Department of Energy

Funds-In Agreement for Research and Development

Appendix A—California Energy Commission

Exhibit A - Statement of Work
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Prepared by the Lawrence Berkeley National Laboratory
June 1, 2011

I. Title of project

Lawrence Berkeley National Laboratory Energy Efficiency Research Projects

II. Energy Commission RFP identification

PIER Efficiency Program Opportunity (January 7, 2001)

III. Background

The U.S. Department of Energy (DOE) has directed the Regents of the University of California to perform the work stated in this Appendix A for the California Energy Commission (Energy Commission). Lawrence Berkeley National Laboratory, a laboratory owned by DOE, is located at 1 Cyclotron Rd., Berkeley, California. The Regents of the University of California, a not-for-profit corporation organized under the laws of the State of California, with its principal place of business at Berkeley, CA, manages and operates Lawrence Berkeley National Laboratory under DOE Contract No. DE-AC02-05CH11231.

The California Energy Resources Conservation and Development Commission (Energy Commission) is an agency organized under the laws of the State of California with a principal place of business at 1516 Ninth Street, Sacramento, California 95814.

IV. Project Goals and Objectives

Problem Statement

California has enacted the Global Warming Solutions Act of 2006 (also known as AB 32). In support of this law, the California Public Utilities Commission, in coordination with the Energy Commission and the California Air Resources Board, developed the California Long Term Energy Efficiency Strategic Plan. These measures call for major reductions in greenhouse gas emissions related to California buildings and industry. These reductions will require a major

improvement in energy efficiency because facility occupants require a reasonable level of indoor environmental quality. Research and technological development is required to meet these goals.
The research projects in this contract address a range of energy-related topics in support of them.

The research focuses on three key components that will contribute to meeting the State goals: increasing end-use and building/facility energy efficiency, end-use monitoring tools, and performance modeling tools. The fifteen research tasks are grouped and summarized based on these three components:

- Improving energy efficiency and performance: use of improved air cleaning methods in tandem with reduced building ventilation (Task 2.1); diagnostics and improved combustion ventilation guidelines and standards to allow for better overall building air tightness (Task 2.12); improved domestic hot water distribution (Task 2.7); inter-connected control of audio-visual components (Task 2.11); expansion of natural gas-fired combined heat and power (CHP) systems with absorption cooling into the small to medium size building population (Task 2.8); improving efficiency of data centers (small server rooms, demonstration projects, and waste heat reuse in large data centers) (Tasks 2.13 to 2.15); and advancement of cool communities measures and standards in California communities (Task 2.5).
- Development of monitoring and communication tools to measure end-use natural gas, water (Task 2.2) and plug load electronic equipment electrical consumption (Task 2.9) that can move into production and consumer markets.
- Development of performance modeling tools and modules: EnergyPlus performance modules and models to support Title 24 Standards software compliance certification and facilitate increased market penetration of low energy systems (Task 2.3), reference data sets for innovative building systems for use in EnergyPlus Title 24 compliance (Task 2.4); system-level design and operation analysis tool to be used by design firms to effectively evaluate new Heating, Ventilation, and Air Conditioning (HVAC) system configurations – either stand-alone or integrated into EnergyPlus or other building-level simulation tools (Task 2.10); and domestic hot water distribution system models for use in the California Code of Regulations (CCR) Title 24 California's Energy Efficiency Standards for Residential and Nonresidential Buildings(Title 24, part VI), (Task 2.6).

Goals of the Agreement

The goals of the Agreement include the following:

- Improve indoor air quality (IAQ) through improved air cleaning technology to substantially reduce the energy required for building ventilation.
- Develop tools needed to provide broader end-use metering information for natural gas and water in homes, in addition to tools for use in end-use studies, energy efficiency standards, and other efforts to control and reduce energy consumption.

- Develop an improved EnergyPlus indirect evaporative cooling model that would provide sufficient flexibility to allow modeling of various advanced hybrid evaporative systems.
- Enable the accreditation of simulation programs for use in Title 24, through providing a subset of reference innovative building energy systems.
- Advance the full suite of heat island mitigation measures—cool roofs, cool pavements, and shade trees—through expansion and dissemination of research about their benefits, including energy savings, Carbon Dioxide (CO_2) emission reduction and global cooling.
- Improve the design of simulation models for water heaters and hot water distribution systems (WH and HWDS) so they are capable of future expansion to accommodate new technologies.
- Improve the efficiency of hot water distribution systems in California.
- Stimulate economic and environmentally sound natural gas-fired combined heat and power (CHP) and Combined Cooling, Heating and Electric Power (CCHP) adoption in California's medium-sized commercial building sector.
- Greatly increase the ability to monitor energy use in buildings and identify opportunities to reduce energy usage by incorporating standard power measurement and reporting capability into power supplies.
- Accelerate the invention, development, design, and rate of adoption of very-low-energy building systems by developing a system-level design and operation analysis tool to be used by design firms to effectively evaluate new HVAC system configurations.
- Save substantial electricity by creating a technology standard for how inter-connected audio/video devices manage their own power state and incorporate this into future products and into communication standards.
- Improve energy efficiency while maintaining occupant health and safety by reducing the combustion appliance barrier to increased air tightening.
- Improve overall energy efficiency over current practice for Information Technology (IT) resources and their support systems when deployed in small server closets and rooms.
- Accelerate the adoption of energy-saving measures in data centers.
- Reduce energy loss in data centers by waste heat in an innovative facility hydronic heating system.

Objectives of the Agreement

- Design, build, test, and demonstrate a new integrated-technology air cleaner (ITAC) that can improve IAQ, in many cases with substantial reductions in ventilation rates and energy consumption.
- Develop the basic tools needed to provide broader end-use metering of gas and water end-uses in homes.
- Develop a flexible EnergyPlus model that would be sufficiently flexible as to allow advanced users the ability to model advanced evaporative cooling systems.
- Develop a set of EnergyPlus Reference Building Energy System Models based

on corresponding design documents that cover the range of building energy systems needed for the Standards Reference Method.

- Characterize the potential benefits of heat island mitigation measures and step up efforts to improve outreach and communication of cool community strategies to key stakeholders, including information on available technologies, cooling and energy benefits, drawbacks to the technologies and incentives or strategies for implementation.
- Develop hot water system simulation models to provide the basic foundational structure of modern, open-source simulation models and support the future development of WH & HWDS simulation models for ongoing code work in California.
- Measure the temperature and flow of water and energy into and out of residential HWDS and calculate the waste of water and energy attributable to the HWDS.
- Identify effective technology-neutral policy options for stimulating economic and environmentally sound natural gas-fired CHP and CCHP adoption in California's medium-sized commercial building sector.
- Develop a proof-of-concept component to obtain energy consumption information by combining both power and communications solutions, and develop a communications protocol that can capitalize on the unique features of this component.
- Extend open-source building modeling and analysis tools enabling users to rapidly: test new ways of integrating heat recovery systems, test the performance of new control sequences, independently add models of new components and systems, and add physics-based models that compute expected performance under various operational scenarios.
- Develop, define, and justify a technology standard for audio/video device power management, and suggest related changes to existing standards.
- Characterize the flow resistance of appliance venting system elements and develop new diagnostics that are less sensitive to wind effects for improved air tightening practices.
- Develop a set of efficiency recommendations that can reduce the energy use of studied server rooms and associated assets by at least one-third.
- Work with Silicon Valley Leadership Group member companies to develop two data center demonstration projects that fit into the host company's strategy for improving energy efficiency and highlight industry best practices that have yet to be adopted or have been newly developed.
- Research and document methods for reusing waste heat from data centers, including an innovative heat reuse system based on hydronic heating.

V. Technical and economic/cost performance objectives

A. The overall technical goal of this project is to increase end-use and building/facility energy efficiency and develop end-use monitoring tools and performance modeling tools to support State goals.

The specific, technical objectives upon which this project's success will be evaluated are:

- Improved end-use and building/facility energy efficiency related to:
  - Improved air cleaning technologies
  - Combustion ventilation guidelines and diagnostics
  - Domestic hot water distribution
  - Inter-connected control of audio-visual components
  - Natural gas-fired CHP and absorption cooling for small and medium buildings
  - Data centers (small server rooms, efficient performance demonstrations, waste heat reuse).
  - Advancement of cool community measures and standards.

- Natural Gas, Water and communicating plug load end-use metering devices.
- Performance modeling tools for design industry and Title 24 (domestic hot water, reference data sets for innovative building systems, and system-level design and operation analysis tool).

B. The overall economic/cost goal of this project is to develop cost-effective, energy efficient end-use and building/facility systems, monitoring and communication equipment, and performance modeling tools.

The specific, economic/cost objectives upon which project's success will be evaluated are:

- Evaluation of effectiveness of individual end-use and building efficiency technologies for use by design and market sectors.
- Development of natural gas, water and communicating plug load end-use metering devices that can be transferred to the marketplace.
- Effective performance modeling tools used within Title 24 process and by the design industry.

VI. Preliminary Activities

1.1 Attend Kick Off Meeting

The Facility Operator's Project Manager (Principal Investigator) shall attend a "kick off" meeting with the Energy Commission Contract Manager to review the Energy Commission's expectations for: accomplishing tasks described in the work statement; administrative requirements in the terms and conditions of the contract (e.g., invoicing, statements vesting title, prior approvals, data disclosure limitations, monthly progress reporting format and content, etc.); and the Energy Commission's roles and responsibilities. The location of this

meeting shall be designated by the Commission Contract Manager.

1.2 Describe Synergistic Projects

Documentation of synergistic project value assessments will be received, reviewed and approved in writing by the Commission Contract Manager before: 1) any PIER funds under this contract are disbursed, and 2) PIER-funded work on Technical Tasks may begin.

Provide the following information about the synergistic projects that will enhance information and technology exchanges with this project:

- Assessed value of each synergistic project.
- Title, contact name, address and telephone number for each identified synergistic project.
- Written concurrence from each technical manager of the identified synergistic projects that information and technology derived from the synergistic project is unrestricted and available for exchange and collaboration in conjunction with this project.

(Note: The Facility Operator need not resubmit this information if it was provided in the Facility Operator's proposal and the information submitted is still valid. The Facility Operator, however, will assist the Energy Commission Contract Manager in locating this proposal information, upon request.)

1.3 Identify Required Permits

No permits required for this project.

1.4 Obtain Required Permits

No permits required for this project.

1.5 Prepare Production Readiness Plan

A Production Readiness Plan is not required for this project.

VII. Description of tasks to be performed

TECHNICAL TASKS

GLOSSARY

Acronym	Definition
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
CCHP	Combined Cooling, Heating, and Electric Power
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
CPR	Critical Project Review
DER-CAM	Distributed Energy Resources Customer Adoption Model
DOE	Department of Energy
Energy Commission	California Energy Commission
HVAC	Heating, Ventilating, and Air Conditioning
HWDS	Hot Water Distribution System
IAQ	Indoor Air Quality
IT	Information Technology
ITAC	Integrated Technology Air Cleaner
LBNL	Lawrence Berkeley National Laboratory
NOx	Nitrogen Oxides
PAC	Project Advisory Committee
PLC	Plug Load Controller
PIER	Public Interest Energy Research
TAG	Technical Advisory Group
TDV	Time Dependent Valuation
Title 24	California's Energy Efficiency Standards for Residential and Nonresidential Buildings, Part VI
VOC	Volatile Organic Compounds
WH	Water Heater

SCOPE OF WORK

This Agreement includes a set of administrative tasks and a set of technical tasks.

The remainder of this work statement defines these technical tasks. Task descriptions include goals, Contractor activities, and deliverables. The deliverables, such as test plans, technical reports and other interim deliverables, for each task are defined to the extent possible, but are subject to change based on recommendations from the Project Manager and the approval of the Energy Commission Contract Manager. The Contractor shall submit a draft of each deliverable, unless described differently in the technical tasks, to the Commission Contract Manager for review and comment in accordance with the approved Schedule of Deliverables. Deliverables not requiring a draft version are indicated by marking "(no draft)" after the deliverable name.

The Energy 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 Energy Commission Contract Manager. The Energy 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.

When creating technical deliverables, the Facility Operator shall use and follow, unless otherwise instructed in writing by the Energy 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

Technical Task List

Task 2.1	Innovative Air Cleaner for Improved IAQ and Energy Savings
Task 2.2	Improved Standards Through End-Use Meter Development
Task 2.3	Gaining Title 24 Credit for Efficient Evaporative Cooling
Task 2.4	Performance Data for Improving Title 24 Compliance Systems
Task 2.5	Urban Heat Island Mitigation Phase 2
Task 2.6	Simulation Models for Improved Water Heating Systems
Task 2.7	Reducing Waste In Residential Hot Water Distribution Systems
Task 2.8	Encouraging Combined Heat And Power in California Buildings
Task 2.9	Efficient Electronics Through Measurement and Communication
Task 2.10	Enabling Tools for Design of Energy-Efficient Building Systems
Task 2.11	Improved Audio-Video Efficiency Through Inter-Device Control
Task 2.12	Building Air-Tightness Through Appliance Venting Standards
Task 2.13	Energy Efficiency in Small Server Rooms
Task 2.14	Data Center Energy Efficiency Demonstration Projects
Task 2.15	Energy Savings Through Data Center Waste Heat Reuse

Task 2.1 INNOVATIVE AIR CLEANER FOR IMPROVED IAQ AND ENERGY SAVINGS

The goal of this task is to improve indoor air quality (IAQ) through improved air cleaning technology to substantially reduce the energy required for building ventilation.

The Contractor shall:

- Complete the design of a prototype integrated technology air cleaner (ITAC)
- Fabricate a prototype ITAC.
- In laboratory chamber studies under controlled conditions, evaluate the performance of the prototype in removing particles, a broad spectrum of indoor volatile organic compounds (VOCs), and ozone. Also measure device energy consumption.
- Prepare a Laboratory Test Results Report.
- Deploy the prototype in a house and evaluate its pollutant removal performance (for VOCs, particles, and ozone) and power consumption periodically over at least a three month period.
- Using information from industry on component and fabrication costs, develop an initial estimate of ITAC cost.
- Prepare an ITAC Design Memorandum documenting the final ITAC design.
- Perform outreach to industry to encourage commercial production of the ITAC and to obtain data for an updated cost estimate.
- Prepare an Outreach Memorandum documenting outreach to industry, industry response, and outreach results.
- Present outreach results and presentation materials to relevant Energy Commission staff as determined by the Energy Commission Contract Manager.
- Form a Project Advisory Committee (PAC) of relevant experts in this field, and conduct meeting as needed for input.
- Participate in a project-wide CPR, jointly coordinated with the PAC.
- Compile results into final project report titled “Innovative Air Cleaner for Improved IAQ and Energy Savings” in the same format as the Final Report, detailed in Task 3.2.

Deliverables:

- Laboratory Test Results Report (no draft)
- ITAC Design Memorandum (no draft)
- Outreach Memorandum (no draft)
- Outreach Presentation Materials (no draft)
- CPR Report
- Innovative Air Cleaner for Improved IAQ and Energy Savings Report

Task 2.2 IMPROVED STANDARDS THROUGH END-USE METER DEVELOPMENT

The goal of this task is to develop the basic tools needed to obtain end-use

metering information for gas and water end-uses in homes that can be used to inform end-use studies, energy efficiency standards, and other efforts to control and reduce energy consumption.

The Contractor shall:

- Review the state of the art in natural gas and water metering focusing on end-use metering efforts.
- Develop specifications for gas and water meters. Review sensing methodologies (flow, pressure, temperature) and study their effectiveness. Select one meter to be moved to the prototyping phase.
- Complete design work on the meter selected for further development, including engineering drawings, component selection, and other design elements.
- Produce a prototype meter based on desired specifications.
- Prepare and submit a Literature Survey and Conceptual Design Memorandum, documenting the review of natural gas and water metering end-use above, as well as conceptual meter designs.
- Design a general purpose wireless module for use in field metering trials. This communication module will have a simple interface for sensor modules, and it will be a wireless network interface capable of providing network connectivity for a wide variety of projects. Develop a data repository and software to transmit and receive data.
- Test selected meter performance in the laboratory where the Contractor will characterize the sensor performance and develop calibration techniques.
- Deploy the sensor in a field test to verify performance in the field.
- Participate in a project-wide CPR, jointly coordinated with the PAC.
- Compile results of the activities within this task into a final project report titled “Improved Standards Through End-Use Meter Development” in the same format as the Final Report, detailed in Task 3.2.

Deliverables:

- Literature Survey and Conceptual Design Memorandum (no draft)
- CPR Report
- Improved Standards Through End-Use Meter Development Report

Task 2.3 TITLE 24 CREDIT FOR EFFICIENT EVAPORATIVE COOLING

The goal of this task is to develop an improved EnergyPlus indirect evaporative cooling model that would provide sufficient flexibility to allow modeling of various advanced hybrid evaporative systems, given sufficient performance data.

The Contractor shall:

- Assess the current state of advanced evaporative systems research and products through a literature review, survey of manufacturers, and review of current efforts to model hybrid evaporative strategies in building simulations.
- Perform field studies to assess the operational performance of the advanced evaporative systems by instrumenting and monitoring the field performance of:

    - Two existing cooling units that meet Western Cooling Challenge (WCC) specifications in Northern California
    - A future cooling unit that meets WCC specifications in Southern California
    - Future additional WCC entries in California
- Develop system performance curves based on collated measured data by:
    - Collating existing laboratory test and field monitoring data
    - Analyzing supplemental laboratory test data and field data, and
    - Developing performance curves or data tables based on measured data
- Develop an indirect evaporative model (Functional EnergyPlus software module) that can be tailored using a combination of system specific performance curves and system operation mode configuration by:
    - Testing the implementation of a simplified model of a single zone hybrid evaporative system using either Modelica or Simulink, utilizing the Building Controls Virtual Test Bed (BCVTB).
    - Developing a "stand-alone" EnergyPlus model implementation strategy.
    - Implementing and testing the model.
- Validate model performance against scenarios based on measured field data.
- Prepare an Interim Report on Field Testing and Data Analyses.
- Present findings of validation results at a relevant conference, such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Conference.
- Submit ASHRAE presentation materials (including but not limited to PowerPoint presentations) on validation results to the CCM.
- Provide Energy Commission staff with access via internet to functional EnergyPlus software module.
- Participate in a project-wide CPR, jointly coordinated with PAC.
- Compile results of the activities within this task into final project report titled "Title 24 Credit for Efficient Evaporative Cooling" in the same format as the Final Report, detailed in Task 3.2.

Deliverables:

- Functional EnergyPlus software module on portable media (no draft)
- Interim Report on Field Testing and Data Analyses (no draft)
- ASHRAE presentation materials on validation results (no draft)
- CPR Report
- Title 24 Credit for Efficient Evaporative Cooling Report

Task 2.4 PERFORMANCE DATA FOR IMPROVING TITLE 24 COMPLIANCE SYSTEMS

The goal of this task is to enable the accreditation of simulation programs for use in Title 24, through providing a subset of reference innovative building energy systems.

The Contractor shall:

- Work with the Energy Commission's High Performance Buildings and Standards

Office to determine the appropriate building and energy systems which will make up the set of reference data sets to be generated in subsequent tasks. These data sets shall adequately represent the variety of nonresidential buildings expected to be newly built or renovated in California over the next twenty years, including high performance buildings with innovative, low energy systems. Energy systems to be covered in this project shall include but not be limited to:

  - Conventional mixing ventilation room air delivery (standard Title 24 system types like packaged single zone, constant air volume, built-up and packaged variable air volume, four pipe fan coil, and other system types).
  - Underfloor air distribution systems
  - Natural ventilation
  - Displacement ventilation
  - Chilled beams
  - Daylight harvesting
  - Dedicated outdoor air systems (coupled with zone equipment only)
  - Evaporative cooling, including water-side free cooling
  - Primary-only, primary-secondary cooling systems
  - Stratified sensible thermal storage
  - Ice storage
  - Single zone Variable Air Volume (VAV)
  - Variable refrigerant flow systems (limited to single operation mode)
  - Dual duct systems (single fan or dual fan)
- Develop a Reference Building Energy Systems Data Set Development Plan.
- Collect and/or develop as needed a set of design documents for each Reference Building Energy System. These design documents shall include but not be limited to:
  - Architectural and mechanical drawings
  - Control sequences of operation
  - Equipment performance data
  - Construction descriptions
- Develop the Building Energy System Design Document Sets.
- For each climate zone, set the envelope construction parameters to match the Energy Commission's Building Energy Efficiency Standards (Standards) and size the equipment as needed to match the loads of the building in the specific climate zone, using the climate zone weather files specified by the Energy Commission for use in the Standards.
- Create EnergyPlus building description models for each set of Building Energy System Design Documents. The Contractor shall work with the Energy Commission's High Performance Buildings and Standards Office to determine which components of the Standards shall be represented by each building model, such that the complete set of models covers all necessary aspects of the Standards Reference Method. This set of Energy Plus Reference Building Energy System Models shall include but not be limited to:

    - Building energy system performance that meets the requirements of the Standards (using the metric of annual Time Dependent Valuation (TDV) of energy use)
    - Building energy system performance that exceeds the energy efficiency requirements of the Standards by 15% in annual TDV terms
    - Building energy system performance that exceeds the energy efficiency requirements of the Standards by 30% in annual TDV terms
- Develop an EnergyPlus Reference Building Energy System Model Set and Reference Building Energy System Data Sets
- Simulate each reference building model for the climate zones specified, working with the Energy Commission's High Performance Buildings and Standards Office to determine the output variables and their reporting frequency to be included in the simulation results. The simulation results shall be stored in a Standards Reference Method Spreadsheet Workbook that is designed at a minimum to receive output data from candidate Standards compliance programs, perform predefined comparisons, and generate comparison reports, as determined in consultation with the Energy Commission's High Performance Buildings and Standards Office.
- Perform verification tests on each Building Energy System Data Set in the workbook. The Contractor shall work with the Energy Commission's Standards Group to identify at least one potential candidate Standards compliance software tool for use in these verification tests and to establish the process to be used in the tests. Remedy any problems identified in the Reference Building Energy System Data Sets and/or the Standards Reference Method Spreadsheet Workbook as a result of these verification tests.
- Prepare a Reference Building Energy System Data Set Verification Test Report.
- Participate in project-wide CPR, jointly coordinated with PAC.
- Compile results of the activities within this task into a project report titled "Performance Data for Improving Title 24 Compliance Systems" in the same format as the Final Report, detailed in Task 3.2.

Deliverables:

- Reference Building Energy System Data Set Development Plan (no draft)
- Building Energy System Design Document Sets (no draft)
- EnergyPlus Reference Building Energy System Model Set (no draft)
- Reference Building Energy System Data Sets (no draft)
- Standards Reference Method Spreadsheet Workbook (no draft)
- Reference Building Energy System Data Set Verification Test Report (no draft)
- Performance Data for Improving Title 24 Compliance Systems Report

Task 2.5 URBAN HEAT ISLAND MITIGATION PHASE 2

The goal of this task is to advance the full suite of heat island mitigation measures—cool roofs, cool pavements, and shade trees—through expansion and dissemination of research about their benefits, including energy savings, CO_2 emission reduction and global cooling. This will help the state save energy, achieve

its GHG emission targets, and improve the health and environment of its communities.

The Contractor shall:

- Advance the progress of the Cool Communities project (PIER Contract 500-08-059R) by:
  - Measurement and analysis of the cool roof demonstration in Fresno
  - Measurement and analysis of the cool pavement demonstration in Davis, with particular attention to seasonal and long-term variations in solar reflectance
  - Updating and maintaining the cool roof website begun in the Cool Communities project by revising and adding information about cool roof products, installers, codes, programs, rebates, and experiences
  - Updating cool roof and cool pavement instructional materials (cool community courses) begun in the Cool Communities project to reflect changes in product availability, codes, programs, rebates, and science, and host the courses online to reach a broader audience
- Compile the results of the activities within the bullet above into a report titled "Cool Communities Update" which shall be included in the final project report. This report shall include but not be limited to:
  - A summary of the measurement results from the Fresno and Davis cool roof demonstrations
  - An analysis of the Fresno and Davis cool roof demonstrations
- Expand outreach and develop model codes and programs. Outreach and development activities will include but not be limited to:
  - Presenting cool community courses to local policy makers, homeowner associations, urban planners, city public works staff, cool roof contractors, roof and pavement industry groups, and/or consultants
  - Compiling programs, policies, incentives, and codes in California that promote cool community measures. Develop model policies and building codes that communities, cities, utilities and others can adopt to promote cool community measures
  - Providing technical assistance to cities, utilities and other stakeholders to adopt cool community programs, including assistance in drafting policies or building codes, implementation of programs, and demonstration of cool community projects and/or communication to community members
- Compile the results of the activities within the bullet above into a report titled "Cool Communities Outreach" which shall be included in the final project report. This report shall include but not be limited to:
  - A summary of all of the activities for outreach and code development, including the model language for cool community policies and building codes
  - New resources (websites, brochures, videos and /or factsheets) developed for cool community strategies
  - A summary of the database of current programs, policies, incentives, and building codes in California that support cool communities
- Quantify benefits of cool community measures by estimating the:

    - Direct air conditioning energy savings, peak power demand reductions, and GHG emission reductions that result from reduced solar heat gain at the building envelope due to cool surface reflection and/or shading
    - Decrease in outside air temperature yielded by widespread use of cool surfaces and/or urban vegetation
    - Indirect air conditioning energy savings, peak power demand reduction, and GHG emission reductions that result from the decrease in outside air temperature yielded by widespread use of cool surfaces and/or urban vegetation
- Compile the results of the activities within the bullet above into a report titled "Cool Communities Benefit Report" which shall be included in the final project report. This report shall include but not be limited to:
    - The methodology developed to characterize the energy and cooling benefits resulting from community wide adoption of cool surfaces and urban vegetation
    - The results obtained for one major urban area in California
- Prepare a Task Update Report that includes but is not limited to:
    - Two monitoring projects (cool pavement and cool roofs)
    - Task activities for outreach and code development, including a list of new presentations, partners and/or programs
    - Task activities to characterize the energy and cooling benefits of cool surfaces and urban vegetation
- Prepare mid-task website updates.
- Participate in a project-wide CPR, jointly coordinated with the PAC.
- Compile results of the activities within this task into a final project report titled "Urban Heat Island Mitigation Phase II" in the same format as the Final Report, detailed in Task 3.2.

Deliverables:
- Cool Communities Update Report (no draft)
- Cool Communities Outreach Report (no draft)
- Cool Communities Benefits Report (no draft)
- Task Update Report
- Mid–task website updates
- CPR Report
- Urban Heat Island Mitigation Phase II Report

Task 2.6 SIMULATION MODELS FOR IMPROVED WATER HEATING SYSTEMS
The goal of this task is to improve the design of simulation models for water heaters and hot water distribution systems (WH and HWDS) so they are capable of future expansion to accommodate new technologies as they develop.

The Contractor shall:
- Perform a Scoping Study to identify what products are currently available and evaluate what they do, how they work, and what algorithms they use. The

Scoping Study will also recommend a strategy for modeling WHs and HWDSs to connect them with residential building energy simulation models.
- Perform a literature review to identify the optimal algorithms and equations to model components of WHs and HWDS.
- Perform water heater testing.
- Prepare a Laboratory Testing Report to guide the design of WH simulation models.
- Develop/revise a water heater simulation model.
- Prepare a WH Simulation Model Report that provides a foundation for the open-source community to maintain and enhance the simulation model.
- Develop/revise a HWDS simulation model.
- Prepare a HWDS Simulation Model Report that provides a foundation for the open-source community to maintain and enhance the simulation model.
- Provide Energy Commission staff with access via internet to WH and HWDS simulation models.
- Participate in a project-wide CPR, jointly coordinated with the PAC.
- Prepare a Future Title 24 Report that provides clear guidance on how tools developed from this project and the results of previous PIER-funded work could be used to shape future Title 24 revisions.
- Compile results of the activities within this task into a final project report titled "Simulation Models for Improved Water Heating Systems" in the same format as the Final Report, detailed in Task 3.2.

Deliverables:
- Scoping Study (no draft)
- Literature Review (no draft)
- Laboratory Testing Report (no draft)
- Revised WH Simulation Model on portable media (no draft)
- WH Simulation Model Report
- Revised HWDS Simulation Model on portable media (no draft)
- HWDS Simulation Model Report
- CPR Report
- Future Title 24 Revisions Report
- Simulation Models for Improved Water Heating Systems Report

Task 2.7 REDUCING WASTE IN RESIDENTIAL HOT WATER DISTRIBUTION SYSTEMS

The goal of this task is to improve the efficiency of hot water distribution systems in California.

The Contractor shall:
- Develop a Field Study Plan for monitoring homes in California to include but not be limited to:
  - Confirming access agreements with the six houses that will be monitored

    - Describing the development, calibration and installation of the wireless sensor networks, and data analysis methodologies
    - Submit Field Study Plan to the Energy Commission Contract Manager for approval, and submit to relevant stakeholders and the human subjects committee (if needed) for review
- Design, develop, and test an initial prototype of the wireless sensor network data acquisition system that includes wireless sensor network specifications. Design, development, and testing activities will include but not be limited to:
    - Writing specifications of wireless sensor network hardware and software based on experience in past water metering and other wireless sensor network studies
    - Developing first articles of the wireless devices and sensors
    - Transitioning first articles to an outside production house
    - Acquiring and calibrating the roughly 240 flow meters and 120 wireless interfaces needed for this study
    - Testing the devices thoroughly before deployment in the field
    - Building a data collection system to automatically transfer field measurement data into a database
    - Applying the wireless data acquisition system to indoor cold water end uses. The same sensor and wireless technology developed for hot water will be used for cold water end uses
- Deploy the sensors in the six field study houses to include but not be limited to:
    - Coordinating with homeowners to schedule installation
    - Obtaining any needed human subjects consent
    - Meeting with homeowners and deploying roughly 40 sensors in each house
- Collect data for roughly six months in each house by:
    - Providing on-going debugging services to the network and the homeowner
    - Decommissioning the wireless sensor networks after the six month study period
- Calculate the water and energy efficiency of the HWDS in the monitored homes, to include but not be limited to:
    - Designing, coding, and implementing software to automatically review and analyze the collected data in the database
    - Summarizing information on indoor hot and cold water uses
    - Summarizing information on HWDS energy and water efficiency
- Prepare a Wireless Sensor Networks Deployment Memorandum that summarizes the deployment of wireless sensor networks in the six field study houses.
- Prepare a Data Collection and Analysis Methodology Memorandum that summarizes the data collection and analysis methodology for the six field study houses.
- Participate in project-wide CPR, jointly coordinated with the PAC.
- Compile results of the activities within this task into final project report titled “Reducing Waste In Residential Hot Water Distribution Systems” in the same format as the Final Report, detailed in Task 3.2.

Deliverables:

- Field Study Plan (no draft)
- Initial Prototype Wireless Sensor Network Specifications (no draft)
- Wireless Sensor Networks Deployment Memorandum (no draft)
- Data Collection and Analysis Methodology Memorandum (no draft)
- CPR Report
- Reducing Waste In Residential Hot Water Distribution Systems Report

Task 2.8 ENCOURAGING COMBINED HEAT AND POWER IN CALIFORNIA BUILDINGS

The goal of this task is to stimulate economic and environmentally sound natural gas-fired combined heat and power (CHP) and combined cooling, heating, and electric power (CCHP) adoption in California's medium-sized commercial building sector.

The Contractor shall:

- Collect and forecast data on equipment performance (including emissions), tariffs, and other relevant parameters for 2020 and 2030, and the test buildings selected.
- Prepare a Collected Data Memorandum that describes collected data.
- Develop multiple scenarios (3-5) that reflect grid decarbonization, changes in equipment performance, and the regulatory environment in 2030.
- Prepare a Forecasts and Scenarios Memorandum that describes forecasts and scenarios.
- Conduct the basic Distributed Energy Resources Customer Adoption Model (DER-CAM) simulations for the chosen buildings for all the scenarios. Regional estimates of emissions, notably for Nitrogen Oxides (NOx), will be derived.
- Prepare a Basic Results of DER-CAM Simulation Memorandum that describes basic results of DER-CAM simulations.
- Perform extended runs including additional side analyses of cap and trade, zero net energy buildings, and feed-in tariffs. Further targeted typical week simulations will be conducted to identify how operations are affected over these periods and how they are changed by policy influences, e.g. different tariff structures.
- Perform focused analysis of the restaurant sector using CHP systems, including the possibilities for daytime power export and heat storage from daytime to evening, use of refrigeration scheduling to lower bills, low-temperature absorption cycle chemistry, available roof and parking space for solar collection.
- Test the efficacy of various policy options (e.g. changes in the feed-in tariff structure) and develop policy analysis.
- Prepare a Side Analyses and Restaurant Analysis Memorandum that provides a detailed description of side analyses and restaurant analysis.
- Prepare a report and presentation of preliminary results for policymakers.
- Participate in a project-wide CPR, jointly coordinated with the PAC.
- Compile results of the activities within this task into a final project report titled

"Encouraging Combined Heat and Power in California Buildings" in the same format as the Final Report, detailed in Task 3.2.

Deliverables:

- Collected Data Memorandum (no draft)
- Forecasts and Scenarios Memorandum (no draft)
- Basic Results of DER-CAM Simulation Memorandum (no draft)
- Side Analyses and Restaurant Analysis Memorandum (no draft)
- Preliminary Results Report (no draft)
- Presentation Materials (no draft)
- CPR Report
- Encouraging Combined Heat and Power in California Buildings Report

Task 2.9 EFFICIENT ELECTRONICS THROUGH MEASUREMENT AND COMMUNICATION

The goal of this task is to greatly increase the ability to monitor energy use in buildings and identify opportunities to reduce energy usage by incorporating standard power measurement and reporting capability into power supplies.

The Contractor shall:

- Define power specifications and constraints, including accuracy and range, taking into account both active and low power modes, by:
  - Outlining accumulation considerations
  - Designing power measurement and accumulation solution
  - Demonstrating a benchtop solution
- Measure and accumulate energy data.
- Develop features of identity for power supplies, including:
  - Identifying means of establishing unique identity, e.g. MAC address
  - Selecting a circuit location for identity information
  - Defining features of identity (e.g., "species", capacity, pairing, location)
  - Demonstrating a benchtop solution
  - Proposing a naming protocol for devices
- Define physical requirements for reliable communication and investigate the suitability of a wired plug load controller (PLC) and wireless solutions.
- Select a communications protocol between the power supply and network and work with standards organizations to establish and adopt the protocol.
- Assemble solutions to each major aspect and demonstrate proof of whole concept.
- Prepare a Power Supply Investigation Technical Memorandum summarizing energy data, features of power supplies, physical communication strategies, and communications protocols between power supply and network.
- Prepare a Power Supply Solutions Technical Memorandum that includes a description of solutions to each major aspect and the proof of whole concept demonstration.

- Attend technical forums and communicate results to relevant individuals and professional groups interested in electronics and energy.
- Submit presentation materials (such as PowerPoint presentations) from technical forums to the CCM.
- Participate in a project-wide CPR, jointly coordinated with PAC.
- Compile results of the activities within this task (including activities with standards-making committees) into a final project report titled “Efficient Electronics through Measurement and Communication” in the same format as the Final Report, detailed in Task 3.2.

Deliverables:
- Power Supply Investigation Technical Memorandum (no draft)
- Power Supply Solutions Technical Memorandum (no draft)
- Presentation materials from technical forums
- CPR Report
- Efficient Electronics through Measurement and Communication Report

Task 2.10 ENABLING TOOLS FOR DESIGN OF ENERGY-EFFICIENT BUILDING SYSTEMS

The goal of this task is to accelerate the invention, development, design, and rate of adoption of very-low-energy building systems by developing a system-level design and operation analysis tool to be used by design firms to effectively evaluate new HVAC system configurations.

The Contractor shall:
- Hold Technical Advisory Group (TAG) meetings at the start and at the middle of the task. The first meeting will refine and extend use cases and requirements on the library development site https://corbu.lbl.gov/trac/bie. The second meeting will be used to obtain feedback on the achieved progress and to gather feedback for updating the requirements.
- Submit minutes from the first TAG meeting to the CCM.
- Establish and prioritize requirements based on feedback from the TAG and users from design firms and industrial companies.
- Implement and validate ready-to-use component and system models, as well as exemplar templates that can be used by design firms to develop models of new HVAC system configurations and explore, assess the performance of, and reduce the risk of adopting new system configurations and their controls. The implementation will be validated using analytical tests and comparative model validation. Examples of new models that decrease energy use, reduce peak demand, and allow integration of renewable energy sources include: evaporative cooling systems, radiant slabs, absorption chillers, desiccant cooling systems with regeneration using solar collectors, and ground-coupled heat exchangers.
- Create a User Guide and augment the existing component model documentation.

- Test the usability of the library for rapid prototyping of energy systems by using the library within DOE-funded Commercial Building Partnership projects.
- Prepare a Use Cases and Requirements Report.
- Release up to five releases of new libraries on http://simulationresearch.lbl.gov/modelica under the existing, free open-source license. Notify the CCM of the releases via email.
- Prepare a New Libraries Summary that describes new libraries released under the free open-source license.
- Prepare a Case Study Report.
- Participate in project-wide CPR jointly coordinated with PAC.
- Compile results from activities within this task into final project report titled "Enabling Tools for Design of Energy Efficient Buildings" in the final report format detailed in Task 3.2.

Deliverables:
- Minutes from TAG meeting #1 (no draft)
- Use Cases and Requirements Report (no draft)
- New Libraries under the free open-source license on portable media
- User guide and augmented model documentation (no draft)
- New Libraries Summary (no draft)
- Case Study Report (no draft)
- Minutes from TAG meeting #2 (no draft)
- CPR Report
- Enabling Tools for Design of Energy Efficient Buildings Report

Task 2.11 IMPROVED AUDIO-VIDEO EFFICIENCY THROUGH INTER-DEVICE CONTROL

The goal of this task is to save substantial electricity by creating a technology standard for how inter-connected audio/video devices manage their own power state and incorporate this into future products and into communication standards.

The Contractor shall:
- Assess existing products and usage by surveying products in use in buildings, on sale in stores, and available on-line, with a focus on the connections between devices.
- Prepare an Existing Product Assessment and Conclusions Memorandum that summarizes the findings from the existing product assessment and makes key conclusions regarding the implications of the findings with regard to saving energy.
- Assess communications link technologies for each common communication technology in audio/video devices, such as High-Definition Multimedia Interface, Video Graphics Array, Display port, Ethernet, analog audio, and various analog video technologies. Evaluate what the technology enables or does not with respect to communicating power and functional information over the link.
- Prepare a Summary of Analysis of Communications Link Technologies, and a discussion of the implications this has for automatic power management.

- Create a set of use cases and candidate device behavior models.
- Outline standards development needs that address shortcomings of current standards and opportunities for new standards.
- Initiate standards development processes to implement research results.
- Prepare a Use Cases, Analysis Method, and Candidate Device Behavior Model Report that outlines the use cases, analysis method, and a candidate device behavior model.
- Prepare a Technology Standards Strategy Memorandum on the strategy for translating research results into technology standards.
- Prepare a Summary of Standard Development Progress and Further Expectations and Needs.
- Participate in project-wide CPR, jointly coordinated with PAC.
- Compile results of activities within this task into final project report titled "Improved Audio-Video Efficiency through Inter-Device Control" in final report format detailed in Task 3.2.

Deliverables:
- Existing Product Assessment and Conclusions Memorandum (no draft)
- Summary of Analysis of Communications Link Technologies (no draft)
- Use Cases, Analysis Method, and Candidate Device Behavior Model Report (no draft)
- Technology Standards Strategy Memorandum (no draft)
- Summary of Standard Development Progress and Further Expectations and Needs (no draft)
- CPR Report
- Improved Audio-Video Efficiency through Inter-Device Control Report

Task 2.12 BUILDING AIR-TIGHTNESS THROUGH APPLIANCE VENTING STANDARDS

The goal of this task is to improve energy efficiency while maintaining occupant health and safety by reducing the combustion appliance barrier to increased air tightening.

The Contractor shall:
- Perform a literature review, which will identify recent advances in combustion safety metrics, diagnostics, and norms, with particular emphasis on recent research and publications related to vent system resistance, wind effects, and simulation of vent system performance.
- Prepare an annotated bibliography of relevant sources found during the literature review.
- Develop a diagnostic method for determining probable maximum depressurization and the likelihood of backdrafting and spillage. Conduct tests to characterize vent flow resistance in the Contractor airflow laboratory using venting systems constructed there to represent typical topologies for various vent sizes and combinations of furnace and water heater vent interconnections.

Using these flow characteristics along with information about the local weather, house air tightness, airflow rates of exhaust devices, duct leakage, flue type, and discharge temperature of the combustion gas, develop a method of calculating the probable maximum depressurization that can be expected and whether sustained backdrafting and spillage could occur.

- Prepare a Diagnostic Development/Test/Simulation Plan.
- Perform field tests and simulations to evaluate the new test method on up to five local houses with various wind exposures to evaluate its practicality. Once the method is deemed reliable, the test results will be extended over a broad range of climates and house/vent combinations using computer software (e.g., CONTAM, TRNSYS, VENTII, FLUESIM) that together can account for the interactions between flow resistances, mechanical equipment operation, building temperatures, and weather on building airflows and pressures, and for the transient thermal response of venting systems.
- Prepare a Field Tests and Simulation Results Report.
- Prepare a peer-reviewed technical paper that describes the new diagnostic method and laboratory tests.
- Disseminate project results in the form of a Diagnostic Test and Air Tightening Guide and input to standards. The information, tools, and procedures generated will be incorporated into a guide that describes the diagnostic procedures and defines air-tightness, air change rate, and unbalanced ventilation constraints to guide air tightening activities while maintaining proper combustion appliance venting.
- Take the diagnostic procedure and guidance developed in this task to American Society for Testing and Materials (ASTM) Performance of Buildings (E6) Committee/Subcommittee for incorporation into their existing guide (E1998-02, Standard Guide for Assessing Depressurization-Induced Backdrafting and Spillage from Vented Combustion Appliances) and to Title 24 for inclusion as a standard method of test.
- Draft standards language and a Draft Standards Language and ASTM and Title 24 Memorandum that describes the status of the related ASTM and Title 24 standards process.
- Prepare a peer-reviewed paper that describes the field tests and the simulation results.
- Participate in project-wide CPR, jointly coordinated with the PAC.
- Compile results into final project report titled “Building Air-Tightness through Appliance Venting Standards” in final report format detailed in Task 3.2.

Deliverables:

- Annotated Bibliography (no draft)
- Diagnostic Development/Test/Simulation Plan (no draft)
- Field Tests and the Simulation Results Report (no draft)
- Technical Paper on New Diagnostic Method and Laboratory Tests (no draft)
- Diagnostic Test and Air Tightening Guide (no draft)
- Draft Standards Language and ASTM and Title 24 Memorandum (No Draft)

- CPR Report
- Building Air-Tightness through Appliance Venting Standards Report

Task 2.13 ENERGY EFFICIENCY IN SMALL SERVER ROOMS
The goal of this task is to improve overall energy efficiency over current practice for IT resources and their support systems when deployed in small server closets and rooms.

The Contractor shall:
- Identify small server room spaces to evaluate at a mixture of various companies and academic institutions.
- Compile a list of identified server spaces, companies, and/or academic institutions.
- Perform a detailed assessment of energy use and cooling effectiveness for each identified space through a combination of measured energy end use, measured thermal performance, and estimates, where measurements are not possible. For the IT equipment, the assessment will include a full inventory of the servers, data storage, and network equipment, measurement of server utilization rates, and collection of institutional data such as the applications that are run on each server, who owns and operates the server, and other pertinent information. Investigate how the IT and infrastructure in these server rooms evolved to the assessed condition.
- Determine IT and infrastructure efficiency measures and expected energy savings for four room configurations and conduct more detailed evaluation of efficiency improvement options. This activity will include a review of the layout of the IT equipment, power distribution efficiency, cooling efficiency options, as well as a review of IT equipment improvements such as server virtualization, consolidation, and migration to a cloud computing model. Energy-efficiency measures and expected energy savings will be developed. Assess the feasibility and barriers of implementing the recommended improvements.
- Prepare a Summary of Configuration Features.
- Develop a list of efficiency measures and potential savings for each configuration.
- Participate in project-wide CPR, jointly coordinated with PAC.
- Compile results of the activities within this task into a final project report titled “Energy Efficiency in Small Server Rooms” in the same format as the Final Report, detailed in Task 3.2.

Deliverables:
- Server Spaces, Companies, or Academic Institutions List (no draft)
- Summary of Configuration Features (no draft)
- Efficiency Measures and Potential Savings List (no draft)
- CPR Report
- Energy Efficiency in Small Server Rooms Report

Task 2.14 DATA CENTER ENERGY EFFICIENCY DEMONSTRATION PROJECTS

The goal of this task is to accelerate the adoption of energy-saving measures in data centers. LBNL will work with Silicon Valley Leadership Group member companies to develop demonstration projects. LBNL will also develop one demonstration project per year and provide a detailed evaluation of the results.

The Contractor shall:

- Develop demonstration projects and match them with host member companies of the Silicon Valley Leadership Group (SVLG), and submit proposed demonstration projects to Energy Commission Contract Manager for approval.
- In year one, establish the first demonstration and a host site, execute the demonstration, and prepare a Data Center Year One Demonstration Report.
- In year two, establish the second demonstration and a host site, execute the demonstration, and prepare a Data Center Year Two Demonstration Report.
- Develop an Interim Yearly List of SVLG Demonstrations and Host Companies.
- Develop a Final Yearly List of SVLG Demonstrations and Host Companies.
- Prepare a PowerPoint presentation of results of first demonstration
- Prepare a PowerPoint presentation of results of second demonstration.
- Participate in a project-wide CPR, jointly coordinated with PAC.
- Compile results of the activities within this task into a final project report "Data Center Energy Efficiency Demonstration Projects" in the same format as the Final Report, detailed in Task 3.2.

Deliverables:

- Data Center Year One Demonstration Report (no draft)
- Data Center Year Two Demonstration Report (no draft)
- Interim Yearly List of Demonstrations and Host Companies (no draft)
- Final Yearly List of Demonstrations and Host Companies (no draft)
- Report and Powerpoint presentation of results of First Demonstration (no draft)
- Report and PowerPoint presentation of results of Second Demonstration (no draft)
- CPR Report
- Data Center Energy Efficiency Demonstration Projects Report

Task 2.15 ENERGY SAVINGS THROUGH DATA CENTER WASTE HEAT REUSE

The goal of this task is to reduce energy loss in data centers by reusing waste heat in an innovative facility hydronic heating system.

The Contractor shall:

- Gather available documentation and reports on design approaches and methods already applied to reuse waste heat.
- Identify energy recovery methods not yet demonstrated in a data center and

their applicability in data centers.
- Develop a checklist to evaluate the opportunity for applying a reuse method in a particular data center to be included in the final project report.
- Develop an Evaluation Report on the status of methods and designs for reusing data center waste heat.
- Evaluate the performance of the Contractor's waste heat recovery system with available meters, sensors, and energy monitoring and control system.
- Prepare an Available and Potential Waste Heat Re-Use Methods Report.
- Produce a Technology Case Study including lessons-learned and energy savings achieved by the Contractor with the combined system of server IBM Rear Door Heat eXchanger and water-to-water heat pump application.
- Participate in a project-wide CPR, jointly coordinated with PAC.
- Compile results of the activities within this task into a final project report titled "Energy Savings through Data Center Waste Heat Reuse" in the same format as the Final Report, detailed in Task 3.2.

Deliverables:
- Evaluation Report (no draft)
- Available and Potential Re-Use Waste Heat Method Report (no draft)
- Technology Case Study (no draft)
- CPR Report
- Energy Savings through Data Center Waste Heat Reuse Report

Task 3.0 Reporting Tasks

All reports shall be delivered to:

Accounting Office, MS-2
California Energy Commission
1516 9th Street, 1st Floor
Sacramento, CA 95814

Task 3.1 Quarterly Progress Reports

The Contractor shall deliver written Quarterly Progress Reports to the Energy Commission Contract Manager by the 30th of the following month, starting after the Department of General Service's contract approval date and continuing each quarter until the Final Report has been accepted by the Energy Commission Contract Manager. Attachment A-1 provides a recommended format and content requirements for the Quarterly Progress Report.

Task 3.2 Final Report

The Final Report shall be a public document. If the Contractor 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. When creating the Final Report, the Facility Operator shall use and follow, unless otherwise instructed in writing by the Energy 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

Subtask 3.2.1 Final Report Outline

- Contractor shall prepare and submit to the Energy Commission Contract Manager for review an outline of the Final Report describing the original purpose, approach and results of the project.

- The outline shall be submitted to the Energy Commission Contract Manager for review. The Energy Commission Contract Manager shall determine if the outline is satisfactory. If the Energy Commission Contract Manager determines that the outline is unsatisfactory, he or she will, in a timely manner, provide to the Contractor written comments, which indicate how the outline can be improved. The Contractor shall revise the outline to meet the Energy Commission Contract Manager's requirements. Upon finding the final report outline satisfactory, the Energy Commission Contract Manager shall provide to the Contractor written approval of it.

Subtask 3.2.2 Draft Final Report for Comment

- The Contractor shall prepare and submit to the Energy Commission Contract Manager a draft Final Report on the project. The format of the report shall follow the approved outline.
- The draft final report shall be submitted to the Energy Commission Contract Manager for review and to determine, in a timely manner, if it is satisfactory. If the Energy Commission Contract Manager determines that it is unsatisfactory, he or she will, provide to the Contractor written comments, which indicate how it can be improved. The Contractor shall revise the draft final report incorporating the Energy Commission Contract Manager's corrections and required changes. Upon finding the revised draft to be satisfactory, the Energy Commission Contract Manager shall provide to the Contractor written approval of it.

Subtask 3.2.3 Final Report

- The Contractor shall prepare Final Report and submit it to the Energy Commission Contract Manager after receiving the Energy Commission Contract Manager's written approval of the draft Final Report. This task shall be deemed complete and accepted by the Energy Commission only when the Energy Commission Contract Manager approves the Final Report in writing.

Upon approval, the Contractor shall submit two unbound copies of the Final Report to the Energy Commission Contract Manager.

Task 3.3 Final Meeting

Contractor shall meet with the Energy Commission Contract Manager to present findings, conclusions, and recommended next steps (if any) for the project.

Contractor will also discuss with the Energy Commission Contract Manager the following contract close-out items:

- What to do with any state-owned equipment (Options), if applicable
- Energy Commission's request for specific "generated" data (not already provided in contract deliverables)
- Need to document Contractor's disclosure of "subject inventions" developed under the contract
- Need to file UCC-1 form re: Energy Commission's interest in patented technology
- Other "surviving" contracts provisions.

VIII. Critical Project Reviews

The Energy Commission will conduct critical project reviews at a point agreed upon with the Energy Commission Contract Manager.

• In coordination with the PAC/TAC in all Technical Tasks

(Note: Critical project reviews are meetings between the Facility Operator, the Energy Commission Contract Manager and other individuals selected by the Energy Commission Contract Manager to provide objective, technical support to the Energy Commission. The purpose of these meetings to discuss with the Facility Operator the status of the project and its progress toward achieving its goals and objectives. These meetings may take place at the Energy Commission offices in Sacramento, or at another, reasonable location determined by the Energy Commission Contract Manager.)

(Note: Prior to the critical project review meeting, the Facility Operator will provide the task deliverable(s) to the Energy Commission Contract Manager sufficiently in advance to allow the Contract Manager's review of the deliverable document(s) before the review meeting. If not already defined in the Work Statement, the Energy Commission Contract Manager shall specify the contents of the deliverable document(s).)

(Note: At the project review meeting, the Facility Operator shall present the required technical information and participate in a discussion about the project with the Energy Commission Contract Manager and other meeting

attendees, if any.

(Note: Following the project review meeting, the Energy Commission will determine whether the Facility Operator is complying satisfactorily with the Work Statement and whether the project is demonstrating sufficient progress toward achieving its goals and objectives to warrant continued PIER financial support for the project.)

IX. Sponsor's Key personnel and Agreement Management

A. The name and area code/phone number of the California Energy Commission's Contract Manager is listed on Exhibit D and is the official technical contact for the Energy Commission.

The Sponsor's Contract Manager is responsible for the day to day project status, decisions and communications with the Facility Operator Project Manager (Principal Investigator). The Energy Commission Contract Manager will review and approve all project deliverables, reports, and invoices.

The Sponsor may change the Contract Manager by notice given to the Facility Operator at any time signed by the Contract Officer of the Energy Commission.

B. The name and area code/phone number of the California Energy Commission's Contract Officer is listed on Exhibit D and will be the Contract Officer for the Agreement and is the official administrative contact for the Energy Commission.

X. Facility Operator's Key Personnel and Agreement Administration

The Facility Operator is obligated to comply with the terms and conditions of its Management and Operating (M&O) Contract with the DOE when performing work under this agreement. The DOE may require substitution of the named "key personnel" under this agreement should the DOE determine that the services of the Project Manager (Principal Investigator) or other named key personnel are necessary to meet the Facility Operator's M&O Contract obligations to the DOE. Should the DOE direct the Facility Operator to substitute the named key personnel under this agreement, the Facility Operator shall inform the Energy Commission of the directed substitution in accordance with paragraphs A and B below. In the event that the Energy Commission does not concur with the substitution of named key personnel as directed by the DOE, this agreement shall be terminated under Article XX, Termination, of the modified terms and conditions.

A. The name and area code/phone number of the National Laboratory's Project Manager (Principal Investigator) is on Exhibit D and will be the Project Manager (Principal Investigator) for this project and is the official technical

contact for Lawrence Berkeley National Laboratory.

The Facility Operator's Project Manager (Principal Investigator) is responsible for the day to day project status, decisions, and communications with the Sponsor's Contract Manager. The Facility Operator's Project Manager (Principal Investigator) will review and approve all project deliverables and reports.

The Facility Operator's Project Manager (Principal Investigator) is designated as "key personnel" under the Agreement. The Energy Commission reserves the right to prior written concurrence of any substitution of the Project Manager (Principal Investigator).

B. The key personnel are listed on Exhibit D in this agreement.

Facility Operator's key personnel may not be substituted without the Energy Commission Contract Manager's prior written concurrence. Such concurrence shall not be unreasonably withheld. All other personnel may be substituted by Facility Operator, with written notification made to the Energy Commission Contract Manager.

C. The name and area code/phone number of National Laboratory Agreement Administrator is on Exhibit D and will be the Agreement Administrator for this Agreement and is the official administrative contact for Lawrence Berkeley National Laboratory.

XI. Facility Operator's key subcontractors

The Facility Operator's key subcontractors are listed on Exhibit D in this agreement.

Facility Operator's key subcontractors may not be substituted without the Energy Commission Contract Manager's prior written concurrence. Such concurrence shall be timely provided and not unreasonably withheld. Delay in written concurrence may result in a work stoppage of subcontract work. All other subcontractors may be substituted by Facility Operator, with written notification made to the Energy Commission Contract Manager.

XII. Report standards

A. The report outline and format will be provided by the Sponsor's Contract Manager to the Facility Operator's Project Manager (Principal Investigator).

B. All reports shall be delivered to the Accounting address shown on Exhibit D.

C. Progress Reports. The Facility Operator shall prepare a Progress Report that summarizes all Agreement activities conducted by the Facility Operator to date,

with an assessment of ability to complete the project within the current budget and any anticipated cost overruns. Each Progress Report is due to the Energy Commission Contract Manager within 30 days after the end of the reporting period. The Energy Commission Contract Manager will specify the report format and contents and the number of copies to be submitted.

D. Final Report and Final Meeting. At the conclusion of the Agreement's technical work as provided for this Appendix A Statement and revised project plan, Facility Operator shall prepare a comprehensive written Final Report, including an Executive Summary. The Energy Commission Contract Manager will review and approve the Final Report.

(Note: Facility Operator will also participate in a Final Meeting with the Energy Commission to present the findings, conclusions, and recommendations. Both the Final Meeting and the Final Report must be consummated on or before the termination date of the Agreement.)

XIII. Schedule

The program will continue for 48 months after advance funding is received by the Regents of the University of California. This Agreement is effective the later date of (1) the date on which it is signed by the last of the parties thereto, or (2) the date on which it is approved by the California Department of General Services as noted on the Standard Agreement, or (3) the date on which the Facility Operator receives advance funding from the Sponsor.

XIV. Budget

SOW Appendix A, Exhibit C shows Energy Commission's Reimbursable Budget.

SOW Appendix A, Exhibit C shows the assessed value of the Federal Administrative Charge not charged to this project.