

**GRANT REQUEST FORM (GRF)**New Agreement EPC-14-013 (To be completed by CGL Office)

Division	Agreement Manager:	MS-	Phone
ERDD	Heather Bird	51	916-327-1473

Recipient's Legal Name	Federal ID Number
The Regents of the University of California on behalf of the Berkeley campus	94-6002123

Title of Project
Very Low-cost MEMS-based Ultrasonic Anemometer for Use Indoors and in HVAC Ducts

Term and Amount	Start Date	End Date	Amount
	4/15/2015	3/30/2019	\$ 2,488,964

**Business Meeting Information**
 ARFVTP agreements under \$75K delegated to Executive Director.

Proposed Business Meeting Date	2/11/2015	<input type="checkbox"/> Consent	<input checked="" type="checkbox"/> Discussion
Business Meeting Presenter	Heather Bird	Time Needed:	5 minutes

Please select one list serve. Select

**Agenda Item Subject and Description**

Proposed resolution approving Agreement EPC-14-XXX with The Regents of the University of California in the amount of \$2,488,964. The purpose of the agreement is to develop two low-cost, low-power, accurate, calibration-free, and compact airflow sensors ('anemometers') for measuring: (1) room airflow in occupied commercial buildings; and (2) volumetric air flow in Heating, Ventilating, and Air Conditioning (HVAC) systems and laboratory fume hoods. The technology will save energy by using the collected data to correct current wasteful HVAC malfunctions that result in inefficient systems and uncomfortable buildings. (EPIC Funding)

**California Environmental Quality Act (CEQA) Compliance**

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":  
 Agreement will not cause direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment because the research tasks involve computer simulations, isolated and controlled laboratory testing, measurements of energy use and indoor environmental conditions as they actually exist in buildings (without influencing them), and surveys of occupant satisfaction.
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: \_\_\_\_\_  
 Common Sense Exemption. 14 CCR 15061 (b) (3)  
 Explain reason why Agreement is exempt under the above section:
- b) Agreement **IS NOT** exempt. (Consult with the legal office to determine next steps.)  
 Check all that apply  
 Initial Study  Environmental Impact Report  
 Negative Declaration  Statement of Overriding Considerations  
 Mitigated Negative Declaration

**List all subcontractors (major and minor) and equipment vendors: (attach additional sheets as necessary)**

Legal Company Name:	Budget
Taylor Engineering, LLC	\$ 80,000
Chirp Microsystems, Inc.	\$ 1,100,000

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<b>List all key partners:</b> (attach additional sheets as necessary)
Legal Company Name:

Budget Information			
Funding Source	Funding Year of Appropriation	Budget List No.	Amount
EPIC	13-14	301.001A	\$2,488,964
R&D Program Area: EERO: Buildings		TOTAL:	\$2,488,964
Explanation for "Other" selection			
Reimbursement Contract #:		Federal Agreement #:	

Recipient's Administrator/ Officer		Recipient's Project Manager	
Name:	Paul Martinez	Name:	Edward Arens
Address:	2150 Shattuck Ave Ste 300	Address:	390 Wurster Hall #1839
City, State, Zip:	Berkeley, CA 94704-5940	City, State, Zip:	BERKELEY, CA 94720-1839
Phone:	510-642-8115 /	Fax:	- -
E-Mail:	psmartin@berkeley.edu	E-Mail:	earens@berkeley.edu

Selection Process Used	
<input checked="" type="checkbox"/> Competitive Solicitation	Solicitation #: PON-13-301
<input type="checkbox"/> First Come First Served Solicitation	

The following items should be attached to this GRF	
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 checked="" type="checkbox"/> N/A <input type="checkbox"/> Attached

_____ Agreement Manager	_____ Date	_____ Office Manager	_____ Date	_____ Deputy Director	_____ Date
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## Exhibit A Scope of Work

### Task List

Task #	CPR <sup>1</sup>	Task Name
1		General Project Tasks
2	X	Produce Anemometers for Measuring Airflows in Rooms and HVAC Systems
3	X	Develop and Field-evaluate Building Applications: Monitoring, Control, and Commissioning
4		Evaluation of Project Benefits
5		Technology/Knowledge Transfer Activities
6		Production Readiness Plan

### Glossary

*Specific terms and acronyms used throughout this scope of work are defined as follows:*

Acronym/Term	Meaning
ASHRAE	American Society of Heating Refrigerating and Air-Conditioning Engineers
ASIC	Application Specific Integrated Circuit
AHR	Air Conditioning, Heating, Refrigeration
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CBE	Center for the Built Environment
CPR	Critical Project Review
CRAC	Computer Room Air Conditioning
EECS	Electrical Engineering and Computer Sciences (department at UC Berkeley), a project partner
FPGA	Field programmable gate array
HVAC	Heating, Ventilating, and Air Conditioning
MEMS	Microelectromechanical system
MicroChirp	A project partner
PG&E	Pacific Gas and Electric (Company)
sMAP	Simple Measurement and Actuation Protocol
TAC	Technical Advisory Committee

<sup>1</sup> 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**

### **I. PURPOSE OF AGREEMENT, PROBLEM/SOLUTION STATEMENT, AND GOALS AND OBJECTIVES**

#### **A. Purpose of Agreement**

The purpose of this Agreement is to fund the development and testing of greatly improved airflow sensing devices for use in indoor spaces and air conditioning systems. The project will also develop practical applications through which the new sensors will improve buildings' energy efficiency, comfort, and safety, in order to accelerate the sensors' manufacture and availability.

#### **B. Problem/ Solution Statement**

##### **Problem**

Air velocity and air flow are currently measured using devices such as hot-wire anemometers or are inferred from pressure measurements. These are inaccurate, failure-prone, and often expensive. They limit the applications in which air speeds and their associated energy flows are measured in buildings, causing very large energy costs and health risks.

##### **Solution**

The Recipient will develop a highly accurate, robust, and low-cost anemometer leveraging a state-of-the-art microelectromechanical system (MEMS) ultrasonic range-finding system recently developed at UC Berkeley. The anemometer is in 3-axis form for monitoring a building's occupied spaces and in a duct-flow form for measuring flow volumes and temperatures in Heating, Ventilating, and Air Conditioning (HVAC) systems and laboratory fume hoods. Both are wireless and easily retrofitted. The Recipient will demonstrate energy-saving HVAC applications of the technology, together with improved thermal comfort and ventilation safety.

#### **C. Goals and Objectives of the Agreement**

##### **Agreement Goals**

The goals of this Agreement are to:

- Reduce HVAC energy use
- Improve occupant thermal comfort and safety

**Ratepayer Benefits:**<sup>2</sup> This Agreement will result in the ratepayer benefits of greater electricity reliability, lower costs, and increased safety by reducing energy waste in HVAC operation, and by enabling more efficient modes of conditioning occupied space. Approximately 30% of HVAC energy is currently wasted due to poor feedback within building control systems, and poor control of airflows. In addition, measurement of room airflow near occupants will produce far more efficient environmental space conditioning by enabling state-of-art local fan control to offset compression-based cooling (up to 50% HVAC savings in California).

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<sup>2</sup> California Public Resources Code, Section 25711.5(a) requires projects funded by the Electric Program Investment Charge (EPIC) to result in ratepayer benefits. The California Public Utilities Commission, which established the EPIC in 2011, defines ratepayer benefits as greater reliability, lower costs, and increased safety (See CPUC "Phase 2" Decision 12-05-037 at page 19, May 24, 2012, [http://docs.cpuc.ca.gov/PublishedDocs/WORD\\_PDF/FINAL\\_DECISION/167664.PDF](http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/167664.PDF)).

## Exhibit A Scope of Work

Power reliability and depth of demand response will both be improved as thermal comfort can be maintained by local fans during periods that chillers are off. The safety of ratepayers is improved as the loss of ventilation air due to blocked or malfunctioning outside air dampers, or flow reversals in laboratory hoods or hospital isolation zones, are detected.

Technological Advancement and Breakthroughs:<sup>3</sup> This Agreement will lead to technological advancement and breakthroughs to overcome barriers to the achievement of the State of California's statutory energy goals by using the measurement data collected by the proposed airspeed technology to correct current wasteful HVAC malfunctions. In addition, results of this agreement will reduce the equipment oversizing and excessive fan speeds coming from designers' and operators' uncertainty over airflows, and condition interiors in which air movement cooling offsets the far more energy-intensive practice of cooling the air. Measurement would encourage the use of efficient naturally ventilated and mixed mode designs, ceiling fans, task ventilation, and personal comfort systems. It would also improve security and energy efficiency in operating laboratories, hospitals, data centers, and clean room facilities.

### Agreement Objectives

The objectives of this Agreement are to:

- Develop a highly accurate, robust, and low-cost ultrasonic anemometer
- Demonstrate HVAC energy savings applications using the anemometer
- Demonstrate improved thermal comfort applications using the anemometer
- Demonstrate improved ventilation safety applications using the anemometer
- Modify codes and standards for the built environment accordingly

## II. 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.

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<sup>3</sup> California Public Resources Code, Section 25711.5(a) also requires EPIC-funded projects to lead to technological advancement and breakthroughs to overcome barriers that prevent the achievement of the state's statutory and energy goals.

## Exhibit A Scope of Work

### 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:

- **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.

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- **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.

#### **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);
- Match fund documentation (subtask 1.7);
- Permit documentation (subtask 1.8);
- Subcontracts (subtask 1.9); and
- Any other relevant topics.

## **Exhibit A Scope of Work**

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 1.10 and 1.11); and
  - Any other relevant topics.
- 
- Provide an *Updated Project Schedule*, *List of Match Funds*, 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 Match Funds (*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.

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.

### **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; and (2) includes recommendations and conclusions regarding continued work on the project.
- 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).

## **Exhibit A Scope of Work**

- Attend the CPR meeting.
- Present the CPR Report and any other required information at each CPR meeting.

### **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 match funding and 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)

### **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.

### **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.

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- 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.
  - 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.

### 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.
- 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 received by California-based entities;
  - Energy Commission funds spent in California (*if applicable*); and
  - Match fund expenditures.

### Products:

- Progress Reports
- Invoices

## **Exhibit A Scope of Work**

### **Subtask 1.6 Final Report**

The goal of this subtask is to prepare a comprehensive Final Report that describes the original purpose, approach, results, and conclusions of the work performed under this Agreement. The CAM will review the Final Report, which will be due at least **two months** before the Agreement end date. When creating the Final Report Outline and the Final Report, the Recipient must use a Style Manual provided by the CAM.

#### **Subtask 1.6.1 Final Report Outline**

##### **The Recipient shall:**

- Prepare a *Final Report Outline* in accordance with the *Style Manual* provided by the CAM.
- Submit a draft of the outline to the CAM for review and comment.
- Once agreement has been reached on the draft, submit the final outline to the CAM. The CAM will provide written approval of the final outline within 10 days of receipt.

##### **Recipient Products:**

- Final Report Outline (draft and final)

##### **CAM Product:**

- Style Manual
- Comments on Draft Final Report Outline
- Approval of Final Report Outline

#### **Subtask 1.6.2 Final Report**

##### **The Recipient shall:**

- Prepare a *Final Report* for this Agreement in accordance with the approved Final Report Outline and the Style Manual provided by the CAM.
- Submit a draft of the report to the CAM for review and comment. Once agreement on the draft report has been reached, the CAM will forward the electronic version for Energy Commission internal approval. Once the CAM receives approval, he/she will provide written approval to the Recipient.
- Submit one bound copy of the Final Report to the CAM.

##### **Recipient Products:**

- Final Report (draft and final)

##### **CAM Product:**

- Comments on Draft Final Report

### **MATCH FUNDS, PERMITS, AND SUBCONTRACTS**

#### **Subtask 1.7 Match Funds**

The goal of this subtask is to ensure that the Recipient obtains any match funds planned for this Agreement and applies them to the Agreement during the Agreement term.

While the costs to obtain and document match funds are not reimbursable under this

## Exhibit A Scope of Work

Agreement, the Recipient may spend match funds for this task. The Recipient may only spend match funds during the Agreement term, either concurrently or prior to the use of Energy Commission funds. Match funds must be identified in writing, and the Recipient must obtain any associated commitments before incurring any costs for which the Recipient will request reimbursement.

### The Recipient shall:

- Prepare a *Match Funds Status Letter* that documents the match funds committed to this Agreement. If no match funds were part of the proposal that led to the Energy Commission awarding this Agreement and none have been identified at the time this Agreement starts, then state this in the letter.

If match funds were a part of the proposal that led to the Energy Commission awarding this Agreement, then provide in the letter:

- A list of the match funds that identifies:
  - The amount of cash match funds, their source(s) (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied.
  - The amount of each in-kind contribution, a description of the contribution type (e.g., property, services), the documented market or book value, the source (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Recipient must identify its owner and provide a contact name, address, telephone number, and the address where the property is located.
- A copy of a letter of commitment from an authorized representative of each source of match funding that the funds or contributions have been secured.
- At the Kick-off meeting, discuss match funds and the impact on the project if they are significantly reduced or not obtained as committed. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide a *Supplemental Match Funds Notification Letter* to the CAM of receipt of additional match funds.
- Provide a *Match Funds Reduction Notification Letter* to the CAM if existing match funds are reduced during the course of the Agreement. Reduction of match funds may trigger a CPR meeting.

### Products:

- Match Funds Status Letter
- Supplemental Match Funds Notification Letter (*if applicable*)
- Match Funds Reduction Notification Letter (*if applicable*)

### Subtask 1.8 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.

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### 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:
  - 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.

### 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 1.9 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).

### Products:

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

## Exhibit A Scope of Work

### **TECHNICAL ADVISORY COMMITTEE**

#### **Subtask 1.10 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 1.11.
- 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.

#### **Products:**

- List of Potential TAC Members
- List of TAC Members

## **Exhibit A Scope of Work**

- Documentation of TAC Member Commitment

### **Subtask 1.11 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.

#### **Products:**

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

# Exhibit A

## Scope of Work

### III. 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 Produce Anemometers for Measuring Airflows in Rooms and HVAC Systems**

The goal of this task is to develop two complete anemometer configurations, for room and duct, together with ancillary sensors, communications, packaging, and user control software.

##### **TASK 2.1 Produce Ultrasonic Sensors (ChirpMicro)**

The goal of this subtask is to develop the ultrasonic air velocity sensors with their embedded control hardware.

##### **The Recipient shall:**

- Perform detailed acoustic simulations to optimize the configuration of the ultrasonic sensors in the anemometer assembly.
- Design and optimize ultrasonic transducers for time-of-flight measurements.
- Fabricate ultrasonic transducers on wafers in a micro fabrication facility.
- Test ultrasonic transducers using electrical impedance measurements, high-frequency microphone measurements, and laser Doppler vibrometry.
- Package ultrasonic transducers according to acoustic design, electronic design, and environmental considerations.
- Design electrical connectors and circuit boards to connect the ultrasonic transducers to the electronic subassembly.
- Design an electronic subassembly to perform the time-of-flight measurement, consisting of:
  - An application specific integrated circuit (ASIC) which has digital inputs and outputs and which transmits and receives analog signals from the ultrasonic transducers;
  - A digital subsystem containing a field programmable gate array (FPGA) or a microcontroller which controls the ASIC and which calculates the time-of-flight of the ultrasonic pulses and averages the time of flight over several measurements;
  - Software or hardware description language to control the measurement.
- Design and manufacture a Prototype Anemometer #1, consisting of ultrasound transducers and the electronic subassembly.
- Develop control software and electronics for transducer activation, pulse detection, sampling, data acquisition, signal processing, and radio communication.
- Develop and test Prototype #1, Room-velocity Anemometer in 3-axis room velocity array in anemometer calibrator and determine performance according to test plan outlined in Task 2.2 below.
- Test Prototype #1, Duct-flow Anemometer in duct and wind tunnel and determine performance according to test plan outlined in Task 2.3 below.
- Refine design of ultrasonic transducers and electronic subassembly in accordance with findings from calibrator and wind tunnel testing of Prototype Anemometer #1.

## Exhibit A Scope of Work

- Design and prototype housings for 3-axis room anemometer array.
- Design and prototype housings for 2x2 and 3x3 duct-flow sensor arrays.
- Design housing for a laboratory-hood flow sensor.
- Develop and assemble refined Prototype #2, Room-velocity Anemometer incorporated within housing together with Task 2.2 components.
- Develop and assemble refined Prototype #2, Duct-flow Anemometer incorporated within housing together with Task 2.2 components.
- Document the equipment, hardware, and software for Prototype #2, Room-velocity Anemometer and Prototype #2, Duct-flow Anemometer.
- Describe the design criteria, specifications, assembly, and calibration testing of anemometers in *Documenting Anemometer Designs and Performance Report*.
- Contribute to writing of *Final Report* (listed under Task 1.6).

### Products:

- Documenting the Anemometer Designs and Performance Report

### TASK 2.2 Develop Carrier Board with Controls, Communications, and Power (EECS)

The goal of this subtask is to develop the carrier board, accessory sensors, firmware, controls, communications, and data acquisition/visualization software of the two anemometer systems.

### The Recipient shall:

- Prepare *Test Plan #1* for design of Carrier Components to make standalone wireless prototype anemometers. Plan will include descriptions of simulations, design optimization, circuitry and packaging for the initial prototype.
- Develop carrier board that contains the Storm wireless sensor mote, an FPGA, the Chirp Microsystems ASIC and magnetometer for self –orientation.
- Develop preliminary firmware that achieves communication with the FPGA (whose firmware is developed by Chirp), as well as power management and wireless communication, with no energy optimizations (obtain readings and transmit over single hop).
- Adapt firmware for long term battery operation, containing parametric design space exploration of duty cycle, sensor multisampling.
- Prepare *CPR Report #1* (see Task 2.3 Products) in accordance with subtask 1.3 (CPR Meetings), documenting development of Carrier Components, Prototype Room-velocity Anemometer and Carrier Components, Prototype Duct-flow Anemometer.
- Participate in the first CPR meeting.
- Evaluate the cost and energy tradeoffs associated with moving the digital signal processing from the FPGA to the microcontroller unit.
- Develop Carrier Components, Refined Prototype #2 Room-velocity Anemometer.
- Develop Carrier Components, Refined Prototype # 2 Duct-flow Anemometer.
- Modify carrier board for design for manufacture.
- Develop software infrastructure for data storage and processing using the protocol Simple Measurement and Actuation Protocol (sMAP).
- Adapt software infrastructure to meet requirements of larger scale deployments, including visualization of the detailed airflow data provided by the anemometers.
- Prepare *Design of Carrier Components, Firmware and Software Report* for both Room-velocity Anemometer Prototype #2 and Duct-flow Anemometer Prototype #2, including specifications, assembly, testing, and performance evaluation.

## Exhibit A Scope of Work

- Contribute to writing of Final Report (listed under Task 1.6).

### Products:

- Test Plan #1
- CPR Report #1
- Design of Carrier Components, Firmware and Software Report

### **TASK 2.3 Calibrate, Optimize, and Characterize Anemometer Performance in Lab**

The goals of this subtask are to: 1) test the initial prototypes in the laboratory to establish their performance characteristics under a range of design and operation parameters; 2) assist the development of the refined prototype which will be used in field testing, and; 3) characterize the final anemometer performance specifications.

### The Recipient shall:

- Following the *Test Plan #1* in Task 2.2, calibrate and evaluate the Prototype Anemometer #1 across different path distances and transducer configurations, using the anemometer calibrator and the boundary layer wind tunnel. Quantify directional sensitivity of room anemometers. Evaluate sampling rates, pulse detection, signal conditioning, averaging methods.
- Evaluate effects of housing design and sensor mounting on airflow and on anemometer accuracy.
- Test and characterize the Prototype #2, Room-velocity Anemometer.
- Test and characterize the Prototype #2, Duct-flow Anemometer.
- Prepare *CPR Report #2*, describing development and testing of Prototype #2, Room-velocity Anemometer, and Prototype #2, Duct-flow Anemometer.
- Participate in the second CPR meeting.
- Compare duct-flow anemometer measurements against flow hood measurements under various duct conditions, as in straight runs, elbows, wake of coils and dampers.
- Prepare *Documenting Anemometer Designs and Performance Report* describing process by which design parameters were optimized through testing.

### Products:

- CPR Report #2
- Documenting Anemometer Designs and Performance Report

### **TASK 3 Develop and Field-evaluate Building Applications: Monitoring, Control, and Commissioning**

The goals of this task are to: 1) develop application strategies for anemometry in rooms and ducts; 2) test the refined Prototype #2 anemometers in the field, to evaluate their practical effectiveness and make final modification to their hardware and software design; 3) develop generalizable empirical evidence of improvements to HVAC system efficiency made possible by improved airflow sensing, and; 4) prepare knowledge transfer materials in support of Task 5.

## **Exhibit A Scope of Work**

### ***The Recipient shall:***

- Procure approximately 50 each of the Prototype #2, Room-velocity Anemometers and Prototype #2 Duct-flow Anemometers, in order to carry out field testing
- Develop procedures for installing/implementing anemometers for specific applications such as monitoring, commissioning, continuous commissioning, and system control
- Prepare generic control sequences based on enhanced airspeed sensing and flow reversal detection in air handlers, VAV boxes, outside air dampers, laboratory flow hoods, and hospitals
- Prepare *Test Plan #2* for field testing of prototype anemometers. Plan will include field testing of prototype anemometers in a test site, such as Sutardja Dai Hall test site, or other site deemed appropriate by the CAM, and include contributions from industrial collaborators such as Price, Big Ass Fans, and Vigilent.
- Evaluate ceiling fan control strategies based on airspeed measurement in the occupied zone.
- Test example Computer Room Air Conditioning (CRAC) control logic based on flow vectors in data center.
- Make final modification to hardware and software design.
- Arrange interactive workshops at PG&E Energy Center and Center for the Built Environment (CBE) demonstrating the anemometers and their applications to the building industry. The products of this activity will be included in Task 5.
- Prepare exhibit for at least one leading trade exposition, such as ASHRAE/AHR or Greenbuild. The products will be included in Task 5. The exhibit would include live demonstration(s) in models of proposed applications.
- Prepare materials specifically addressing the benefits of the technology for standards and codes, such as energy, environmental quality and public health, products to be included in Task 5.
- Prepare ASHRAE Journal paper for professional publication and academic peer-review. The products will be included in Task 5. The papers will cover each of the individual applications in appropriate combinations.
- Prepare *CPR Report #3*, describing testing results and recommendations for control sequences and implementation guidance, and field evaluations by industrial collaborators. This report will include activities from Subtask 2.2 and Task 3.
- Participate in the third CPR meeting.

### **Products:**

- Test Plan #2
- CPR Report #3

## Exhibit A Scope of Work

### TASK 4 Evaluation of Project Benefits

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 have 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

### **TASK 5 Technology/Knowledge Transfer Activities**

The goal of this task is to develop a plan to make the knowledge gained, experimental results, and lessons learned available to the public and key decision makers.

### **The Recipient shall:**

- Prepare an *Initial Fact Sheet* at start of the project that describes the project Use the format provided by the CAM.
- Prepare a *Final Project Fact Sheet* at the project's conclusion that discusses results Use the format provided by the CAM.
- Prepare a *Technology/Knowledge Transfer Plan* that includes:
  - An explanation of how the knowledge gained from the project will be made available to the public, including the targeted market sector and potential outreach to end users, utilities, regulatory agencies, and others
  - A description of the intended use(s) for and users of the project results
  - Published documents, including date, title, and periodical name
  - Copies of documents, fact sheets, journal articles, press releases, and other documents prepared for public dissemination These documents must include the Legal Notice required in the terms and conditions. Indicate where and when the documents were disseminated.
  - A discussion of policy development State if project has been or will be cited in government policy publications, or used to inform regulatory bodies.
  - The number of website downloads or public requests for project results
  - Additional areas as determined by the CAM

## Exhibit A Scope of Work

- Conduct technology transfer activities in accordance with the *Technology/Knowledge Transfer Plan*. These activities will be reported in the Progress Reports
- When directed by the CAM, develop *Presentation Materials* for an Energy Commission-sponsored conference/workshop on the results of the project
- Prepare a *Technology/Knowledge Transfer Report* on technology transfer activities conducted during the project

### **Products:**

- Initial Fact Sheet
- Final Project Fact Sheet
- Presentation Materials
- Technology/Knowledge Transfer Plan
- Technology/Knowledge Transfer Report

### **TASK 6 Production Readiness Plan**

The goal of this task is to determine the steps that will lead to the manufacturing of technologies developed in this project or to the commercialization of the project's results.

*Note: Because this project team will not be engaged in the manufacture of the final anemometers (excepting at most the MEMS sensor elements), this plan will describe only the parts of final manufacturing that we have direct experience with. This will include primarily the requirements and costs of MEMS production, the cost of the populated carrier board, and intellectual property information.*

### **The Recipient shall:**

- Prepare a *Production Readiness Plan*. The degree of detail in the plan should be proportional to the complexity of producing or commercializing the proposed product, and to its state of development. As appropriate, the plan will discuss the following:
  - Critical production processes, equipment, facilities, personnel resources, and support systems needed to produce a commercially viable product
  - Internal manufacturing facilities, supplier technologies, capacity constraints imposed by the design under consideration, design-critical elements, and the use of hazardous or non-recyclable materials The product manufacturing effort may include "proof of production processes."
  - The estimated cost of production
  - The expected investment threshold needed to launch the commercial product
  - An implementation plan to ramp up to full production
  - The outcome of product development efforts, such as copyrights and license agreements
  - Patent numbers and applications, along with dates and brief descriptions
  - Other areas as determined by the CAM

### **Products:**

- Production Readiness Plan

## **Exhibit A Scope of Work**

### **IV. PROJECT SCHEDULE**

Please see the attached Excel spreadsheet.

STATE OF CALIFORNIA

STATE ENERGY RESOURCES  
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION - RE: UNIVERSITY OF CALIFORNIA, BERKELEY

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

**RESOLVED**, that the Energy Commission approves Agreement EPC-14-013 with the Regents of the University of California, on behalf of the Berkeley Campus for a \$2,488,964 grant to develop low-cost, low-power, accurate, calibration-free, and compact airflow sensors (anemometers) for measuring: (1) room airflow in occupied commercial buildings; and (2) volumetric air flow in Heating, Ventilating, and Air Conditioning (HVAC) systems and laboratory fume hoods. The technology will save energy by using the collected data to correct current wasteful HVAC malfunctions that result in inefficient systems and uncomfortable buildings; 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 February 25, 2015.

AYE: [List of Commissioners]

NAY: [List of Commissioners]

ABSENT: [List of Commissioners]

ABSTAIN: [List of Commissioners]

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Harriet Kallemeyn,  
Secretariat