STATE OF CALIFORNIA

GRANTS/CONTINGENT AWARD REQUEST

CEC-270 (Revised 02/10) CALIFORNIA ENERGY COMMISSION

To: Grants and Loans Office Date: 3/4/2013
Project Manager: Zhiqin (Jessica) Zhang Phone Number: 916-327-1397
Office: Energy Generation Research Office Division: Energy Research and Development MS- 43
Project Title: Breakthrough Power Density for Rooftop PV Applications

Type of Request: *(check one)*

☒ **New Agreement:** *(include items A-F from below)* Agreement Number: PIR-12-019

Program: PIER E / Renewables
Solicitation Name and/or Number: PON-12-502-42 (Community Scale Renewable Energy Development, Deployment and Integration)
Legal Name of Recipient: Sun Synchrony
Recipient's Full Mailing Address: 3014 ENCINAL AVENUE, APT 2
ALAMEDA, CA 94501-4866
Recipient's Project Officer: James Hoffman Phone Number: 510 769 5109
Agreement Start Date: 6/7/2013 Agreement End Date: 3/31/2015

☐ **Amendment :** *(Check all that apply)* Agreement Number:

- ☐ Term Extension – New End Date:
- ☐ Work Statement Revision *(include Item A from below)*
- ☐ Budget Revision *(include Item B from below)*
- ☐ Change of Scope *(include Items A – F as applicable from below)*
- ☐ Other:

ITEMS TO ATTACH WITH REQUEST:

A. Work Statement
B. Budget
C. Recipient Resolution, if applicable. (Resolution may be requested in Special Conditions if not currently available.)
D. Special Conditions, if applicable.
E. CEQA Compliance Form
F. Other Documents as applicable
- Copy of Score Sheets
- Copy of Pre-Award Correspondence
- Copy of All Other Relevant Documents

California Environmental Quality Act (CEQA)

☐ CEC finds, based on recipient's documentation in compliance with CEQA:
- ☐ Project exempt: NOE filed:
- ☐ Environmental Document prepared: NOD filed:
- ☐ Other:

☒ CEC has made CEQA finding described in CEC-280, attached

Funding Information:

*Source #1: PIER-E	Amount: $ 475,095.00	Statute: 11-	FY: 12-13	Budget List #: 501.027J
*Source #2:	Amount: $	Statute:	FY:	Budget List #:
*Source #3:	Amount: $	Statute:	FY:	Budget List #:

If federally funded, specify federal agreement number:

*** Source Examples include ERPA, PIER-E, PIER-NG, FED, GRDA, ARFVT, OTHER.**

Business Meeting Approval: *(refer to Business Meeting Schedule)*

Proposed Business Meeting Date: 5/8/2013 ☐ Consent ☒ Discussion
Business Meeting Participant: Zhiqin (Jessica) Zhang Time Needed: 5 minutes

Agenda Notice Statement: *(state purpose in layperson terms)*

Possible approval of a ☒ Grant / ☐ Contingent Award to…
SUN SYNCHRONY. Possible approval of Agreement PIR-12-019 with Sun Synchrony for a $475,095 grant to develop a new type of rooftop deployable PV module using light concentration to provide breakthrough power conversion efficiency. (PIER electricity funding) Contact: Zhiqin Zhang. (5 minutes)

Project Manager	Date	Office Manager	Date	Deputy Director	Date

Exhibit A
WORK STATEMENT

TECHNICAL TASK LIST

Task #	CPR	Task Name
1	N/A	Administration
2		Develop Tracking Mount Hardware
3		Improve CPV Module Hardware
4		Develop Electronics and Software
5		System Integration and Production
6	X	Performance and Durability Testing
7		Set Up Technology Demonstration Testbed
8		Develop Models for Lifecycle Cost Analysis
9		Performance Data Collection and Analysis

KEY NAME LIST

Task #	Key Personnel	Key Subcontractors	Key Partner
1	James Hoffman - Sun Synchrony	Sandia National Laboratory	
2	James Hoffman	Sandia National Laboratory	
3	James Hoffman	Sandia National Laboratory	
4	James Hoffman		
5	James Hoffman	Sandia National Laboratory	
6	James Hoffman	Sandia National Laboratory	
7	James Hoffman		City College of San Francisco
8	James Hoffman		
9	James Hoffman	Sandia National Laboratory	

Exhibit A
WORK STATEMENT

GLOSSARY

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

Term/ Acronym	**Definition**
AC	Alternating Current
CAD	Computer Aided Design
CEC	California Energy Commission
CPM	Commission Project Manager
CPR	Critical Project Review
CPV	Concentrating Photo-Voltaic
DC	Direct Current
IV	Electrical current (I) and Voltage
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCOE	Levelized Cost Of Energy
mm	Millimeter
MPP	Maximum Power Point
OCM	Optifold CPV Module
OHM	Optifold Heliotropic Module
PCB	Printed Circuit Board
PV	Photo-Voltaic
STC	Standard Test Conditions
SunSpring™	Novel tilt-up muli-axis tracker using opposed tension and compression
SiOx	Silicon Oxides
TCOe	Total Cost of Ownership of Energy

Exhibit A
WORK STATEMENT

Problem Statement:

A fundamental problem with PV-based community-scale electricity production is the relatively low power density of currently available roof-mount-compatible PV modules. The flat-plate solar panels, ranging in power efficiency from about 10% to 20%, do not support zero-net-energy (ZNE) installations. For example, the vast majority of multi-story air-conditioned buildings in California cannot achieve zero net grid electricity usage with flat-plate panels alone, because they lack sufficient roof space to support an installation of sufficient yield. Furthermore, the presence of shadow-casting heating, ventilation and air conditioning (HVAC) and other equipment on such buildings, combined with the shade-intolerance of the crystalline silicon panels makes the energy gap even wider.

Goals of the Agreement:

The goal of this project is to generate greater efficiencies in solar energy conversion than is currently feasible with flat-plate PV, resulting in more power per square meter of rooftop and advance the state of the art in rooftop CPV in support of enhanced penetration of the technology to buildings and institutions within the state. This project will develop a new type of rooftop-deployable PV module using light concentration to provide breakthrough power conversion efficiency. The project will leverage Sun Synchrony's concentrating module, integrating it with a novel tilt-up tracker and power conversion electronics to create a community-scale electricity generation system with higher power density.

Objectives of the Agreement:

The objectives of this project are to develop a new generation of the CPV technology invented by Sun Synchrony, and to combine it with unique tracking technology to support the advent of CPV on rooftops throughout the regions of California with the appropriate solar resource for the product. Data collected from the testbeds and the modeling efforts would be analyzed and disseminated to catalyse the development of manufacturing and installation of the technology statewide.

Technical Objectives:

Technical Objectives of this agreement are to provide:

1. Module power density by area and weight: 350 W/m^2 (35% efficiency) and 20 W/kg at STC (DNI resource of 1000)
2. Increase in energy production per rated watt of module and balance-of-system electronics with novel tilt-up tracker, providing 45 degrees tilt-up in any direction, within 0.7 degrees pointing accuracy

3. Self-stow to flush in-base flat position triggered by high-winds or drive failure, rated to withstand 100 mph winds in stowed position
4. Qualification of system and components for projected 30-year life
5. Scalable plan for maintaining site performance, and testing, using swappable micro-inverter equipped units

Economic Objectives:

The economic objectives of this agreement are the following cost targets:

1. Installed cost of below $2.50/W, when fully commercialized, in mean California rooftop site conditions
2. Module Bill-of-Materials cost below $1.60W at 20 MW/year capacity

TASK 1 ADMINISTRATION

Instructions for Submitting Electronic Files and Developing Software

Electronic File Format
The Recipient will deliver an electronic copy (CD ROM or memory stick or as otherwise specified by the Commission Project Manager (CPM) of the full text of any Agreement products in a compatible version of Microsoft Word (.doc).

The following describes the accepted formats of electronic data and documents provided to the Energy Commission as products and establishes the computer platforms, operating systems, and software versions that will be required to review and approve all software deliverables.

- Data sets will be in Microsoft (MS) Access or MS Excel file format.
- PC-based text documents will be in MS Word file format.
- Documents intended for public distribution will be in PDF file format, with the native file format provided as well.
- Project management documents will be in MS Project file format.

Software Application Development
If this Scope of Work includes any software application development, including but not limited to databases, websites, models, or modeling tools, the Recipient will use the following standard Application Architecture components in compatible versions:

- 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 Energy Commission's Information Technology Services Branch.

Task 1.1 Attend Kick-off Meeting

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

The Recipient shall:

- Attend a "Kick-Off" meeting with the CPM, the Grants Officer, and a representative of the Accounting Office. The Recipient shall bring its Project Manager, Agreement Administrator, Accounting Officer, and others designated by the CPM to this meeting. The administrative and technical aspects of this Agreement will be discussed at the meeting. Prior to the kick-off meeting, the CPM will provide an agenda to all potential meeting participants.

  The administrative portion of the meeting shall include, but not be limited to, the following:
  - Discussion of the terms and conditions of the Agreement
  - Discussion of Critical Project Review (Task 1.2)
  - Match fund documentation (Task 1.6) *No work may be performed until this documentation is in place.*
  - Permit documentation (Task 1.7)
  - Discussion of subcontracts needed to carry out project (Task 1.8)

  The technical portion of the meeting shall include, but not be limited to, the following:
  - The CPM's expectations for accomplishing tasks described in the Scope of Work
  - An updated Schedule of Products
  - Discussion of Progress Reports (Task 1.4)
  - Discussion of Technical Products (Product Guidelines located in Section 5 of the Terms and Conditions)
  - Discussion of the Final Report (Task 1.5)

The CPM shall designate the date and location of this meeting.

- Submit an updated Schedule of Products, List of Match Funds, and List of Permits to the CPM.

Recipient Products:

- Updated Schedule of Products
- Updated List of Match Funds
- Updated List of Permits

Commission Project Manager Product:

- Kick-Off Meeting Agenda

Task 1.2 Critical Project Review (CPR) Meetings

The goal of this task is to determine if the project should continue to receive Energy Commission funding to complete this Agreement and to identify any needed modifications to the tasks, products, schedule, or budget.

CPRs provide the opportunity for frank discussions between the CPM and the Recipient. The CPM may schedule CPRs as necessary, and CPR costs will be borne by the Recipient.

Participants include the CPM and the Recipient, and may include the Commission Grants Officer, the Energy Research and Development Division technical lead, other Energy Commission staff and Management, and any other individuals selected by the CPM to provide support to the Energy Commission.

The Commission Project Manager shall:

- Determine the location, date, and time of each CPR meeting with the Recipient. These 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 Commission Project Manager.
- Send the Recipient the agenda and a list of expected participants in advance of each CPR. If applicable, the agenda shall include a discussion of both match funding and permits.
- Conduct and make a record of each CPR meeting. One of the outcomes of this meeting will be a schedule for providing the written determination described below.
- Determine whether to continue the project, and if so whether modifications are needed to the tasks, schedule, products, and/or budget for the remainder of the Agreement. If the CPM 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 written determination in accordance with the schedule. The written response may include a requirement for the Recipient to revise one or more products that were included in the CPR.

The Recipient shall:

- Prepare a CPR Report for each CPR that discusses the progress of the Agreement toward achieving its goals and objectives. This report shall include recommendations and conclusions regarding continued work on the project. This report shall be submitted along with any other products identified in this Scope of Work. The Recipient shall submit these documents to the CPM and any other designated reviewers at least 15 working days in advance of each CPR meeting.
- Present the required information at each CPR meeting and participate in a discussion about the Agreement.

Commission Project Manager Products:

- Agenda and a list of expected participants
- Schedule for written determination
- Written determination

Recipient Product:

- CPR Report(s)

Task 1.3 Final Meeting

The goal of this task is to close out this Agreement.

The Recipient shall:

- Meet with Energy Commission staff to present the project findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement.

  This meeting will be attended by, at a minimum, the Recipient, the Commission Grants Office Officer, and the CPM. The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be divided into two separate meetings at the discretion of the CPM.

  The technical portion of the meeting shall involve the presentation of an assessment of the degree to which project and task goals and objectives were achieved, in addition to findings, conclusions, recommended next steps (if any) for the Agreement, and recommendations for improvements. The CPM will determine the appropriate meeting participants.

The administrative portion of the meeting shall involve a discussion with the CPM and the Grants Officer about the following Agreement closeout items:
  - Disposition of any equipment purchased with Energy Commission funds
  - Energy Commission's request for specific "generated" data (not already provided in Agreement products)
  - Need to document Recipient's disclosure of "subject inventions" developed under the Agreement
  - "Surviving" Agreement provisions
  - Final invoicing and release of retention
- Prepare written documentation of any agreements made between the Recipient and Commission staff during the meeting.
- Prepare a schedule for completing the closeout activities for this Agreement.

Products:
- Written documentation of meeting agreements
- Schedule for completing closeout activities

Task 1.4 Monthly Progress Reports

The goal of this task is to periodically verify that satisfactory and continued progress is made towards achieving the research objectives of this Agreement on time and within budget.

The objectives of this task are to summarize activities performed during the reporting period, to identify activities planned for the next reporting period, to identify issues that may affect performance and expenditures, and to form the basis for determining whether invoices are consistent with work performed.

The Recipient shall:
- Prepare a Monthly Progress Report that summarizes all Agreement activities conducted by the Recipient for the reporting period, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Each progress report is due to the CPM within 10 days of the end of the reporting period. The recommended specifications for each progress report are contained in the Terms and Conditions of this Agreement.
- In each Monthly Progress Report and invoice, document and verify:
  - Energy Commission funds received by California-Based Entities (CBEs);
  - Energy Commission funds spent in California; and
  - Match fund expenditures
  - Synopsis of project progress.

Exhibit A
WORK STATEMENT

Product:

- Monthly Progress Reports

Task 1.5 Final Report

The goal of the Final Report is to assess the project's success in achieving its goals and objectives, advancing science and technology, and providing energy-related and other benefits to California.

The objectives of the Final Report are to clearly and completely describe the project's purpose, approach, activities performed, results, and advancements in science and technology; to present a public assessment of the success of the project as measured by the degree to which goals and objectives were achieved; to make insightful observations based on results obtained; to draw conclusions; and to make recommendations for further projects and improvements.

The Final Report shall be a public document. If the Recipient has obtained confidential status from the Energy Commission and will also prepare a confidential version of the Final Report, the Recipient shall perform the following activities for both the public and confidential versions of the Final Report.

The Recipient shall:

- Prepare an Outline of the Final Report.
- Prepare a Final Report following the approved outline and the latest version of the Final Report guidelines which will be provided by the CPM. The CPM shall provide written comments on the Draft Final Report within 15 working days of receipt. The Final Report must be completed at least 90 days before the end of the Agreement Term.
- Submit one bound copy of the Final Report with the final invoice.

Products:

- Draft Outline of the Final Report
- Final Outline of the Final Report
- Draft Final Report
- Final Report
- Prepare a Final Report following the approved outline and the latest version of the Final Report guidelines which will be provided by the Commission Project Manager. The Commission Project Manager shall provide written comments on the Draft Final Report within fifteen (15) working days of receipt. The Final Report must be completed at least 60 days before the end of the Agreement Term.
- Submit one bound copy of the Final Report with the final invoice.

Task 1.6 Identify and Obtain Matching Funds

The goal of this task is to ensure that the match funds planned for this Agreement are obtained for and applied to this Agreement during the term of this Agreement.

The costs to obtain and document match fund commitments are not reimbursable through this Agreement. Although the Energy Commission budget for this task will be zero dollars, the Recipient may utilize match funds for this task. Match funds shall be spent concurrently or in advance of Energy Commission funds for each task during the term of this Agreement. Match funds must be identified in writing and the associated commitments obtained before the Recipient can incur any costs for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the Commission Project Manager at least 2 working days prior to the kick-off meeting. 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, state such 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 each cash match fund, its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied.
    - Amount of each in-kind contribution, a description, documented market or book value, and its 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 shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located.
- Provide a copy of the letter of commitment from an authorized representative of each source of cash match funding or in-kind contributions that these funds or contributions have been secured. For match funds provided by a grant a copy of the executed grant shall be submitted in place of a letter of commitment.
- Discuss match funds and the implications to the Agreement if they are reduced or not obtained as committed, at the kick-off meeting. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide the appropriate information to the Commission Project Manager if during the course of the Agreement additional match funds are received.
- Notify the Commission Project Manager within 10 days if during the course of the Agreement existing match funds are reduced. Reduction in match funds

must be approved through a formal amendment to the Agreement and may trigger an additional CPR.

Products:

- A letter regarding match funds or stating that no match funds are provided
- Copy(ies) of each match fund commitment letter(s) (if applicable)
- Letter(s) for new match funds (if applicable)
- Letter that match funds were reduced (if applicable)

Task 1.7 Identify and Obtain Required Permits

The goal of this task 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. Although the Energy Commission budget for this task will be zero dollars, the Recipient shall budget match funds for any expected expenditures associated with obtaining permits. Permits must be identified in writing and obtained before the Recipient can make any expenditure for which a permit is required.

The Recipient shall:

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the Commission Project Manager at least 2 working days prior to the kick-off meeting. If there are no permits required at the start of this Agreement, then state such in the letter. If it is known at the beginning of the Agreement that permits will be required during the course of the Agreement, provide in the letter:
  - A list of the permits that identifies the:
  - Type of permit
  - Name, address and telephone number of the permitting jurisdictions or lead agencies
  - The schedule the Recipient will follow in applying for and obtaining these permits
- Discuss the list of permits and the schedule for obtaining them at the kick-off meeting and develop a timetable for submitting the updated list, schedule and the copies of the permits. The implications to the Agreement 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 the Progress Reports and will be a topic at CPR meetings.
- If during the course of the Agreement additional permits become necessary, provide the appropriate information on each permit and an updated schedule to the Commission Project Manager.
- As permits are obtained, send a copy of each approved permit to the Commission Project Manager.

- If during the course of the Agreement permits are not obtained on time or are denied, notify the Commission Project Manager within 5 working days. Either of these events may trigger an additional CPR.

Products:

- Letter documenting the permits or stating that no permits are required
- A copy of each approved permit (if applicable)
- Updated list of permits as they change during the term of the Agreement (if applicable)
- Updated schedule for acquiring permits as changes occur during the term of the Agreement (if applicable)

Task 1.8 Obtain and Execute Subcontracts

The goal of this task is to ensure quality products and to procure subcontracts required to carry out the tasks under this Agreement consistent with the terms and conditions of this Agreement and the Recipient's own procurement policies and procedures. It will also provide the Energy Commission an opportunity to review the subcontracts to ensure that the tasks are consistent with this Agreement, that the budgeted expenditures are reasonable and consistent with applicable cost principles.

The Recipient shall:

- Manage and coordinate subcontractor activities.
- Submit a draft of each subcontract required to conduct the work under this Agreement to the Commission Agreement Manager for review.
- Submit a final copy of the executed subcontract.
- If Recipient decides to add new subcontractors, it shall notify the Commission Agreement Manager.

Products:

- Request for new subcontractors, or letter stating that no subcontracts are required
- Draft subcontracts
- Final subcontracts

Exhibit A
WORK STATEMENT

TECHNICAL TASKS

TASK 2: DEVELOP TRACKING MOUNT HARDWARE

The goal of this task is to refine baseline design of the Optifold Heliotropic Module's (OHM) tilt-up tracking mount (SunSpring™) to develop, fabricate and test second-generation prototype.

Task 2.1: Tracking Mount Design and Modeling

The goal of this task is to refine the design of the SunSpring tracking mount through mechanical modeling and simulation to optimize features of the second-generation prototypes.

The Recipient shall:

- Develop mechanical models and simulations of the mount encompassing its operating modes and ranges of motion.
- Use models to refine specification parameters, such as the relative force functions of extension and retraction springs.
- Finalize the CAD model of the second-generation version of SunSpring with the benefit of the mechanical models and performance data from the baseline prototype.
- Obtain quotes for vendor-fabricated parts not yet quoted, select vendors, and order tooling, parts, and processing.
- Produce Baseline Status Report describing the design of baseline tracking mount.

Products:

- Baseline Status Report (No draft).

Task 2.2: Tracking Mount Fabrication

The goal of this task is to build versions of the SunSpring tracking mount, in conjunction with OHM's CPV module, to support the successive stages of pilot deployments.

The Recipient shall:

- Complete baseline prototype for tracking mount.
- Obtain raw materials for components to be fabricated in-house.
- Build one complete prototype of the second-generation mount, and perform tests to validate the compatibility of components and spring force functions.
- Build 20 copies of the tracking mount.
- Submit a Fabrication Report describing the status of the fabrication on the second-generation mount.

Products:

- Fabrication Report (No draft).

TASK 3: IMPROVE CPV MODULE HARDWARE

The goal of this task is to improve the Optifold CPV Module (OCM) (the concentrator component of the OHM and develop it to a volume-manufacture-ready state, moving from a build-out and testing of the current generation, to the design refinement, production, and testing of an optimized second generation.

Task 3.1: Reflectors

The goal of this task is to improve the design and fabrication of the Optifold reflectors that the OCM is based on to achieve the goals of high concentrating performance and long-life durability in the sun.

The Recipient shall:

- Use existing stock of reflector quadrants to perform characterization and analysis of geometric accuracy, surface smoothness, and surface reflectivity.
- Use existing stock of bright-nickel electroplated reflector quadrants as substrate for vacuum-metalization coating.
- Contract use magnetron sputtering to apply high-reflectance coatings containing silver over aluminum in two or three batches employing different variants of passivating compounds to protect the silver.
- Initiate a battery of long-term exposure experiments on selected quadrants to test durability – particularly of the silver.
- Develop an improved version of the reflector with the following features:
    - Reflector is molded in one piece instead of four.
    - Portions of reflector around receivers comprise channels that function as a waveguide to direct stray light onto the cells, without a homogenizer optic.
- Contract production of an injection mold with the following features:
    - Steel composition.
    - A single-shot, two-piece one-pull design.
    - A reflector-side surface roughness of less than 10nm.
    - A service life of at least 900 shots
- Contract production of a batch of 900 reflector parts from the new mold.
- Contract use magnetron sputtering to apply a high-reflectance coating to 800 of the reflector parts, possibly in several variants designed to test silver passivation methods in long-term use.
- Subject reflector to test to characterize geometric accuracy, surface smoothness, and surface reflectance.

- Produce Reflector Status Report describing the status of reflector parts for the baseline prototypes.
- Produce Parts Status Report describing the development of second-generation parts.

Products:

- Reflector Status Report (No draft).
- Parts Status Report (No draft).

Task 3.2: Receiver Assemblies

The goal of this task is to improve the design and fabrication of the receiver assemblies that house the multi-junction solar cells to improve performance and durability and reduce build times.

The Recipient shall:

- Conduct thermal performance tests of receiver assemblies and interfacing components using existing first-generation prototype.
- Finalize design refinements to first-generation receiver assemblies.
- Order parts for 200-400 first-generation receivers.
- Streamline production of first-generation receiver assemblies.
- Construct 200 receiver assemblies for baseline prototype build.
- Develop one or more alternative designs for the second-generation prototype coordinating with the improved reflector design described in Task 3.1.
- Develop custom 2x2 mm cell design working with cell supplier.
- Order cells and parts for 2,000 – 5,000 receiver assemblies.
- Build several prototype receiver assemblies
- Conduct tests on the new receiver assemblies designed to expose flaws, including on-sun experiments of receivers installed in reflectors.
- Select preferred receiver design, make any needed design changes, and systemize assembly production.
- Build 2,000 – 5,000 receiver assemblies.
- Write section describing design and fabrication of receiver assemblies for the second generation prototypes to be included in the tenth Monthly Progress Report.
- Produce Design and Fabrication Report describing the design and fabrication of receiver assemblies for the second-generation prototypes.

Products:

- Design and Fabrication Report (No draft).

Task 3.3: Enclosure

The goal of this task is to develop an improved enclosure for the OCM component of the Optifold Heliotropic Module (OHM) that is durable and weather resistant, and performs the various functions of transmitting light through its cover glass, enforcing reflector alignment, dissipating heat from the receiver assemblies, and managing interior humidity.

The Recipient shall:

- Obtain correctly-sized tempered glass panes with SiOx-based anti-reflective coatings.
- Finalize the Computer Aided Design (CAD) model for the second-generation version of the OCM.
- Fabricate frame and back-plate components.
- Fabricate climate control hardware components of the OCM, including desiccant column, ballast column, and valves.
- Build a complete enclosure equipped with logging instruments to measure temperature and humidity within and without the enclosure.
- Initiate long-term outdoor experiment, with continuous recording of instrument readings, and periodic adjustments to climate control mechanism.
- Use results to refine enclosure design and fabrication procedures.
- Source and obtain quotes for parts, materials, and processing.
- Produce at least twenty full weather-qualified prototypes to be combined with tracking mounts for deployment on the testbed site described in Task 7.
- Produce Enclosure Design and Testing Report describing the design and testing of the enclosure, its environmental control systems, and the performance in field tests.

Products:

- Enclosure Design and Testing (No draft).

TASK 4: DEVELOP ELECTRONICS AND SOFTWARE

The goal of this task is to develop and refine the electronics and software of the OHM, encompassing direct current (DC) and alternating current (AC) power conversion, light direction sensing, and motor control.

Task 4.1: Cluster Electronics

The goal of this task is to refine the electronics associated with a single cluster of four reflectors and 16 cells, which performs DC power conversion of the cells' outputs and periodically performs current sensing of them for direction sensing, directed by an embedded microcontroller.

Exhibit A
WORK STATEMENT

The Recipient shall:

- Employ existing PCB design, and revise if necessary.
- Create at least two prototype clusters with complete electronics.
- Troubleshoot any issues with the circuits.
- Port control code to TI-430 embedded controller.
- Test and validate maximum power point function.
- Test and validate string switching and current sensing functions.
- Contract fabrication of 50-100 populated boards for baseline prototype build.
- Inspect production run, develop procedure for installation in Task 5.1.
- Explore feasibility of including low-power wireless hardware to support inter-cluster communication.
- Create modified PCB design for second generation OHM prototypes.
- Contract fabrication of 800 populated boards for the second generation build.
- Inspect production run, and develop procedure for installation in Task 5.2.
- Produce Cluster Implementation Report describing implementation of cluster electronics.

Products:

- Cluster Implementation Report (No draft).

Task 4.2: Module Electronics

The goal of this task is to refine the electronics that operates at the module level, such as tracking motor control, power aggregation from the clusters, and grid-interactive AC power conversion.

The Recipient shall:

- Employ existing PCB design for motor driver, and revise if necessary.
- Integrate motor driver into baseline OHM unit, connecting cluster circuit to motor driver and motor driver leads to tracking servomechanism wire harnesses.
- Use baseline OHM unit to test tracking function.
- Create modified PCB design, if necessary, for second generation of OHM prototypes, and roll PCB fabrication into an order for cluster PCBs described in task 4.1.
- Evaluate different electrical architectures for the electrical interconnect of the clusters within a module that support graceful degradation of module power as outputs of clusters vary due to shade, soiling, or malfunction.
- Select design and fabricate the electrical interconnect for the nine clusters in a module.
- Create a module controller circuit having the following functions:
  - Power aggregation management for parallel array of cluster circuits.
  - Record voltage and current of the circuit
  - Record instrument readings

  - Record tracking history
  - Periodically report data upstream to the internet
- Produce Module Implementation Progress Report describing progress on implementation of module electronics.

Products:

- Module Implementation Progress Report (No draft).

TASK 5: SYSTEM INTEGRATION AND PRODUCTION

The goal of this task is to coordinate the execution of Tasks 2, 3, and 4, and manage the production of successive generations of complete prototype systems.

Task 5.1: Baseline Prototype Completion

The goal of this task is to complete a baseline prototype of the OHM in a short time-frame using components and systems previously developed by Sun Synchrony.

The Recipient shall:

- Assess the readiness of components and systems extant at the Project's initiation for building a fully-functional prototype of the OHM.
- Select and procure third-party components and systems needed to fill gaps in assembling a functioning prototype.
- Assemble prototypes of the OHM using the OCM in conjunction with either an early prototype of the SunSpring tracking mount or a third-party two-axis mount.
- Demonstrate the use the Optifold Module's light direction sensing to control tracking.
- Prepare a Demo Prototype Specifications CD containing specifications for a demonstration prototype of a complete functional OHM unit.

Products:

- Demo Prototype Specifications CD.

Task 5.2: Second-Generation Prototypes

The goal of this task is to complete several copies of a version of the OHM that incorporates design and fabrication improvements based on experience with the first generation.

The Recipient shall:

- Monitor and coordinate the design and fabrication activities of Tasks 2 through 4 to ensure compatibility between different sub-systems.

- Assemble a second-generation prototype of the OHM based on second-generation OCM and SunSpring component systems.
- Perform testing of the prototype to uncover design and production flaws.
- Make needed adjustment to component fabrication procedures to rectify flaws, and systemize assembly procedures for efficiency and quality control.
- Produce at least twenty full weather-qualified prototypes to be combined with tracking mounts for deployment on the testbed site described in Task 7.
- Prepare a Prototype Specifications CD containing specifications for a functional OHM prototype to the CEC.

Products:

- Prototype Specifications CD.

TASK 6: PERFORMANCE AND DURABILITY TESTING

The goal of this task is to characterize the performance and durability of the system and its components using standard testing methods and reputable testing laboratories.

Task 6.1 CPV Unit Performance Testing

The goal of this task is to characterize the performance and durability of generations of the OHM's CPV unit isolated from the tracking mount and microinverter.

The Recipient shall:

- Deliver a baseline prototype of the OCM to the Sandia Laboratories PV testing facility in New Mexico for extended outdoor performance characterization.
- Use a baseline prototype of the CPV unit to obtain electrical characterizations using a flash tester with a ½-degree beam of collimated light including:
  - Light and dark IV curves for the unit
  - Output power and efficiency
  - Acceptance angle
- Deliver the OCM unit of a second-generation OHM to the Sandia Laboratories PV testing facility in New Mexico for extended outdoor performance characterization.
- Produce OCM Results and Analysis Report describing results and analysis of the OCM tests.

Products:

- OCM Results and Analysis (No draft).

Task 6.2 Module Performance and Durability Testing

The goal of this task is to characterize the performance and durability of generations of the OHM, integrating the OCM, tracking mount, and microinverter.

The Recipient shall:

- Conduct wind load testing on the integrated module.
- Conduct thermal condition testing on the integrated module.
- Conduct precipitation testing on the integrated module.
- Conduct damp heat testing on the integrated module.
- Conduct hail strike testing on the integrated module.
- Produce a Performance and Durability Results Report describing the results for performance and durability testing.

Products:

- Performance and Durability Results Report (No draft).

TASK 7: SET UP TECHNOLOGY DEMONSTRATION TESTBED

The goal of this task is to set up and maintain a roof-sited installation of operating OHM units to serve as a testbed for performance monitoring and analysis, while simultaneously serving as a technology demonstration platform to support renewable energy education and training.

Task 7.1: Site Selection and Engineering Review

The goal of this task is to finalize the selection of a site for the testbed and verify the suitability of the site through an engineering review.

The Recipient shall:

- Select a testbed site that meets the project's requirements in the type of roof, solar exposure, access security, and location convenience.
- Work with the site host – Peralta Community Colleges District – to secure access to the site, and plan the installation's use of the site over time, with consideration of access by community college students and staff.
- Obtain any necessary permits to begin installation (See Task 1.7).
- Produce Site and Engineering Review Report describing the site selection and engineering review.

Products:

- Draft Site and Engineering Review Report.
- Final Site and Engineering Review Report.

TASK 7.2: Site Preparation, Initial Testbed Installation

The goal of this task is to make any required preparations to the testbed site, and install the initial system and instrumentation on the Peralta Community College District building (PCCD). The testbed modules will include both Sun Synchrony's novel concentrating optifold heliotropic modules (OHMs), as well as conventional flat-plate modules that will operate side-by-side with the OHM units to provide comparison data. The expected collective peak output for the several baseline OHM modules is in a range of 100-500 watts.

The Recipient shall:

- Perform any physical modifications to the site needed to secure the small array of test units.
- Install the initial testbed array.
- Obtain and install solar resource measuring instruments.
- Obtain and Install weather-monitoring instruments, providing measurement of temperature, humidity, precipitation, and wind speed.
- Establish internet connectivity to enable real-time web-based access to instrument readings.
- Prepare Site Preparation and Installation Report describing the site preparation and installation.

Products:

- Site Preparation and Installation Report (No draft).

TASK 7.3: Testbed Upgrade, Grid Connection

The goal of this task is to upgrade and expand the testbed with improved OHM prototypes, and implement grid connectivity to begin using the generated power.

A second-generation version of the OHM, calls for the deployment of OHM modules totaling at least 2kW, and a total installed power rating, including the conventional modules, of at least 5kW will be installed at the community college campuses of the Peralta Community Colleges District. The expected installation's total roof-area footprint is to be less than 300 square feet.

The Recipient shall:

- Make any needed arrangements to prepare the building to accept power generated by the array.
- Make any physical site modifications required to support the larger array.
- Install a racking or cabling system to secure the units to the roof surface.
- Install the new units on the racking system.
- Connect the outputs of the units' inverters to the building's power mains.
- Produce Testbed Upgrade Report describing the Testbed upgrade.

Products:

- Testbed Upgrade Report (No draft).

TASK 8: DEVELOP MODELS FOR LIFECYCLE COST ANALYSIS

The goal of this task is to develop a set of models to understand and accurately predict: the manufacturing cost of the OHM at different levels of scale-up, the cost of electricity produced by it in several scenarios, the life-cycle or total cost of ownership, and environmental and social impacts.

Task 8.1 Manufacturing Cost Model

The goal of this task is to develop a highly detailed and accurate model of manufacturing cost and throughput using software designed for modeling such.

The Recipient shall:

- Develop a comprehensive manufacturing specification of the mass-production version of the OHM.
- Develop a process flow architecture based on this specification that describes the layout and operation of a factory dedicated to producing the OHM.
- Collect cost data on the manufacturing inputs such as raw materials.
- Input this data into Wright Williams and Kelly's (WWK) cost modeling software and generate various analyses of cost and throughput.
- Generate estimates of cost as a function of manufacturing volume, by creating scenarios at different levels of throughput and automation.
- Based on the model, show production cost as a function of volume, the attribution of cost to the manufacturing inputs, and labor inputs.
- Produce Manufacturing Cost Model Report detailing the manufacturing cost model.

Products:

- Manufacturing Cost Model Report (No draft).

Task 8.2: Levelized Cost Model

The goal of this task is to estimate the Levelized Cost of Electricity (LCOE) for the production model of OHM given a range of climates and assumptions.

The Recipient shall:

- Develop an LCOE model, based on industry-standard formulae.
- Use as inputs to the LCOE model: the manufacturing cost model developed for the OHM (See Task 8.1); Performance characteristics of the OHM corresponding to those stipulated in the Quantitative Goals section of the

Project Narrative; and at least two sets of solar resource data based on at least three hypothetical sites – on in Northern California, one in the Central Valley, and one in the San Fernando Valley.
- Produce LCOE Report detailing LCOE analysis.

Products:
- Draft LCOE Report.
- Final LCOE Report.

Task 8.3: Total Cost of Ownership Model

The goal of this task is to develop a model to estimate the Total Cost of Ownership for energy (TCOe) for the production model of OHM given a range of climates and assumptions. Unlike LCOE, TCOe considers the avoided cost of grid electricity offset by a PV installation.

The Recipient shall:
- Develop an TCOe model, using software developed for such modeling
- Employ the same device performance and site resource data as in the LCOE model (See Task 8.2).
- Produce a hypothetical case study to show the comparative TCOe performance of the OHM, a SunPower module, a polycrystalline silicon module, and a thin-film module such as First Solar – installed on the same building.
- Produce TCOe Report detailing TCOe analysis.

Products:
- TCOe Report (No draft).

Task 8.4: Life Cycle Assessment

The goal of this task is to develop a model to develop a Life-Cycle Assessment (LCA) for the OHM, and a comparative analysis to the LCAs of other PV devices.

The Recipient shall:
- Develop a Life Cycle Inventory (LCI) of the OHM
- Perform a cradle-to-grave assessment, emphasizing material and energy inputs in relation to generated electricity, and including:
  - A quantified estimate of the OHM's life-cycle carbon intensity in greenhouse gas emissions.
  - An examination of scenarios for re-cycling and re-using the OHM's components and materials, and ownership models supporting such.
  - Parallel reference assessments of representative flat-plate products including polycrystalline silicon modules.

- Provide an analysis of the expected economic impact on California of the manufacture and deployment of the OHM at several different levels of production scale-up of the at several different levels of production scale-up, including:
  - Data on potential job creation, economic development, and increased state revenue.
  - Data on avoided costs compared to other renewable energy systems.
  - Produce LCA Report detailing LCA findings

Products:

- Draft LCA Report.
- Final LCA Report

TASK 9: PERFORMANCE DATA COLLECTION AND ANALYSIS

The goal of this task is to collect performance data from operating units, primarily the field-test units in the Technology Demonstration Testbed of Task 7, to analyze that data, to use it to support the analysis in Task 8, and to include the data and analysis in the Final Report.

The Recipient shall:

- Develop a plan to collect and organized performance data generated by the field-test units.
- Troubleshoot any issues identified.
- Collect at least 6 months of data from the Technology Demonstration Testbed, including but not limited to:
  - Power generation by each of the test units, sampled at intervals of less than 30 seconds.
  - Tracking history of each of the test units.
  - Weather and solar resource conditions sampled at intervals similar to those used for the units.
  - Internal temperature and humidity of test module enclosures.
- Provide data about the Testbed host building, including:
  - Any current and planned use of renewable energy at the facility.
  - Any energy efficiency measures used in the facility that may exceed Title 24 standards in Part 6 of the California Code Regulations.
  - A profile of the building's energy use and offsets provided by the Testbed.
- Compare module performance targets and benchmarks provided in the proposal to the CEC with actual performance measurements of the second-generation OHM in both laboratory and field tests.
- Compare performance characteristics of the second-generation OHM to the projected characteristics of the production model used for the analysis in Task 8.

- Produce Activity Summary Report detailing all activities conducted in this task.

Products:

- Draft Activity Summary Report.
- Final Activity Summary Report.

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) COMPLIANCE

Award Number: PIR-12-019 Date: 3 / 3 / 13

Note: The Energy Commission Project Managers Manual includes detailed instructions on how to complete this section, with examples of grants that are "Projects" and are not "Projects". When the Project Manager is completing this section, if questions arise as to the appropriate answers to the questions below, please consult with the Energy Commission attorney assigned to review grants or loans for your division.

1. Is grant/loan considered a "Project" under CEQA? ☒ Yes *(skip to question #2)* ☐ No *(continue with question #1)*

   Please complete the following: *[Public Resources Code (PRC) 21065 and 14 California Code of Regulations (CCR) 15378]:*

   Explain why the grant/loan is ***not*** considered a "Project"? The grant/loan will not cause a direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment because grant/loan involves:

2. If grant/loan is considered a "Project" under CEQA: *(choose either **IS** or **IS NOT**)*

   ☒ Grant/loan **IS** exempt:

   ☒ Statutory Exemption: *(List PRC and/or CCR section numbers)* PRC 21080(b)(1); 14 CCR 15268

   ☒ Categorical Exemption: *(List CCR section number)* 15306

   ☐ Common Sense Exemption. *(14 CCR 15061(b)(3))*

   Explain reason why the grant/loan is exempt under the above section:

   The work involves assembling several solar PV parts into a system, data collection, and life cycle analysis study. A small demonstration area (300 sq feet or less) will be installed on existing buildings. Ministerial permits are anticipated for this limited part of the project.

Please attach draft Notice of Exemption (NOE). Consult with the Energy Commission attorney assigned to your division for instructions on how to complete the NOE.

☐ Grant/loan **IS NOT** exempt. The Project Manager needs to consult with the Energy Commission attorney assigned to your division and the Siting Office regarding a possible initial study.