



**CALIFORNIA
ENERGY COMMISSION**



**California Energy Commission
August 09, 2023 Business Meeting
Backup Materials for Agenda Item No 10:
Antora Energy, Inc.**

The following backup materials for the above-referenced agenda item are available in this PDF packet as listed below:

1. Proposed Resolution
2. Grant Request Form
3. Scope of Work

STATE OF CALIFORNIA
STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION: Antora Energy, Inc.

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

RESOLVED, that the CEC approves agreement EPC-23-010 with Antora Energy, Inc. for a \$2,999,695 grant to expand their pilot-scale manufacturing line in Sunnyvale for thermophotovoltaic (TPV) cells that convert radiant heat into electricity. The novel TPV cells are combined with inexpensive thermal storage to create a cost-effective long-duration energy storage system capable of providing 200 hours of capacity. This project will develop and scale new TPV cell manufacturing techniques to reduce system costs; and

FURTHER BE IT RESOLVED, that the Executive Director or their designee shall execute the same on behalf of the CEC.

CERTIFICATION

The undersigned Secretariat to the CEC 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 CEC held on August 09, 2023.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

Kristine Banaag
Secretariat



GRANT REQUEST FORM (GRF)

A. New Agreement Number

IMPORTANT: New Agreement # to be completed by Contracts, Grants, and Loans Office.

New Agreement Number: EPC-23-010

B. Division Information

1. Division Name: ERDD
2. Agreement Manager: Anthony Ng
3. MS-:51
4. Phone Number: 916-445-5297

C. Recipient's Information

1. Recipient's Legal Name: Antora Energy, Inc.
2. Federal ID Number: 82-4788390

D. Title of Project

Title of project: Manufacturability of Low-Cost InGaAs Thermophotovoltaic Devices

E. Term and Amount

1. Start Date: 8/23/2023
2. End Date: 7/31/2026
3. Amount: \$2,999,695.00

F. Business Meeting Information

1. Are the ARFVTP agreements \$75K and under delegated to Executive Director? No
2. The Proposed Business Meeting Date: 8/9/2023 .
3. Consent or Discussion? Discussion
4. Business Meeting Presenter Name: Anthony Ng
5. Time Needed for Business Meeting: 5 minutes.
6. The email subscription topic is: EPIC (Electric Program Investment Charge).

Agenda Item Subject and Description:

Antora Energy, Inc. Proposed resolution approving agreement EPC-23-010 with Antora Energy, Inc. for a \$2,999,695 grant to expand their pilot-scale manufacturing line in Sunnyvale for thermophotovoltaic (TPV) cells that convert radiant heat into electricity, and adopting staff's determination that this action is exempt from CEQA. The novel TPV cells are combined with inexpensive thermal storage to create a cost-effective long-duration energy storage system capable of providing 200 hours of capacity. This project will develop and scale new TPV cell manufacturing techniques, to reduce system costs. (EPIC Funding) Contact: Anthony Ng (Staff Presentation: 5 minutes)



G. California Environmental Quality Act (CEQA) Compliance

1. Is Agreement considered a “Project” under CEQA?

Yes

If yes, skip to question 2.

If no, complete the following (PRC 21065 and 14 CCR 15378) and explain why Agreement is not considered a “Project”:

2. If Agreement is considered a “Project” under CEQA answer the following questions.

a) Agreement **IS** exempt?

Yes

Statutory Exemption?

No

If yes, list PRC and/or CCR section number(s) and separate each with a comma. If no, enter “None” and go to the next question.

PRC section number: None

CCR section number: None

Categorical Exemption?

Yes

If yes, list CCR section number(s) and separate each with a comma. If no, enter “None” and go to the next question.

CCR section number: Cal. Code Regs., tit. 14, § 15301 ;

Common Sense Exemption? 14 CCR 15061 (b) (3)

No

If yes, explain reason why Agreement is exempt under the above section. If no, enter “Not applicable” and go to the next section.

The project is exempt under Cal. Code Regs., tit. 14, § 15301 because proposed project activities consist of laboratory work, modeling, design, testing, and other activities that consist of the operation and minor alteration of existing laboratory and manufacturing facilities and existing mechanical equipment already occupied and utilized by the project team and will involve negligible or no expansion of existing or former use. These activities will occur at three existing laboratory and manufacturing facilities.

b) Agreement **IS NOT** exempt.

IMPORTANT: consult with the legal office to determine next steps.

No



If yes, answer yes or no to all that applies. If no, list all as “no” and “None” as “yes”.

Additional Documents	Applies
Initial Study	No
Negative Declaration	No
Mitigated Negative Declaration	No
Environmental Impact Report	No
Statement of Overriding Considerations	No
None	Yes

H. Subcontractors

List all Subcontractors listed in the Budget (s) (major and minor). Insert additional rows if needed. If no subcontractors to report, enter “No subcontractors to report” and “0” to funds. **Delete** any unused rows from the table.

Subcontractor Legal Company Name	CEC Funds	Match Funds
No subcontractors to report	\$	\$

I. Vendors and Sellers for Equipment and Materials/Miscellaneous

List all Vendors and Sellers listed in Budget(s) for Equipment and Materials/Miscellaneous. Insert additional rows if needed. If no vendors or sellers to report, enter “No vendors or sellers to report” and “0” to funds. **Delete** any unused rows from the table.

Vendor/Seller Legal Company Name	CEC Funds	Match Funds
AXT, Inc.	\$300,000	\$0
Sumitomo Electric U.S.A., Inc.	\$300,000	\$0
Celestica LLC	\$45,000	\$0
Micro Dicing Services, LLC	\$32,000	\$0
Covalent Metrology Services Inc.	\$25,000	\$0
Hastest Solutions, Inc.	\$25,000	\$0
Eurofins EAG Material Science LLC	\$10,000	\$0
Microlink Devices, Inc.	\$0	\$70,000
TBD	\$170,000	\$235,000

J. Key Partners



List all key partner(s). Insert additional rows if needed. If no key partners to report, enter “No key partners to report.” **Delete** any unused rows from the table.

Key Partner Legal Company Name
No key partners to report

K. Budget Information

Include all budget information. Insert additional rows if needed. If no budget information to report, enter “N/A” for “Not Applicable” and “0” to Amount. **Delete** any unused rows from the table.

Funding Source	Funding Year of Appropriation	Budget List Number	Amount
EPIC	21-22	301.001I	\$ 2,999,695

TOTAL Amount: \$2,999,695

R&D Program Area: EDMFB: EDMF

Explanation for “Other” selection Not applicable

Reimbursement Contract #: Not applicable

Federal Agreement #: Not applicable



L. Recipient’s Contact Information

1. Recipient’s Administrator/Officer

Name: Leah Kirkland
Address: 1244 Reamwood Ave
City, State, Zip: Sunnyvale, CA 94089-2225
Phone: 919-414-0521
E-Mail: Leah.Kirkland@Antora.Energy

3. Recipient’s Project Manager

Name: Haley Gilbert
Address: 4385 Sedge St
City, State, Zip: Fremont, CA 94555-1159
Phone: 510-984-4866
E-Mail: Haley@Antora.Energy

M. Selection Process Used

There are three types of selection process. List the one used for this GRF.

Selection Process	Additional Information
Competitive Solicitation #	Not applicable
First Come First Served Solicitation #	Not applicable
Other	Follow-on funding

N. Attached Items

1. List all items that should be attached to this GRF by entering “Yes” or “No”.

Item Number	Item Name	Attached
1	Exhibit A, Scope of Work/Schedule	Yes
2	Exhibit B, Budget Detail	Yes
3	CEC 105, Questionnaire for Identifying Conflicts	Yes
4	Recipient Resolution	No
5	Awardee CEQA Documentation	No



STATE OF CALIFORNIA
CALIFORNIA ENERGY COMMISSION

Grant Request Form
CEC-270 (Revised 9/2022)

Approved By

Individuals who approve this form must enter their full name and approval date in the MS Word version.

Agreement Manager: Anthony Ng

Approval Date: Agreement Manager's Approval Date

Branch Manager: Anthony Ng

Approval Date: Office Manager's Approval Date

Director: Deputy Director Name

Approval Date: Deputy Director's Approval Date

**Exhibit A
Scope of Work Template
Antora Energy, Inc.**

I. TASK ACRONYM/TERM LISTS

A. Task List

Task #	CPR ¹	Task Name
1		General Project Tasks
2	X	Thermophotovoltaic Cell Process from 6-inch InP with ELO
3		Thermophotovoltaic Module Process Development
4		Demonstrate Reliability of Thermophotovoltaics
5		Evaluation of Project Benefits
6		Technology/Knowledge Transfer Activities

B. Acronym/Term List

Acronym/Term	Meaning
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CEC	California Energy Commission
CPR	Critical Project Review
ELO	Epitaxial Lift-off
FMEA	Failure Mode and Effects Analysis
IOU	Investor-owned utility
Recipient	Antora Energy, Inc.
TAC	Technical Advisory Committee
TPV	Thermophotovoltaic

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

A. Purpose of Agreement

The purpose of this Agreement is to fund the demonstration of the following key de-risking steps towards manufacturable low-cost indium gallium arsenide (InGaAs) thermophotovoltaics (TPVs): demonstrate reproducible epitaxial liftoff (ELO) of high-yield InGaAs TPV devices, and scale the process to 6" wafers; demonstrate a scalable process flow for module assembly consistent with future high-volume manufacturing; and prove the reliability of the TPV cells and modules manufactured using these techniques.

B. Problem/ Solution Statement

Problem

The industrial sector depends on reliable heat and power around the clock, and fossil fuels are the only option capable of providing this cost-effectively today. The result: Manufacturing is the

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

Exhibit A

Scope of Work Template

Antora Energy, Inc.

largest greenhouse gas source on the planet, at >30% of global emissions. The rapid growth of inexpensive wind & solar has created the unprecedented opportunity to replace this fossil energy with clean power. But renewables are being held back by intermittency. Recipient's technology solves this problem by turning variable wind and solar electricity into reliable, on-demand heat and power for industry. Recipient has nearly completed work on a pilot demonstration of a proposed long duration thermal storage battery. Recipient's "thermal battery" is charged with electricity and discharges both electricity and heat. At the core of this system is a thermophotovoltaic (TPV) engine that converts stored heat into electricity.

Recipient's thermal battery is composed of low-cost, commercial-off-the-shelf components—except for the TPV cell, which is manufactured using an expensive indium phosphide (InP) semiconductor substrate that dominates the overall system cost. A shift to low-cost TPV production is needed to achieve widespread commercial success and gigaton-scale impact. The 6" ELO development proposed here is a key piece of that cost reduction. Recipient has also developed a power-dense module architecture and will need to develop the wafer-scale manufacturing process that will enable building modules at scale.

Solution

Recipient team members are among the most experienced ELO photovoltaics researchers in the world and have been key players in commercializing ELO in solar photovoltaics over the last decade. Therefore, we have a keen interest to transfer this manufacturing approach to Recipient's TPV development to drive down costs. Scaling up this manufacturing method for Recipient opens up the possibility for the expensive InP substrate to be re-used multiple times, amortizing its cost, and dramatically lowering overall production cost. Just recently, our team successfully demonstrated this technique for Recipient's TPV at the bench-scale. In addition to this, we have begun engaging with substrate vendors regarding 6" InP, and have learned that 6" InP is now available from multiple suppliers. Scaling our 4" process up to 6" will further improve the economics of manufacturing by allowing for twice as many devices to be fabricated per wafer (with most of the production steps limited by throughput-per-wafer rather than throughput-per-device). Our ultimate goal is to make large-area TPV modules, and therefore to further accelerate the development of TPV we propose here to bring many of the module fabrication capabilities that we currently outsource into our facility in Sunnyvale.

In summary, this project will de-risk the technical challenges to ELO TPV manufacturing on 6" substrates and demonstrate a fabrication capability from epiwafers through finished modules. Removing the technical risk from these processes will unlock the investment we need for full commercial-scale production. This in turn will enable the rapid decarbonization of industry—including unlocking >70 GW of zero-emissions industrial power in the US and eliminating over a gigaton/year of CO₂ emissions in the US alone.

C. Goals and Objectives of the Agreement

Agreement Goals

The goals of this Agreement are to:

- Demonstrate ELO of high-yield InGaAs TPV devices from 6" wafers.
- Demonstrate a scalable process flow for module assembly consistent with future high-volume manufacturing. Purchase and install the toolset for running that process, in California.
- Prove the reliability of the TPV cells and modules manufactured using these techniques.

Exhibit A Scope of Work Template Antora Energy, Inc.

- Update our technoeconomic models with learnings gained regarding cost, yield, & performance.

Ratepayer Benefits:² This Agreement will result in a reduction in the cost of Recipient's heat-to-electricity conversion, and therefore a reduction in cost for our thermal batteries. This will result in lower costs to ratepayers because our thermal battery reduces the need for expensive gas peaker plants. California investor-owned utility (IOU) ratepayers will also benefit from improved air quality due to the elimination of harmful emissions from diesel generators currently used to provide power during grid outages. Deployment of our TPV-enabled, ultra-low-cost energy storage products will also improve infrastructure resiliency, reduce peak loads, and ultimately help the state reach its goal of 100% carbon-free electricity by 2045.

In addition to ultra-low-cost energy storage, Recipient's TPV heat engine also enables a suite of other energy applications that will benefit California ratepayers and help the state reach its aggressive statutory energy goals. While Recipient's TPV engine was developed to enable low-cost electrical energy storage, and this remains our primary mission, substantial interest from other firms in the energy and industrial sectors has opened new possibilities for the rapid commercialization of standalone TPV converters. The major missing elements in the widespread deployment of our technology are the high costs and limited production capacity of our high-efficiency TPV cells.

Technological Advancement and Breakthroughs:³ California has established an ambitious goal of relying entirely on zero-emission energy sources for its electricity by the year 2045. To do this, many experts believe that long-duration energy storage is a necessary, and currently missing, piece of the energy puzzle. Recipient has developed a new type of solid-state heat engine that unlocks multiple renewable energy applications critical to achieving a reliable, inexpensive, and zero-carbon energy system in California. Recipient's TPV heat engine—which operates like a solar photovoltaic panel and converts heat radiated from any high-temperature source directly into electricity—is high-efficiency, solid-state, and has the potential to be low-cost. Recipient has leveraged funding from the US Department of Energy, National Science Foundation, and private investors, as well as partnerships with National Renewable Energy Laboratory, Lawrence Berkeley Laboratory, and University of California Santa Barbara, to develop a prototype TPV converter with higher efficiency than any other type of solid-state heat engine in existence. This has led to initial sales and further customer inquiries from multiple sectors, but our high costs continue to limit our ability to efficiently deliver products to these customers. Now, in order to meet the cost requirements of our customers, we propose to develop ELO as a low-cost approach to scaling up our TPV manufacturing.

Agreement Objectives

The objectives of this Agreement are to:

- Demonstrate ELO of InGaAs TPV devices from 6" wafers, with >80% ELO success and device yield no lower than for a non-ELO control, for a population of at least 20 wafers.

² 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).

Exhibit A
Scope of Work Template
Antora Energy, Inc.

- Demonstrate a scalable process for module assembly consistent with future high-volume manufacturing.
- Purchase and install the toolset for running the module assembly process at our facility in California.
- Develop cell and module reliability test plans based on Failure Mode and Effects Analysis (FMEA). Order and install reliability test equipment. Execute the reliability test plans, proving that our TPV is consistent with >10 years of operation.
- Update our technoeconomic models with learnings gained regarding cost, yield, & performance.

Exhibit A

Scope of Work Template

Antora Energy, Inc.

III. TASK 1 GENERAL PROJECT TASKS

PRODUCTS

Subtask 1.1 Products

The goal of this subtask is to establish the requirements for submitting project products (e.g., reports, summaries, plans, and presentation materials). Unless otherwise specified by the Commission Agreement Manager (CAM), the Recipient must deliver products as required below by the dates listed in the **Project Schedule (Part V)**. All products submitted which will be viewed by the public, must comply with the accessibility requirements of Section 508 of the federal Rehabilitation Act of 1973, as amended (29 U.S.C. Sec. 794d), and regulations implementing that act as set forth in Part 1194 of Title 36 of the Federal Code of Regulations. All technical tasks should include product(s). Products that require a draft version are indicated by marking “**(draft and final)**” after the product name in the “Products” section of the task/subtask. If “(draft and final)” does not appear after the product name, only a final version of the product is required. With respect to due dates within this Scope of Work, “**days**” means working days.

The Recipient shall:

For products that require a draft version, including the Final Report Outline and Final Report

- 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.
- Consider incorporating all CAM comments into the final product. If the Recipient disagrees with any comment, provide a written response explaining why the comment was not incorporated into the final product.
- Submit the revised product and responses to comments within 10 days of notice by the CAM, unless the CAM specifies a longer time period, or approves a request for additional time.

For products that require a final version only

- Submit the product to the CAM for acceptance. The CAM may request minor revisions or explanations prior to acceptance.

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 California Energy Commission’s (CEC) 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.

Exhibit A Scope of Work Template Antora Energy, Inc.

The following describes the accepted formats for electronic data and documents provided to the CEC 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.
 - Project management documents will be in Microsoft Project file format, version 2007 or later.
- **Software Application Development**
Use the following standard Application Architecture components in compatible versions for any software application development required by this Agreement (e.g., databases, models, modeling tools), unless the CAM approves other software applications such as open source programs:
- Microsoft ASP.NET framework (version 3.5 and up). Recommend 4.0.
 - Microsoft Internet Information Services (IIS), (version 6 and up) Recommend 7.5.
 - Visual Studio.NET (version 2008 and up). Recommend 2010.
 - C# Programming Language with Presentation (UI), Business Object and Data Layers.
 - SQL (Structured Query Language).
 - Microsoft SQL Server 2008, Stored Procedures. Recommend 2008 R2.
 - Microsoft SQL Reporting Services. Recommend 2008 R2.
 - XML (external interfaces).

Any exceptions to the Electronic File Format requirements above must be approved in writing by the CAM. The CAM will consult with the CEC'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 CEC 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;
- Invoicing and auditing procedures;
- Administrative products (subtask 1.1);
- CPR meetings (subtask 1.3);
- Match fund documentation (subtask 1.7);

Exhibit A Scope of Work Template Antora Energy, Inc.

- 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 (subtask 1.5);
 - Final Report (subtask 1.6);
 - Technical Advisory Committee meetings (subtasks 1.10 and 1.11); and
 - Any other relevant topics.
- Provide *Kick-off Meeting Presentation* to include but not limited to:
 - Project overview (i.e. project description, goals and objectives, technical tasks, expected benefits, etc.)
 - Project schedule that identifies milestones
 - List of potential risk factors and hurdles, and mitigation strategy
 - Provide an *Updated Project Schedule, Match Funds Status Letter, and Permit Status Letter*, 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:

- Kick-off Meeting Presentation
- Updated Project Schedule (*if applicable*)
- Match Funds Status Letter (subtask 1.7) (*if applicable*)
- Permit Status Letter (subtask 1.8) (*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 CEC 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 CEC 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 CEC.

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.

Exhibit A Scope of Work Template Antora Energy, Inc.

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

The CAM shall:

- Determine the location, date, and time of each CPR meeting with the Recipient's input.
- Send the Recipient a *CPR Agenda* with 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)

CAM Products:

- CPR Agenda(s)
- 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 CEC 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.

Exhibit A Scope of Work Template Antora Energy, Inc.

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 procured equipment.
 - The CEC's request for specific "generated" data (not already provided in Agreement products).
 - Need to document the Recipient's disclosure of "subject inventions" developed under the Agreement.
 - "Surviving" Agreement provisions such as repayment provisions and confidential products.
 - Final invoicing and release of retention.
- Prepare a *Final Meeting Agreement Summary* that documents any agreement made between the Recipient and Commission staff during the meeting.
- Prepare a *Schedule for Completing Agreement Closeout Activities*.
- Provide copies of *All Final Products* on a USB memory stick, organized by the tasks in the Agreement.

Products:

- Final Meeting Agreement Summary (*if applicable*)
- Schedule for Completing Agreement Closeout Activities
- All Final 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 progress made on all Agreement activities as specified in the scope of work for the preceding month, including accomplishments, problems, milestones, products, schedule, fiscal status, and 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.
- Submit a monthly or quarterly *Invoice* that follows the instructions in the "Payment of Funds" section of the terms and conditions, including a financial report on Match Funds and in-state expenditures.

Products:

- Progress Reports
- Invoices

Exhibit A

Scope of Work Template

Antora Energy, Inc.

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.

When creating the Final Report Outline and the Final Report, the Recipient must use the CEC 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 *Energy Commission Style Manual* provided by the CAM.

Recipient Products:

- Final Report Outline (draft and final)

CAM Product:

- Energy Commission Style Manual
- Comments on Draft Final Report Outline
- Acceptance of Final Report Outline

Subtask 1.6.2 Final Report

The Recipient shall:

- Prepare a *Final Report* for this Agreement in accordance with the approved Final Report Outline, Energy Commission Style Manual, and Final Report Template provided by the CAM with the following considerations:
 - Ensure that the report includes the following items, in the following order:
 - Cover page (**required**)
 - Credits page on the reverse side of cover with legal disclaimer (**required**)
 - Acknowledgements page (optional)
 - Preface (**required**)
 - Abstract, keywords, and citation page (**required**)
 - Table of Contents (**required**, followed by List of Figures and List of Tables, if needed)
 - Executive summary (**required**)
 - Body of the report (**required**)
 - References (if applicable)
 - Glossary/Acronyms (If more than 10 acronyms or abbreviations are used, it is required.)
 - Bibliography (if applicable)
 - Appendices (if applicable) (Create a separate volume if very large.)
 - Attachments (if applicable)
- Submit a draft of the Executive Summary to the TAC for review and comment.
- Develop and submit a *Summary of TAC Comments on Draft Final Report* received on the Executive Summary. For each comment received, the recipient will identify in the summary the following:
 - Comments the recipient proposes to incorporate.
 - Comments the recipient does propose to incorporate and an explanation for why.

Exhibit A Scope of Work Template Antora Energy, Inc.

- Submit a draft of the report to the CAM for review and comment. The CAM will provide written comments to the Recipient on the draft product within 15 days of receipt.
- Incorporate all CAM comments into the *Final Report*. If the Recipient disagrees with any comment, provide a *Written Responses to Comments* explaining why the comments were not incorporated into the final product.
- Submit the revised *Final Report* electronically with any Written Responses to Comments within 10 days of receipt of CAM's Written Comments on the Draft Final Report, unless the CAM specifies a longer time period or approves a request for additional time.

Products:

- Summary of TAC Comments on Draft Final Report
- Draft Final Report
- Written Responses to Comments (*if applicable*)
- Final Report

CAM Product:

- Written Comments on the Draft Final Report

MATCH FUNDS, PERMITS, AND SUBCONTRACTS

Subtask 1.7 Match Funds

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

While the costs to obtain and document match funds are not reimbursable under this 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 CEC funds. Match funds must be identified in writing, and the Recipient must obtain any associated commitments before incurring any costs for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a *Match Funds Status Letter* that documents the match funds committed to this Agreement. If no match funds were part of the proposal that led to the CEC 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 CEC 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.

Exhibit A Scope of Work Template Antora Energy, Inc.

- If different from the solicitation application, provide 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:
 - 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*)

Exhibit A Scope of Work Template Antora Energy, Inc.

- 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 each 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, 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.
- Help set the project team's goals and contribute to the development and evaluation of its statement of proposed objectives as the project evolves.
- Provide a credible and objective sounding board on the wide range of technical and financial barriers and opportunities.

Exhibit A

Scope of Work Template

Antora Energy, Inc.

- Help identify key areas where the project has a competitive advantage, value proposition, or strength upon which to build.
- Advocate, to the extent the TAC members feel is appropriate, on behalf of the project in its effort to build partnerships, governmental support, and relationships with a national spectrum of influential leaders.
- Ask probing questions that insure a long-term perspective on decision-making and progress toward the project's strategic goals.

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 Template

Antora Energy, Inc.

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.

The TAC shall:

- Help set the project team's goals and contribute to the development and evaluation of its statement of proposed objectives as the project evolves.
- Provide a credible and objective sounding board on the wide range of technical and financial barriers and opportunities.
- Help identify key areas where the project has a competitive advantage, value proposition, or strength upon which to build.
- Advocate on behalf of the project in its effort to build partnerships, governmental support and relationships with a national spectrum of influential leaders.
- Ask probing questions that insure a long-term perspective on decision-making and progress toward the project's strategic goals.
- Review and provide comments to proposed project performance metrics.
- Review and provide comments to proposed project Draft Technology Transfer Plan.

Products:

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

Subtask 1.12 Project Performance Metrics

The goal of this subtask is to finalize key performance targets for the project based on feedback from the TAC and report on final results in achieving those targets. The performance targets should be a combination of scientific, engineering, techno-economic, and/or programmatic metrics that provide the most significant indicator of the research or technology's potential success.

The Recipient shall:

- Complete and submit the project performance metrics from the *Initial Project Benefits Questionnaire*, developed in the Evaluation of Project Benefits task, to the CAM.
- Present the draft project performance metrics at the first TAC meeting to solicit input and comments from the TAC members.

Exhibit A
Scope of Work Template
Antora Energy, Inc.

- Develop and submit a *TAC Performance Metrics Summary* that summarizes comments received from the TAC members on the proposed project performance metrics. The *TAC Performance Metrics Summary* will identify:
 - TAC comments the Recipient proposes to incorporate into the *Initial Project Benefits Questionnaire*, developed in the Evaluation of Project Benefits task.
 - TAC comments the Recipient does not propose to incorporate with and explanation why.
- Develop and submit a *Project Performance Metrics Results* document describing the extent to which the Recipient met each of the performance metrics in the *Final Project Benefits Questionnaire*, developed in the Evaluation of Project Benefits task.
- Discuss the *Project Performance Metrics Results* at the Final Meeting.

Products:

- TAC Performance Metrics Summary
- Project Performance Metrics Results

Exhibit A
Scope of Work Template
Antora Energy, Inc.

IV. TECHNICAL TASKS

TASK 2 THERMOPHOTOVOLTAIC CELL PROCESS FROM 6-INCH INDIUM PHOSPHIDE WITH EPITAXIAL LIFTOFF

The goals of this task are to demonstrate the feasibility of ELO on 6-inch substrates, and to use this process to fabricate TPV cells to supply the module production and reliability tasks. This will de-risk 6" InP ELO for future manufacturing scaling, both from a technical and a supply chain perspective.

The Recipient shall:

- Down select best-known ELO epitaxial designs & processes from previous successful results.
- Map 6-inch InP wafer supply chain. Negotiate 6-inch InP project supply agreement(s). Place substrate orders.
- Demonstrate manufacturable 4-inch InP ELO.
- Transfer epitaxial design from 4-inch to 6-inch InP with comparable uniformity (for example, in terms of photoluminescence and haze).
- Demonstrate manufacturable 6-inch InP ELO with supply chain including multiple epitaxy reactors.
- Process 6-inch InP epitaxy into TPV cells.
- Fabricate at least 15 kW of TPV cells, for use in module process development and cell reliability tests.
- Update TPV technoeconomic models with learnings on 6-inch InP & ELO cost, yield, & performance.
- Prepare a *Cell Manufacturing Process Plan* which includes but is not limited to:
 - Plan of attack for substrate purchasing, ELO development, 4-inch to 6-inch transition, and cell fabrication and test.
 - Contingency plans if technical barriers are encountered.
- Prepare a draft *Cell Manufacturing Process Report* which includes but is not limited to:
 - Process development and results, including ELO and a transition from 4-inch to 6-inch substrates.
 - Description of the TPV cell fabrication process.
 - Discussion of how the TPV cells were characterized.
 - Details of performance and yield of the TPV cells.
 - Technical issues, and lessons learned.
 - Updates to TPV technoeconomic models with learnings on 6-inch InP & ELO cost, yield, & performance.
- Submit the draft *Cell Manufacturing Process Report* to the CAM for feedback and incorporate changes as requested in the final *Cell Manufacturing Process Report*.
- Prepare a *CPR Report* in accordance with subtask 1.3 (CPR Meetings).
- Participate in a CPR meeting.

Products:

- TPV cell manufacturing process plan
- TPV cell manufacturing process report (draft & final)
- CPR Report

Exhibit A
Scope of Work Template
Antora Energy, Inc.

TASK 3 THERMOPHOTOVOLTAIC MODULE PROCESS DEVELOPMENT

The goals of this task are to down select the module architecture, module assembly process, and toolset that will be localized at our facility in California, and then use these to fabricate 5 kW of TPV modules for use in reliability studies.

The Recipient shall:

- Down-select architecture & processes for 500W module design.
- Order module production equipment.
- Install & commission module assembly tools.
- Fabricate 5 kW of TPV modules for use in reliability studies.
- Create a *TPV Module Assembly Toolset Plan*, detailing:
 - Discussion of the proposed module architecture and process flow, how these were chosen given other possibilities, and any challenges arising from these choices when considering the toolset required for module assembly.
 - Discussion of the intended module assembly toolset and facility, and why these are appropriate given the goals.
 - Any lessons learned during these activities.
- Prepare a draft *TPV Module Assembly Toolset Report*, which includes but is not limited to:
 - Description of the TPV module assembly process.
 - Detailed discussion of the module assembly toolset and vendors that were selected, and why.
 - Discussion of how the TPV modules were characterized.
 - Details of performance and yield of the TPV modules.
 - Technical issues, and lessons learned.
- Submit the draft *TPV Module Assembly Toolset Report* to the CAM for feedback, and incorporate changes as requested in the final *TPV Module Assembly Toolset Report*.

Products:

- TPV Module Assembly Toolset Plan
- TPV Module Assembly Toolset Report (draft & final)

TASK 4 DEMONSTRATE RELIABILITY OF THERMOPHOTOVOLTAICS

The goal of this task is to demonstrate that Recipient's TPV products (including cells and modules) have reliability consistent with > 10 years in operation.

The Recipient shall:

- Develop cell reliability test plan based on FMEA.
- Order and install reliability test equipment.
- Execute preliminary cell reliability test plan on cells from 4-inch wafers.
- Develop module reliability test plan based on module FMEA.
- Execute cell and module reliability test plans.
- Create a *TPV Cell Reliability Test Plan*, detailing:
 - The cell reliability test plan that was developed, based on FMEA.
 - Discussion of the intended cell reliability test toolset and facility, and discussion of why they are suitable.

Exhibit A Scope of Work Template Antora Energy, Inc.

- Create a *TPV Module Reliability Test Plan*, detailing:
 - The module reliability test plan that was developed, based on FMEA.
 - Discussion of the intended module reliability test toolset and facility, and discussion of why they are suitable.
- Prepare a draft *TPV Cell and Module Reliability Test Report*, which includes but is not limited to:
 - Discussion of the results of the reliability testing, and what they imply about our TPV product lifetime.
 - Discussion of the methodology followed, and any deviations between the final methodology and the initial methodology (as outlined in the plan).
 - Any technical issues that arose and how they were surmounted.
 - Lessons learned during this phase of the project.
- Submit the draft *TPV Cell and Module Reliability Test Report* to the CAM for feedback, and incorporate changes as requested in the final *TPV Cell and Module Reliability Test Report*.

Products:

- TPV Cell Reliability Test Plan
- TPV Module Reliability Test Plan
- TPV Cell and Module Reliability Test Report (draft & final)

TASK 5 EVALUATION OF PROJECT BENEFITS

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

The Recipient shall:

- Complete the *Initial Project Benefits Questionnaire*. The Initial Project Benefits Questionnaire shall be initially completed by the Recipient with 'Kick-off' selected for the 'Relevant data collection period' and submitted to the CAM for review and approval.
- Complete the *Annual Survey* when received from CEC each year. The Annual Survey includes but is not limited to the following information:
 - Technology commercialization progress
 - New media and publications
 - Company growth
 - Follow-on funding and awards received
- Complete the *Final Project Benefits Questionnaire*. The Final Project Benefits Questionnaire shall be completed by the Recipient with 'Final' selected for the 'Relevant data collection period' and submitted to the CAM for review and approval.
- Respond to CAM questions regarding the questionnaire drafts.
- Complete and update the project profile on the CEC's public online project and recipient directory on the [Energize Innovation website \(www.energizeinnovation.fund\)](http://www.energizeinnovation.fund), and provide *Documentation of Project Profile on EnergizeInnovation.fund*, including the profile link.
- If the Prime Recipient is an Innovation Partner on the project, complete and update the organizational profile on the CEC's public online project and recipient directory on the [Energize Innovation website \(www.energizeinnovation.fund\)](http://www.energizeinnovation.fund), and provide *Documentation of Organization Profile on EnergizeInnovation.fund*, including the profile link.

Exhibit A Scope of Work Template Antora Energy, Inc.

Products:

- Initial Project Benefits Questionnaire
- Annual Survey(s)
- Final Project Benefits Questionnaire
- Documentation of Project Profile on EnergizeInnovation.fund
- Documentation of Organization Profile on EnergizeInnovation.fund

TASK 6 TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES

The goal of this task is to ensure the learning that resulted from this project is captured and disseminated so that similar efforts build on the lessons learned.

The Recipient shall:

- Develop and submit a *Project Case Study Plan* that outlines how the Recipient will document the planning, establishment, and operation of the project. The *Project Case Study Plan* should include:
 - An outline of the objectives, goals, and activities of the case study.
 - The organization that will be conducting the case study and the plan for conducting it.
 - A list of professions and practitioners involved in the project's development.
 - Specific activities the recipient will take to ensure the learning that results from the project is disseminated to those professions and practitioners.
 - Presentations/webinars/training events to disseminate the results of the case study.
- Present the Draft Project Case Study Plan to the TAC for review and comment.
- Develop and submit a *Summary of TAC Comments* that summarizes comments received from the TAC members on the draft *Project Case Study Plan*. This document will identify:
 - TAC comments the recipient proposes to incorporate into the *Final Technology Transfer Plan*.
 - TAC comments the recipient does not propose to incorporate and explanation why.
- Submit the final *Project Case Study Plan* to the CAM for approval.
- Execute the final *Project Case Study Plan* and develop and submit a *Project Case Study (draft and final)*
- When directed by the CAM, develop presentation materials for a CEC sponsored conference/workshop(s) on the project.
- When directed by the CAM, participate in annual EPIC symposium(s) sponsored by the CEC.
- Provide at least (6) six High Quality Digital Photographs (minimum resolution of 1300x500 pixels in landscape ratio) of pre and post technology installation at the project sites or related project photographs.

Products:

- Project Case Study Plan (draft and final)
- Summary of TAC Comments
- Project Case Study (draft and final)
- High Quality Digital Photographs

Exhibit A
Scope of Work Template
Antora Energy, Inc.

V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.