occupant control, LEED certification, and Intelligent Building Operation rank as the most value features for the customer.

LRP Project 6.2 suggests a design tool might be the most useful in the form of a user guide to illustrate the system benefits to the customer. The customer or specifier will not have input regarding the specifics of the protocol. Furthermore, DALI, by its very nature is flexible and adaptable in application. If specified, therefore, it will, undoubtedly, be able to achieve the given system's requirements. The key to its success will be user acceptance. For this reason, LRP 6.2 Project Team suggests that it would be best to develop a user guide, which could inform the designer, specifier, and clients of the benefits of the system. By illustrating the ultimate flexibility of the system, the user will be able to judge whether or not such flexibility (and at what cost) merits the use of a DALI system on a given project.

<u>Recommendation</u>: Given the complex nature of the DALI technology, a user guide would be helpful for market acceptance. However, given limited time and budget for LRP Project 6.2, AEC recommends that no design tool be developed under LRP Project 6.2 for this project. The Watt Stopper may want to encourage NEMA to develop some type of users guide.

- AEC recommends that a Case Study be created under LRP Project 6.2 presenting the energy performance results and lessons learned from the installations of the DALI technology in LRP Project 5.4.

Software Tool Development

This section summarizes briefly the software tool development. The following is a list of the projects that were top candidates for the development of a software design tool:

- LRP Project 3.3 Classroom Photosensor
- LRP Project 3.1 Retrofit Fluorescent Dimming
- LRP Project 3.2 Load-shedding Technology
- LRP Project 4.5 Integrated Classroom Lighting
- LRP Project 2.1 Exterior LED Luminaires
- LRP Project 2.3 Low Profile LEDs
- LRP Project 4.4 Portable Office Lighting

In order to be responsive to schedule and budget limitations, AEC recommends that the LRP Project 3.3 Classroom Photosensor be selected the final candidate and that a software tool be developed for this project using available resources. This goal of this software tool will be to assist in the proper implementation of photosensor electric lighting control systems by providing guidance and analysis for classroom specific photosensor system design.

In order to meet the LRP schedule, it will be necessary to complete the Design Tools by October 2004. This is an aggressive schedule, particularly if creating the software tool components for the LRP Project 3.3 Classroom Photosensor. **Table 2** shows the proposed schedule to complete software development:

Table 2: Software Development Schedule

Dec, 2004	Create a Technical Advisory Group Kick Off Meeting for Conceptual Design Review of Software Tool
Feb, 2004	Beta Version of Command Line Program-- Radiance Calculation Engine

April, 2004	Working Command Line Program, Beta Version of User Interface
July, 2004	Beta Version of Final Program
Sept, 2004	Pre-Release of Program
Oct, 2004	Final Release of Program

Case Studies

As mentioned previously, AEC is responsible for writing four Case Studies to highlight and document the progress of selected LRP lighting technologies. The goal of these Case Studies is to assist in promoting the LRP lighting technologies and products in specific market segments. The technologies of LRP elements are frequently designed to target specific market segments, such as K-12 schools, commercial outdoor lighting, office lighting, stairwells, and so on. AEC will develop application-oriented case studies, based on information provided by the LRP Project Teams, on the application and performance of the LRP lighting technology and product. The following are the leading candidates for the development of case studies:

- LRP Project 2.3- LED Low Profile Fixture
- LRP Project 4.1 – Bathroom Lighting Control System
- LRP Project 4.5- Integrated Classroom Lighting System
- LRP Project 5.1- Bi-Level Stairwell Fixture Performance
- LRP Project 5.4- DALI Lighting Control Device Standard Development

The case studies will be selected from the above list. Key characteristics for selection are where sample technologies have been installed and monitored data has been gathered. Findings, lessons learned, usage data, and calculated performance will be summarized in the Case Studies.