

New Agreement EPC-16-056 (To be completed by CGL Office)

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| ERDD | Karen Perrin | 916-327-1467 |
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| DOE- Lawrence Berkeley National Laboratory | 94-2951741 |
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| Performance Evolution, Specification and Verification of Building Control Sequences (STAGE II) | | |
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|-----------|-----------|--------------|
| 6/10/2017 | 6/30/2020 | \$ 1,000,000 |
|-----------|-----------|--------------|

 ARFVTP agreements under \$75K delegated to Executive Director.

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|--------------------------------|--------------|----------------------------------|--|
| Proposed Business Meeting Date | 5/10/2017 | <input type="checkbox"/> Consent | <input checked="" type="checkbox"/> Discussion |
| Business Meeting Presenter | Karen Perrin | Time Needed: | 5 minutes |

Please select one list serve. EPIC (Electric Program Investment Charge)

Agenda Item Subject and Description

DOE-LAWRENCE BERKELEY NATIONAL LABORATORY. Proposed resolution approving Agreement EPC-16-056 with the Department of Energy's Lawrence Berkeley National Laboratory for a \$1,000,000 grant to develop building control software tools that will enable building designers to compare performance implications of different control strategies based on building requirements. Adoption of the tool will improve design and implementation of building controls with a potential to reduce energy use by 12 percent. This project is a cost share grant to the U.S. DOE's \$2,000,000 in funding. (EPIC funding) Contact: Karen Perrin (5 minutes)

1. Is Agreement considered a "Project" under CEQA?

 Yes (skip to question 2) No (complete the following (PRC 21065 and 14 CCR 15378)):

Explain why Agreement is not considered a "Project":

2. If Agreement is considered a "Project" under CEQA:

 a) Agreement **IS** exempt. (Attach draft NOE)

 Statutory Exemption. List PRC and/or CCR section number: _____

 Categorical Exemption. List CCR section number: Cal. Code Regs., tit 14, § 15306 and § 15301
 Common Sense Exemption. 14 CCR 15061 (b) (3)

Explain reason why Agreement is exempt under the above section: This is a software development project.

§ 15306 provides an exemption for basic data collection, research, experimental management, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource. This project will involve data collection in the form of historical and real-time sensor and actuator signals from automation systems in buildings and will not result in a serious or major disturbance to environmental resources.

§ 15301 provides an exemption for the operation, repair, maintenance, and minor alteration of existing public or private structures, facilities, mechanical equipment, involving negligible or no expansion of use beyond that existing. This project will involve software development at existing facilities which currently conduct software development activities. The project could also involve the installation of control design and a functional verification tool in existing buildings which would consist of the operation and minor alteration of existing buildings and mechanical equipment which would involve negligible or no expansion of use beyond that existing.

 b) Agreement **IS NOT** exempt. (Consult with the legal office to determine next steps.)

Check all that apply

 Initial Study

 Negative Declaration

 Mitigated Negative Declaration

 Environmental Impact Report

 Statement of Overriding Considerations

GRANT REQUEST FORM (GRF)

CEC-270 (Revised 10/2015)

CALIFORNIA ENERGY COMMISSION



| | |
|-----------------------------|--------|
| Legal Company Name: | Budget |
| ARUP | |
| Building Intelligence Group | |
| | |

| |
|---------------------------------------|
| Legal Company Name: |
| Integral Group |
| ControlCo |
| Stanford University |
| kW Engineering |
| Building Intelligence Group |
| CBRE |
| DOE |
| Taylor Engineering |
| Pacific Northwest National Laboratory |

| Funding Source | Funding Year of Appropriation | Budget List No. | Amount |
|-----------------------------------|-------------------------------|------------------------------------|-------------|
| EPIC | 15-16 | 301.001C | \$1,000,000 |
| | | | \$ |
| R&D Program Area: EERO: Buildings | | | \$1,000,000 |
| Explanation for "Other" selection | | | |
| Reimbursement Contract #: | | Federal Agreement #: DE-FOA-001383 | |

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|-------------------|-------------------------------|-------------------|------------------------------|
| Name: | Betsy Quayle | Name: | Michael Wetter |
| Address: | 1 Cyclotron Rd MS 56A-0120 | Address: | 1 Cyclotron Rd, MS 90R400 |
| City, State, Zip: | Berkeley, CA 94720-8130 | City, State, Zip: | Berkeley, CA 94720-8099 |
| Phone: | 510-486-7391 / | Fax: | - - |
| Phone: | 510-486-6990 / | Fax: | - - |
| E-Mail: | bequayle@lbl.gov | E-Mail: | mwetter@lbl.gov |

| | |
|---|----------------------------|
| <input checked="" type="checkbox"/> Competitive Solicitation | Solicitation #: PON-14-308 |
| <input type="checkbox"/> First Come First Served Solicitation | |

| | |
|---|---|
| 1. Exhibit A, Scope of Work | <input checked="" type="checkbox"/> Attached |
| 2. Exhibit B, Budget Detail | <input checked="" type="checkbox"/> Attached |
| 3. CEC 105, Questionnaire for Identifying Conflicts | <input checked="" type="checkbox"/> Attached |
| 4. Recipient Resolution | <input checked="" type="checkbox"/> N/A <input type="checkbox"/> Attached |
| 5. CEQA Documentation | <input type="checkbox"/> N/A <input checked="" type="checkbox"/> Attached |

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|-------------------|------|----------------|------|-----------------|------|
| Agreement Manager | Date | Office Manager | Date | Deputy Director | Date |
|-------------------|------|----------------|------|-----------------|------|

Exhibit A Scope of Work

I. TASK AND ACRONYM/TERM LIST

A. Task List

| Task # | CPR ¹ | Task Name |
|--------|------------------|--|
| 1 | | General Project Tasks |
| 2 | | Specification |
| 3 | x | Controls Design Tool |
| 4 | x | Functional Verification Tool |
| 5 | | Case Studies |
| 6 | | Commercialization and Market Transformation Plan |
| 7 | | Evaluation of Project Benefits |

B. Acronym/Term List

| Acronym/Term | Meaning |
|--------------|---|
| API | Application Programming Interface |
| ASHRAE | American Society of Heating, Refrigeration and Air-Conditioning Engineers |
| BACnet | Building Automation and Control Networking Protocol (under ASHRAE) |
| BCL | Building Component Library (a software that is part of OpenStudio) |
| BCVTB | Building Controls Virtual Test Bed, a LBL-developed and DOE-supported software |
| CAM | Commission Agreement Manager |
| CAO | Commission Agreement Officer |
| CDL | Controls Description Language (a vendor-neutral language that will be used to express the control sequences) |
| CPR | Critical Project Review |
| GUI | Graphical User Interface |
| HVAC | Heating, ventilation and air-conditioning |
| REST | representational state transfer, an architectural style of an API that is used extensively in web-enable software |
| SOEP | Spawn of EnergyPlus (the new version of EnergyPlus that is currently in development at DOE and that will allow modeling of actual controls) |
| TAC | Technical Advisory Committee |
| TC | Technical Committee (of ASHRAE) |
| UML | Unified Modeling Language, used to define software architecture and interaction |

¹ Please see subtask 1.3 in Part III of the Scope of Work (General Project Tasks) for a description of Critical Project Review (CPR) Meetings.

Exhibit A

Scope of Work

II. PURPOSE, PROBLEM/SOLUTION STATEMENT, AND GOALS AND OBJECTIVES

A. Purpose Of Agreement And Project

The purpose of this Agreement is to provide Electric Program Investment Charge (EPIC) cost share funding for the Recipient's federally-funded project, which received an award under federal funding opportunity DE-FOA-0001383. The purpose of the agreement is to develop an integrated set of tools to enable design engineers to use energy-efficient ASHRAE-developed or custom control sequences for commercial buildings, specify them for control providers and then verify their correct implementation. Such a process provides end-to-end quality control. Energy Commission funds will be used for tasks 1 to 7.

B. Problem/ Solution Statement

Problem

Correct design and implementation of building control strategies, embodied in sequences of operation, are critical to achieving good performance, especially with respect to energy consumption. However, in most cases, the sequences of operation are not explicitly defined by the design engineer. There are no tools available to designers that enable them to compare the performance implications of different control strategies and then choose the best strategy to suit the requirements of the project. Also, simulation-based estimates of energy performance that are generated for code compliance, or for energy rating systems such as LEED, are generally idealized and typically differ significantly from what is actually implemented in the building. This difference between design and operation contributes significantly to the gap between expected and actual performance.

A further problem is that there is no mechanism for ensuring that a sequence of operations is implemented correctly, even if the detailed sequence of operation has been specified by the designer. This is particularly a problem for innovative, high performance buildings, where the contractor and the service technicians may be unfamiliar with the systems and their intended operation.

Solution

The Recipient will develop a process with an integrated set of tools to enable design engineers to specify energy-efficient control sequences for commercial buildings and then verify their correct implementation, providing end-to-end quality control. Using tools and process, a mechanical designer can select an energy-efficient, ASHRAE GPC36-developed control sequence or custom control sequence from a library, test and adapt it as needed for the particular building, and export it for submission to the control provider, who can then write a quote and later implement it in the building automation system. The commissioning agent will reuse the original specification to conduct end-to-end quality control tests in which the installed sequence of operation is verified against the specification from the mechanical designer.

Agreement Goals

The goal of the project is to address the more than 1 quad per year energy waste resulting from common deficiencies in implemented building control strategies in the US, ~5% of this in California.

Ratepayer Benefits:

The project will result in the ratepayer benefit of greater electricity reliability and lower costs by reducing the energy use of commercial buildings through more robust and efficient operation of them. This will also improve thermal and visual comfort while reducing both energy costs and equipment maintenance costs. Specifically, the adoption of the technology to be developed in the proposed project will result in improved design and implementation of building controls. The

Exhibit A Scope of Work

energy savings from widespread adoption of the processes and tools to be developed can be estimated by noting that the majority of primary energy savings associated with commissioning are related to building controls. The primary energy consumption of US commercial buildings with floor area larger than 50,000 square feet is 18 quads per year. Assuming that the technologies to be developed in the proposed project can save 12 percent in 50 percent of these buildings, the potential savings are estimated at approximately 1.1 quads per year nationally and 0.05 quads per year. In California, saving Investor Owned Utility (IOU) ratepayers an estimated maximum of \$300,000,000 per year.

Additionally, when assuming a 25 percent adoption in the target market five years after project completion and 75 percent ten years after: If 10 percent of the target existing buildings have a controls retrofit each year and the new construction rate is 1.5 percent per year, after 10 years, the annual savings from existing buildings will have ramped up to near 40 percent of the maximum, i.e. about \$120 million per year for IOU ratepayers.

Other benefits that are harder to numerically quantify are more robust operation of buildings that provide fast and slow demand response and load shifting to the electrical grid, thereby contributing to increased electrical grid stability. Building control sequences that provide load shedding through active or passive thermal storage, or temporal reduction of heating, cooling, ventilation or lighting, are generally more complex. Tools and process allow mechanical engineers to design and test the performance and correct operation of such sequences during the design phase, and verify their correct implementation during the operational phase.

Technological Advancement and Breakthroughs:

The project will lead to technological advancement and breakthroughs to overcome barriers to the achievement of the State of California's statutory energy goals by developing a process and associated tools that rectify building controls with building technologies that integrate active façade, lighting and heating, ventilation and air-conditioning (HVAC) with the smart grid to provide fast and slow demand response. A project breakthrough will be that designers can use pre-tested ASHRAE GPC 36 control sequences or custom control sequences, adapt them as needed, or develop custom control sequences, and optimize and test their impact on energy use, peak power reduction, indoor air quality and thermal and visual comfort. Once they meet the performance requirements, the mechanical engineer can export them in a control-vendor-neutral format in order to obtain cost estimates. Once a controls contractor is selected for the job, the control contractor can implement the control sequence either manually, as is done today, or automatically using light-weight code generators. In either case, the commissioning provider will use the original electronic specification to conduct functional verification, thereby conducting an end-to-end quality control that ensures that the original design intent is realized.

Project Objectives

The objectives of the project are to develop:

- A process that allows performance quantification of competing control sequences, and an end-to-end quality control between the as-designed and as-installed control sequence
- Technologies that support the process, mainly;
 - a controls design tool that will (1) enable the selection and performance comparison of building control strategies that reduce energy and peak power while increasing air quality and comfort, and (2) export a sequence of operations, expressed in a digital form using an open-standard controls description language (CDL), that starts from well-tested sequences (e.g., ASHRAE GPC 36).

Exhibit A Scope of Work

- a CDL which is an electronic, vendor-neutral specification of the controls intent that can be used by control providers to provide cost estimates and to generate programming code for the vendor's product line.
- a functional verification tool that takes CDL, together with a list of control points, and verifies that the specification has been implemented correctly in the building control system.

III. TASK 1 GENERAL PROJECT TASKS

PRODUCTS

Subtask 1.1 Products

The goal of this subtask is to establish the requirements for submitting project products (e.g., reports, summaries, plans, and presentation materials). Unless otherwise specified by the Commission Agreement Manager (CAM), the Recipient must deliver products as required below by the dates listed in the **Project Schedule (Part V)**. Products that require a draft version are indicated by marking “**(draft and final)**” after the product name in the “Products” section of the task/subtask. If “(draft and final)” does not appear after the product name, only a final version of the product is required. With respect to due dates within this Scope of Work, “**days**” means working days.

The Recipient shall:

For products that require a draft version

- Submit all draft products to the CAM for review and comment in accordance with the Project Schedule (Part V). The CAM will provide written comments to the Recipient on the draft product within 15 days of receipt, unless otherwise specified in the task/subtask for which the product is required.
- Submit the final product to the CAM once agreement has been reached on the draft. The CAM will provide written approval of the final product within 15 days of receipt, unless otherwise specified in the task/subtask for which the product is required.
- If the CAM determines that the final product does not sufficiently incorporate his/her comments, submit the revised product to the CAM within 10 days of notice by the CAM, unless the CAM specifies a longer time period.

For products that require a final version only

- Submit the product to the CAM for approval.
- If the CAM determines that the product requires revision, submit the revised product to the CAM within 10 days of notice by the CAM, unless the CAM specifies a longer time period.

For all products

- Submit all data and documents required as products in accordance with the following Instructions for Submitting Electronic Files and Developing Software:

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- **Electronic File Format**
Submit all data and documents required as products under this Agreement in an electronic file format that is fully editable and compatible with the Energy Commission's software and Microsoft (MS)-operating computing platforms, or with any other format approved by the CAM. Deliver an electronic copy of the full text of any Agreement data and documents in a format specified by the CAM, such as memory stick or CD-ROM.

The following describes the accepted formats for electronic data and documents provided to the Energy Commission as products under this Agreement, and establishes the software versions that will be required to review and approve all software products:

- Data sets will be in MS Access or MS Excel file format (version 2007 or later), or any other format approved by the CAM.
- Text documents will be in MS Word file format, version 2007 or later.
- Documents intended for public distribution will be in PDF file format.
- The Recipient must also provide the native Microsoft file format.
- Project management documents will be in Microsoft Project file format, version 2007 or later.

- **Software Application Development**
Use the following standard Application Architecture components in compatible versions for any software application development required by this Agreement (e.g., databases, models, modeling tools), unless the CAM approves other software applications such as open source programs:
 - Microsoft ASP.NET framework (version 3.5 and up). Recommend 4.0.
 - Microsoft Internet Information Services (IIS), (version 6 and up) Recommend 7.5.
 - Visual Studio.NET (version 2008 and up). Recommend 2010.
 - C# Programming Language with Presentation (UI), Business Object and Data Layers.
 - SQL (Structured Query Language).
 - Microsoft SQL Server 2008, Stored Procedures. Recommend 2008 R2.
 - Microsoft SQL Reporting Services. Recommend 2008 R2.
 - XML (external interfaces).

Any exceptions to the Electronic File Format requirements above must be approved in writing by the CAM. The CAM will consult with the Energy Commission's Information Technology Services Branch to determine whether the exceptions are allowable.

MEETINGS

Subtask 1.2 Kick-off Meeting

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

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The Recipient shall:

- Attend a “Kick-off” meeting with the CAM, the Commission Agreement Officer (CAO), and any other Energy Commission staff relevant to the Agreement. The Recipient will bring its Project Manager and any other individuals designated by the CAM to this meeting. The administrative and technical aspects of the Agreement will be discussed at the meeting. Prior to the meeting, the CAM will provide an agenda to all potential meeting participants. The meeting may take place in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

The administrative portion of the meeting will include discussion of the following:

- Terms and conditions of the Agreement;
- Administrative products (subtask 1.1);
- CPR meetings (subtask 1.3);
- Permit documentation (subtask 1.7);
- Subcontracts (subtask 1.8); and
- Any other relevant topics.

The technical portion of the meeting will include discussion of the following:

- The CAM’s expectations for accomplishing tasks described in the Scope of Work;
- An updated Project Schedule;
- Technical products (subtask 1.1);
- Progress reports and invoices (subtask 1.5);
- Final Report (subtask 1.6);
- Technical Advisory Committee meetings (subtasks 1.9 and 1.10); and
- Any other relevant topics.

- Provide an *Updated Project Schedule* and *List of Permits*, as needed to reflect any changes in the documents.

The CAM shall:

- Designate the date and location of the meeting.
- Send the Recipient a *Kick-off Meeting Agenda*.

Recipient Products:

- Updated Project Schedule (if applicable)
- Updated List of Permits (if applicable)

CAM Product:

- Kick-off Meeting Agenda

Subtask 1.3 Critical Project Review (CPR) Meetings

The goal of this subtask is to determine if the project should continue to receive Energy Commission funding, and if so whether any modifications must be made to the tasks, products, schedule, or budget. CPR meetings provide the opportunity for frank discussions between the Energy Commission and the Recipient. As determined by the CAM, discussions may include project status, challenges, successes, advisory group findings and recommendations, final report preparation, and progress on technical transfer and production readiness activities (if applicable). Participants will include the CAM and the Recipient, and may include the CAO and any other individuals selected by the CAM to provide support to the Energy Commission.

Exhibit A

Scope of Work

CPR meetings generally take place at key, predetermined points in the Agreement, as determined by the CAM and as shown in the Task List on page 1 of this Exhibit. However, the CAM may schedule additional CPR meetings as necessary. The budget will be reallocated to cover the additional costs borne by the Recipient, but the overall Agreement amount will not increase. CPR meetings generally take place at the Energy Commission, but they may take place at another location, or may be conducted via electronic conferencing (e.g., WebEx) as determined by the CAM.

If the awarding federal agency conducts similar project review meetings, the Recipient will notify the CAM and invite him/her to participate (subject to the awarding federal agency's approval), either by teleconference or in-person. The federal agency's meetings may be used in place of the Commission's CPR meetings, at the discretion of the CAM.

The Recipient shall:

- Prepare a CPR Report for each CPR meeting that: (1) discusses the progress of the Agreement toward achieving its goals and objectives; (2) includes recommendations and conclusions regarding continued work on the project; and (3) includes copies of any correspondence with the awarding federal agency that relates to the project's status. Examples of correspondence include reports, summaries, letters, or emails that discuss project performance or the results of project review meetings with the federal agency.
- Submit the CPR Report along with any other Task Products that correspond to the technical task for which the CPR meeting is required (i.e., if a CPR meeting is required for Task 2, submit the Task 2 products along with the CPR Report).
- Attend the CPR meeting.
- Present the CPR Report and any other required information at each CPR meeting.
- Notify the CAM of any project review meetings conducted by the awarding federal agency, and invite the CAM to participate in the meetings by teleconference or in-person (subject to the awarding federal agency's approval).

The CAM shall:

- Determine the location, date, and time of each CPR meeting with the Recipient's input.
- Send the Recipient a CPR Agenda and a List of Expected CPR Participants in advance of the CPR meeting. If applicable, the agenda will include a discussion of permits.
- Conduct and make a record of each CPR meeting. Provide the Recipient with a Schedule for Providing a Progress Determination on continuation of the project.
- Determine whether to continue the project, and if so whether modifications are needed to the tasks, schedule, products, or budget for the remainder of the Agreement. If the CAM concludes that satisfactory progress is not being made, this conclusion will be referred to the Deputy Director of the Energy Research and Development Division.
- Provide the Recipient with a Progress Determination on continuation of the project, in accordance with the schedule. The Progress Determination may include a requirement that the Recipient revise one or more products.

Recipient Products:

- CPR Report(s)
- Task Products (draft and/or final as specified in the task)

Exhibit A Scope of Work

CAM Products:

- CPR Agenda
- List of Expected CPR Participants
- Schedule for Providing a Progress Determination
- Progress Determination

Subtask 1.4 Final Meeting

The goal of this subtask is to complete the closeout of this Agreement. If the awarding federal agency conducts similar project review meetings, the Recipient will notify the CAM and invite him/her to participate (subject to the awarding federal agency's approval), either by teleconference or in-person. The federal agency's meetings may be used in place of the Commission's Final meeting, at the discretion of the CAM.

The Recipient shall:

- Meet with Energy Commission staff to present project findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement. This meeting will be attended by the Recipient and CAM, at a minimum. The meeting may occur in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be divided into two separate meetings at the CAM's discretion.

- The technical portion of the meeting will involve the presentation of findings, conclusions, and recommended next steps (if any) for the Agreement. The CAM will determine the appropriate meeting participants.
- The administrative portion of the meeting will involve a discussion with the CAM and the CAO of the following Agreement closeout items:
 - Disposition of any state-owned equipment.
 - Need to file a Uniform Commercial Code Financing Statement (Form UCC-1) regarding the Energy Commission's interest in patented technology.
 - The Energy Commission's request for specific "generated" data (not already provided in Agreement products).
 - Need to document the Recipient's disclosure of "subject inventions" developed under the Agreement.
 - "Surviving" Agreement provisions such as repayment provisions and confidential products.
 - Final invoicing and release of retention.
- Prepare a Final Meeting Agreement Summary that documents any agreement made between the Recipient and Commission staff during the meeting. Include a copy of any federal agency correspondence (e.g., report, summary, letter, or email) that discusses project findings, conclusions, or recommendations.
- Prepare a Schedule for Completing Agreement Closeout Activities.
- Provide All Draft and Final Written Products on a CD-ROM or USB memory stick, organized by the tasks in the Agreement.
- Notify the CAM of any project review meetings conducted by the awarding federal agency, and invite the CAM to participate in the meetings by teleconference or in-person (subject to the awarding federal agency's approval).

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Energy Commission-Funded Products:

- Final Meeting Agreement Summary (if applicable)
- Schedule for Completing Agreement Closeout Activities
- All Draft and Final Written Products

REPORTS AND INVOICES

Subtask 1.5 Progress Reports and Invoices

The goals of this subtask are to: (1) periodically verify that satisfactory and continued progress is made towards achieving the project objectives of this Agreement; and (2) ensure that invoices contain all required information and are submitted in the appropriate format.

The Recipient shall:

- Submit a monthly *Progress Report* to the CAM. Each progress report must:
 - Summarize all Agreement activities conducted by the Recipient for the preceding month, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. See the Progress Report Format Attachment for the recommended specifications.
 - Provide a synopsis of the project progress, including accomplishments, problems, milestones, products, schedule, fiscal status, and any evidence of progress such as photographs.
 - Include copies of any federal agency correspondence that relates to the project's status. Examples of correspondence include reports, summaries, letters, or emails that discuss project performance and the results of project review meetings with the federal agency.
- In lieu of the monthly progress report and with the CAM's approval, submit one or more progress reports submitted to the awarding federal agency. The federal report(s) must contain information similar to that required in the Energy Commission monthly progress reports.
- Submit a monthly or quarterly Invoice that follows the instructions in the "Payment of Funds" section of the terms and conditions. In addition, each invoice must document and verify:
 - Energy Commission funds spent in California.

Energy Commission-Funded Products:

- Progress Reports
- Invoices

Subtask 1.6 Final Report

The goal of this subtask is to prepare a Final Report that discusses the results of the project, including energy benefits to California ratepayers. The CAM will review and approve the Final Report, which will be due at least **two months** before the Agreement end date.

The Recipient shall:

- Prepare a *Final Report* that follows the Style Manual provided by the CAM and includes the following items, at a minimum:
 - **Cover Page**
 - **Summary of Project Purpose and Results**
 - **Discussion** that includes the following, at a minimum:
 - a. Project goals and the approach to meeting the goals
 - b. Activities performed

Exhibit A Scope of Work

- c. Project results, including:
 - Success of the project as measured by the degree to which goals and objectives were achieved;
 - How the project has resulted in the ratepayer benefits and technological advancements and breakthroughs identified in the solicitation proposal and Part II of the Scope of Work;
 - Projected cost reduction impact and other benefits resulting from the project, including how the project has supported California's economic development in the near term and the number of jobs created or sustained;
 - How the project results will be used by California industry, markets and others
 - d. The project budget, including:
 - The total project cost and the cost share of all funding partners;
 - How the Energy Commission funding was spent on the project, including any unique products and benefits
 - e. Observations, conclusions, and recommendations for further RD&D projects and improvements.
- If a *Final Federal Report* is required by the federal agency:
 - Submit a draft of the report to the CAM on the date the draft is due to the federal agency (subject to the federal agency's approval).
 - Submit the approved final version of the report and *Written Confirmation of the Federal Agency's Approval of the Final Federal Report* (e.g., email or letter), upon receipt of the written confirmation.

CAM Product:

- Style Manual

Recipient Products:

- Final Report (draft and final)
- Federal Agency Report (draft and final)
- Written Confirmation of the Federal Agency's Approval of the Final Federal Report

PERMITS, AND SUBCONTRACTS

Subtask 1.7 Permits

The goal of this subtask is to obtain all permits required for work completed under this Agreement in advance of the date they are needed to keep the Agreement schedule on track. Permit costs and the expenses associated with obtaining permits are not reimbursable under this Agreement, with the exception of costs incurred by University of California recipients. Permits must be identified and obtained before the Recipient may incur any costs related to the use of the permit(s) for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a *Permit Status Letter* that documents the permits required to conduct this Agreement. If no permits are required at the start of this Agreement, then state this in the letter. If permits will be required during the course of the Agreement, provide in the letter:

Exhibit A Scope of Work

- A list of the permits that identifies: (1) the type of permit; and (2) the name, address, and telephone number of the permitting jurisdictions or lead agencies.
- The schedule the Recipient will follow in applying for and obtaining the permits.

The list of permits and the schedule for obtaining them will be discussed at the Kick-off meeting (subtask 1.2), and a timetable for submitting the updated list, schedule, and copies of the permits will be developed. The impact on the project if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in progress reports and will be a topic at CPR meetings.

- If during the course of the Agreement additional permits become necessary, then provide the CAM with an *Updated List of Permits* (including the appropriate information on each permit) and an *Updated Schedule for Acquiring Permits*.
- Send the CAM a *Copy of Each Approved Permit*.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the CAM within 5 days. Either of these events may trigger a CPR meeting.

Energy Commission-Funded Products:

- Permit Status Letter
- Updated List of Permits (if applicable)
- Updated Schedule for Acquiring Permits (if applicable)
- Copy of each Approved Permit (if applicable)

Subtask 1.8 Subcontracts

The goals of this subtask are to: (1) procure subcontracts required to carry out the tasks under this Agreement; and (2) ensure that the subcontracts are consistent with the terms and conditions of this Agreement.

The Recipient shall:

- Manage and coordinate subcontractor activities in accordance with the requirements of this Agreement.
- Incorporate this Agreement by reference into each subcontract.
- Include any required Energy Commission flow-down provisions in each subcontract, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subcontract terms.
- If required by the CAM, submit a draft of each *Subcontract* required to conduct the work under this Agreement.
- Submit a final copy of the executed subcontract.
- Notify and receive written approval from the CAM prior to adding any new subcontractors (see the discussion of subcontractor additions in the terms and conditions).

Energy Commission-Funded Products:

- Subcontracts (*draft if required by the CAM*)

Exhibit A Scope of Work

TECHNICAL ADVISORY COMMITTEE

Subtask 1.9 Technical Advisory Committee (TAC)

The goal of this subtask is to create an advisory committee for this Agreement. The TAC should be composed of diverse professionals. The composition will vary depending on interest, availability, and need. TAC members will serve at the CAM's discretion. The purpose of the TAC is to:

- Provide guidance in project direction. The guidance may include scope and methodologies, timing, and coordination with other projects. The guidance may be based on:
 - Technical area expertise;
 - Knowledge of market applications; or
 - Linkages between the agreement work and other past, present, or future projects (both public and private sectors) that TAC members are aware of in a particular area.
- Review products and provide recommendations for needed product adjustments, refinements, or enhancements.
- Evaluate the tangible benefits of the project to the state of California, and provide recommendations as needed to enhance the benefits.
- Provide recommendations regarding information dissemination, market pathways, or commercialization strategies relevant to the project products.

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

- Researchers knowledgeable about the project subject matter;
- Members of trades that will apply the results of the project (e.g., designers, engineers, architects, contractors, and trade representatives);
- Public interest market transformation implementers;
- Product developers relevant to the project;
- U.S. Department of Energy research managers, or experts from other federal or state agencies relevant to the project;
- Public interest environmental groups;
- Utility representatives;
- Air district staff; and
- Members of relevant technical society committees.

The Recipient shall:

- Prepare a *List of Potential TAC Members* that includes the names, companies, physical and electronic addresses, and phone numbers of potential members. The list will be discussed at the Kick-off meeting, and a schedule for recruiting members and holding the first TAC meeting will be developed.
- Recruit TAC members. Ensure that each individual understands member obligations and the TAC meeting schedule developed in subtask 1.10.
- Prepare a *List of TAC Members* once all TAC members have committed to serving on the TAC.
- Submit *Documentation of TAC Member Commitment* (such as Letters of Acceptance) from each TAC member.

Energy Commission-Funded Products:

- List of Potential TAC Members
- List of TAC Members
- Documentation of TAC Member Commitment

Exhibit A Scope of Work

Subtask 1.10 TAC Meetings

The goal of this subtask is for the TAC to provide strategic guidance for the project by participating in regular meetings, which may be held via teleconference.

The Recipient shall:

- Discuss the TAC meeting schedule with the CAM at the Kick-off meeting. Determine the number and location of meetings (in-person and via teleconference) in consultation with the CAM.
- Prepare a *TAC Meeting Schedule* that will be presented to the TAC members during recruiting. Revise the schedule after the first TAC meeting to incorporate meeting comments.
- Prepare a *TAC Meeting Agenda* and *TAC Meeting Back-up Materials* for each TAC meeting.
- Organize and lead TAC meetings in accordance with the TAC Meeting Schedule. Changes to the schedule must be pre-approved in writing by the CAM.
- Prepare *TAC Meeting Summaries* that include any recommended resolutions of major TAC issues.

Energy Commission-Funded Products:

- TAC Meeting Schedule (draft and final)
- TAC Meeting Agendas (draft and final)
- TAC Meeting Back-up Materials
- TAC Meeting Summaries

IV. TECHNICAL TASKS

*Products that require a draft version are indicated by marking “(draft and final)” after the product name in the “Products” section of the task/subtask. If “(draft and final)” does not appear after the product name, only a final version of the product is required. **Subtask 1.1 (Products)** describes the procedure for submitting products to the CAM.*

TASK 2: SPECIFICATION

The goal of this task is to gain general agreement among stakeholders about requirements for the software, process, and control specification to avoid scope creep and expensive code redesign that may lead to project delays.

The Recipient shall:

- Develop a *Controls Description Language Summary* to include the following:
 - Use case descriptions for control design, specification, and functional verification, with input from, and review by the TAC.
- Post first process workflow and functional requirements on website at GitHub.org.
- Post v1.0 specification of CDL on website at GitHub.org

Products:

- Controls Description Language Summary

TASK 3: CONTROLS DESIGN TOOL

The goal of this task is to develop a controls design tool that will enable mechanical designers to compare performance (energy, peak power, air quality, comfort) of operational sequences and

Exhibit A Scope of Work

export these sequences for bidding by control vendors. The tool will include preconfigured and user-extensible control sequences, and it will be integrated in OpenStudio.

Subtask 3.1 Requirements and Software Architecture

The goal of this task is to identify the requirements of the controls design tool, and design its software architecture to avoid expensive redesign due to potential scope creep.

The Recipient shall:

- Develop requirements for Unified Modeling Language (UML), used to define software architecture and interaction.
- Provide a *UML Requirements and Diagram Summary* to include the following:
 - UML workflow and interaction diagrams (a standard way to visual software interaction and architecture) based on use cases from Task 2 with input from, and to be reviewed by the TAC.
 - Post UML diagrams for the software architecture on website GitHub.org
- Provide *CPR Report #1* and participate in a CPR Meeting per Task1.3

Products:

- UML Requirements and Diagram Summary
- CPR Report #1

Subtask 3.2: Implementation of Control Sequences For Secondary HVAC Systems

The goal of this task is to make available to mechanical designers a library of control sequences for secondary HVAC systems (e.g. air handling units) that can be used as-is, or adapted to a particular project, for performance assessment (energy, comfort, etc.) and for export for specification and functional verification. Also, custom sequences and verification tests can be added, for example, if a design firm repeatedly uses its own sequences.

The Recipient shall:

- Develop a *Summary Diagram for Control Library for Secondary HVAC Systems* which covers the following:
 - Prioritize sequences from ASHRAE GPC 36, as well as custom sequences, and implement them in the Modelica Buildings Library (MBL) using a subset of the Modelica language (to be specified in this task) that can be mapped into the CDL.
 - Implement a control sequence library for use in the control design and specification tool.
 - Verify the sequences vs. implemented sequences (such as in Eikon from ASHRAE GPC 36 or RP 1455) where available, and implement automated regression tests for all sequences.
 - Post a version of the Control Library for Secondary HVAC Systems in Modelica on <http://GitHub.org/lbl-srg/modelica-buildings>.

Products:

- Summary Diagram for Control Library for Secondary HVAC Systems

Subtask 3.3: Implementation of Control Sequences for Primary HVAC Systems, Façade and Lighting

The goal of this task is to make available to mechanical designers, a library of control sequences for primary HVAC systems (e.g. heating/cooling plants), active facades, and lighting systems that can be used as-is, or adapted to a particular project, for performance assessment (energy, comfort, etc.) and for export for specification and functional verification. Also, custom

Exhibit A Scope of Work

sequences and verification tests can be added, for example, if a design firm repeatedly uses its own sequences.

The Recipient shall:

- Develop a *Summary for Control Library for Primary HVAC Systems, Facade and Lighting* to include the following:
 - Prioritize sequences from ASHRAE GPC 36, as well as custom sequences, and implement them in the Modelica Buildings Library (MBL)
 - Implement a control sequence library for use in the control design and specification tool.
 - Verify the sequences vs. implemented sequences (such as in Eikon from ASHRAE GPC 36 or RP 1455) where available, and implement automated regression tests for all sequences.
 - Post a version of the Control Library for Primary HVAC Systems, Façade and Lighting in Modelica on <http://GitHub.org/lbl-srg/modelica-buildings>.

Products:

- Summary for Control Library for Primary HVAC Systems, Facade and Lighting

Subtask 3.4: Implementation of the Graphical User Interface

The goal of this task is to integrate a graphical user interface (GUI) to make the control design tool accessible to design firms. Performance visualization of control sequence variants will take advantage of established reporting capabilities in OpenStudio by building upon control-specific measure reports.

The Recipient shall:

- Develop a *Summary of Control Design Tool* to include the following:
 - Develop the GUI using an existing JavaScript library for block diagram and schematic modeling
 - Write code that auto-generates visual representations of the control blocks from their CDL representation to immediately reflect changes in the CDL representation in the GUI.
 - Post a first version of the GUI of the Control Design Tool on GitHub.org.

Products:

- Summary for Control Design Tool

Subtask 3.5: CDL Export to English Language and a Product Line

The goal of this task is to provide control contractors and commissioning agents with an English-language description of the control sequence, and demonstrate to the TAC that CDL can be mapped into a proprietary controls programming language (as a proof of concept validation).

The Recipient shall:

- Develop *Summary of English Language Export Program* to include all of the following:
 - Write code that automatically generates English-language descriptions from the CDL model annotation that describe the functionality, inputs, outputs, and parameters of each control block, and the connections among control blocks.
 - Demonstrate a proof-of-concept automatic translation (to be determined by the TAC, to controls vendors).
 - Post the English Language Export Program on GitHub.org.

Exhibit A Scope of Work

Products:

- Summary for English Language Export Program

Subtask 3.6: OpenStudio Integration

The goal of this task is to integrate the controls design tool in OpenStudio and make it an element of the OpenStudio–Spawn of EnergyPlus (SOEP) or similar tool chain.

The Recipient shall:

- Develop a *Summary for OpenStudio Software* to describe the following activities:
 - Add to OpenStudio’s electron/JavaScript-based SOEP HVAC and control editor functionality required for the controls design and export. This will allow use of the controls design tool in the OpenStudio framework.
 - Add an Application Programming Interface (API) that allows OpenStudio users to select a control sequence stored in the Building Component Library (BCL) a zip file that contains the sequence specification and required models—and configure a control sequence through an OpenStudio Measure. Code will process this measure and send the needed commands to the API of the controls design tool, which then may instantiate and configure an ASHRAE GPC 36 sequence or custom control sequence.
 - Post Software in the OpenStudio GitHub repository for distribution in future EnergyPlus releases, which integrates the control design tool in OpenStudio.

Products:

- Summary for OpenStudio Software

TASK 4: FUNCTIONAL VERIFICATION TOOL

The goal of this task is to develop a functional verification tool that takes the specification of sequences as an input; a set of functional verification tests; and, a list of control points, and then verifies that the specification is implemented correctly. For commissioning, the tool will identify which parts of the implemented sequence fail to conform to the designer’s specification.

Subtask 4.1: Requirements and Software Architecture

The goal of this task is to identify the requirements of the functional verification tool, and design its software architecture to avoid expensive redesign due to potential scope creep.

The Recipient shall:

- Develop a *UML Diagram Summary* to include all of the following:
 - Written specification of sequences, functional verification tests; a list of control points, and verification tool.
 - Development of UML workflow and interaction diagrams (a standard way to visual software interaction and architecture) based on use cases from Task 2 with input from, and review by the TAC.
 - Posting of UML diagrams for the software architecture on GitHub.org

Products:

- UML Diagram Summary

Subtask 4.2: Implementation of Hardware Interface.

The goal of this task is to access historical and real-time sensor and actuator signals from a variety of building automation systems through BACnet and REST request.

Exhibit A Scope of Work

The Recipient shall:

- Develop a *Software Implementation Summary* to include all of the following:
 - Implementation of software that leverage existing hardware/software interfaces that have been developed in other DOE projects, such as VOLLTRON and the BCVTB, to exchange data between hardware, measured data, and the verification test module.
 - Posting software for accessing measured data, posted on GitHub.org

Products:

- Software Implementation Summary

Subtask 4.3: Implementation of Verification Test Module

The goal of this task is to implement the control sequence verification test module that will be the core of the functional verification tool. The verification test module will allow integration in a GUI suitable for use in commissioning. This GUI will use the same software core as the control design tool, but it will have additional features that are only needed for the verification of the as-installed sequence.

The Recipient shall:

- Develop a *Summary of Control Verification Test Module* to include all of the following:
 - Implementation of an API that allows the functional verification tool to receive measured sensor data, measured control signals, and execute the control sequence specification associated with these inputs.
 - Implementation of software that returns the simulated control signals, deviations between measured and simulated signals, and success indicators (satisfied, undecided [if not tested sufficiently], or violated) together with a list of what needs further testing or has violated the specification.
 - Posting first version of the Summary of Controls Verification Test Module on GitHub.org.
- Provide *CPR Report #2* and participate in a CPR Meeting per Task1.3

Products:

- Summary of Control Verification Test Module
- CPR Report #2

Subtask 4.4: Implementation of GUI

The goal of this task is to make the controls verification and the hardware interface accessible to commissioning providers through a web-enabled GUI.

The Recipient shall:

- Develop a *Summary of First Version of Control Verification GUI* and a *Summary of Second Version of Control Verification GUI* to include all of the following:
 - Development of a GUI for commissioning providers, using JavaScript that runs in a web browser, either locally or as a cloud application, and that integrates the tools from subtasks 4.1 and 4.2.
 - Posting first version of the Controls Verification GUI on GitHub.org
 - Posting second version of the Controls Verification GUI that incorporates feedback from end-user testing on GitHub.org.

Exhibit A Scope of Work

Products:

- Summary of First Version of Control Verification GUI
- Summary of Second Version of Control Verification GUI

TASK 5: CASE STUDIES

The goal of this task is to validate the usability of the control design and functional verification tool as applied to real buildings and obtain feedback from real-world applications.

The Recipient shall:

- Conduct a case study that involves HVAC secondary systems
- Conduct a case study that involves HVAC primary systems façade and lighting controls.
- Conduct a case study that integrates primary and secondary HVAC, façade and lighting controls.
- Write *Case Study Report for Secondary HVAC System*, including the efforts for setup, configuration, and the anticipated time and energy savings, and impacts on other ratepayer benefits such as electricity reliability and lower costs.
- Write *Case Study Report for Primary HVAC System Façade and Lighting Controls*, including the efforts for setup, configuration, and the anticipated time and energy savings, and impacts on other ratepayer benefits such as electricity reliability and lower costs.
- Write *Case Study Report for System that Integrates Primary and Secondary HVAC, Façade and Lighting Controls*, including the efforts for set up, configuration, and the anticipated time and energy savings, , and impacts on other ratepayer benefits such as electricity reliability and lower costs.

Products:

- Case Study Report for Secondary HVAC System
- Case Study Report for Primary HVAC System, Façade and Lighting Controls
- Case Study Report for System that Integrates Primary and Secondary HVAC, Façade and Lighting Controls

TASK 6: COMMERCIALIZATION AND MARKET TRANSFORMATION PLAN

The goal of this task is to ensure commercialization and market transformation.

The Recipient shall:

- Develop a commercialization and market transformation plan, under the leadership of the industrial partners and in collaboration with building owners, mechanical design firms, control vendors, and professional organizations, including ASHRAE TC 1.4 (Controls Theory and Applications) and GPC 36 (High Performance Sequences of Operation for HVAC Systems).
- Write the *Draft Commercialization and Market Transformation Plan* with the goal to show value and obtain commitment from large owners and design firms for the process. Provide to CAM for review and comment.
- Write the *Final Commercialization and Market Transformation Plan*, incorporating CAM comments.

Products:

- Draft Federal Commercialization and Market Transformation Plan
- Final Federal Commercialization and Market Transformation Plan

Exhibit A Scope of Work

TASK 7: EVALUATION OF PROJECT BENEFITS TO CALIFORNIA IOU ELECTRIC RATEPAYERS

The goal of this task is to report the benefits resulting from this project.

The Recipient shall:

- Complete three Project Benefits Questionnaires that correspond to three main intervals in the Agreement: (1) *Kick-off Meeting Benefits Questionnaire*; (2) *Mid-term Benefits Questionnaire*; and (3) *Final Meeting Benefits Questionnaire*.
- Provide all key assumptions used to estimate projected benefits, including targeted market sector (e.g., population and geographic location), projected market penetration, baseline and projected energy use and cost, operating conditions, and emission reduction calculations. Examples of information that may be requested in the questionnaires include:
 - For Product Development Projects and Project Demonstrations:
 - Published documents, including date, title, and periodical name.
 - Estimated or actual energy and cost savings, and estimated statewide energy savings once market potential has been realized. Identify all assumptions used in the estimates.
 - Greenhouse gas and criteria emissions reductions.
 - Other non-energy benefits such as reliability, public safety, lower operational cost, environmental improvement, indoor environmental quality, and societal benefits.
 - Data on potential job creation, market potential, economic development, and increased state revenue as a result of the project.
 - A discussion of project product downloads from websites, and publications in technical journals.
 - A comparison of project expectations and performance. Discuss whether the goals and objectives of the Agreement have been met and what improvements are needed, if any.
 - Additional Information for Product Development Projects:
 - Outcome of product development efforts, such copyrights and license agreements.
 - Units sold or projected to be sold in California and outside of California.
 - Total annual sales or projected annual sales (in dollars) of products developed under the Agreement.
 - Investment dollars/follow-on private funding as a result of Energy Commission funding.
 - Patent numbers and applications, along with dates and brief descriptions.
 - Additional Information for Product Demonstrations:
 - Outcome of demonstrations and status of technology.
 - Number of similar installations.
 - Jobs created/retained as a result of the Agreement.
 - For Information/Tools and Other Research Studies:
 - Outcome of project.
 - Published documents, including date, title, and periodical name.

Exhibit A Scope of Work

- A discussion of policy development. State if the project has been cited in government policy publications or technical journals, or has been used to inform regulatory bodies.
 - The number of website downloads.
 - An estimate of how the project information has affected energy use and cost, or has resulted in other non-energy benefits.
 - An estimate of energy and non-energy benefits.
 - Data on potential job creation, market potential, economic development, and increased state revenue as a result of project.
 - A discussion of project product downloads from websites, and publications in technical journals.
 - A comparison of project expectations and performance. Discuss whether the goals and objectives of the Agreement have been met and what improvements are needed, if any.
- Respond to CAM questions regarding responses to the questionnaires.

The Energy Commission may send the Recipient similar questionnaires after the Agreement term ends. Responses to these questionnaires will be voluntary.

Products:

- Kick-off Meeting Benefits Questionnaire
- Mid-term Benefits Questionnaire
- Final Meeting Benefits Questionnaire

V. **Project schedule:** Please see the attached Excel spreadsheet.

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION - RE: DOE-LAWRENCE BERKELEY NATIONAL LABORATORY

RESOLVED, that the State Energy Resources Conservation and Development Commission (Energy Commission) adopts the staff CEQA findings contained in the Agreement or Amendment Request Form (as applicable); and

RESOLVED, that the Energy Commission approves Agreement EPC-16-056 with the Department of Energy's Lawrence Berkeley National Laboratory for a \$1,000,000 grant to develop building control software tools that will enable building designers to compare performance implications of different control strategies based on building requirements. Adoption of the tool will improve design and implementation of building controls with a potential to reduce energy use by 12 percent. This project is a cost share grant to the U.S. DOE's \$2,000,000 in funding; and

FURTHER BE IT RESOLVED, that the Executive Director or his/her designee shall execute the same on behalf of the Energy Commission.

CERTIFICATION

The undersigned Secretariat to the Commission does hereby certify that the foregoing is a full, true, and correct copy of a Resolution duly and regularly adopted at a meeting of the California Energy Commission held on May 10, 2017.

AYE: [List of Commissioners]

NAY: [List of Commissioners]

ABSENT: [List of Commissioners]

ABSTAIN: [List of Commissioners]

Cody Goldthrite,
Secretariat