

**Exhibit A  
SCOPE OF WORK**

**TECHNICAL TASK LIST**

<b>Task #</b>	<b>CPR</b>	<b>Task Name</b>
1	N/A	Administration
2.16	X	<del>Research and Development Activities in Lighting Efficiency</del>
3.14	X	<del>Technology Transfer Activities</del>

**KEY NAME LIST**

<b>Task #</b>	<b>Key Personnel</b>	<b>Key Subcontractor(s)</b>	<b>Key Partner(s)</b>
1	Prof. Michael Siminovitch Prof. Konstantinos Papamichael <del>Bruce Pelton</del> <b>Keith Graeber</b>	N/A	N/A
2	Prof. Michael Siminovitch Prof. Konstantinos Papamichael <del>Bruce Pelton</del> <b>Keith Graeber</b>	New Buildings Institute	3M, ACUITY GROUP, BETA LIGHTING, CAPRI LIGHTING, CREE, EXCLARA, EVERLAST, FINELITE, FULL SPECTRUM SOLUTIONS, GUTH, HADCO, HUBBELL, iCELL SYSTEMS, KUMHO, LITHONIA, LUMILEDS, LUTRON, LUXIM, MITSUBISHI SOLAR, OSRAM SYLVANIA, OSRAM OPTO. PHILIPS, SAMSUNG, SOMFY, SUNOPTICS, UBC, UNIVERSAL DEVICES, UNIVERSAL DISPLAY, WATTSTOPPER/LEGRAND PG&E, SACRAMENTO MUNICIPAL UTILITY DISTRICT, SAN DIEGO GAS AND ELECTRIC, SOUTHERN CALIFORNIA EDISON
3	Prof. Michael Siminovitch Prof. Konstantinos Papamichael <del>Bruce Pelton</del> <b>Keith Graeber</b>	N/A	DGS

## GLOSSARY

Specific terms and acronyms used throughout this work statement are defined as follows:

Acronym	Definition
AIA	American Institute of Architects
ALA	American Lighting Association
ALG	Advanced Lighting Guideline
AIM	Advanced Metering Interface
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CA	California
CCC	California Community Colleges
CCM	Commission Contract Manager
CIE	Commission Internationale de l'Éclairage ( <i>the International Commission on Illumination</i> )
CFL	Compact Fluorescent Lamp
CLTC	California Lighting Technology Center
CSU	California State University
CPR	Critical Project Review
DGS	Department of General Services
DOE	United States Department of Energy
DR	Demand Response
Energy Commission	California Energy Commission
HID	High-intensity Discharge
IALD	International Association of Lighting Designers
IESNA	Illuminating Engineering Society of North America
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
NBI	New Buildings Institute
NEMA	National Electrical Manufacturers Association
OLED	Organic Light Emitting Diode
PAC	Project Advisory Committee
PG&E	Pacific Gas and Electric
PIER	Public Interest Energy Research
PV	Photovoltaic
RD&D	Research Design and Development
SCE	Southern California Edison
SCLTC	Southern California Lighting Technology Center
SDGE	San Diego Gas & Electric
SMUD	Sacramento Municipal Utility District
UBC	University of British Columbia
UC	University of California
UCC.1	Uniform Commercial Code (Financing Statement)
UCD	University of California, Davis
UL	Underwriters Laboratories
USGBC	United States Green Building Council

## **Problem Statement**

California's legislation calls for significant increase in lighting energy efficiency with 25% target reduction in residential buildings and 50% in commercial buildings. To meet these ambitious goals California needs to develop new lighting technologies for new and retrofit applications, support market adoption and install in new and existing buildings.

Development of new technologies requires several phases, starting with initial laboratory prototypes and ending with commercial products. These phases include laboratory and field testing of laboratory and commercial prototypes and then pilot installations of commercial products to demonstrate feasibility and benefits towards market adoption, which also requires significant outreach in the form of educational and training activities.

## **Goals of the Agreement**

The goal of this Agreement is to conduct a set of research activities that follow the successful pattern the UCD California Lighting Technologies Center (CLTC) has followed since its establishment in 2004, to very effectively develop new lighting technologies and bring them to the market.

This scope of work includes a set of coordinated activities that directly support the mission of the California Energy Commission's (Energy Commission) Public Interest Energy Research (PIER), and are built on the key successes and activities of California Lighting Technology Center (CLTC) over its first four years of operation. The specific tasks have been developed directly from discussions with the Energy Commission, utility partners and with the support of the National Electrical Manufacturers Association (NEMA) directorate.

## **Objectives of the Agreement**

The objectives of this Agreement are to produce a group of products, technologies and knowledge that will meet specifically outlined PIER goals of improving energy cost/value by developing energy-efficient lighting technologies and bringing them to the market through research, development, outreach and technology transfer activities, in collaboration with the Energy Commission, California utilities, industry, and academic and professional institutions. It will also address a secondary objective of strengthening California's economy by partnering with the lighting industry, lighting professionals, the electric utility community, the building industry, the Energy Commission and other governmental agencies.

## **TASK 1.0 ADMINISTRATION**

### **MEETINGS**

#### **Task 1.1 Attend Kick-off Meeting**

The goal of this task is to establish the lines of communication and procedures for implementing this Agreement.

#### **The Contractor shall:**

- Attend a “kick-off” meeting with the Commission Contract Manager, the Contracts Officer, and a representative of the Accounting Office. The Contractor shall bring their Project Manager, Contract Administrator, Accounting Officer, and others designated by the Commission Contract Manager to this meeting. The administrative and technical aspects of this Agreement will be discussed at the meeting. Prior to the kick-off meeting, the Commission Contract Manager will provide an agenda to all potential meeting participants.

The administrative portion of the meeting shall include, but not be limited to, the following:

- Terms and conditions of the Agreement
- CPRs (Task 1.2)
- Match fund documentation (Task 1.7)
- Permit documentation (Task 1.8)

The technical portion of the meeting shall include, but not be limited to, the following:

- The Commission Contract Manager’s expectations for accomplishing tasks described in the Scope of Work;
- An updated Schedule of Deliverables
- An updated Gantt Chart
- Progress Reports (Task 1.4)
- Technical Deliverables (Task 1.5)
- Final Report (Task 1.6)
- Establish the PAC (Task 1.10)
- PAC Meetings (Task 1.11)

The Commission Contract Manager shall designate the date and location of this meeting.

#### **Contractor Deliverables:**

- An Updated Schedule of Deliverables
- An Updated Gantt Chart
- An Updated List of Match Funds
- An Updated List of Permits
- Schedule for Recruiting PAC Members

### **Commission Contract Manager Deliverables:**

- Final Report Instructions

### **Task 1.2 Critical Project Review (CPR) Meetings**

The goal of this task is to determine if the project should continue to receive Energy Commission funding to complete this Agreement and if it should, are there any modifications that need to be made to the tasks, deliverables, schedule or budget.

CPRs provide the opportunity for frank discussions between the Energy Commission and the Contractor. CPRs generally take place at key, predetermined points in the Agreement, as determined by the Commission Contract Manager and as shown in the Technical Task List above and in the Schedule of Deliverables. However, the Commission Contract Manager may schedule additional CPRs as necessary, and, if necessary, the budget will be reallocated to cover the additional costs borne by the Contractor, but the overall contract amount will not increase.

Participants include the Commission Contract Manager and the Contractor, and may include the Commission Contracts Officer, the PIER Program Team Lead, other Energy Commission staff and Management as well as other individuals selected by the Commission Contract Manager to provide support to the Energy Commission.

### **The Commission Contract Manager shall:**

- Determine the location, date and time of each CPR meeting with the Contractor. These meetings generally take place at the Energy Commission, but they may take place at another location.
- Send the Contractor the agenda and a list of expected participants in advance of each CPR. If applicable, the agenda shall include a discussion on both match funding and permits.
- Conduct and make a record of each CPR meeting. One of the outcomes of this meeting will be a schedule for providing the written determination described below.
- Determine whether to continue the project, and if continuing, whether or not to modify the tasks, schedule, deliverables and budget for the remainder of the Agreement, including not proceeding with one or more tasks. If the Commission Contract Manager concludes that the project needs a formal amendment or that satisfactory progress is not being made and the project needs to be ended, these conclusions will be referred to the Commission's Research, Development and Demonstration Policy Committee for its concurrence.
- Provide the Contractor with a written determination in accordance with the schedule. The written response may include a requirement for the Contractor to revise one or more deliverable(s) that were included in the CPR.

**The Contractor shall:**

- Prepare a CPR Report for each CPR that discusses the progress of the Agreement toward achieving its goals and objectives. This report shall include recommendations and conclusions regarding continued work of the projects. This report shall be submitted along with any other deliverables identified in this Scope of Work. Submit these documents to the Commission Contract Manager and any other designated reviewers at least 15 working days in advance of each CPR meeting.
- Present the required information at each CPR meeting and participate in a discussion about the Agreement.

**Contractor Deliverables:**

- CPR Report(s)
- CPR deliverables identified in the Scope of Work

**Commission Contract Manager Deliverables:**

- Agenda and a List of Expected Participants
- Schedule for Written Determination
- Written Determination

**Task 1.3 Final Meeting**

The goal of this task is to closeout this Agreement.

**The Contractor shall:**

- Meet with the Energy Commission to present the findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement.
- This meeting will be attended by, at a minimum, the Contractor, the Commission Contracts Officer, and the Commission Contract Manager. The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be two separate meetings at the discretion of the Commission Contract Manager.
- The technical portion of the meeting shall present findings, conclusions, and recommended next steps (if any) for the Agreement. The Commission Contract Manager will determine the appropriate meeting participants.
- The administrative portion of the meeting shall be a discussion with the Commission Contract Manager and the Contracts Officer about the following Agreement closeout items:
  - What to do with any state-owned equipment (Options)
  - Need to file UCC.1 form re: Energy Commission's interest in patented technology
  - Energy Commission's request for specific "generated" data (not already provided in Agreement deliverables)
  - Need to document Contractor's disclosure of "subject inventions" developed

- under the Agreement
- “Surviving” Agreement provisions, such as repayment provisions and confidential deliverables
- Final invoicing and release of retention
- Prepare a schedule for completing the closeout activities for this Agreement.

**Deliverables:**

- Written documentation of meeting agreements and all pertinent information
- Schedule for completing closeout activities

**REPORTING**

**See Exhibit D, Reports/Deliverables/Records.**

**Task 1.4 Monthly Progress Reports**

The goal of this task is to periodically verify that satisfactory and continued progress is made towards achieving the research objectives of this Agreement.

**The Contractor shall:**

- Prepare progress reports which summarize all Agreement activities conducted by the Contractor for the reporting period, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Each progress report is due to the Commission Contract Manager within 10 working days after the end of the reporting period. Attachment A-2, Progress Report Format, provides the recommended specifications.

**Deliverables:**

- Monthly Progress Reports

**Task 1.5 Test Plans, Technical Reports and Interim Deliverables**

The goal of this task is to set forth the general requirements for submitting test plans, technical reports and other interim deliverables, unless described differently in the Technical Tasks. When creating these deliverables, the Contractor shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

<http://www.energy.ca.gov/contracts/pier/contractors/index.html>

**The Contractor shall:**

- Unless otherwise directed in this Scope of Work, submit a draft of each deliverable listed in the Technical Tasks to the Commission Contract Manager for review and comment in accordance with the approved Schedule of Deliverables. The

Commission Contract Manager will provide written comments back to the Contractor on the draft deliverable within 10 working days of receipt. Once agreement has been reached on the draft, the Contractor shall submit the final deliverable to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final deliverable within 5 working days of receipt. Key elements from this deliverable shall be included in the Final Report for this project.

### **Task 1.6 Final Report**

The goal of this task is to prepare a comprehensive written Final Report that describes the original purpose, approach, results and conclusions of the work done under this Agreement. The Commission Contract Manager will review and approve the Final Report. The Final Report must be completed on or before the termination date of the Agreement. When creating these deliverables, the Contractor shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

<http://www.energy.ca.gov/contracts/pier/contractors/index.html>

The Final Report shall be a public document. If the Contractor has obtained confidential status from the Energy Commission and will be preparing a confidential version of the Final Report as well, the Contractor shall perform the following tasks for both the public and confidential versions of the Final Report.

#### **The Contractor shall:**

- Prepare a draft outline of the Final Report.
- Submit the draft outline of Final Report to the Commission Contract Manager for review and approval. The Commission Contract Manager will provide written comments back to the Contractor on the draft outline within 10 working days of receipt.
- Once agreement has been reached on the draft, the Contractor shall submit the final outline to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final outline within 5 working days of receipt.
- Prepare the draft Final Report for this Agreement in accordance with the approved outline.
- Submit the draft Final Report to the Commission Contract Manager for review and comment. The Commission Contract Manager will provide written comments within 10 working days of receipt. The Final Report will cover the entire program (Tasks 1-3) of this Agreement, with individual appendices for each project of Task 2. The project-level appendices will be prepared so as to also serve as stand-alone documents on the model of the overall program Final Report.
- Once agreement on the draft Final Report has been reached, the Commission Contract Manager shall forward the electronic version of this report for Energy Commission internal approval. Once the approval is given, the Commission Contract Manager shall provide written approval to the Contractor within 5 working days.

- Submit one bound and one electronic disk copy of the Final Report with the final invoice.

**Deliverables:**

- Draft Outline of the Final Report
- Final Outline of the Final Report
- Draft Final Report
- Final Report

**MATCH FUNDS, PERMITS, AND ELECTRONIC FILE FORMAT**

**Task 1.7 Identify and Obtain Matching Funds**

The goal of this task is to ensure that the match funds planned for this Agreement are obtained for and applied to this Agreement during the term of this Agreement.

The costs to obtain and document match fund commitments are not reimbursable through this Agreement. While the PIER budget for this task will be zero dollars, the Contractor may utilize match funds for this task. Match funds shall be spent concurrently or in advance of PIER funds during the term of this Agreement. Match funds must be identified in writing, and the associated commitments obtained before the Contractor can incur any costs for which the Contractor will request reimbursement.

**The Contractor shall:**

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting:
  1. If no match funds were part of the proposal that led to the Energy Commission awarding this Agreement and none have been identified at the time this Agreement starts, then state such in the letter.
  2. If match funds were a part of the proposal that led to the Energy Commission awarding this Agreement, then provide in the letter:
    - A list of the match funds that identifies the:
      - Amount of each cash match fund, its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied.
      - Amount of each in-kind contribution, a description, documented market or book value, and its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Contractor shall identify its owner and provide a contact name, address and telephone number, and the address where

the property is located.

- A copy of the letter of commitment from an authorized representative of each source of cash match funding or in-kind contributions that these funds or contributions have been secured.
- Discuss match funds and the implications to the Agreement if they are significantly reduced or not obtained as committed, at the kick-off meeting. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide the appropriate information to the Commission Contract Manager if during the course of the Agreement additional match funds are received.
- Notify the Commission Contract Manager within 10 working days if during the course of the Agreement existing match funds are reduced. Reduction in match funds may trigger an additional CPR.

**Deliverables:**

- A letter regarding Match Funds or stating that no Match Funds are provided
- Letter(s) for New Match Funds
- A copy of each Match Fund commitment letter
- Letter that Match Funds were Reduced (if applicable)

**Task 1.8 Identify and Obtain Required Permits**

The goal of this task is to obtain all permits required for work completed under this Agreement in advance of the date they are needed to keep the Agreement schedule on track.

Permit costs and the expenses associated with obtaining permits are not reimbursable under this Agreement. While the PIER budget for this task will be zero dollars, the Contractor shall show match funds for this task. Permits must be identified in writing and obtained before the Contractor can incur any costs related to the use of the permits for which the Contractor will request reimbursement.

**The Contractor shall:**

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting:
  1. If there are no permits required at the start of this Agreement, then state such in the letter.
  2. If it is known at the beginning of the Agreement that permits will be required during the course of the Agreement, provide in the letter:

- A list of the permits that identifies the:
    - Type of permit
    - Name, address and telephone number of the permitting jurisdictions or lead agencies
  - Schedule the Contractor will follow in applying for and obtaining these permits.
- The list of permits and the schedule for obtaining them will be discussed at the kick-off meeting, and a timetable for submitting the updated list, schedule and the copies of the permits will be developed. The implications to the Agreement if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in the progress reports and will be a topic at CPR meetings.
  - If during the course of the Agreement additional permits become necessary, then provide the appropriate information on each permit and an updated schedule to the Commission Contract Manager.
  - As permits are obtained, send a copy of each approved permit to the Commission Contract Manager.
  - If during the course of the Agreement permits are not obtained on time or are denied, notify the Commission Contract Manager within 5 working days. Either of these events may trigger an additional CPR.

**Deliverables:**

- A letter documenting the Permits or stating that no Permits are required
- Updated list of Permits as they change during the Term of the Agreement
- Updated schedule for acquiring Permits as it changes during the Term of the Agreement
- A copy of each approved Permit

**Task 1.9 Electronic File Format**

The goal of this task is to unify the formats of electronic data and documents provided to the Energy Commission as contract deliverables. Another goal is to establish the computer platforms, operating systems and software that will be required to review and approve all software deliverables.

**The Contractor shall:**

- Deliver documents to the Commission Contract Manager in the following formats:
- Data sets shall be in Microsoft (MS) Access or MS Excel file format.
- PC-based text documents shall be in MS Word file format.
- Documents intended for public distribution shall be in PDF file format, with the native file format provided as well.

- Project management documents shall be in MS Project file format.
- Request exemptions to the electronic file format in writing at least 90 days before the deliverable is submitted.

**Deliverables:**

- Electronic versions of documents as applicable
- A letter requesting exemption from the Electronic File Format (if applicable)

**Program Advisory Committee (PAC)**

**Task 1.10 Establish the PAC**

The goal of this task is to create an advisory committee for this Agreement.

The PAC should be composed of diverse professionals. The number can vary depending on potential interest and time availability. The Contractor’s Project Manager and the Commission Contract Manager shall act as co-chairs of the PAC. The exact composition of the PAC may change as the need warrants. PAC members serve at the discretion of the Commission Contract Manager.

The PAC may be composed of qualified professionals spanning the following types of disciplines:

- Researchers knowledgeable about the project subject matter
- Members of the trades who will apply the results of the project (e.g., designers, engineers, architects, contractors, and trade representatives)
- Public Interest Market Transformation Implementers
- Product Developers relevant to project subject matter
- U.S. Department of Energy Research Manager
- Public Interest Environmental Groups
- Utility Representatives
- Members of the relevant technical society committees

The PAC will be structured to allow for subgroups of technical advisors oriented around the three broad subject areas of Task 2: daylighting, interior lighting and exterior lighting as indicated in the following tables (final confirmation will occur per Task 1.10 as noted below):

**PAC: Daylighting Advisors: Tasks 2,1, 2.2, 2.3, 2.4, 2.5**

Name	Affiliation
Dr.Moji Navvab	University of Michigan
Judie Porter	Architectural Energy Corp

Francis Rubinstein	Lawrence Berkeley National Laboratory
Bill Starr	UC Davis
George Loisos	Loisos+Ubbelohde
Lisa Heschong	Heschong Mahone Group
Abby Vogen, Rick Mistrick, Marilyn Andersen	Energy Ctr of Wisc. Penn State U  MIT

**PAC: Exterior Lighting Advisors: Tasks 2.6, 2.7, 2.8, 2.9**

<b>Name</b>	<b>Affiliation</b>
Nancy Clanton	Clanton Assoc.
Ralph Williams	Wal-Mart
Karl Johnson	CIEE;
Len Pettis	CSU
Michael Barber	Municipality of Anchorage
Jim Benya	Benya Lighting Design
Ronald Gibbons	Virginia Tech
Chris Cioni	UC Davis
Dave Bisbee	SMUD

**PAC: Interior Lighting Advisors Task 2.910, 2.11, 2.12, 2.13, 2.14**

<b>Name</b>	<b>Affiliation</b>
Jim Benya	Benya Lighting Design

Dr. Sam Berman	Lawrence Berkeley National Laboratory
Connie Samla,	SMUD
Ron Runkles,	NEMA
Mike Niels,	MN Engineering
Carol Jones,	PNNL
Kevin Hauser,	University of Pennsylvania,
Dale Tiller,	University of Nebraska
Peter Ngai,	Peerless
Terry Clark	Finelight
Mary Matteson Bryan	PG & E
William Semmes	DGS
Doug Avery	SCE

The purpose of the PAC is to:

- Provide overall guidance in research direction. The guidance may include scope of research; research methodologies; timing; coordination with other research. The guidance may be based on:
  - technical area expertise
  - knowledge of market applications
  - linkages between the agreement work and other past, present or future research (both public and private sectors) they are aware of in a particular area.
- Review deliverables. Provide specific suggestions and recommendations for needed adjustments, refinements, or enhancement of the deliverables.
- Evaluate tangible benefits to California of this research and provide recommendations, as needed, to enhance tangible benefits.
- Provide recommendations regarding information dissemination, market pathways or commercialization strategies relevant to the research products.

**The Contractor shall:**

- Prepare a draft list of potential PAC members that includes name, company, physical and electronic address, and phone number and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting. This list will

be discussed at the kick-off meeting and a schedule for recruiting members and holding the first PAC meeting will be developed.

- Recruit PAC members and ensure that each individual understands the member obligations described above, as well as the meeting schedule outlined in Task 1.11.
- Prepare the final list of PAC members.
- Submit letters of acceptance or other comparable documentation of commitment for each PAC member.

**Deliverables:**

- Draft List of PAC Members
- Final List of PAC Members
- Letters of acceptance, or other comparable documentation of commitment for each PAC Member

**Task 1.11 Conduct PAC Meetings**

The goal of this task is for the PAC to provide strategic guidance to this project by participating in regular meetings or teleconferences.

**The Contractor shall:**

- Discuss the PAC meeting schedule, keyed to the PAC activities in Task 2, at the kick-off meeting.
- Determine the number of face-to-face meetings and teleconferences and the location of PAC meetings in consultation with the Commission Contract Manager. This draft schedule shall be presented to the PAC members (see Task 1.10) during recruiting and finalized at the first PAC meeting.
- Organize and lead PAC meetings in accordance with the schedule. Changes to the schedule must be pre-approved in writing by the Commission Contract Manager.
- Prepare PAC meeting agenda(s) with back-up materials for agenda items.
- Prepare PAC meeting summaries, including recommended resolution of major PAC issues.

**Deliverables:**

- Draft PAC Meeting Schedule
- Final PAC Meeting Schedule
- PAC Meeting Agenda(s) with Back-up Materials for Agenda Items
- Written PAC meeting summaries, including recommended resolution of major PAC issues

**TECHNICAL TASKS**

The Contractor shall prepare all deliverables in accordance with the requirements in Task 1.5. Deliverables not requiring a draft version are indicated by marking “(no draft)” after the deliverable name.

The Contractor shall engage Minor Subcontractors pursuant to State Contract Manual Section 3.06 Agreements with Other Governmental Entities and Public Universities (Rev 10/05). Draft subcontracts, along with explanations of how the Section 3.06 requirements have been met, shall be submitted to the Commission Contract Manager for approval.

## **Task 2 Research and Development Activities in Lighting Efficiency**

The goal of this task is to develop new energy-efficient lighting products and bring them to the market in partnerships with industry, California utilities and large end users. Through extended interactions with these partners, CLTC proposes to focus on the development and commercialization of a portfolio of new technologies, considering potential energy savings and probability for technical and market penetration success. The process for the development of each technology involves a series of steps that start with development of laboratory prototypes, proceeds with development of commercial prototypes and ends with development of commercial products. The process involves extensive testing and evaluation, initially in the laboratory and then in the field. Each technology will eventually be targeted for inclusion in the Emerging Technologies portfolios of the CA utilities, codes and standards process, as well as educational and training programs.

The devices specified in Task 2.1 and possibly that in Task 2.3 are covered by three US Patent applications filed in the pursuit of research under BERG 54919A/06-07B. The licensing provisions of these patents make provisions for up to four non-exclusive licensees. Two companies (The Watt Stopper/Legrand and Axis Technologies) have licensed these patents. Under the terms of the license the companies pay an initial license fee and subsequent royalties to the University of California. The technology in Task 2.2 is subject to an invention disclosure filed with the University of California. Any additional intellectual property that comes from the research funded by this Interagency Agreement will be handled in a similar fashion. Intellectual property created solely by University researchers will be licensed according to the regulations of the University of California. The normal practice is to offer the first such license to the commercial partner(s) on such project. If the commercial partners choose not to pursue such licensure the technology is then offered to other firms in the field to be licensed on a competitive basis. In cases where the commercial partner contributes to the IP formation the University and the commercial partner will jointly seek patent or trade secret protection for the developed technology. The University will license its portion to the commercial partner in return for a license fee and ongoing royalties. The University has an obligation to pay royalties to the Energy Commission pursuant to the terms of its earlier agreements with the Energy Commission and the terms of this Agreement (Exhibit E, Provision 4).

### **Task 2.1 Commercial Dual Loop Lighting Controls for Skylight Applications**

The 2008 version of Non Residential Title-24 Standards requires use of skylights in commercial building spaces larger than 8,000 sq ft, i.e., most of the big box, warehouse and office buildings in California. Reliable, cost-effective control of electric lighting

based on available daylight is critical for the success of this measure. Current sensor/control technologies do not provide reliable, sustained operation in cost-effective ways.

CLTC has developed laboratory prototypes of a new electric lighting control system for daylight harvesting in skylight applications. The new system offers increased reliability through use of two differently-purposed photo sensors for the determination of indoor daylight levels and decreased cost through automatic, continuous monitoring.

The CLTC laboratory prototype, currently being field-tested in the West Sacramento Wal-Mart store, has demonstrated very successful performance. This task will focus on bringing this new technology to the market through the development of commercial products, in collaboration with manufacturing partners such as Watt Stopper/Legrand, test bed participants such as Wal-Mart, and California utilities such as PG&E and SMUD.

### **The Contractor shall:**

- Work with manufacturing partners such as Watt Stopper/Legrand to develop commercial prototypes of the dual loop photosensing control technology for field-testing in big box retail stores to validate the approach and algorithms, summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Watt Stopper/Legrand, test bed participants such as a Wal-Mart store in the utility partner such as PG&E territory, and a big box retailer in the SMUD territory to install commercial prototypes and monitoring equipment in the field, summarize task results in a memorandum on task activity and lessons learned.
- Monitor the operation of the commercial prototypes by collecting data on electric lighting output, and overall light levels to evaluate energy, luminous performance, and end-user satisfaction and summarize task results in a memorandum on task activity and lessons learned.
- Based on the results from previous activity in Task 2.1 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned.
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.1 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities consistent with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10 - determine steps that will lead to the manufacturing of the technology products developed in this project or to the commercialization of the project's results.
- Prepare a report describing all task activities and findings, including final specifications of technology and results from laboratory, field testing, and cost

effectiveness. This task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverables:**

- 1-2 page memorandum as to field-test ready prototypes.
- 1-2 page memorandum as to installation of commercial prototypes in the field
- 1-2 page memorandum as to documentation of monitored performance
- 1-2 page memorandum for PAC review as to commercial product specification
- Revised specification as per PAC review
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix

**Task 2.2 Smart Windows & Skylights**

This project will develop a prototype for a new generation of automated operable (AKA “Smart”) windows and skylights in collaboration with manufacturing partners such as Lutron, SOMFY and fenestration manufacturers, as well as CA utilities. The smart window and skylight systems will include multiple interior and exterior sensors (e.g., for temperature, occupancy, light, humidity, etc.) and integrated electronics that execute algorithms to maximize energy efficiency as well as comfort through smart operation of the operable fenestration system.

A key element of the proposed Smart Windows and Skylights is the integration of occupancy sensing, which allows for very different operation during occupied and unoccupied times. Just as occupancy sensors are used to turn off electric lights when no one is in the space, they can be used to adjust operable fenestration systems to minimize heat losses or gains depending on interior and exterior conditions, e.g., indoor and outdoor temperature, solar heat gain, etc., read by the integrated sensors and integrated with the other building systems, sensors and rules trees.

The operable elements will include shading systems, e.g. venetian blinds, and screens, for control of solar heat gain and glare, and ventilation systems, e.g., vents and fans, for natural ventilation and cooling. The sensors will include occupancy/vacancy sensors for occupancy detection, photo sensors for interior and exterior light levels, air temperature sensors for interior and exterior temperature levels, humidity sensors for interior and exterior humidity, and radiant temperature sensors for solar heat gain.

For the purposes of the proposed prototype, the controller will be implemented using a computer that executes the control algorithms. Commercial versions will have the algorithms encoded in micro-controllers that are integrated in the fenestration system. The control logic will mimic what smart humans would do, if they were continuously monitoring sensor input, e.g.:

- Operate vents and fans based on outdoor and indoor temperature, to maximize natural ventilation and cooling.
- In the absence of occupants, minimize solar heat gain during cooling seasons by maximizing shading, even if it will eliminate daylight in the space and the electric lights are off by rule.
- In the presence of occupants optimize daylight penetration for comfort and energy savings through electric lighting controls. The amount of permissible daylighting can be set by rule.

The prototype will be tested in the laboratory, using two controllable chambers to represent the interior and exterior fenestration environments.

**The Contractor shall:**

- Design and build Smart Windows and Skylights, which will include shading, vents, fans, light and temperature sensors, all connected to a computer that receive sensor signals and sends operation commands for lighting, shading, and ventilation and summarize task results in a memorandum on task activity and lessons learned.
- Design and build two chambers, one on each side of the Smart Windows and Skylights prototype, which will include light sources and heat lamps to control light levels and temperatures in each chamber. A high intensity light source will be used to simulate direct solar radiation in the exterior chamber. A switch will be used to simulate occupancy in the interior chamber and summarize task results in a memorandum on task activity and lessons learned.
- Develop control algorithms for the automatic operation of the Smart Windows and Skylights system and summarize task results in a memorandum on task activity and lessons learned
- Demonstrate the Smart Windows and Skylights to window and skylight manufacturers and form partnerships for the development of commercial products and summarize task results in a memorandum on task activity and lessons learned.
- Estimate energy savings from operation of smart fenestration systems considering various California climates and occupancy scenario and summarize task results in a memorandum on task activity and lessons learned.
- Assist manufacturing partners such as (Lutron, SOMFY), and fenestration manufacturers to develop commercial Smart Windows and Skylight prototypes and summarize task results in a memorandum on task activity and lessons learned.
- Work with California utilities and the PAC to test and evaluate the commercial prototypes in the field towards verification of energy savings and refinement of controls and control algorithms and summarize task results in a memorandum on task activity and lessons learned.
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.2 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.

- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.910
- Prepare a report describing all task activities and findings, including final specifications of technology and results from laboratory and field testing and cost effectiveness. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to laboratory prototype
- 1-2 page memorandum as to laboratory testing environment
- 1-2 page memorandum as to control algorithms
- 1-2 page memorandum as to demonstration of smart fenestration operation
- 1-2 page memorandum as to estimation of energy savings
- 1-2 page memorandum as to commercial prototypes
- 1-2 page memorandum as to installation of commercial prototypes in the field
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix

**Task 2.3 Dual Photosensor Controls for Side-Daylighting Applications**

This objective of this project is to develop dual photo sensor control systems for side-daylighting applications, in collaboration with manufacturing partners such as Watt Stopper/Legrand and Southern California Edison. Dual photo sensor controls for electric lighting in daylit spaces show significant promise for increased reliability and cost-effectiveness. CLTC has developed a dual-loop control system specifically for skylight applications, in collaboration with manufacturing partners such as Watt Stopper/Legrand and test bed participants such as Wal-Mart (see Task 2.1).

Implementation in skylight applications is relatively easier than in side-daylighting applications, mainly because the two sensors can be part of a single unit placed under a skylight. In side-daylighting applications the two sensors may be in separate locations and their signal may be affected with window and shading systems operation. Moreover, a single outdoor sensor can serve as one of the two sensors for all daylit spaces, greatly reducing the overall cost of dual sensor controls for daylighting.

**The Contractor shall:**

- Design dual-sensors for side-daylit spaces, which will include consideration of alternative sensor positions, view directions, and angular sensitivities and summarize task results in a memorandum on task activity and lessons learned.
- Develop laboratory prototypes of the most promising designs and summarize task results in a memorandum on task activity and lessons learned.

- Test the laboratory prototypes to ensure proper operation under intentional attempts to make them fail, modifying the technology accordingly towards final specifications and control algorithms for commercial products and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Watt Stopper/Legrand to develop viable commercial versions of the technology suitable for field testing and evaluation and summarize task results in a memorandum on task activity and lessons learned
- Work with manufacturing partners such as Watt Stopper/Legrand and California Utilities such as Southern California Edison to install commercial prototypes and test them in the field and summarize task results in a memorandum on task activity and lessons learned.
- Based on the results from the previous activity in Task 2.3 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned. Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.3 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.910.
- Prepare a report describing all task activities and findings, including final specifications of technology and results from laboratory, field testing and cost effectiveness. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to dual sensor alternative designs
- 1-2 page memorandum as to laboratory prototypes
- 1-2 page memorandum as to Test Laboratory Prototypes
- 1-2 page memorandum as to commercial prototypes
- 1-2 page memorandum as to testing of commercial prototypes
- 1-2 page memorandum for PAC review as to commercial product specification
- Revised specification as per PAC review
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix

**Task 2.4 Daylight Optimization for Skylight Applications**

One of the most common problems in skylight applications is glare due to high luminance ratios between bright skylight glazing and relatively darker ceiling or interior

roof surfaces. Moreover, excessive daylight contributes to increased solar heat gain, compromising the electric lighting savings.

CLTC will collaborate with test bed partners like Wal-Mart, manufacturing partners such as Sunoptics, and California utilities such as SCE and PG&E to develop technologies that reducing the glare from skylights by filtering and redirecting a fraction of the incoming daylight towards the ceiling, as well as technologies that automatically adjust the transmission of skylights, modulating the incoming daylight to control incoming daylight and associated solar heat gain. This technology will be incorporated into the structure and design of next generation skylights rather than being add-on devices.

**The Contractor shall:**

- Work with test bed partners such as Wal-Mart and California utilities such as SCE and PG&E to select test bed participants such as Wal-Mart stores and other commercial spaces with skylights for testing and evaluation of new technologies and summarize task results in a memorandum on task activity and lessons learned.
- Work with test bed partners such as Wal-Mart and California utilities such as SCE and PG&E to measure and evaluate the luminous and energy performance of the existing skylights in the selected test sites and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Lutron and Sunoptics to develop fixed technologies involving optics within or below the skylight well that redirect some of the incoming daylight to illuminate the ceiling area so as to reduce contrast and associated glare and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Lutron and Sunoptics to develop operable technologies that automatically modulate the incoming daylight to reduce excessive daylight (non-shadowing methods) and associated solar heat gains and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Sunoptics and Lutron to develop commercial prototypes of developed technologies and summarize task results in a memorandum on task activity and lessons learned.
- Work with Wal-Mart, manufacturing partners such as Sunoptics, California utilities such as SCE, and PG&E to install the new technologies in the selected test sites for testing and evaluation and summarize task results in a memorandum on task activity and lessons learned.
- Measure and evaluate the performance of the new technologies with respect to daylight levels and glare, as well as increased energy savings through automatic modulation of skylight transmittance and summarize task results in a memorandum on task activity and lessons learned.
- Based on the results of the automated operable technologies, estimate energy savings and cost effectiveness and summarize task results in a memorandum on task activity and lessons learned.
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.4 to market consistent with achievement of project task goals.

- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.
- Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory and field testing and cost effectiveness. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to selection of testing sites
- 1-2 page memorandum as to performance of existing skylights
- 1-2 page memorandum as to glare-reducing technologies
- 1-2 page memorandum as to operable daylight modulation technologies
- 1-2 page memorandum as to commercial prototypes
- 1-2 page memorandum as to Installation of new technologies in the field
- 1-2 page memorandum as to performance of operable systems
- 1-2 page memorandum as to energy savings and cost-effectiveness of daylight modulation technologies
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix

**Task 2.5 Solar Canopy for Core Daylighting**

Researchers at the University of British Columbia (UBC) have developed “Solar Canopy”, a combination of moveable and fixed mirrors with a horizontal light-pipe that redirects and distributes direct sunlight into the core of multistory buildings. The light pipe is integrated with fluorescent lighting, which is automatically dimmed based on available sunlight. Solar Canopy is currently being demonstrated at a UBC campus building in Vancouver, B.C.

This kind of system is feasible today because of the relatively recent availability of films with very high reflectance that line the light distribution channel. The particular solution that the researchers at UBC developed has a very efficient system for distributing light throughout the building. Potential benefits include reduction in use of electric lighting, both overall and during periods of peak electricity usage, and better psychological connection of occupants to exterior conditions.

CLTC will collaborate with UBC, manufacturing partners such as 3M, and test bed participants such as UC Davis to test the feasibility of this system for the mid-Central Valley latitude and climate, by installing it at a building at UCD and monitoring its

performance for a period of time long enough to allow for estimation of annual performance on comfort, energy and peak electricity demand.

**The Contractor shall:**

- Collaborate with UBC and UCD to install the Solar Canopy system at an appropriate testing site at UCD and ensure proper operation and summarize task results in a memorandum on task activity and lessons learned.
- Instrument the test site to allow collection of vital data and summarize task results in a memorandum on task activity and lessons learned.
- Develop testing protocols in collaboration with UBC, and monitor performance over a solstice-to-solstice period to enable evaluation of annual performance, including an equinox and the summer and winter solstices, so as to understand the system's performance vs. the ecliptic and summarize task results in a memorandum on task activity and lessons learned.
- Analyze the monitored performance data and use them with mathematical models for estimation of annual energy savings and peak demand reduction and summarize task results in a memorandum on task activity and lessons learned.
- Evaluate the cost effectiveness of Solar Canopy based on the annual performance evaluation and the potential for reduced product and installation costs through commercial production and summarize task results in a memorandum on task activity and lessons learned.
- Based on the results from the previous activity in Task 2.5 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.5 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.
- Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory, field testing, maintenance and durability issues and cost effectiveness. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to Installation at UCD campus building
- 1-2 page memorandum as to test site instrumentation
- 1-2 page memorandum as to testing protocols and performance monitoring
- 1-2 page memorandum as to performance evaluation
- 1-2 page memorandum to cost-effectiveness
- 1-2 page memorandum for PAC review as to commercial product specification
- Revised specification as per PAC review

- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix

## **Task 2.6 Develop Exterior Lighting Technologies - High-efficiency Bi-level Smart Wall Packs**

Most commercial and industrial buildings have exterior wall-mounted fixtures used for common area and security lighting. These fixtures commonly operate over extended hours. The most common light sources in these fixtures are high-pressure sodium and mercury vapor, both of which have poor color rendering and little or no controllability. Typical optical systems simply spray the light sideways and upwards, creating more light pollution and glare than effective illumination. CLTC demonstrated optical controls on wall packs using conventional light sources as part of PIER research in the 2002-2009 program (contracts 500-01-041 and UC MR-044). LEDs and induction lamps can offer greater efficiency, color rendering and controllability both optically and in combination with occupancy and photo sensors.

CLTC will work with manufacturing partners such as Guth Lighting and Lumileds to develop new LED wall-packs with integrated optics and controls and with manufacturing partners such as Everlast to develop new Induction wall-packs with integrated optics and controls. These luminaires will direct light where needed, providing occupancy-based bi-level control. Focusing the light where needed can result in significant energy savings and occupancy based bi-level controls can provide even higher energy savings. The fixtures will be demonstrated at test bed participants such as UC, CSU, and CCC campuses with California utilities such as PG&E and SCE.

### **The Contractor shall:**

- Work with test bed partners such as UC, CSU, CCC, California utilities such as PG&E and SCE, to identify and select representative test sites for testing and evaluation of new technologies and summarize task results in a memorandum on task activity and lessons learned.
- Measure the performance of the existing wall packs with respect to hours of operation, energy requirements, and light distribution and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Guth and Everlast to develop enhanced LED and induction luminaires with optical controls that distribute light where needed, greatly reducing energy requirements and light pollution. The new luminaires will include occupancy, daylight, and DR controls and summarize task results in a memorandum on task activity and lessons learned.
- Develop suitable control systems for the new luminaires and modifications of ballasts and drivers to institute bi-level control and summarize task results in a memorandum on task activity and lessons learned.

- Construct sample functional fixtures (laboratory prototypes) with integrated controls that will be usable for on-site performance analysis (field evaluations) and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Guth, Everlast, test bed participants such as UC, CSU, CCC, California utilities such as PG&E, and SCE to install the new luminaires in the test locations and summarize task results in a memorandum on task activity and lessons learned.
- Measure and evaluate the performance of the new luminaires with respect to energy requirements, light distribution, and controls operation and summarize task results in a memorandum on task activity and lessons learned.
- Based on the results from the previous activity in Task 2.6 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned.
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.6 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.
- Prepare a report describing all activities and findings, including final specifications of technology, results from laboratory, field testing and cost effectiveness when compared to conventional technology. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum regarding test locations
- 1-2 page memorandum regarding existing lighting performance
- 1-2 page memorandum regarding new LED/luminaires
- 1-2 page memorandum as to new control systems
- 1-2 page memorandum as to lab prototypes
- 1-2 page memorandum as to new luminaires in test locations
- 1-2 page memorandum as to performance evaluation
- 1-2 page memorandum for PAC review as to commercial product specification
- Revised specification as per PAC review
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix

**~~Task 2.7 LED / Induction Longevity in Exterior Applications~~**

Both LEDs and induction lamps promise longevity far beyond that of conventional discharge lamps. In many cases, the financial viability of such fixtures is based on long life and low maintenance. With these new technologies, manufacturers are offering luminaires with a service life of up to 25 years. If insects penetrate the housing, hatch and die there, the light output may be reduced. If birds defecate or nest on top of LED heat sinks, the thermal performance will certainly be compromised. Existing UL standards evaluate polymers for flammability, dielectric and structure, not for optical properties through 25 years of UV exposure in places like Southern California.

CLTC will collaborate with manufacturing partners such as Beta Lighting, Full Spectrum Solutions and California utilities such as SCE, to evaluate the ability of current range of exterior induction and LED luminaires to sustain light output after extended exposure to ozone, insects, dirt, extended high levels of UV radiation and bird nests.

### **The Contractor shall:**

- Work with manufacturing partners such as Beta Lighting, Full Spectrum Solutions, Inc., and California utilities such as SCE to test fixtures through prolonged UV exposure that would be expected over anticipated life in various climates. This test will be conducted in short-art chambers that provide accelerated UV degradation, equivalent of many years of sun exposure, and will focus on measuring effects on light output and mechanical integrity and summarize task results in a memorandum on task activity and lessons learned
- Work with manufacturing partners such as Beta Lighting, Full Spectrum Solutions, Inc., and California utilities such as SCE to test fixtures exposed to insect populations such as those that would be expected over the projected life of the fixture. Measurements will be focused on evaluating the thermal and optical consequences of insect infiltration, which will then be projected over the effective lamp life to estimate effects over time. The UC Davis Entomology Department will advise on the type and make-up of insect populations throughout California's microclimates and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Beta Lighting, Full Spectrum Solutions, Inc., and California utilities such as SCE to test the effect of dirt, pollutants, environmental moisture, salt air and particulate matter (i.e. soot, tire dust), debris, and nesting materials on optical and thermal properties, which will be used with quality engineering standards to determine effective life projections of light output and probability for failure of electronics and LED and induction lamp degradation due to increased stress or optical deterioration and summarize task results in a memorandum on task activity and lessons learned.
- Based on the results from the previous activity in Task 2.7 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.7 to market consistent with achievement of project task goals.

- ~~Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.~~
- ~~Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post-Contract Support Strategies described in Task 3.10.~~
- ~~Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory, field testing and cost effectiveness. Final task report will serve as a standalone appendix to the Final Report for the overall project.~~

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**Deliverable:**

- ~~1-2 page memorandum as to UV effects testing protocol and setup, UV effects results~~
- ~~1-2 page memorandum as to Insect effects testing protocol and setup, Insect effects results~~
- ~~1-2 page memorandum as to Dirt, debris and nesting effects testing protocol and setup, Dirt, debris and nesting effects results~~
- ~~1-2 page memorandum for PAC review as to commercial product specification~~
- ~~Revised specification as per PAC review~~
- ~~Project-level Market Connections Deliverables per Task 3~~
- ~~Project-level Technology Transfer Deliverables per Task 3~~
- ~~Project-level Production Readiness Plan Deliverables per Task 3~~
- ~~Final Report Appendix~~

**Task 2.8 Smart Exterior Dark-Sky Friendly, Historically-accurate Lighting**

Many community test bed participants such as Huntington Beach, Pasadena, San Diego, San Francisco, Pleasanton, Santa Clara, Coalinga, Fresno, etc. have exterior luminaires that fit within the cultural design contexts of their downtowns or historic neighborhoods. These fixtures are typically highly inefficient and a large part of their flux is directed towards the sky. Typical light source for these luminaires are high-pressure sodium lamps, which have poor color rendering capabilities and relatively short life.

CLTC will collaborate with manufacturing partners such as Guth, Lumileds, Osram Sylvania, Hadco; test bed participants such as the City of Huntington Beach, Orange County, the California State Parks, and California utilities such as SCE to develop new LED exterior luminaries that maintain the overall appearance of historic luminaries and use optics and bi-level controls to improve energy efficiency and reduce light pollution.

**The Contractor shall:**

- In collaboration with test bed participants such as the City of Huntington Beach, Orange County, and California State Parks, survey existing decorative historical luminaires in the beach area of Huntington Beach and the adjoining state beaches and select fixtures and sites for the development and testing of the new luminaires and summarize task results in a memorandum on task activity and lessons learned.

- Measure and evaluate the performance of existing historical fixtures with respect to energy and light distributions and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Hubbell and Lumileds to design alternate configurations and optics for the historical fixtures that will provide the desired candlepower distributions (deliver maximal flux with minimal glare), and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Hubbell and Lumileds to design alternate controls that will provide occupancy sensing level control, daylight sensing dimming, and demand response capability and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Hubbell and Lumileds to produce luminaires prototypes of the new designs for testing and evaluation in the field and summarize task results in a memorandum on task activity and lessons learned.
- Work with test bed participants such as the City of Huntington Beach, Orange County, State of California, and manufacturers such as Lumileds and Hubbell, to install the prototype luminaires and measure their performance with respect to energy and lighting distributions and summarize task results in a memorandum on task activity and lessons learned.
- Measure and evaluate the performance of the new fixtures with respect to energy requirements, light distribution and output, community acceptability and compare it with the performance of the original fixtures and summarize task results in a memorandum on task activity and lessons learned.
- Based on the results from the previous activity in Task 2.8 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.8 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.
- Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory, field testing and cost effectiveness when compared with original fixtures. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to selection of testing sites and fixtures
- 1-2 page memorandum as to evaluation of existing fixtures
- 1-2 page memorandum as to designs of new optics
- 1-2 page memorandum as to design of new controls

- 1-2 page memorandum as to prototypes of new LED fixtures
- 1-2 page memorandum as to installation of new LED fixtures in test sites
- 1-2 page memorandum as to evaluation of new LED fixtures
- 1-2 page memorandum for PAC review as to commercial product specification
- Revised specification as per PAC review
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix

## Task 2.9 Side Projecting LEDs with PV Power and Control

Typically new municipal, freeway, and airport signage require that large trenches must be made for high voltage electrical supply and/or control wires. When this heavy wiring is required on roadways, ramps, taxiway, and runways, significant costs are borne by the agency involved, coupled with high risk to the installation crews and traveling public. Typical fixtures are relatively short-lived and maintenance has risks similar to installation. **Advancements in photovoltaic panels, energy-storage technologies and direct DC systems have made highly energy-efficient, self-sustaining residential and commercial building a near-term possibility.** CLTC believes that there have been enough advances in LEDs, photovoltaic arrays, wireless controls, and polymer lithium ion batteries to create sign lighting that is grid-connected through direct burial DC circuits installed in slit trenches and dependable enough for critical applications in transportation. **warrant evaluation of these technologies for use in forthcoming residential, commercial or industrial energy-efficiency research projects.**

### The Contractor shall:

- In collaboration with the manufacturing partners such as Guth Lighting, and experts such as Ron Gibbons of the University of Virginia, design new sign lighters using high-power, high-efficacy LEDs and arrays of optics to direct the light in extremely targeted patterns that do not create visual pollution or distracting glare and summarize task results in a memorandum on task activity and lessons learned.
- In collaboration with the manufacturing partners such as Mitsubishi Solar, design, identify and test photovoltaic arrays with efficiency adequate to provide power even on days with inclement weather and **for select typical residential or commercial applications.** Summarize task results in a **memorandum including the state of commercially available photovoltaic arrays, and associated control systems.**
- In collaboration with the manufacturing partners such as iCell Systems, design, identify and test polymer lithium ion storage battery arrays **or similar energy storage technologies** and summarize task results in a memorandum **including the state of commercially available energy storage technologies, and associated control systems.** In collaboration with the manufacturing partners such as Echelon Corporation, create radio frequency control systems that preserve and extend **battery life and status reporting systems** and summarize task results in a memorandum on task activity and lessons learned.

- ~~In collaboration with the task partners, test and evaluate the new luminaires in the laboratory and in the field towards final specifications for commercial products and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Work with the Task's industry partners to develop commercial prototypes for testing in real world applications and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Work with industry and utility partners, test bed participants such as roadway system managers such as federal property managers, education campus managers, CalTrans, and airport managers/Federal Aviation Authority to install commercial prototypes in the field for demonstration and evaluation. The installation will include monitoring equipment for energy and luminous distributions. These tests will be conducted at selected roadways, small airports, and/or military facilities. Summarize task results in a memorandum on task activity and lessons learned~~
- ~~Monitor and evaluate the performance of the commercial prototypes in the field with respect to energy requirements, light distribution and output, and acceptability to the organization. Summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Based on the results from the previous activity in Task 2.9 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned~~
- ~~Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.9 to market consistent with achievement of project task goals.~~
- ~~Perform project level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.~~
- ~~Perform project level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.~~
- ~~Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory, field testing and cost effectiveness compared to existing technology. Final task report will serve as a standalone appendix to the Final Report for the overall project.~~
- **Identify niche applications which could act as early adopters of PV sourced, DC-direct lighting systems and summarize these findings in a memorandum.**
- **Complete a system specification for PV sourced, DC-direct lighting systems for niche applications previously identified as potential early adopters of the technology. Provide a system specification for each of these applications.**
- **Develop examples of the specified systems in the laboratory in order to demonstrate the technical feasibility of the designs and provide a detailed specification of each demonstrated system noting specific products used and/or modifications made to the general specification.**
- **Monitor and evaluate the performance of the laboratory prototypes with respect to electrical, energy, economic and photometric performance.**

**Quantify results and summarize in a memorandum on task activity and lessons learned.**

- **Based on the results from the previous activity in Task 2.9 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners (the PAC will review the specifications and may require the Contractor to revise them). Summarize task results in a memorandum on task activity and lessons learned (the PAC will review the memorandum).**
- **Within the framework of the Program-wide Market Connections (Task 3), if applicable, bring the products developed by Task 2.9 to market consistent with achievement of project task goals.**
- **Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.**
- **Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.**
- **Prepare a Final Task Report describing all activities and findings, including final specifications of technology and results from laboratory testing. The Final Task Report will serve as a standalone appendix to the Final Report for the overall project.**

**Deliverable:**

- 1-2 page memorandum as to luminaires design
- 1-2 page memorandum as to PV Array design
- 1-2 page memorandum as to Battery Arrays design
- 1-2 page memorandum as to control system design
- 1-2 page memorandum as to laboratory prototypes
- 1-2 page memorandum as to commercial prototypes
- 1-2 page memorandum as to installation of commercial prototypes in the field
- 1-2 page memorandum as to monitoring and evaluation of field performance
- 1-2 page memorandum for PAC review as to commercial product specification
- Revised specification as per PAC review
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix
- **1-2 page memorandum regarding state of commercially available photovoltaic arrays, and associated control systems**
- **1-2 page memorandum regarding state of commercially available energy storage technologies, and associated control systems**
- **1-2 page memorandum as to niche applications which may serve as early adopters of PV-sourced, DC-direct lighting systems**

- **System specification appropriate for each niche application**
- **1-2 page memorandum as to design and performance of laboratory prototypes**
- **Detailed specification on each laboratory prototype**
- **If applicable, 1-2 page memorandum for PAC review as to commercial product specification**
- **If applicable, revised specification as per PAC review**
- **Project-level Market Connections Deliverables per Task 3**
- **Project-level Technology Transfer Deliverables per Task 3**
- **Project-level Production Readiness Plan Deliverables per Task 3**
- **Final Task Report (submitted as an appendix to the Final Project Report)**

## **Task 2.10 Develop Interior Lighting Technologies/Retrofit LED Downlights**

In order to construct samples of solid-state fixtures in this task, CLTC will require a machining center to fabricate heat-sink structures. Previously these were purchased from custom vendors who charged thousands of dollars for each and took weeks to provide a small set of the needed components. By having that capacity inside the CLTC time will be saved and the machine should pay for itself over the course of the first year. The CLTC will construct an appropriate enclosure to house precision machine tools to both provide a stable environment and keep machining debris contained away from critical optical instruments.

This task will focus on developing new LED downlight fixtures that offer improved visual comfort and include occupancy and demand response controls, in collaboration with manufacturing partners such as Capri/Lumileds, Lithonia/Cree and SMUD.

Downlights are among the most used fixtures in residential applications and are increasingly used in commercial applications. In prior work CLTC has demonstrated a method to reduce glare and simplify wiring and installation complexity with improved thermal performance of new fixtures. The resultant fixtures are very promising but fall short in two areas: they still have high local brightness and are expensive. Generally, the LED heat sinks give off too much heat and make it unfeasible for recessed cans.

The proposed project will focus on providing a second path of light to the ceiling area surrounding each fixture, which will reduce the contrast and resulting glare. The second part of the effort involves consumer cost reduction strategies. CLTC will examine techniques for using many low cost, high efficacy emitters to achieve high efficiency and reduced overall costs. There is also an excellent potential of using existing wiring and fixture bodies with innovative control systems to retrofit the far larger population of existing recessed downlights. This project aims to further refine this kind of product and to make it available for the far larger constellation of retrofit applications.

### **The Contractor shall:**

- Modify and calibrate its existing swing-arm goniophotometer spectrometer to enable the device to evaluate the spectral light distribution, intensity and colorimetry of fixture systems produced under this Task and solid-state fixtures in other tasks. The

modifications to the device will allow the Contractor to measure light distribution, spectroscopic content and color fidelity of luminaires and summarize task results in a memorandum on task activity and lessons learned

- In collaboration with the Task partners, design new downlight fixtures that use multiple arrays of low-cost high efficacy LEDs and direct some of the light towards the surrounding ceiling area. The new fixtures will include a replacement control system that will permanently alter the existing wiring systems for direct DC use under drivers with appropriate occupancy and demand response controls (create new solid-state lighting fixtures that can utilize conventional wiring for permanent retrofits without the need for substantial reconstruction) and summarize task results in a memorandum on task activity and lessons learned
- In collaboration with the Task partners, test and evaluate the new luminaires in the laboratory and in the field towards final specifications for commercial products and summarize task results in a memorandum on task activity and lessons learned
- Work with the Task's industry partners to develop commercial prototypes of systems for testing in real world applications and summarize task results in a memorandum on task activity and lessons learned.
- Work with industry and utility partners to install commercial prototypes in field for demonstration and evaluation. The installation will include monitoring equipment for energy and luminous distributions and summarize task results in a memorandum on task activity and lessons learned
- Monitor and evaluate the field performance of the commercial prototypes in the field with respect to energy requirements, light distribution and glare reduction, towards final specifications for commercial products. Summarize task results in a memorandum on task activity and lessons learned.
- Based on the results from the previous activity in Task 2.10 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.10 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.
- Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory, field testing and cost effectiveness compared to conventional technology. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to modified goniophotometer
- 1-2 page memorandum as to laboratory LED (luminaires) prototypes

- 1-2 page memorandum as to fixture evaluation
- 1-2 page memorandum as to commercial prototypes
- 1-2 page memorandum as to installation of commercial prototypes in the field
- 1-2 page memorandum as to performance of commercial prototype performance.
- 1-2 page memorandum for PAC review as to commercial product specification
- Revised specification as per PAC review
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix

### **~~Task 2.11 Digital Open Source Lighting Controls Commissioning Tool~~**

~~As digital technology is becoming the standard in lighting controls, the National Electrical Manufacturers Association (NEMA) has developed a new digital lighting controls open protocol (available without charge or license to all manufacturers and all users, i.e. "open source"), referred to as NEMA 243. This new protocol is based on DALI (Digital Addressable Lighting Interface), extending it to support more than ballasts, i.e., sensors, switches and controllers.~~

~~CLTC has been working with NEMA on debugging, testing and demonstrating NEMA 243 in two installations: one at CLTC and the other in two UC Davis campus classrooms. Both installations show promise for significant energy savings through tuning of luminaires output and implementation of scenes (preset light levels for one or more fixtures within a given space) and smart operation (appropriate response to environmental conditions within a controlled space) based on sensors and control algorithms.~~

~~While installation of digital controls is very simple, as all components (ballasts, controllers, switches, sensors, etc.) are linked in a linear way, commissioning can be pretty challenging. Commissioning involves grouping of luminaires and development of control algorithms by allowing specification of control algorithms based on the values of sensor signals and the state of the lighting systems components.~~

~~Pursuant to Contract UC MR-022, CLTC is working on the development of digital lighting controls technology which will be completed in spring 2011. This project is focused on the development of the actual commissioning tool in collaboration with NEMA lighting controls manufacturers.~~

#### **~~The Contractor shall:~~**

- ~~Develop specifications for a commissioning tool at the end of the current project with NEMA and Energy Commission, to allow interaction and setup of digital lighting control systems by installers, commissioning agents and building users and summarize task results in a memorandum on task activity and lessons learned.~~

- Determine the component parts of the program and develop a list of modules required to bring the data into the tools and summarize task results in a memorandum on task activity and lessons learned.
- Create computer code of commissioning software which includes user-friendly interface (alpha version) and data verification and summarize task results in a memorandum on task activity and lessons learned.
- Assure that alpha version of commissioning software is distributed to the controls vendors for their evaluation and input and summarize task results in a memorandum on task activity and lessons learned.
- Resolve problems and issues. Refine the product. Produce a more final version (beta version) and summarize task results in a memorandum on task activity and lessons learned.
- Distribute the beta version to the manufactures that will review and test it and summarize task results in a memorandum on task activity and lessons learned.
- Complete the needed modifications and offer source code to NEMA for free distribution to the industry and submission to CIE as a world standard and summarize task results in a memorandum on task activity and lessons learned.
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.11 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.
- Prepare a report describing all task activities and findings, including final specifications of technology and results from laboratory and field testing. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to commissioning tool requirements
- 1-2 page memorandum as to developed list of needed software modules
- 1-2 page memorandum as to Alpha version of the commissioning software
- 1-2 page memorandum as to distribution of alpha version and evaluation protocol
- 1-2 page memorandum as to Beta version of the commissioning software
- 1-2 page memorandum as to distribution of Beta version of software
- 1-2 page memorandum as to Final Version of Commissioning Software
- 1-2 page memorandum for PAC review as to commercial product specification
- Revised specification as per PAC review
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix

## Task 2.12 Wallwash for Task-ambient Demand Responsive Ambient Lighting

The benefits of task/ambient lighting have been demonstrated in a number of PIER research projects and demonstrations. However, office spaces that rely on task lighting have an unfortunate side effect known as “cave effect”. The low levels of ambient light and the carefully controlled light on work surfaces leave little available illumination on vertical surfaces. This causes a feeling of a dark and dismal environment for the occupants.

CLTC will collaborate with manufacturing partners such as Finelite, Samsung and PG&E to develop strategies and technologies that direct ambient light on walls and vertical surfaces to minimize the cave effect and contribute to widespread use of task-ambient approaches. Focusing ambient lighting on vertical surfaces has the potential to decrease overall ambient lighting energy requirements.

~~Hallways, corridors and other non-task and walk-off building areas are among the least visually critical areas and thus best targets for demand response reductions. There is a distinct need to create demand responsive controls for these lighting applications.~~

The “Office of the Future” project, a multi-utility initiative led by the Design and Engineering Services office of SCE, has determined the requirements for the office environment as we meet targets for 25% and 50% energy reductions and finally achieving net zero energy design. Control and duty cycling of peripheral loads looks like a key component of future strategies. This must be combined with occupant comfort to maintain productivity. Many studies show that the typical office space is occupied only half the time during the work day. Occupancy sensitive control of task lights, monitors and other plug loads is key.

CLTC will work with manufacturers such as Finelite, Elliptipar, Watt Stopper/Legrand, and test bed partners like PG&E, SCE, SMUD and DGS to develop a ~~wall-washing luminaire system with controls that adjust lighting based on demand response signals from utilities, which can also be exploited for cycling of plug loads, such as personal space heaters, simultaneously reducing their demand in response to the same DR signal.~~ **complete task/ambient lighting system design and performance specification that includes all necessary lighting elements, including wall wash and accent lighting. Develop and implement a study designed to obtain subjective evaluation of design concepts and performance.**

### The Contractor shall:

- Work with test bed partners such as DGS, PG&E, SCE, SMUD and manufacturers such as Finelite for identification and selection of appropriate test locations in office buildings and summarize task results in a memorandum on task activity and lessons learned.
- Work with test bed partners such as DGS to measure the energy requirements of the existing lighting systems in the test locations.

- **Develop vertical illumination strategies including wall wash and accent lighting, if appropriate. Summarize in a memorandum.**
- Measure the performance of existing systems with respect to energy requirements and luminous comfort, especially luminance ratios for evaluation of cave effect and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturers such as Elliptipar, Finelite and Samsung to develop new luminaires that direct ambient lighting to vertical surfaces to reduce cave effects and improve overall light distribution. The new luminaires will seamlessly interoperate with the balance of Task and ambient lighting in the office environment and summarize task results in a memorandum on task activity and lessons learned. **specify complete task/ambient lighting systems Summarize task results in a memorandum.**
- ~~Work with manufacturers such as Finelite and Watt Stopper/Legrande to develop luminaires with demand response (DR) controls for testing and evaluation at the test locations and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Work with manufacturers such as Elliptipar, Finelite, Samsung, Watt Stopper/Legrand and test bed partners like PG&E to install new luminaires and controls where applicable in the selected test sites and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Test, collect and evaluate the DR performance data of the new luminaires and their controls with respect to load reduction and occupant acceptance with respect to energy requirements and luminous comfort and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Based on the results from the previous activity in Task 2.12 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Develop a specification for guidance of commercial practice so that the “Cave-Effect” will no longer be a deterrent to the adoption of Task/ambient strategies and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.12 to market consistent with achievement of project task goals.~~
- ~~Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.~~
- ~~Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.~~
- ~~Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory and field testing. Final task report will serve as a standalone appendix to the Final Report for the overall project.~~
- **Work with manufacturers such as Elliptipar, Finelite, Samsung, Watt Stopper/Legrand and test bed partners like PG&E to install, measure and**

verify complete task/ambient systems at selected test sites. Summarize task results in a memorandum on task activity and lessons learned.

- Based on the results from the previous activity in Task 2.12 develop specifications for complete systems after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners. Summarize task results in a memorandum on task activity and lessons learned.
- Develop a specification for guidance of commercial practice so that the “Cave-Effect” will no longer be a deterrent to the adoption of Task/ambient strategies (the PAC will review the specification and may require the Contractor to revise it). Summarize task results in a memorandum on task activity and lessons learned.
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.12 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.
- Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory and field testing. Final task report will serve as a standalone appendix to the Final Report for the overall project.

#### **Deliverable:**

- 1-2 page memorandum as to test locations for existing lighting performance
- 1-2 page memorandum as to measurement of performance of existing systems
- 1-2 page memorandum as to development of vertical illumination strategies
- ~~1-2 page memorandum as to new luminaires with DR controls New Wallwash Fixtures~~
- ~~1-2 page memorandum as to measurement and evaluation~~
- ~~1-2 page memorandum as to installation of new luminaires in test locations~~
- **1-2 page memorandum as to installation, measurement and verification of complete task/ambient lighting systems in test locations**
- 1-2 page memorandum for PAC review as to commercial product specification
- Revised specification as per PAC review
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Task Report (submitted as an appendix to the Final Project Report)

#### **Task 2.13 Solid State Luminaires for High Bay, Poles, and Office Applications**

Plasma light sources were originally developed for video equipment such as projectors and television sets. They operate on physical principles similar to those used in high-intensity discharge (HID) lamps, the most significant differences being 1) the gas in the capsule is excited magnetically instead of by a high-intensity electric discharge and 2) the device is miniaturized, the light-emitting capsule being approximately half the size of a jelly bean.

Plasma light sources have strong potential for higher efficacy than linear fluorescent lamps, with better color rendition and longer life. They are also dimmable. As very-nearly point sources, plasma lights can be used effectively with optical materials to provide desired candlepower distributions. They have the potential to change the paradigm of ceiling light fixtures that occupy a large fraction of the ceiling real estate, because a single plasma source the size of a few cubic inches can replace multiple fluorescent fixtures in office spaces. This implies significant reduction in materials, transportation, storage and maintenance costs. Adding controllability and light quality with high color rendering and efficacy makes plasma sources very attractive from energy, comfort, sustainability and cost points of view for office, pole and high bay lighting.

CLTC will collaborate with manufacturing partners such as Luxim, SCE and PG&E and SMUD to develop plasma luminaires for test bed participants such as athletic venues, warehouses, street lighting and open office applications, focusing on the design of optics for direct, indirect and direct/indirect approaches that will provide uniform illumination throughout open space areas without glare and shadows. Prototypes will be developed and tested in typical recreational athletics venues, warehouses, street lighting and office settings and compared with current lighting options with respect to illuminance and luminance distributions, luminaire efficacy and efficiency, energy requirements and economics.

**The Contractor shall:**

- Collaborate with manufacturing partners such as Luxim to design and fabricate prototype luminaires for direct, indirect and direct/indirect illumination in sports venues, warehouses, street lighting and open office spaces. The development will include initially computer-aided design of optics to produce desired candlepower distributions for direct and indirect lighting approaches and then iteration of fabrication of prototypes and refinement of the most promising designs approaches and summarize task results in a memorandum on task activity and lessons learned.
- Work with manufacturing partners such as Luxim, SCE, SMUD and PG&E to identify and select appropriate test sites for the new luminaires. The spaces will be selected based on designs that will be selected for field testing and summarize task results in a memorandum on task activity and lessons learned.
- Work with test bed partners such as SCE, SMUD and PG&E to install plasma prototype luminaires in the selected test sites and measure and evaluate their performance (e.g., energy consumption, light distribution) and summarize task results in a memorandum on task activity and lessons learned.

- Based on the results from the previous activity in Task 2.13 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned.
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.13 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.
- Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory, field testing and cost effectiveness relative to conventional technologies. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to luminaire designs, laboratory prototypes
- 1-2 page memorandum as to test site selection
- 1-2 page memorandum as to installation of solid-state prototypes in the field
- 1-2 page memorandum for PAC review as to commercial product specification
- Revised specification as per PAC review
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3
- Final Report Appendix

**Task 2.14 OLEDs for Office Ambient Lighting**

Organic Light Emitting Diodes (OLEDs) are made up into arrays of devices on luminous panels. While these panels cannot, as yet, provide general illumination they appear to be suitable for ambient illumination. They may well lend themselves to integration in **many applications. For example,** office partition systems where they will be close to the target area so that they may light without being obtrusive.

OLEDs are a new technology that will require a new type of control and new mounting techniques. Their planar nature may allow us to merge them into standard office partitions. ~~It is hoped that their gentle glow will provide the ambient illumination while conventional LED sources will provide specific Task illumination. The combined technologies should provide energy efficient, comfortable lighting for many years without service.~~ **luminaires, furniture or other products. It is hoped that their gentle glow will provide general diffuse illumination, in contrast to traditional LEDs which delivered a focused beam of light.**

**CLTC shall investigate the current state of OLEDs including market analysis, identification of price structures necessary to facilitate successful competition with traditional LEDs, and laboratory evaluation of commercially available OLED samples. This information will be used to prepare a white paper focused on the current state of OLEDs and their potential use in general illumination applications.**

**The Contractor shall:**

- Obtain and provide OLED panels for evaluation and summarize task results in a memorandum on task activity and lessons learned.
- Measure luminous and energy performance of existing OLED panels and map light distributions. The performance of the systems will be measured against office lighting requirement and summarize task results in a memorandum on task activity and lessons learned. **against traditional LED samples. Summarize results in a memorandum on task activity and lessons learned.**
- ~~Integrate the OLED panels into prototype office partitions and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Work with test bed partners such as DGS to equip office suites with the new systems~~
- ~~Measure and evaluate the luminous and energy performance of the new luminaires and controls at the test sites (e.g., energy requirements, light distribution and occupant satisfaction). The results of the measurements and associated human factors evaluations will determine if there is potential for this new technology and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.14 to market consistent with achievement of project task goals.~~
- ~~Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.~~
- ~~Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.~~
- ~~Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory, field testing and cost effectiveness compared to conventional technology. Final task report will serve as a standalone appendix to the Final Report for the overall project.~~
- **Perform an economic evaluation to determine necessary pricing structures required to make OLEDs competitive with traditional LEDs. Provide an Economic Summary Report with supporting economic calculations.**
- **Prepare a white paper on the state-of-the-art OLEDs, including market potential and technology status, which will serve as a standalone appendix to the final overall project report.**

**Deliverable:**

- 1-2 page memorandum as to OLED panel sourcing

- 1-2 page memorandum as to measurement of OLEDS lighting performance
- ~~1-2 page memorandum as to office system prototypes~~
- ~~1-2 page memorandum as to office prototype with integrated OLED panels~~
- ~~1-2 page memorandum as to Installation of systems in DGS facilities~~
- ~~1-2 page memorandum as to evaluation of luminaires in test locations~~
- ~~1-2 page memorandum for PAC review as to commercial product specification~~
- ~~Revised specification as per PAC review~~
- ~~Project-level Market Connections Deliverables per Task 3~~
- ~~Project-level Technology Transfer Deliverables per Task 3~~
- ~~Project-level Production Readiness Plan Deliverables per Task 3~~
- ~~Final Report Appendix~~
- **Economic summary report with supporting calculations**
- **White Paper on OLEDs (submitted as an appendix to the Final Project Report)**

### Task 2.13 Next Generation LED Residential Lighting and Manufacturer Training

~~LEDs have much to offer as a solution for residential lighting. They have high luminaire and application efficacy, are long-lived and are well-suited for control. Because of their small size and unidirectional output, LED sources offer potential for new form factors, shapes and candlepower distributions. To date, lighting designs have treated LEDs as though they performed just like traditional light sources.~~

~~CLTC will work with manufacturing partners such as Intematix, Acuity and SDGE to develop the next generation of LED residential lighting that will greatly reduce energy consumption and will yield extended demand offset together with instantaneous demand response capabilities. Consumers will get better controls and should not have to replace the light source for the duration of their mortgage. These benefits would add value and make it more probable that consumers would acquire and utilize the more efficient fixtures despite higher costs.~~

~~Existing manufacturers of decorative residential lighting fixtures are very capable in the areas of metal bending, glass and finishes and packaging. They need help with new LED technologies that require knowledge and experience with thermodynamics, electronics and optics. CLTC will work with manufacturing partners such as Acuity to develop the next generation of residential LED luminaires.~~

~~The target will be decorative LED-based luminaires, which, in addition to light sources and optics will include occupancy detection and DR controls. Creative ways will be developed to integrate heat sink structures into fixtures with shapes and patterns attractive to consumers. Because this work would target leading US manufacturers of lighting, it is assumed that other manufacturers will seek to emulate the outcomes, speeding the technology from the lab to the marketplace.~~

**LEDs have much to offer the residential lighting market. They can deliver high luminaire and application efficacy, are long-lived and well-suited for control. Due to their small size and unidirectional output, LED sources offer the potential for**

new form factors, shapes and candlepower distributions; although, to date, lighting designs have treated LEDs as though they performed just like traditional light sources.

Manufacturers of decorative residential lighting fixtures are very capable in the areas of metal bending, glass use, finishes and packaging. They need help with new LED technologies, which require knowledge and experience with thermodynamics, electronics and optics. CLTC will work with manufacturing partners such as Acuity Brands Lighting on education and training to support industry development of the next generation of residential LED luminaires.

CLTC will work with manufacturing partners such as Intematix, Acuity and SDGE to develop examples of the next generation of LED residential lighting that will greatly reduce energy consumption and will yield extended demand offset together with instantaneous demand response capabilities. Homeowners will get better controls and should not have to replace the light source for the duration of their mortgage. These benefits add value and make it more probable that consumers acquire and utilize the more efficient luminaires despite higher costs. Using these examples, CLTC will work with industry partners on education and outreach to build a strong foundation of expertise within industry regarding proper design and development of cutting-edge LED luminaires for residential applications.

The target will be industry education to support development of the next generation of LED-based luminaires, which, in addition to light sources and optics may include occupancy detection and other controls. Creative prototypes will be developed to demonstrate proper heat sink structures within fixtures with shapes and patterns attractive to consumers. As this work will target leading US lighting manufacturers, it is assumed that other manufacturers will seek to emulate the outcomes, speeding the technology from the lab to the marketplace.

#### **The Contractor shall:**

- ~~In collaboration with manufacturing partners such as Intematix and Acuity, design next generation (low cost) LED luminaires for decorative residential lighting, which will include high efficiency LED light sources and advanced occupancy and DR controls. These new luminaires, intended to take advantage of the inherent properties of solid state lighting, will include self-illuminated shades with molded phosphorescent polymers excited by integrated LED sources. The new luminaires will focus on aesthetics, thermal management and candlepower distributions that match residential decorative and low and moderate level Task applications.~~
- ~~Develop appropriate drivers and controls for the new LED luminaires. The controls components will include occupancy and DR controls for increased energy efficiency and peak demand reduction and summarize task results in a memorandum on task activity and lessons learned.~~

- ~~Work with the manufacturing partners such as Intematix and Acuity to develop prototypes of new luminaire designs for laboratory and field testing and evaluation. Some fixtures will be modifications of existing designs, others completely novel and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Work with test bed partners such as SDGE and other CA utilities to demonstrate and evaluate fixture performance of the prototype luminaires and controls in the field and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Based on the results from the previous activity in Task 2.15 develop specifications for commercial products after consultations with the PAC as outlined in Task 1.10 and in collaboration with manufacturing partners and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.15 to market consistent with achievement of project task goals.~~
- ~~Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.~~
- ~~Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.~~
- ~~Prepare a report describing all task activities and findings, including final specifications of technology and results from laboratory and field testing. Final task report will serve as a standalone appendix to the Final Report for the overall project.~~
- **In collaboration with manufacturing partners such as Intematix and Acuity Brands Lighting, design prototypes of next generation (low cost) LED luminaires for decorative residential lighting, which will include high efficiency LED light sources and controls. Luminaire examples will focus on aesthetics, thermal management and candlepower distributions that match residential decorative and low and moderate level task applications. Summarize results and key lessons in a memorandum.**
- **Work with test bed partners such as SDGE and other CA utilities to demonstrate and evaluate fixture performance of the prototype luminaires and controls in the field. Summarize task results in a memorandum on task activity and lessons learned.**
- **Using prototypes from the previous activity as examples, develop presentations, materials, and other educational components to support industry training.**
- **Coordinate and conduct industry training events, which may include educational activities at industry trade shows and conferences. Summarize this work in a memorandum on educational activities, including topics that may require further support within industry.**
- **As appropriate, perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.**

- As appropriate, perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.
- Prepare a Final Task Report describing all task activities and findings, including final specifications of technology and results from laboratory and field testing. The Final Task Report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- ~~1-2 page memorandum as to design of new LED luminaires~~
- ~~1-2 page memorandum as to design/sourcing of drivers, occupancy and DR controls~~
- ~~1-2 page memorandum as to developing prototypes for testing and evaluation~~
- ~~1-2 page memorandum as to Installation new luminaires in the field~~
- ~~1-2 page memorandum for PAC review as to commercial product specification~~
- ~~Revised specification as per PAC review~~
- ~~Project-level Market Connections Deliverables per Task 3~~
- ~~Project-level Technology Transfer Deliverables per Task 3~~
- ~~Project-level Production Readiness Plan Deliverables per Task 3~~
- ~~Final Report Appendix~~
- 1-2 page memorandum as to design of example (prototype) LED luminaires
- 1-2 page memorandum on testing and performance evaluation of prototypes
- 1-2 page summary of educational events conducted and training materials prepared to support this task, with copies of materials attached
- Prepare Program-level Technology Transfer Deliverables per Task 3 (as appropriate)
- Prepare Project-level Production Readiness Plan Deliverables per Task 3 (as appropriate)
- Final Task Report (submitted as an appendix to the Final Project Report)

**Task 2.16 ~~CPR for R&D Activities~~**

**The Contractor shall:**

- ~~18 months after the start of work under this Interagency Agreement conduct a Critical Project Review pursuant to the provisions of Task 1.2. Specific arrangements for this task are specified in Task 1.2.~~

**Deliverable:**

- ~~CPR report per Task 1.2~~

**Task 2.17 Smart Corridors**

CLTC conducted a survey of energy use across the UCD campus. Energy demand and consumption data were collected by application, in order to identify critical energy consuming processes and opportunities for deep energy savings.

Surprisingly, surveys found unassigned spaces such as corridors, stairwells, storage rooms, and maintenance closets to be the largest lighting energy consumers on campus. These results led to a dramatic paradigm shift in how to address demand response. Traditionally, primary occupancy spaces such as personal office spaces, break rooms, and conference rooms are subjected to electric lighting load shed during critical demand response events. Based on these findings, CLTC proposes to initiate an adaptive, demand sensitive design for target areas with no occupant ownership (e.g. – corridors, bathrooms, storage areas). By shifting load shed priorities from primary to secondary spaces, CLTC expects an increase in energy savings and user acceptance of demand load reductions.

The important underlying assumption that corridors and stairwells are large energy users in commercial and institutional sectors is derived from an energy assessment of the University of California – Davis campus-wide energy use by CLTC. This showed that campus-wide, corridors contributed approximately 30% of the energy use. By assuming that corridors are characterized by low occupancy, the goal of this project is to prove that equipping corridors with proper Smart Corridor technologies will yield significant energy savings.

The Contractor shall:

- Identify corridor and other secondary space smart lighting system designs that facilitate dynamic light level adjustment within these spaces based on occupancy, time of day, and critical event (DR) status.
- Develop intelligent control strategies that optimize safety and lighting performance with minimal overall energy use, and combine control strategies with technologies to produce system specifications for Smart Corridor Lighting systems.
- Prepare a System Specification report.
- Design and build prototype systems in the laboratory. Complete testing and evaluation activities to quantify energy, economic and photometric performance.
- Prepare a System Evaluation report.
- Within the framework of the Program-wide Market Connections (Task 3), bring the products developed by Task 2.13 to market consistent with achievement of project task goals.
- Perform project-level Technology Transfer activities with the preparation and implementation of the Program-level Technology Transfer Plan described in Task 3.2.
- Perform project-level Production Readiness Plan activities consistent with the Program-level Production Readiness Plans and Post Contract Support Strategies described in Task 3.10.

- Prepare a final report of task activities, to be submitted as an appendix to the Final Project Report.

**Contractor Deliverables:**

- System Specification report
- System Evaluation report
- Final report appendix.
- Project-level Market Connections Deliverables per Task 3
- Project-level Technology Transfer Deliverables per Task 3
- Project-level Production Readiness Plan Deliverables per Task 3

**Task 2.18 Establish 2007 Lighting Energy Baseline for AB1109**

In 2007 California approved Assembly Bill (AB) 1109, requiring the implementation of regulation “structured to reduce average statewide electrical energy consumption by not less than 50% from the 2007 levels for indoor residential lighting and not less than 25% from the 2007 levels for indoor commercial and outdoor lighting by 2018.”

AB 1109 implementation requires determination of the 2007 lighting energy baseline, using metrics that will facilitate the development of regulations and monitoring of progress for each of the three lighting categories. CLTC shall develop the methodology and implementation plan necessary to estimate the 2007 lighting energy baseline. This procedure shall be implemented by others or under a separate funding award.

**The Contractor shall:**

- In collaboration with the CEC, CLTC will develop precise definitions of the categories "indoor residential lighting", "indoor commercial lighting", and "outdoor lighting", and identify appropriate metrics, i.e., normalization of lighting energy use (per building, area, etc.) that will facilitate AB 1109 implementation and monitoring of progress.
- Identify data sources for each lighting category, including sources such as the CEC, CA utilities, EIA, CPUC, and other entities.
- Investigate data sources and determine existence, availability, breadth and quality of data. If necessary, revise the category definitions and metrics developed in the previous item for the best use of available data.
- Based on available data sources, develop a methodology for determining the 2007 lighting baseline, based on the results from previous items.

- **Provide a draft report on study methodology and implementation to the CEC for review.**
- **Modify report as necessary, based on CEC comments.**
- **Provide a final report the methodology and implementation plans for determining the 2007 California Lighting Baseline, which will serve as an Appendix to the Program final report to be provided in accordance with Task 1.6.**

**Contractor Deliverables:**

- **Draft Report on Methodology and Implementation Plan for Determination of the 2007 California Lighting Baseline.**
- **Final Report.**

**Task 3 Program-Wide Market Connections**

The goal of this task is to shape and support technology development and early deployment efforts in order to accelerate the technology diffusion process. The ultimate outcome of this market connections element is broadening market adoption of the energy-efficient lighting products developed in Task 2, including codes and standards covering qualified products. Given the range of products included in Task 2, activities will be related to the stage of product development and market readiness of each product. For most of them, additional market connection activities will be required beyond the timeline of this Agreement.

The Program-wide Market Connections Element will:

- Work with manufacturers or product developers or both parties to enhance their product business case and market appeal, and 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 the technologies to demonstrate reliability and energy savings;
- Facilitate technology transfer and market adoption to disseminate information about the products, energy savings and other benefits;
- Inform code and standards processes of products developed under Task 2; and
- Develop market support strategies, to be included in the Final Report, for the post-contract period.

**Task 3.1 Program-wide Market Connections Strategy**

The objectives of this task are to design a Program-Wide Market Connections strategy that unifies market connectivity for the energy-efficient lighting products developed in Task 2, to ensure the strategy progresses according to schedule, and maintains clear lines of communication within the project team and with the Commission Contract

Manager. The Program-wide Market Connections Strategy is intended to guide the entire set of energy-efficient lighting solutions developed in Task 2 to achieve a level of market acceptance consistent with reaching energy savings goals, to inform energy codes and other processes, and to identify future market-driven public interest lighting research opportunities.

**The Contractor shall:**

- Develop the concepts in Task 3 into a detailed plan for program-wide market connections.
- Present the market connections strategy to the PAC, making revisions to the plan as needed.
- Obtain CCM approval of the Program-wide Market Connections Plan for implementation.
- Prepare a report describing Program Market Connections activity conducted throughout the agreement

**Deliverables:**

- Report on Program Market Connections

**Task 3.2 Program-level Technology Transfer Plan**

The goal of this task is to make available to key decision-makers the knowledge gained, experimental results and lessons learned from the energy-efficient lighting products developed in Task 2.

**The Contractor shall:**

- Prepare a Program-wide Technology Transfer Plan. The plan shall explain how the knowledge gained in this project will be made available to the public. The level of detail expected is least for research-related projects and highest for demonstration projects. Key elements from this report shall be included in the Task 3.10 Final Report. The Plan will integrate key findings from the Project-level technology transfer plans into product development, Project market connections, and Program-wide market connection elements. The Project elements to be reviewed include:
  - Product and market description
  - Business case for the manufacturer
  - Value proposition for the customer
  - Current product development status and needs
  - Supply chain requirements
  - Key market barriers
  - Reaching and convincing the buyer
  - Economic rationale for this product
  - Unit energy savings potential
- At the programmatic level, the development and implementation of this plan shall include appropriate participants from each project in Task 2. The Plan will include

development of technology-specific specification sheets and descriptions for all of the projects to communicate project features and benefits.

- Prepare, and include in the Program-wide Technology Transfer Plan, a standard technology transfer template for use with each product of Task 2.

**Deliverables:**

- Final Technology Transfer Plan
- A standard technology transfer template for use with each product of Task 2.

**Task 3.3 Partnership Development/Technology Transfer to Lighting Industry**

While there are many major lighting manufacturers that supply California, the majority of their divisions as well as the typical manufacturer in California are still a hand-assembly operation. These firms are perceiving the state's policy shifts towards energy efficiency lighting, as exemplified by AB1109 of 2007 (Huffman), but they generally lack expertise in the areas of advanced electronics, optics, thermals and controls to be able to build next generation lighting fixtures. As such, they have not typically taken advantage of the public specifications made available by PIER, with the result that the California marketplace does not have a rich/diverse set of energy-efficient lighting products. CLTC will form and work with a stakeholder task force aligned with industry associations like ALA and various LED, driver, optic and controls makers to provide training that will allow manufacturers to produce energy-efficient lighting products.

**The Contractor shall:**

- Form a Stakeholder task force including the manufacturing partners such as ALA, Lumileds, Osram Opto, Samsung, Advance Transformer, Exclara to identify the necessary components of a training curriculum for fixture manufacturers and summarize task results in a memorandum on task activity and lessons learned.
- Assemble/prepare the training curriculum, determine the deployment steps, and summarize task results in a memorandum on task activity and lessons learned.
- Upon CCM approval, conduct beta class trainings in several locations to test the curriculum package. Based on feedback from the beta classes, revise the curriculum and, obtain approval from the CCM,
- Distribute curriculum to stakeholder groups for use in conducting training sessions throughout the State and summarize task results in a memorandum on task activity and lessons learned.
- Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory and field testing. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to Stakeholder Task force creation
- 1-2 page memorandum as to initial curriculum
- 1-2 page memorandum as to beta class training, curriculum revision and distribution
- Final Report Appendix

### **Task 3.4 Develop university-level training program for design professionals**

The objective of this task is to provide design professionals with knowledge about energy efficient lighting strategies and technologies (Lighting Lectureship Program). There are currently no University level courses to teach this material. This has been requested by the design community, utilities and the University. Such a program should be able to provide the design professional community with a grasp of new technologies (particularly PIER technologies) and their proper application for compliance with new Title 20 and 24 codes and UL/IESNA standards.

#### **The Contractor shall:**

- Meet with stakeholders such as AIA, IALD, and higher education institutions to determine optimal content requirement and other factors for successful coursework and summarize task results in a memorandum on task activity and lessons learned.
- Offer the initial course and seek University of adoption of it in future curricula and summarize task results in a memorandum on task activity and lessons learned.
- Prepare a report describing recommendations to develop/maintain the lectureship program under this task. Final task report will serve as a standalone appendix to the Final Report for the overall project.

#### **Deliverable:**

- 1-2 page memorandum as to development of Lighting Lectureship Program
- 1-2 page memorandum as to adoption of Lighting Lectureship Program
- Final Report Appendix

### **Task 3.5 DGS Program**

The State of California is one of the largest landlords in the world. The DGS operates a broad range of structures for the State of California. They run the gamut from multi-story offices to garages and warehouses. The buildings of DGS are a great place to demonstrate new technologies and conduct tests to validate their performance. The Contractor will also work with DGS to create training programs and manuals to support DGS in their implementation of the Governor Schwarzenegger's Executive Order ([Executive Order S-20-04](#)) for the reduction of the state's carbon footprint.

#### **The Contractor shall:**

- Work with manufacturing partners such as Lutron, Universal Devices, Watt Stopper/Legrand, Finelite, and SMUD, PG&E, SDG&E and SCE to demonstrate and evaluate current state-of-the-art technologies in State structures within the utilities' territories (Consult with DGS on Demonstration Lighting Retrofit Programs) and summarize task results in a memorandum on task activity and lessons learned.
- Work with DGS staff to identify buildings for field trials of new and innovative technologies and conduct the field trials using State office buildings, warehouses and parking areas as living laboratories. Summarize task results in a memorandum on demonstration of advanced lighting technologies in DGS buildings.

- Equip separate floors or areas of State structures with different lighting technologies and contrast and compare them with control areas and summarize task results in a memorandum on task activity and lessons learned.
- ~~Prepare a manual detailing efficient lighting practices and strategies for conservation throughout the DGS system and summarize task results in a memorandum on task activity and lessons learned.~~
- Prepare a report describing all activities and findings, including final specifications of technology with results from laboratory, field testing and cost effectiveness of the technology. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to Consultation with DGS on Demonstration Lighting Retrofit Programs
- 1-2 page memorandum as to demonstration of advanced lighting technologies in DGS buildings
- Best Practices Manual for DGS
- 1-2 page memorandum as to development of manual
- Final Report Appendix

**~~Task 3.6 Inform Codes and Standards Processes/Evaluation of Scotopic Lighting Effects~~**

~~Much has been written about the visual benefits of high color temperature lighting for low-level illumination under dark-adapted eye conditions. Currently, though, there are no established standards for differential illumination levels for high color temperature sources. Many municipalities in the State of California are prepared to institute high color temperature lighting measures without the benefit of established standards.~~

~~The Contractor will partner with industry associations, academic institutions, manufacturers and California utilities, such as IESNA, The University of Virginia, manufacturing partners such as Full Spectrum Solutions, Beta Lighting and SCE, to conduct human factors experiments to test the performance of critical visual Tasks under illumination of different color temperatures and intensities. Measurements will include actual Task performance of various populations performing visual Tasks of varying complexity from walking a path to driving a car.~~

~~The results of the tests will be used to provide guidance until larger studies can thoroughly establish the differential lighting standards.~~

**The Contractor shall:**

- ~~Collaborate with project partners to identify and select testing sites (Scotopic) in parking lots, recreational sporting venues, ski areas and/or racetracks or other venues as may be available and summarize task results in a memorandum on task activity and lessons learned.~~

- ~~Work with manufacturing partners such as Full Spectrum Solutions, Metrolight, Luxim and Beta Lighting for design and preparation of light sources with different color temperatures and controls for intensity and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Identify selected luminaires for use in subsequent tests in Task 2.15.~~
- ~~Work with industry associations like the Spectral Effects IESNA Committee and academics like Ron Gibbons of Virginia Tech, and the PAC to develop testing protocols for human subjects to use in evaluation of color temperature effects on visibility and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Identify a group of test subjects of varying age, gender and racial make-up based on the testing protocol and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Work with SCE (or other utility) to install the luminaires selected in Task 2.15 in the test sites and prepare the sites for the testing of subjects and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Implement testing protocols and measure performance of subjects conducting identical visual tasks under different lighting color temperatures and intensities and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Evaluate the performance measurement results to determine the relationship between low and high color temperature light levels based on measured performance and summarize task results in a memorandum on task activity and lessons learned.~~
- ~~Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory and field testing. Final task report will serve as a standalone appendix to the Final Report for the overall project.~~

**Deliverable:**

- ~~1-2 page memorandum as to identification of Scotopic test sites~~
- ~~1-2 page memorandum as to development /identification of Scotopic fixtures~~
- ~~1-2 page memorandum as to creation of Scotopic test protocol~~
- ~~1-2 page memorandum as to identification of test subjects.~~
- ~~1-2 page memorandum as to testing setup~~
- ~~1-2 page memorandum as to test protocol implementation~~
- ~~1-2 page memorandum as to analysis of subject test results.~~
- ~~Final Report Appendix~~

**Task 3.7 Support for Development of CA Building and Appliance Standards**

The purpose of this Task is to inform the building and appliance standards processes of the potential value of energy-efficient lighting products developed during Task 2 and other proven lighting technologies from the PIER program and to foster collaboration between industry and the Commission.

Due to its collaborative, partnership-based operating structure, the CLTC is uniquely positioned as a public entity with a very strong understanding of the needs, desires, and

plans of the lighting industry. This market intelligence can be tapped by the Commission to inform the state's building and appliance codes and standards processes of energy savings obtainable from Task 2 and related PIER-funded lighting technologies. By leveraging the knowledge base and industry connections of the CLTC, the Commission could expect their code planning processes to be both more efficacious and more widely supported by the industry.

**The Contractor shall:**

- Work with the Commission to provide information about major trends in the lighting industry and their potential effect on shaping CA Title-20 and Title-24 Standards and summarize task results in a memorandum on task activity and lessons learned.
- Work with the Commission and industry to facilitate communication and interaction through roundtable meetings focusing on specific Title-20, Title-24 issues, and legislation related to lighting and daylighting and summarize task results in a memorandum on task activity and lessons learned.
- Provide technical input on lighting and daylighting code and standard development through reviews, comments and suggestions for the 2011 versions of T-20 and T-24 energy standards and summarize task results in a memorandum on task activity and lessons learned.
- Provide technical support and assistance in testing and evaluating technologies to resolve issues and provide information for decision making for specific PIER RD&D lighting technologies and summarize task results in a memorandum on task activity and lessons learned.
- Continue to assist the Energy Commission to resolve critical technical issues as needed and provide technical support to validate the applicability and impact of proposed policies in the lighting area. Summarize task results in a memorandum on task activity and lessons learned.
- Provide 10 hours of expert testimony on behalf of the Energy Commission as may be required in the legislative process.
- Participate in committees and conferences of major lighting, sustainability and energy associations such as those organized by IESNA, NEMA, DOE, USGBC LEED, Energy Star, ASHRAE, etc., provide leadership and technical support for the development of industry standards, such as prescriptive and performance metrics, process protocols for measurements, simulations and evaluations and summarize task results in a memorandum on task activity and lessons learned.
- Prepare a report describing all activities and findings, including final specifications of technology and results from laboratory and field testing. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to Report on Market Trends
- 1-2 page memorandum as to Hosting of Roundtable with Industry and Commission
- 1-2 page memorandum as to Input on Codes and Standards
- 1-2 page memorandum as to technical support for standards RD&D as needed
- 1-2 page memorandum as to providing technical support for policies as needed
- 1-2 page memorandum on testimony given

- 1-2 page memorandum as to conferences and associations
- Final Report Appendix

### **Task 3.8 Market Adoption/Outreach for Technology Transfer**

The purpose of this Task is to inform key audiences about new and emerging lighting and daylighting technologies and help form partnerships for accelerated wide spread acceptance and use. CLTC will engage in outreach activities as a means of technology transfer to key institutions, agencies, and other audiences such as California state agencies, academic institutions and trade organizations.

Build institutional connections between PIER research and California State agencies and academic institutions

The purpose of this Task is to build institutional connections between PIER lighting research and California state agencies and academic institutions in order to expose them to Task 2 outcomes and other PIER lighting technologies, understand specific needs and inform the PIER Lighting R&D process.

Buildings owned by the State of California are key opportunities to demonstrate PIER lighting technologies and learn about the needs of large end-users. The CLTC has cultivated these relationships over the last three years through the Memorandum of Understanding established with the Department of General Services and the PIER technologies demonstration program in UC and CSU campuses.

#### **The Contractor shall:**

- Build institutional connections between PIER research and California State agencies and academic institutions and extend them to include, but not limited to, CA Community College Districts, School Facilities Planning Division of the California Department of Education, California Department of Parks and Recreation, CA Department of Corrections and Rehabilitation, and other state agencies. Summarize task results in a memorandum on task activity and lessons learned.
- Host annual roundtable meetings with state agencies and academic institutions, focusing on presenting the available PIER technology portfolio, sharing success stories and lessons learned, identifying market trends and needs and establishing future research and demonstration projects and summarize task results in a memorandum on task activity and lessons learned.
- Determine which State agencies require input as to lighting energy efficiency.
- Develop agreements with state agencies and academic institutions to provide technical support on energy-efficient lighting technologies and applications. Technical support will place a strong emphasis on identifying opportunities for PIER-developed technologies and will include the following:
  - Site audits and evaluation
  - Plan review for new buildings and planned renovations, Interaction with facility managers and end users to understand needs

- Provide technical support during the preparation of lighting-related specifications, codes, and policies
- Provide technical support for lighting procurement, including group procurement initiatives and summarize task results in a memorandum on task activity and lessons learned.
- Develop and maintain contact with the firms and institutions involved in the sustainable buildings effort.
- Inform these firms as to efficient lighting practices especially those highlight PIER technologies.
- Prepare a report describing outreach for technology transfer activities. Submit the draft to the CCM for review and comment, make necessary changes and submit the final report to the CCM. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum as to relationship development activities
- 1-2 page memorandum as to Annual Roundtable Meeting Reports
- 1-2 page memorandum on technical support activities
- 1-2 page memorandum on outreach to the Green Buildings Industry
- Final Report Appendix

**Task 3.9 PIER Technology Support**

The purpose of this Task is to accelerate lab to the marketplace connections of PIER research through a number of technology transfer activities with the industry and research communities. These activities include organizing and hosting roundtable meetings and conferences/forums as well as producing and managing outreach materials such as [www.thelightingportal.com](http://www.thelightingportal.com) and guidelines for energy efficient lighting practice.

**The Contractor shall:**

- Host three annual roundtable meetings with academic institutions to exchange ideas on how to improve their adoption of PIER technologies in the energy efficiency arena. Areas of focus for the roundtable meetings will include the current PIER portfolio and methods to educate and train professionals on their installation and operation and summarize task results in a memorandum on task activity and lessons learned.
- Host three annual Industry-Utility forums as a State-wide event. Areas of focus of the forum will vary from year to year to address emerging needs and opportunities. The focus of the planned forums will be determined in collaboration with industry and utilities and summarize task results in a memorandum on task activity and lessons learned.
- Prepare a Residential Lighting Guide that updates the version issued for the 2005 Title 24 requirements, reflecting the changes mandated by the 2008 Title 24 standards and including new technology solutions such as solid state lighting
- Prepare an Office lighting design guide

- Prepare a hospitality facility (Hotel/motel) lighting guide
- Prepare a Daylight harvesting controls guide for both skylit and sidelit spaces
- Summarize task results in a memorandum on task activity and lessons learned. The memorandum will include the design guides as attachments.
- Extend the existing daylighting sections and organize them together with additional sections into a new Advanced Lighting Guideline (ALG) Daylighting Chapter.
- Extending the light sources and controls sections to include information about LED and induction light sources, luminaires and controls.
- As a subcontractor, New Buildings Institute (NBI) will integrate the new Chapter and Sections in the updated version of ALG and make the document available as a stand-alone document as well as a new, expandable web site. Summarize task results in a memorandum on task activity and lessons learned.
- Expand The Lighting Portal web site with by the addition of self-sustaining functionality, such as a secure Group Purchasing Program that will allow DGS, UC, CSU and CCC units to consolidate their purchases of PIER technologies to steeply reduce the costs. The content-enhancement work will focus on streamlining the web site to best serve the communication needs of key participant groups. Add video clips and other content-enhancements demonstrating PIER technologies and summarize task results in a memorandum on task activity and lessons learned.
- Work in collaboration with utilities and industry to develop training programs that will produce trained professionals for the installation, commissioning, operation and maintenance of new and emerging energy efficient lighting technologies.
- Assist the curriculum collaborators by developing training programs and contributing to education and training efforts through curriculum development, lectures and seminars and summarize task results in a memorandum on task activity and lessons learned.
- Prepare a report describing outreach for PIER technology support activities. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverable:**

- 1-2 page memorandum on status of Annual Academic Roundtables
- 1-2 page memorandum as to Annual Utility-Industry Forums
- 1-2 page memorandum as to design guides development
- 1-2 page memorandum as to enhancements to Advanced Lighting Guidelines 2009
- 1-2 page memorandum as to sustainability and content-enhancement of The Lighting Portal
- 1-2 page memorandum as to professional development training
- Final Report Appendix

**Task 3.10 Program-level Production Readiness Plans and Post Contract Support Strategies**

The objective of this task is to bring the Production Readiness Plans and Post Contract Support Strategies together where the results of all tasks can easily be accessed.

**The Contractor shall:**

- Combine all of the individual project-levels production readiness programs into a single comprehensive document and summarize task results in a memorandum on task activity and lessons learned.
- Combine all of the post contract support strategies into single comprehensive document and summarize task results in a memorandum on task activity and lessons learned.
- Prepare a report describing Post Production Readiness Program support Strategies. Final task report will serve as a standalone appendix to the Final Report for the overall project.

**Deliverables:**

- 1-2 page memorandum as to project-level production readiness programs
- Final Report Appendix

**~~Task 3.11 CPR for Program-Wide Market Connections~~**

**~~The Contractor shall:~~**

- ~~24 months after the start of the work under this Interagency Agreement conduct a Critical Project Review pursuant to the provisions of Task 1.2. Specific arrangements for this task are specified in Task 1.2.~~

**~~Deliverable:~~**

- ~~CPR report per Task 1.2~~