

Department of Energy

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Funds-In Agreement for Research and Development

Appendix A—California Energy Commission

Exhibit A - Statement of Work

Exhibit B - Task Deliverables, Schedule,

Exhibit C - Budget

Exhibit D - List of Contacts And Addresses

Exhibit E - Confidential Deliverables and Intellectual Property Lists

Prepared by the Lawrence Berkeley National Laboratory
March 26, 2008

I. Title of project

Research for Improved Ventilation Specifications in Title 24: Demand Controlled Ventilation and Classroom Ventilation

II. California Energy Commission RFP identification

N/A

III. Background

The U.S. Department of Energy has directed the University of California to perform the work stated in this Appendix A for the California Energy Commission. Lawrence Berkeley National Laboratory, a laboratory owned by the Department of Energy, is located at 1 Cyclotron Road, Berkeley, CA, 94720. 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 1111 Franklin Street, Oakland, CA 94607-5200, manages and operates Lawrence Berkeley National Laboratory under DOE Contract No. DE-AC02-05CH11231.

The California Energy Resources Conservation and Development Commission (California 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

Ventilation rates in buildings affect heating and cooling energy use and occupant health, satisfaction, and work performance. Codes and standards, including CEC's Title 24, specify minimum ventilation rates that must strike a balance between energy conservation goals and the need to maintain acceptable indoor environmental conditions for health, comfort, and performance. In some circumstance, codes specify technical strategies for achieving appropriate ventilation rates.

Due to major gaps in current information, it is uncertain what specifications to include in Title 24 pertaining to carbon dioxide sensors used in demand controlled ventilation (DCV) systems. Key questions need to be addressed, such as:

- Can the commercially available CO₂ sensors used routinely for DCV measure CO₂ with sufficient accuracy, and, if so, what are the appropriate sensor specifications and maintenance recommendations for Title 24?
- Why do some or many of the CO₂ sensors used for DCV have large errors and can maintenance and calibrations reduce errors to acceptable levels?
- Where should the CO₂ sensors be installed?

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It is also uncertain what specifications to include in Title 24 to define appropriate minimum ventilation rates (balancing human needs with energy conservation) in buildings in general, and in schools in particular. The lack of well-supported specifications for minimum ventilation rates in schools that balance occupant welfare with energy conservation has two adverse consequences: current underventilation of some schools with adverse effects on health and performance of students, and overventilation of other schools, wasting money and energy. Furthermore, little or no information is available on the amount of ventilation, and associated heating and cooling, in California schools that is unnecessary, either because it exceeds the amount required to avoid impairing health and performance, or because it occurs in unoccupied classrooms.

V. Technical and economic/cost performance objectives

A. The overall technical goal of this project is to develop the information needed to evaluate and, as necessary, suggest revised specifications in CEC’s Title 24 pertaining to demand controlled ventilation and classroom ventilation. Realization of this research goal will directly support achievement of the even broader PIER program goals:

- improving the energy cost/value of California’s electricity, and
- improving the environmental and public health costs/risk of California’s electricity.

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

Demand Controlled Ventilation Research

- 1) Improving our understanding of the in-situ performance of carbon dioxide (CO₂) sensors/transmitters used with DCV systems, including, to the degree possible, our understanding of how sensor performance varies with sensor age, sensor technical features (e.g., single versus dual beam, auto zero), and sensor calibration history.
- 2) To the degree practical, determining causes of large CO₂ measurement errors.
- 3) Evaluating requirements for CO₂ sensor installation locations.
- 4) Assessing potential energy savings in California from use of DCV systems in general office spaces
- 5) Evaluating alternatives to the standard practice of using distributed low-cost CO₂ sensor-transmitters for DCV:
 - a. Centralized CO₂ instruments with multi-point sampling via tubes and pumps
 - b. People counters
- 6) Suggesting revisions to DCV specifications in Title 24:
 - a. Accuracy specifications
 - b. Required sensor features and capabilities (e.g., should certain technical features be required or excluded)
 - c. Installation requirements (e.g., number and locations of sensors)
 - d. Sensor acceptance requirements

Classroom ventilation research

- 7) Measuring ventilation rate much more accurately than in prior classroom studies, yet inexpensively
- 8) Describing ventilation rates, using this more accurate method, in California classrooms in

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multiple climate zones

- 9) Providing information on relationships between daily classroom VR and absence in elementary school students in California schools, including how this relationship changes at different VRs (i.e., if the relationship is nonlinear)
- 10) Providing information on the amount of *unnecessary* ventilation, heating, and cooling in California classrooms, related both to ventilation rates above what is necessary for student welfare, and to the ventilation of unoccupied classrooms
- 11) Providing data allowing initial decisions on trade-offs between different VRs in classrooms and associated costs and benefits, including potential economic savings based on the amount of time that classroom HVAC systems operate unnecessarily
- 12) Demonstrating an effective, economical prototype research strategy, suitable for simplified collection of further data to allow better policy decisions on VR guidelines.

C. Economic/cost goal and objectives

Overall economic/cost goal and specific economic/cost objectives are not applicable to this project; however, the suggested revisions to Title 24 pertaining to DCV will need to strike a balance between DCV costs and performance. Changes in practice in response to this research are expected to have economic benefits. The project should lead to better performing DCV systems that result in energy cost savings in some buildings and health cost savings and work performance increases in other buildings. In addition, the results of this study will contribute to PRC goal 25620.1.(b) by “[developing and helping bring to market] increased energy efficiency in buildings, appliances, lighting, and other applications beyond applicable standards, thereby benefiting electric utility customers.”

In particular, the schools with classrooms monitored in this study would have the option to keep the Nose units in the study classrooms at no charge if they begin paying the nominal fee for having the sensors monitored over time. Thus the ability to track adequacy of ventilation or conditioning of unoccupied classrooms may continue within at least 100 California classrooms, which could lead to energy and cost reductions and also decreased absenteeism (and improved health). This program and its benefits may spread to additional California classrooms as well. The market for use of information from this study, and the technology demonstrated in this study, is very large, including all K-12 schools in California, and ultimately the U.S. (in which ventilation, heating, and cooling energy costs over \$3 billion annually), as well as post-secondary classrooms.

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 California Energy Commission Contract Manager to review the California 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, Quarterly progress reporting format and content, etc.); and the California Energy Commission’s roles and responsibilities. The location of this meeting shall be designated by the California Energy Commission Contract Manager.

1.2 Describe Synergistic Projects

While this research builds upon and benefits from our prior similar research, we have no current synergistic projects. However, this research will capitalize on CEC-supported

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laboratory-based testing of new CO₂ sensors by the Iowa Energy Office. The leader of the research at Iowa Energy Center has agreed to collaborate with us in the development of suggestions pertaining to future specifications for DCV in Title 24.

1.3 Identify Required Permits

No permits are required for this project.

1.4 Obtain Required Permits

No permits are required for this project.

1.5 Prepare Production Readiness Plan

This project does not involve the design, development, or demonstration of energy-related technology; consequently, a production readiness plan is not required.

VII. Description of tasks to be performed

TECHNICAL TASKS

GLOSSARY

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

CFM	Cubic feet per minute
CO ₂	Carbon dioxide
CPR	Critical Project Review
DCV	Demand Controlled Ventilation
DOE	Department of Energy
SES	Socioeconomic status
VR	Ventilation rate
Y1, Y2	Year 1 and Year 2 of the school study (2008-09 school year and 2009-10 school year)

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 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. The Commission Contract Manager will provide written comments back to the Contractor on the draft deliverable within 5 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 2 working days of receipt. Key elements from this deliverable shall be included in the Final Report for this project.

Technical Task List

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Task 2.1	Field studies of CO₂ sensor performance
Task 2.2	Causes of large CO₂ measurement errors
Task 2.3	Pilot evaluation of CO₂ DVC with multi-point sampling systems
Task 2.4	Pilot evaluation of optical people counting for DCV
Task 2.5	Potential energy savings from use of CO₂ DCV in general office spaces
Task 2.6	Dissemination of results of DCV research
Task 2.7	Preparation for classroom field study
Task 2.8	Y1 Data Collection and Preliminary Analysis
Task 2.9	Y2 Data Collection
Task 2.10	Data analyses, reporting of findings and outreach

Task 2.1 Field studies of CO₂ sensor performance

The goals of this task are: a) to evaluate the in-situ accuracy of CO₂ sensors used for CO₂ DCV and, to the degree possible via analyses of the data, determine how accuracy varies with sensor age, sensor technical features, and sensor calibration history; b) to identify causes of sensor accuracy failures; and c) to evaluate requirements for CO₂ sensor installation locations. The resulting information will be used in Task 2.6 to develop suggestions for related specifications in Title 24.

The Contractor shall:

- Provide a Building List of 25 candidate buildings for study.
- Provide a Sensor List of CO₂ sensors to be tested including without limitation sensor models, technology types and manufacturers.
- Evaluate the accuracy of CO₂ sensors in 25 buildings.
- Employ bags of primary standard CO₂ calibration gases to evaluate sensor performance at several CO₂ concentrations when appropriate.
- Process multipoint calibration data to obtain an offset error and slope or sensor gain error using a least-squares linear regression of measured CO₂ concentration versus “true” CO₂ concentration.
- Perform a single-point calibration check of the building’s CO₂ sensors using a co-located and calibrated reference instrument, when a multi-point calibration is not possible.
- Record the make and model numbers of sensor.
- Combine the sensor data from the 25 buildings with existing data from eight buildings (44 sensors) and process data to obtain absolute errors and percentage errors.
- Collect data (to the degree available) from facility managers on year of sensor installation, sensor cost and installed cost, sensor calibration history, how the sensors are being used for ventilation control (e.g., CO₂ setpoint and control strategy).
- Analyze sensor data to determine how accuracy varies with sensor age, type, and calibration history.
- Perform multipoint measurements of CO₂ in six to eight spaces suitable for DCV.
- Perform the multipoint monitoring during a period of space utilization (i.e., when a meeting is held within a meeting room) using calibrated high-accuracy CO₂ analyzers.
- Analyze data to determine how CO₂ concentrations vary with location and measurement height in the occupied space and to determine how well the concentration in the return air duct represents that in the occupied space.

Deliverables:

- Building List

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- Sensor List

Task 2.2 Causes of large CO₂ measurement errors

The goal of this task is to determine causes of large CO₂ measurement errors for sensors used in DCV systems. Although inspection and testing may fail to identify the causes of measurement errors, this work will, at a minimum, determine whether the faulty sensors can be made functional via calibration and adjustment.

The Contractor shall:

- Obtain at least eight “faulty” sensors (such as sensors from the task 2.1 field studies with errors over 200 ppm), by offering the facility manager a new sensor suitable as a replacement for the faulty sensor.
- Conduct laboratory tests to determine if the faulty sensors can be calibrated to give accurate CO₂ data.
- Inspect faulty sensors for obvious broken parts and dirt clogged airflow paths.
- Clean optical components, if accessible, and determine if sensor accuracy improves.
- Check infrared sources for reduced output if practical¹.
- Prepare a Summary Report of faulty sensors and their technology type.

Deliverables:

- Summary Interim Report

Task 2.3 Pilot evaluation of CO₂ DVC with multi-point sampling systems

The goal of this task is to provide an initial indication of the potential for DCV of CO₂ monitoring using more stable and accurate CO₂ sensors coupled with multipoint sampling systems.

The Contractor shall:

- Perform field tests in two buildings to assess measurement accuracy of commercial CO₂ monitoring systems with multipoint sampling.
- Interview facility managers to learn about their experience with such systems.
- Solicit cost estimates from both manufacturers and facility managers
- Analyze the resulting data to provide an indication of the practicality and possible benefits of more widespread use of these systems for DCV.
- Submit a Report on CO₂-based DCV (covering Tasks 2.1, 2.2, 2.3). This Report shall include, but not be limited to, in-situ CO₂ sensor accuracy, reasons for large sensor errors, and practicality and possible benefits of CO₂ DVC with multi-point sampling systems

Deliverables:

- Report on CO₂-based DCV (covering Tasks 2.1, 2.2, 2.3)

Task 2.4 Pilot evaluation of optical people counting for DCV

¹ Evaluation of IR sources is contingent on manufacturers providing specifications for new properly performing sources. Such information is not in the normal technical specifications provided by manufacturers.

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The goal of this task is to provide an initial indication of the potential of optical-based people counting technologies for use in DCV systems.

The Contractor shall:

- Select two buildings to test people counting strategies in consultation with the CCM.
- Assess the opportunities at the test locations, determine the best people counting strategy and obtain people counting hardware and software after consultation with the CCM.
- Evaluate the accuracy of the two people counting systems under controlled laboratory conditions, including single persons passing through a doorway at various walking speeds and simultaneous or near simultaneous passage of multiple people through the doorway.
- Deploy the two people counting systems in buildings and over a two month period, at several times, compare counts of occupants indicated by the counting systems to manual counts of occupancy. Collect data when systems are used to count people entering and exiting a meeting room and also a full building or section of a building.
- Analyze data to determine counting accuracy.
- Compile data on cost of the people counting systems and compare it to the cost of CO₂ sensors.
- Prepare an Optical People Counter Accuracy Technical Report. This Report shall include without limitation all aspects and elements of this task with emphasis on counting accuracy.

Deliverables:

- Optical People Counter Accuracy Technical Report

Task 2.5 Potential energy savings from use of CO₂ DCV in general office spaces

The goal of this task is to estimate the possible energy savings in California from widespread use of DCV in general office spaces.

The Contractor shall:

- Develop an estimate of the average minimum ventilation rate in California office buildings without DCV using data from the U.S. Environmental Protection Agency's BASE survey of 100 office buildings across the U.S., and more recent data if such data become available.
- Select the existing prototypical medium-size office building developed for the U.S. Department of Energy's simulations of building energy performance. This prototype reflects typical medium-size office building characteristics in the Department of Energy's Commercial Building Energy Survey. Assign equipment efficiencies consistent with Title 24 requirements.
- Employ the EnergyPlus program to predict HVAC energy consumption in the prototypical office building with and without DCV, the predictions will be made for each California Climate zone
- Perform a simple cost benefit analysis comparing the predicted energy cost savings with the costs of DCV.
- Prepare a DCV Energy Savings Technical Report. This Report shall include without limitation all aspects and elements of this task with emphasis on a discussion on the potential energy savings from the use of DCV in general office buildings within California.

Deliverables:

- DCV Energy Savings Report

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Task 2.6 Dissemination of results of DCV research

The goal of this task is to provide suggestions pertaining to the DCV specifications in Title 24 and to disseminate research results to stakeholders.

The Contractor shall:

- Utilize results of Tasks 2.1-2.5 to develop a set of recommendations pertaining to future specifications for DCV in Title 24 addressing the following:
 - CO₂ sensor accuracy specifications.
 - Required CO₂ sensor features or capabilities.
 - CO₂ measurement locations (e.g., height above floor, whether to allow measurements in return ducts).
 - Recommended sensor calibration intervals.
 - Acceptance requirements for CO₂ sensor systems used in DCV.
 - Use of more expensive and accurate CO₂ sensors in conjunction with multi-point sampling systems.
 - Allowing use of optical people counting systems.
 - Requiring DCV in new general office buildings.
- Develop the above-described recommendations on DCV in collaboration with staff from the Iowa Energy Center, who are conducting tests of new sensors in the laboratory as part of CEC Agreement 500-02-004, WA# 034.
- Develop the recommendations on DCV in consultation with CEC staff, and prepare a DCV/Title 24 Recommendations Report detailing these recommendations.
- Produce a project web page on DCV, which will serve as another vehicle for dissemination of the research project results.
- Make a DCV Presentation on the results of the DCV tasks to HVAC professionals at a Pacific Energy Center seminar or at a similar venue, and submit any PowerPoint presentations or other materials generated in the preparation.
- Include in these Deliverables discussions of energy impacts as discovered in Task 2.5.

Deliverables:

- DVC/Title 24 Recommendations Report
- DCV web page
- DCV Presentation Materials

Task 2.7 Preparation for classroom field study

The goal of this task is to produce a study protocol approved by the Human Subjects Committee, obtain agreement for participation from a sufficient number of classrooms, and prepare for the subsequent analyses.

The Contractor shall:

- Prepare a Field Study Plan. This Plan shall include without limitation a detailed study protocol specifying all methods, including interactions with subjects and handling of subject data. The Field Study Plan shall also include a travel plan which must be approved by the CCM.
- Obtain approval of the detailed study protocol from the U.C. Berkeley and/or LBNL Human Subjects

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Committee, confirming that the study goals, methods, benefits, and risks are consistent with appropriate guidelines for the study of human subjects (this is not a permit).

- Develop computer programs for downloading, processing, and interpreting the real-time data (on CO₂, temperature, and relative humidity) from the classroom and outdoor sensors
 - Estimation of ventilation rate per person from indoor minus outdoor CO₂ data
 - Estimation of time that each classroom conditions the indoor air after students have left for the day (estimates will exclude the one hour before classes begin each morning)
 - Crude determination (if feasible) of presence of functioning economizer, based on substantial increase in VR during periods of suitable outside temperatures
- Following the sampling strategy [outlined in Figure 2 and described in more detail in Appendix](#), obtain agreement for participation of a sufficient number of classrooms: 50-100 to be included for both the 1st and 2nd years, plus an additional 50-100 classrooms for the 2nd year, including both site-built and portable classrooms
- Install air quality monitors at each participating school
 - Install one in each study classroom
 - Install one in an outside location
- Connect indoor and outdoor monitors to the Internet
- Confirm the operation of the installed sensors
- Pretest all aspects of the study, including sufficient classroom-level participation

Deliverables:

- Field Study Plan

Task 2.8. Y1 Data Collection and Preliminary Analysis

The goals of this task involve collecting and processing study data from the initial Y1 classrooms and performing preliminary statistical analyses.

The Contractor shall:

- Collect classroom, student, and school data over a 10.5 month school year, including:
 - Absence data faxed from each school to the Contractor by school staff at least monthly, and double key-entered into a database; this will be data on total daily student absence, but where feasible the Contractor will also collect separate data on illness-related and non-illness-related absences.
 - Confounding variables that may be related to both ventilation rate and absence, including school-level variables obtained from public data sources such as:
 - outdoor temperature,
 - outdoor air pollutant concentrations,
 - neighborhood socioeconomic status (SES), and
 - student-level data aggregated at the classroom level obtained from schools, such as gender and SES (in case both levels of SES confound independently).
 - Real-time, continuously collected sensor data, checked and retrieved over the Internet at least bi-monthly (along with spreadsheet summaries of data provided by the air quality monitors installed in Task 2.6).

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- Analyze the first month of collected data as a check and revise the collection procedures as necessary.
- Process the Y1 real-time environmental data and perform preliminary statistical analyses:
 - Estimate ventilation rates and conditioning time of unoccupied classrooms.
 - Describe the distribution of ventilation rates and absence rates for all classrooms and for selected subgroups such as by type of construction and climate.
 - Estimate relationships between Ventilation Rate (VR) and absence at specific VRs, adjusting for potential confounding variables.
- Revise the Y2 protocol as necessary and feasible, based on preliminary analyses of Y1 data.
- Prepare a Y1 Data Collection Report summarizing the work performed in this task.

Deliverables:

- Y1 Data Collection Informal Report

Task 2.9. Y2 Data Collection

The goals of this task include enrolling 50-100 new classrooms within a new set of schools, plus any additional needed to replace non-continuing Y1 classrooms, according to the sampling selection methods in the Field Study Plan, and to collect study data over the next school year in this larger set of classrooms.

The Contractor shall:

- Select and enroll the necessary number of additional elementary schools and classrooms in the included school districts, using the same sampling strategy as in Y1. These will be additional schools within the Y1 school districts and grouped climate zones.
- Install sensors both inside the classrooms and outdoors in the additional Y2 schools, and confirm their proper operation.
- Follow the same real-time data collection procedure and schedules as in Y1 (Task 2.8) over the 10.5 month school year:
 - Collecting real-time CO2 measurement data
 - Collecting daily absence data
 - Collecting data on confounding variables at the school level and the classroom-aggregate level
- Prepare a Y2 Data Collection Report summarizing the work performed in this task.

Deliverables:

- Y2 Data Collection Informal Report

Task 2.10. Data analyses, reporting of findings and outreach

The goal of this task is to process the Y2 real-time environmental data and perform statistical analyses of the combined Y1 and Y2 data.

The Contractor shall:

- Estimate the ventilation rates and conditioning time of unoccupied classrooms.

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- Describe the distribution of ventilation rates and absence rates for all classrooms and for selected subgroups such as by type of construction and climate.
- Estimate the relationships between VR and absence at specific VRs, adjusting for potential confounding variables.
- Calculate, as feasible, the proportion of classrooms with effectively operating economizers.
- Estimate the energy consumption and financial cost of ventilating all study classrooms if they were ventilated at the mean VR observed.
- Estimate the benefits (decreased student absence and increased state payments) versus costs (energy consumption and financial cost) if all classrooms provided VRs at the current guideline levels (15 cfm/person in Title 24) vs. the mean observed VR, and also if at 20 cfm/person vs. 15/cfm/person.
- Estimate the amount of time that classroom ventilation systems run unnecessarily in unoccupied classrooms, and the potential savings in energy and financial cost if ventilation systems were operated only when necessary; e.g., from an hour before occupancy each day till half an hour after occupancy ceases.
- In consultation with the CCM, give a Findings Presentation to Energy Commission staff, and submit any PowerPoint presentations or other materials developed in the preparation. The Findings Presentation shall summarize the findings of Tasks 2.7 through 2.10.
- In consultation with the CCM, prepare and submit a Findings Trade Journal Article targeted to either school decision-makers or school facilities operators summarizing the findings of Tasks 2.7 – 2.10.

Deliverables:

- Findings Presentation Materials
- Findings Trade Journal Article

Immediately following the Technical Tasks should be the Reporting Tasks listed below:

Task 3 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 prepare written Quarterly Progress Reports to the Commission Contract Manager by the 30th of the following month, starting after the Department of General Service's contract approval date and shall continue each month until the Final Report has been accepted by the 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. The Contractor shall follow the latest version of the PIER Final Report guidelines published on the Energy Commission's Web Site at

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<http://www.energy.ca.gov/contracts/pier/contractors/index.html> at the time the Contractor begins performing this Task unless otherwise instructed in writing by the Commission Contract Manager.

Subtask 3.2.1 Final Report Outline

- Contractor shall prepare and submit to the Commission Contract Manager for review an outline of the Final Report describing the original purpose, approach and results of the project. PIER Final Report guidelines are published on the Energy Commission's Web Site at <http://www.energy.ca.gov/contracts/pier/contractors/index.html>, and shall be used unless otherwise instructed in writing by the Commission Contract Manager.
- The outline shall be submitted to the Commission Contract Manager for review. The Commission Contract Manager shall determine if the outline is satisfactory. If the 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 Commission Contract Manager's requirements. Upon finding the final report outline satisfactory, the 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 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 Commission Contract Manager for review and to determine, in a timely manner, if it is satisfactory. If the 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 Commission Contract Manager's corrections and required changes. Upon finding the revised draft to be satisfactory, the 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 Commission Contract Manager after receiving the Commission Contract Manager's written approval of the draft Final Report. This task shall be deemed complete and accepted by the Commission only when the Commission Contract Manager approves the Final Report in writing. Upon approval, the Contractor shall submit two unbound copies of the Final Report to the Commission Contract Manager.

Task 3.3 Final Meeting

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

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

- What to do with any state-owned equipment (Options), if applicable
- 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: Commission's interest in patented technology
- Other "surviving" contracts provisions.

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VIII. Critical Project Reviews

The California Energy Commission will conduct critical project reviews at the conclusion of the following tasks:

- CPRs are TBD to be determined by the Contract Manager at a following date.

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(Note: Critical project reviews are meetings between the Facility Operator, the California Energy Commission Contract Manager and other individuals selected by the California Energy Commission Contract Manager to provide objective, technical support to the California 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 California Energy Commission Contract Manager.)

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(Note: Prior to the critical project review meeting, the Facility Operator will provide the task deliverable(s) to the California 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 California 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 California Energy Commission Contract Manager and other meeting attendees, if any.)

(Note: Following the project review meeting, the California 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

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- 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 California 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 California 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 California 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 California 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.

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Should the DOE direct the Facility Operator to substitute the named key personnel under this agreement, the Facility Operator shall inform the California Energy Commission of the directed substitution in accordance with paragraphs A and B below. In the event that the California 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.

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 California 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 California 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 California 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 California 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 California 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 California Energy Commission Contract Manager within 30 days after the end of the reporting period. The California Energy Commission Contract Manager will specify the report format and contents and the number of copies to be submitted.

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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 California Energy Commission Contract Manager will review and approve the Final Report.

(Note: Facility Operator will also participate in a Final Meeting with the California 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.)

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XIII. Schedule

The program will continue for 42-36 months after advance funding is received by 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.

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XIV. Budget

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

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

SOW Appendix A, Attachment A-2 shows assessed value of synergistic projects. The assessed value of such synergistic projects does not constitute a funding contribution or obligation (either cash or in-kind) on the part of the DOE or the Facility Operator.

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