

**GRANT REQUEST FORM (GRF)**

CEC-270 (Revised 02/13)

CALIFORNIA ENERGY COMMISSION

New Agreement EPC-14-007 (To be completed by CGL Office)

| Division | Agreement Manager: | MS- | Phone        |
|----------|--------------------|-----|--------------|
| ERDD     | Mike Kane          | 43  | 916-327-1530 |

| Recipient's Legal Name   | Federal ID Number |
|--|-------------------|
| The Regents of the University of California, on behalf of the Davis campus | 94-6036494        |

| Title of Project  |
|---|
| Improving Short-Term Wind Power Forecasting through Measurements and Modeling of the Tehachapi Wind Resource Area |

| Term and Amount | Start Date | End Date  | Amount       |
|-----------------|------------|-----------|--------------|
|                 | 1/15/2015  | 7/15/2017 | \$ 1,000,000 |

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

|                                |            |                                  |  |
|--------------------------------|------------|----------------------------------|--|
| Proposed Business Meeting Date | 12/10/2014 | <input type="checkbox"/> Consent | <input checked="" type="checkbox"/> Discussion |
| Business Meeting Presenter     | Mike Kane  | Time Needed:                     | 5 minutes                                      |

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

**Agenda Item Subject and Description**

Proposed resolution approving Agreement EPC-14-007 with The Regents of the University of California on behalf of the Davis campus for a \$1,000,000 grant to improve the accuracy of short-term forecasting of wind power production ramps in the Tehachapi Wind Resource Area (Contact: Mike Kane) 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":

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: 14 CCR 15306  
 Common Sense Exemption. 14 CCR 15061 (b) (3)  
 Explain reason why Agreement is exempt under the above section:  
 Class 6 - Basic data collection, research, experimental management, and resource evaluation activities that do not result in major disturbances to an environmental resource.  
 Project includes a modeling phase, a field measurement phase and an analysis phase. Assets for field measurement phase were installed for another Energy Commission funded project (500-11-010) and this project will extend the use of these assets for a period of approximately one year after the termination of data collection by the previous project. The extant assets include:  
 - Radar wind profiler and radio acoustic sounding system for continuous measurement of wind and temperature up to 3000 meters above ground level.  
 - Two frame-mounted sonic ranging and detecting (SODAR) units for continuous measurement of wind up to 600 meters above ground level.  
 - A microwave radiometer and a mini-SODAR are located at the Windmatic facility near the Tehachapi municipal airport.

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     |
|---------------------------------|------------|
| MESO, Inc                       | \$ 224,985 |
| Sonoma Technology, Inc.         | \$ 297,947 |
| AWS Truepower, LLC              | \$ 73,580  |
| Atmospheric Systems Corporation | \$ 1,590   |

**GRANT REQUEST FORM (GRF)**

CEC-270 (Revised 02/13)

CALIFORNIA ENERGY COMMISSION



|   |
|---|
| <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             | \$1,000,000 |
|                                   |                               |                      | \$          |
|                                   |                               |                      | \$          |
|                                   |                               |                      | \$          |
|                                   |                               |                      | \$          |
|                                   |                               |                      | \$          |
| R&D Program Area:                 | EGRO: Renewables              | TOTAL:               | \$1,000,000 |
| Explanation for "Other" selection |                               |                      |             |
| Reimbursement Contract #:         |                               | Federal Agreement #: |             |

| Recipient's Administrator/ Officer |                               |      |              | Recipient's Project Manager |   |      |              |
|------------------------------------|-------------------------------|------|--------------|-----------------------------|---|------|--------------|
| Name:                              | Randi Jenkins                 |      |              | Name:                       | C.P. van Dam  |      |              |
| Address:                           | 1850 RESEARCH PARK DR STE 300 |      |              | Address:                    | UC, Davis Mechanical and Aerospace<br>Engr.<br>One Shields Avenue |      |              |
| City, State, Zip:                  | DAVIS, CA 95618-6153          |      |              | City, State, Zip:           | Davis, CA 95616   |      |              |
| Phone:                             | 530-754-8323 /                | Fax: | 530-752-0333 | Phone:                      | 530-752-7741 /  | Fax: | 530-752-4158 |
| E-Mail:                            | rljenkins@ucdavis.edu         |      |              | E-Mail:                     | cpvandam@ucdavis.edu  |      |              |

| Selection Process Used  |                            |
|---|----------------------------|
| <input checked="" type="checkbox"/> Competitive Solicitation  | Solicitation #: PON-13-303 |
| <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 type="checkbox"/> N/A            | <input checked="" type="checkbox"/> Attached |  |

Agreement Manager

Date

Office Manager

Date

Deputy Director

Date

## Exhibit A Scope of Work

### I TASK, ACRONYM, AND TERM LISTS

#### A. Task List

| Task # | CPR <sup>1</sup> | Task Name   |
|--------|------------------|---|
| 1      |                  | General Project Tasks   |
| 2      |                  | Forecast Sensitivity Assessment: Error Analysis                       |
| 3      | X                | Field Measurement Campaign  |
| 4      |                  | Short-Term Wind Ramp Forecasting Improvements: WRF Modifications      |
| 5      |                  | Very Short-Term Wind Ramp Forecasting Improvements: Empirical Methods |
| 6      |                  | Wind Ramp Forecast System: Evaluation and Finalization                |
| 7      |                  | Evaluation of Project Benefits  |
| 8      |                  | Technology/Knowledge Transfer Activities                              |

#### B. Acronym/Term List

| Acronym/Term      | Meaning   |
|-------------------|---|
| BOFS              | Baseline Operational Forecast System                                      |
| BLs               | Boundary Layers   |
| CAISO             | California Independent System Operator                                    |
| CAM               | Commission Agreement Manager  |
| CAO               | Commission Agreement Officer  |
| CPR               | Critical Project Review   |
| EBOFS             | Enhanced Baseline Operational Forecast System                             |
| Energy Commission | California Energy Commission  |
| IOFS              | Improved Operational Forecast System                                      |
| GSI               | Gridpoint Statistical Interpolation                                       |
| MS                | Microsoft   |
| NOAA              | National Oceanic and Atmospheric Administration                           |
| NWP               | Numerical Weather Prediction  |
| PBL               | Planetary Boundary Layer  |
| Recipient         | The Regents of the University of California on behalf of the Davis campus |
| TAC               | Technical Advisory Committee  |
| TWRA              | Tehachapi Pass Wind Resource Area   |
| WRF               | Weather Research and Forecasting  |
| WRF-ARW           | Weather Research and Forecasting – Advanced Research WRF                  |

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

<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

### A. Purpose of Agreement

The purpose of this Agreement is to fund work to improve short-term (0-15 hours) and very short-term (0-3 hours) forecasting of wind power production ramps (i.e., large, rapid changes in wind power production) in the Tehachapi Pass Wind Resource Area (TWRA).

### B. Problem/ Solution Statement

#### Problem

Wind power ramps are one of the most challenging renewable integration issues for balancing authorities, potentially impacting electricity costs, grid reliability, and greenhouse gas emissions. They are difficult to predict because of the diverse, complex meteorological processes that drive them. Accurate prediction is particularly difficult in the extremely complex terrain of the TWRA, which hosts California's greatest concentration of installed wind power.

#### Solution

The Recipient will perform a meteorological field measurement campaign closely coordinated with the implementation of an array of computational modeling improvements. The field measurements will focus specifically on phenomena that drive wind ramps in the TWRA, providing a critical study and validation dataset for the modeling improvements. The computational efforts will pursue two avenues for improvement: (1) the modeling of the underlying physics in numerical weather prediction (NWP) forecast software and (2) advanced empirical/statistical methods focused on very short-term (0-3 hour) forecasts of wind ramps.

### C. Goals and Objectives of the Agreement

#### Agreement Goals

The goals of this Agreement are to:

- Improve the accuracy of short-term (0-15 hour) and very short-term (0-3 hour) forecasts of wind power ramps in the TWRA.
- Contribute a public dataset and modeling software improvements to the renewable energy forecasting research community to facilitate further study of wind power ramps and other meteorological phenomena in the TWRA.

Ratepayer Benefits:<sup>2</sup> Uncertainty and variability of generation and demand in the electric grid can detrimentally impact system reliability. They also require the grid operator to carry power generating reserves, which emit greenhouse gasses and incur costs directly borne by ratepayers. Uncertainty and variability are inherently present in all power systems, but power forecast error of large amounts of wind power can be a significant contributor to the overall system uncertainty.

This Agreement focuses on improving the power forecasts of wind plants in the TWRA. The TWRA is particularly important in California as it is the state's largest wind resource area, with the most installed wind power capacity and ongoing growth. Its terrain hosts complex

---

<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

meteorological processes that make accurate wind power forecasting challenging. Improved forecasts in the TWRA will reduce uncertainty, benefiting ratepayers by bolstering grid reliability and reducing the amount of generating reserves needed, thereby reducing direct costs and emissions.

### Technological Advancement and Breakthroughs:<sup>3</sup>

The anticipated advances and breakthroughs in this project will result in more accurate predictions of the timing and amplitude of large regional changes in wind power production. It is expected that the increase in accuracy will be the result of the gathering of additional real-time atmospheric data through the deployment of a targeted array of sensors as well as weather prediction model refinements that are specifically formulated to improve wind prediction in complex terrain. This will facilitate more cost-effective deployment of generation and transmission assets while maintaining high system reliability. The net result will be lower costs for the integration of high levels of wind power penetration on the California grid, facilitating the state's renewable energy deployment and emissions reduction goals.

### Agreement Objectives

The objectives of this Agreement are to:

- Complete a forecast sensitivity error analysis to identify and quantify the parameters that most significantly impact wind ramp forecast errors.
- Conduct a one-year measurement campaign in the TWRA, focused on the phenomena that drive wind ramps.
- Implement improvements to computational modeling of flow physics at low-levels in complex terrain.
- Implement statistical and empirical methods to make very short-term correlations between meteorological measurements and wind turbine and wind plant production.
- Incorporate the improvements to computational modeling and the statistical and empirical correlations described above into a state-of-the-art wind power forecast system.
- Validate the modeling improvements for low-levels in complex terrain and immediately incorporate them into forecasts of wind power and wind power ramps in the TWRA provided to the California Independent System Operator (CAISO).

## I. 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.

---

<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.

- **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:

## Exhibit A Scope of Work

- 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.

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

## **Exhibit A Scope of Work**

- 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).
- 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.

## **Exhibit A Scope of Work**

- 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.
  - 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

## Exhibit A Scope of Work

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 and approve 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

#### **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.

##### **Products:**

- Final Report (draft and final)

### **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 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.

## Exhibit A Scope of Work

### 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.

### 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.

### **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*)

## **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,

## **Exhibit A Scope of Work**

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
- 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.

## **Exhibit A**

### **Scope of Work**

#### **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

### II. 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 Forecast Sensitivity Assessment: Error Analysis**

The goal of this task is to determine the sensitivity of wind ramp forecast errors to key components of Weather Research and Forecasting (WRF) model physics schemes.

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

- Identify ten historical cases for each of three variability modes (diurnal cycle, mid-latitude, monsoonal flow) in the TWRA for a total of 30 cases.
- Generate historical NWP forecasts for the 30 cases.
- Analyze results from all cases to assess relative error sensitivity in power production as well as ramp event timing, amplitude and duration.
- Write an *Error Analysis Report* summarizing the findings and recommendations for sensor deployment and NWP model improvements based on the error analysis. The report will include but not be limited to:
  - Identification of 30 historical cases to characterize meteorological variability in the TWRA.
  - Historical NWP forecasts for each of the 30 cases.
  - Analysis of the 30 cases to assess relative error sensitivity in power production as well as ramp event timing, amplitude and duration.

##### **Products:**

- Error Analysis Report

#### **TASK 3 Field Measurement Campaign**

The goals of this task are to provide a robust set of meteorological data for (1) characterizing the meteorological processes that influence lower boundary-layer winds in the TWRA and (2) improving short-term and very short-term wind forecasts (up to 15 hours and from 0 to 3 hours). To help meet this objective, the recipient will install instruments and continue operating existing instruments for one year.

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

- Develop a *Field Measurement Plan* that outlines all activities, sites, operations, and procedures to be followed during installation, operation, and removal of the instruments.
- Make slight adjustments to the operations of the existing WindSense sites, which could include operating settings and perhaps relocating an instrument.
- Install the ceilometer near the Tehachapi Airport.
- Operate real-time data acquisition system to acquire all data and a website for distributing the data in real-time.
- Operate all instruments, perform periodic maintenance, and perform emergency repairs.
- De-install all of the instruments at the end of the one-year field measurement campaign.

## Exhibit A Scope of Work

- Compute boundary layer heights from the wind profiler, Sodar, and Ceilometer data
- Quality control all winds, temperature, moisture, and boundary layer height data.
- Deliver the validated final data set to project participants and the National Oceanic and Atmospheric Association (NOAA) Meteorological Assimilations Data Ingest System (MADIS).
- Write a *Field Measurement Campaign Report* that provides data, analysis, and discussion resulting from the implementation of the Field Measurement Plan.
- Participate in CPR as described in task 1.3 and prepare *CPR report*.

### Products:

- Field Measurement Plan
- Field Measurement Campaign Report
- CPR Report

### **TASK 4 Short-Term Wind Ramp Forecasting Improvements: WRF Modifications**

The goal of this task is to configure and improve a weather forecast system that can provide more accurate short-term, low-level wind forecasts over complex terrain. To achieve this goal, the recipient will focus on the improvement of the critical components in a forecasting system, including initial conditions through data assimilation, planetary boundary layer (PBL) parameterization, and a high-spatial resolution which resolves complex terrain and flow features. The recipient's weather forecasting system will consist of the WRF (Skamarock et al. 2008) model and the Gridpoint Statistical Interpolation (GSI) hybrid variational and ensemble data assimilation system (hereafter referred to as "GSI-hybrid") (Lorenc 2003; Wang 2010). The newly developed Shin-Hong PBL scheme (Shin et al. 2013) will be implemented into WRF for this project.

### **The Recipient shall:**

- Implement observational operators into GSI-hybrid.
- Develop preprocessors and decoders for new observations.
- Implement the new Shin-Hong PBL scheme in WRF.
- Validate and refine Shin-Hong PBL scheme using observations and case studies.
- Submit developed code to the public Weather Research and Forecasting-Advanced Research Weather Research and Forecasting (WRF-ARW) repository.
- Write a *Short-Term Wind Ramp Forecasting Improvements Report* detailing the short-term modeling improvements in WRF documenting method development and performance improvements. The report will include but not be limited to:
  - Discussion of data assimilation improvements including development of preprocessors and decoders for new observations and implementation of observational operators into GSI-hybrid.
  - Discussion of implementation of the Shin-Hong PBL scheme into WRF.
  - Discussion of validation and tuning of the Shin-Hong PBL scheme in WRF.
  - An electronic copy of the code submitted to the public WRF-ARW repository will be attached to the Short-Term Wind Ramp Forecasting Improvements Report. This is in addition to the requirements set forth in Task 1.1. The report will detail when and how this code was submitted.

### Products:

- Short-Term Wind Ramp Forecasting Improvements Report (draft and final).

## **Exhibit A Scope of Work**

### **TASK 5 Very Short-Term Wind Ramp Forecasting Improvements: Empirical Methods**

The goal of this task is to develop a multi-component, very short-term wind ramp forecasting tools designed for the 0- to 3-hour look-ahead period.

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

- Develop a real-time ingest and quality control system that handles historical and real-time data sets including (but not limited to) data from the project's sensor network.
- Classify forecasts into regimes using one or more high-resolution numerical models and observed data.
- Determine time-lagged spatial relationships within each regime that have utility in predicting wind farm and aggregate power output and ramp rates.
- Employ regimes and time-lagged statistical relationships to predict power output and ramp rates on both an individual facility and aggregate scale. Incorporate feature tracking algorithm to estimate the timing of very short-term ramps within the forecast system.
- Write a *Very Short-Term Wind Ramp Forecasting Report* evaluating the improvements in very short-term forecasting. The report will include but not be limited to:
  - An overview of the methods employed for very short-term (i.e., 0- to 3- hour) wind ramp forecasting improvements.
  - A discussion of real-time data ingest and quality control systems.
  - Evaluations of improvements to the accuracy of the short-term wind ramp forecasts.

#### **Product:**

- Very Short-Term Wind Ramp Forecasting Report (draft and final).

### **TASK 6 Wind Ramp Forecast System: Evaluation and Finalization**

The goal of this task is to configure, operate, and evaluate the real-time Baseline Operational Forecast System (BOFS), real-time Enhanced Baseline Operational Forecast System (EBOFS), and retrospective Improved Operational Forecast System (IOFS).

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

- Run the BOFS in real-time for a period of one year.
- Run the EBOFS in real-time for a period of one year.
- Run the IOFS retrospectively for a non-continuous period of six months based on cases identified to be of most interest, based on input from the Technical Advisory Committee.
- Compare performance of BOFS, EBOFS, and IOFS at raw model level, statistically-adjusted output of each NWP component, and ensemble composites for each operational forecast system.
- Compare performance of BOFS, EBOFS, and IOFS for the entire 0- to 15-hour time horizon with emphasis on the very short-term period (0- to 3-hour).
- Compare performance of BOFS, EBOFS, and IOFS for ramp timing, amplitude, and duration for individual sites and site aggregates for the entire 0- to 15-hour time horizon with emphasis on the very short-term period (0- to 3-hour).
- Write an *Improved Operational Forecast System Report* evaluating the Improved Operational Forecast System. The report will include but not be limited to:
  - An overview of the BOFS, EBOFS, and IOFS operational forecast systems.

## Exhibit A Scope of Work

- A discussion of the evaluation periods selected for the IOFS performance evaluation.
- A comparison of the overall performance of the BOFS, EBOFS, and IOFS in the 0- to 15-hour forecast horizon, with emphasis on the very short term (0- to 3-hour).
- A comparison of the ramp forecast performance of the BOFS, EBOFS, and IOFS in the 0- to 15-hour forecast horizon, with emphasis on the very short term (0- to 3-hour).

### Product:

- Improved Operational Forecast System Report (draft and final).

### TASK 7 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:

## Exhibit A Scope of Work

- 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.
  - 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 8 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

## **Exhibit A Scope of Work**

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.
- 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 (draft and final)
- Final Project Fact Sheet (draft and final)
- Presentation Materials (draft and final)
- Technology/Knowledge Transfer Plan (draft and final)
- Technology/Knowledge Transfer Report (draft and final)

### **III. PROJECT SCHEDULE**

Please see the attached Excel spreadsheet.

STATE OF CALIFORNIA

STATE ENERGY RESOURCES  
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION - RE: THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, DAVIS

**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-14-007 with **The Regents of the University of California on behalf of the Davis campus** for a **\$1,000,000** grant to improve the accuracy of short-term forecasting of wind power production ramps in select wind resource area of California; 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 December 10, 2014

AYE: [List of Commissioners]

NAY: [List of Commissioners]

ABSENT: [List of Commissioners]

ABSTAIN: [List of Commissioners]

---

Harriet Kallemeyn,  
Secretariat