California Energy Commission
July 10, 2024 Business Meeting
Backup Materials for Swift Solar 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

[PROPOSED]

RESOLUTION NO: 24-0710-13a

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION: Swift Solar 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-24-001 with Swift Solar Inc. for a $2,999,880 grant. This agreement will fund the design and build-out of an LRIP line to manufacture high-performance perovskite-silicon tandem photovoltaic (PV) modules, including testing for efficiency and reliability in multiple applications, at a research and development site in the San Francisco Bay Area; 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 July 10, 2024.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

_____
Kristine Banaag
Secretariat

STATE OF CALIFORNIA
CALIFORNIA ENERGY COMMISSION

CEC-270 (Revised 01/2024)

GRANT REQUEST FORM (GRF)

A. New Agreement Number

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

New Agreement Number: EPC-24-001

B. Division Information

1. Division Name: ERDD
2. Agreement Manager: Michael Ferreira
3. MS-:51
4. Phone Number: 510-364-8808

C. Recipient's Information

1. Recipient's Legal Name: Swift Solar Inc.
2. Federal ID Number: 82-3547302

D. Title of Project

Title of project: Scaling Solar Cell to Module Conversion for High Efficiency Perovskite Tandems

E. Term and Amount

1. Start Date: 8/1/2024
2. End Date: 3/31/2029
3. Amount: $2,999,880.00

F. Business Meeting Information

1. Are the ARFVTP agreements $75K and under delegated to Executive Director? No
2. The Proposed Business Meeting Date: 7/10/2024 .
3. Consent or Discussion? Discussion
4. Business Meeting Presenter Name: Benson Gilbert
5. Time Needed for Business Meeting: 10 minutes.
6. The email subscription topic is: EPIC (Electric Program Investment Charge).

Agenda Item Subject and Description:

Swift Solar Inc. Proposed resolution approving agreement EPC-24-001 with Swift Solar Inc. for a $2,999,880 grant, and adopting staff's determination that this action is exempt from CEQA. This agreement will fund the design and build-out of an LRIP line to manufacture high-performance perovskite-silicon tandem photovoltaic (PV) modules, including testing for efficiency and reliability in multiple applications, at a research and development site in the San Francisco Bay Area (EPIC Funding) Contact: Michael Ferreira.

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":

Agreement will not cause direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment because:

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.

Cal. Code Regs., tit. 14, sect. 15301 provides that projects which consist of the operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, and which involve negligible or no expansion of existing or former use at the time of the lead agency's determination, are categorically exempt from the provisions of the California Environmental Quality Act (CEQA). Work under this proposed project will include paper studies for cost modeling of the manufacturing line, laboratory research and development of perovskite solar cells, including materials and processing and characterization, planning and implementing testing methods and design of perovskite modules for vehicle integration and rooftop deployment. This project will include the installation of approximately 2,000 square-feet of new equipment, to establish the cell-to-module manufacturing line. The new equipment to be installed which does not include pathways, service access, material positioning and movement, and support functions. The paper studies, laboratory research and installation of equipment will all be located at an existing, approximately 10,000 square-foot building in an industrial area located in the San Francisco Bay Area. Minor interior modifications, such as minor electrical work, may be required to accommodate new equipment installations and operation. The modules produced on the LRIP line will be tested in open rack (modules mounted on racking typical of rooftop application) and vehicle-integrated applications. For the vehicle-integrated application, testing will be conducted with approximately 1-2 existing vehicles.

Testing will involve limited driving in recipient's parking lot and possibly local streets to measure solar output at different orientations. For open rack application, testing will be conducted at contract and partner environmental weathering sites located in various climate zones. This project will result in negligible or no expansion of use beyond that already existing. Therefore, the project falls within section 15301 and will not have a significant effect on the environment.

The project does not involve impacts on any particularly sensitive environment; will not impact an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies; does not involve any cumulative impacts of successive projects of the same type in the same place that might be considered significant; does not involve unusual circumstances that might have a significant effect on the environment; will not result in damage to scenic resources within a highway officially designated as a state scenic highway; the project site is not included on any list compiled pursuant to Government Code section 65962.5; and the project will not cause a substantial adverse change in the significance of a historical resource. Therefore, none of the exceptions to categorical exemptions listed in CEQA Guidelines section 15300.2 apply to this project, and this project will not have a significant effect on the environment.

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. Is this project considered "Infrastructure"?

No

I. 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	$ 0	**$** 0

J. 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
No vendors to report	**$**	**$**

K. 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

L. 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	22-23	301.001J	$ 2,999,880

TOTAL Amount: $ 2,999,880

R&D Program Area: ESB: Renewables

Explanation for "Other" selection Not applicable

Reimbursement Contract #: Not applicable

Federal Agreement #: Not applicable

M. Recipient's Contact Information

1. Recipient's Administrator/Officer

Name: Julie Linton

Address: 981 Bing St

City, State, Zip: San Carlos, CA 94070-5321

Phone: 801-870-3818

E-Mail: julie.linton@swiftsolar.com

3. Recipient's Project Manager

Name: Joel Jean

Address: 981 Bing St

City, State, Zip: San Carlos, CA 94070-5321

Phone: 650-297-7943

E-Mail: joel@swiftsolar.com

N. Selection Process Used

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

Selection Process	Additional Information
Competitive Solicitation #	GFO-21-304R2
First Come First Served Solicitation #	Not applicable
Other	Not applicable

O. 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	Yes
5	Awardee CEQA Documentation	Yes

Approved By

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

Agreement Manager: Michael Ferreira

Approval Date: 4/18/2024

Branch Manager: Anthony Ng

Approval Date: 5/13/2024

Director: Delegated to Branch Manager

Approval Date: 5/13/2024

Exhibit A
Scope of Work
Swift Solar Inc.

I. TASK ACRONYM/TERM LISTS

A. Task List

Task #	CPR[1]	Task Name
1		General Project Tasks
2		Equipment Specification and Integration Planning
3		Equipment Ordering
4		Site Selection and Facilitation
5	X	Equipment Installation and Process Qualification
6		Secure Material Supply Chain
7		Module Production and Quality Monitoring
8		Field Installation, Testing, and Certification
9		Validate and Update Manufacturing Cost Model, Energy Yield Model, and Market Approach
10		Plan for GW Scale
11		Evaluation of Project Benefits
12		Technology/Knowledge Transfer Activities

B. Acronym/Term List

Acronym/Term	Meaning
BRIDGE	Bring Rapid Innovation Development to Green Energy
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CEC	California Energy Commission
CPR	Critical Project Review
EPIC	Electric Program Investment Charge
EV	Electric Vehicle
FAT	Factory Acceptance Test
GHG	Greenhouse Gas
GW	Gigawatt (1 billion watts) production capacity per year
IEC	International Electrotechnical Commission
LCOE	Levelized Cost of Electricity
LRIP	Low Rate Initial Production
MW	Megawatt (1 million watts) production capacity per year
PV	Photovoltaic
QA/QC	Quality assurance / Quality control
R&D	Research and development
Recipient	Swift Solar Inc.
SAT	Site Acceptance Test
Si	Silicon
SOP	Standard Operating Procedure
TAC	Technical Advisory Committee

[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
Swift Solar Inc.

Acronym/Term	Meaning
BRIDGE	Bring Rapid Innovation Development to Green Energy
UL	Underwriters Laboratories

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

A. Purpose of Agreement

The purpose of this Agreement is to fund the design and build-out of a Low Rate Initial Production (LRIP) line for the manufacture of high-performance perovskite-silicon tandem photovoltaic (PV) modules, which will be tested for efficiency and reliability in specialized applications (e.g., EVs and aerospace) and conventional rooftop and utility-scale solar applications.

B. Problem/ Solution Statement

Problem

Today's dominant solar PV products are limited in both efficiency and application. Current silicon single-junction technology will reach its practical module efficiency ceiling of ~25% within the next 5–10 years. Limited efficiency increases area requirements and/or lowers solar power output. Current silicon PV is also heavy and rigid, and therefore challenging to use in many applications. This restricts applications to rooftop and utility-scale PV and leaves emerging applications such as electric mobility and aerospace lacking easily integrated solar options. As electricity demand continues to grow, California ratepayers need more efficient and affordable PV that can be integrated into a wider range of products.

Cell-to-Module conversion processes are well established in the silicon (Si) PV industry. Offerings from several equipment and material vendors enable low-cost and high-throughput module assembly. But high-efficiency perovskite tandem cells, while similar in format to traditional cells, are not directly compatible with Si module designs and processes. Direct application of existing processes will result in low-efficiency and/or short-lived perovskite modules. Conventional encapsulant materials react with perovskites, and conventional backsheets are too permeable to protect moisture-sensitive cells. Furthermore, low thermal budgets and mechanically weak cell layers make perovskite cell interconnections particularly challenging.

Solution

The Swift Solar Inc. (Recipient) has developed perovskite-silicon tandem solar cells that raise the theoretical PV efficiency limit to over 45%, with a practical module limit of ~35%. This compares to today's silicon PV technology with a practical module limit of ~25%. The Recipient's core perovskite technology also provides the additional benefits of higher power density (both with respect to weight and area), applicability to curved surfaces, and superior aesthetics. These attributes will allow PV integration in new applications such as electric vehicle (EV) roofs.

To overcome cell-to-module conversion challenges, the Recipient has developed unique proof-of-concept designs and processes. The Recipient has developed solutions to perovskite-specific moduling challenges through the Bring Rapid Innovation Development to Green Energy (BRIDGE) project awarded by the Energy Commission with grant EPC-21-012 executed on March 9th, 20222, and internal research and development (R&D) efforts—identifying compatible materials for tandem module assembly and developing unique interconnect designs and processes. This proposed project will represent the first-ever LRIP of these solutions for two-terminal perovskite-silicon tandem PV, proving that the technology can be scaled to the gigawatt (GW) level. The project involves initial establishment of process and equipment specifications with multiple equipment vendors, followed by equipment purchasing for the Cell-to-Module conversion line.

Equipment purchased for each unit operation will be selected to be transferable to the next stage of scale-up—i.e., a 50–100 megawatt (MW) production line. For some steps, a single tool can reach that capacity; for others, each tool can handle ~10MW, and duplicates will be purchased. The Recipient will leverage its PV module and process engineering experience and supplement the existing team with additional product engineers and manufacturing experts. The toolset for cell-to-module conversion will consist of leading-edge (yet readily available) equipment developed for Si PV—innovations will come from encapsulation material choice & processing, modifications to the perovskite cell structure to enable low temperature and mechanically robust cell interconnects and adapting standard equipment and processes for novel applications. All manufacturing steps will require cell handling during or between unit operations. Since perovskite solar cells are much more sensitive to handling than standard Si cells, the Recipient will specify handling criteria and work with tool vendors to optimize robotic handling of tandem cells.

This cell-to-module production proof of concept will help derisk the Recipient's next-generation perovskite PV technology for high-volume manufacturing, which is needed to unlock its full potential for high-value applications and to facilitate entry into established PV markets. The project will produce both specialized module formats for vehicle integration and standard module formats with higher efficiency for grid-connected applications.

C. Goals and Objectives of the Agreement

Agreement Goals

The overall goal of this Agreement is to transition perovskite-silicon tandem technology from R&D to LRIP by leveraging the Recipient's existing cell LRIP line and by translating module prototyping technology developed under BRIDGE to automated commercial manufacturing equipment and processes. This technology development and scaling work targets two high-level outcomes:

- Preparing perovskite tandem technology for domestic high-volume manufacturing, establishing the USA and California in particular as leaders in next-generation PV technology.
- Providing benefits to ratepayers and the grid by minimizing peak loads by enabling onboard solar charging of EVs, increasing the power generated by any solar project by 25+%, and lowering the levelized cost of electricity (LCOE) of residential and utility-scale solar generation.

Ratepayer Benefits:[2] This Agreement will result in the ratepayer benefit of lower costs by readying perovskite tandem solar cell technology for scale-up and deployment. High-efficiency tandems will increase California rooftop and utility-scale solar energy production by 25+%, at an estimated cost savings per kWh of 10–30+% (depending on technology generation and installation methods). The Recipient projects a 10% lower residential LCOE for perovskite-silicon tandems than baseline c-Si PV in 2030 without accounting for potential cost savings from new deployment strategies. California investor-owned utility ratepayers will thus benefit directly from lower electricity prices, reduced greenhouse gas (GHG) emissions, and greater accessibility for low-income households.

EV drivers will also benefit from solar-integrated EVs via cost savings, increased convenience, and longer battery lifetime. Reducing EV charging requirements with onboard solar should help drive more equitable EV adoption. All ratepayers will benefit from adoption of efficient vehicle-integrated PV in several ways—peak load reduction, system-wide cost savings, reduced GHG and local air pollutant emissions, and increased infrastructure reliability and resilience.

Technological Advancement and Breakthroughs:[3] This Agreement will lead to technological advancement and breakthroughs to overcome barriers to the achievement of the State of California's statutory energy goals by improving novel perovskite tandem cell technology and integrating it into EVs and conventional solar products. The Recipient's perovskite technology will increase the practically attainable power conversion efficiency of solar cells from 26% to 35%. This agreement will enable module prototyping capabilities and further accelerate the use of efficient tandem PV technology in EVs and many other solar applications.

Agreement Objectives

The objectives of this Agreement are to:

- Specify, purchase, and install tools for fabrication and qualification of perovskite-silicon tandem modules made with full wafer-size cells
- Use cell-to-module LRIP tools and prototyping capabilities to build efficient PV modules suitable for traditional and vehicle-integrated applications, leveraging the Recipient's existing cell development line and cell-to-module conversion prototypes developed under BRIDGE
- Scale up commercial-size module assembly using commercially relevant techniques, thus moving from one-off prototypes to LRIP with metrics including quality, yield, throughput, and cost by
    - Working with established material and tool vendors
    - Adapting the cell production process to ensure compatibility with mature cell-to-module tooling
- Evaluate real-world performance and long-term reliability of LRIP tandem modules by

[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).

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

  - Carrying out field testing with federal test facilities (e.g., Sandia National Laboratories)
  - Performing Underwriter Laboratories (UL) and International Electrotechnical Commission (IEC) qualification testing
- Outline a plan for full rate production of tandem modules at 100MW and 1GW scale by
  - Establishing supply chain partnerships
  - Validating techno-economic models
  - Getting customer feedback on product prototypes

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.

  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);
- 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. 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.

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

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.
- 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.

    - 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)*
- 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.
- 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 ensure 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
Swift Solar 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 ensure 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 section of 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.

- 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
Swift Solar Inc.

IV. TECHNICAL TASKS

TASK 2 EQUIPMENT SPECIFICATION AND INTEGRATION PLANNING

The goal of this task is to specify equipment to handle cells and modules and run the required processes for a LRIP pilot line for cell-to-module conversion. A plan will be made to ensure that the different tools required to run cell interconnection processes, moduling processes, and module performance and reliability testing can be integrated into one automated production line.

The Recipient shall:

- Establish specification and acceptance criteria for all process steps that involve manufacturing equipment. This will cover incoming cell quality control and sorting, cell interconnection, module processing, module testing and packing, and routine module reliability testing for quality assurance. This task ensures that the equipment purchased later will deliver the required module efficiency and stability as well as operational quality (throughput, maintenance, uptime). Specific focus areas include:
    - Cell handling and automation
    - Unit process specifications for the output of each process step
    - Throughput requirements
    - Tool input and output interfaces
    - Control system, data management
    - Safety
    - Maintenance requirements and expected up-time
    - Buffers and storage
- Write an *Equipment Specification and Acceptance Criteria Report* that includes but is not limited to a table of acceptance criteria for each tool that includes sections on each of the bullets above.
- Simulate the integrated manufacturing line workflow using commercially available software typically used for these purposes (e.g. Siemens Tecnomatix or AnyLogic). This will identify which process steps are likely to limit line throughput and identify where multiple tools may be needed to eliminate bottlenecks.
    - Write an *Integrated Manufacturing Line Workflow Report* that includes information on how the simulations are performed, expected line throughput, a proposed maintenance schedule, and number and working hours (including shift operation) of operators and engineers on staff.
- Develop a cost model for the cell-to-module part of a production line. The Recipient will use vendor quotes and tool specifications to establish the capital expenditure, throughput expectations, material usage, labor requirements, and facility costs.
    - Write a *Draft Cost Model Report* that includes a final estimated cost per module along with a breakdown of capital expenditures (to be refined with input from Task 3), material costs (to be refined with input from Task 6), labor costs, and facility costs. It will include a short description of how these parameters might change or be improved for a future mass production facility.

Products:

- Equipment Specification and Acceptance Criteria Report
- Integrated Manufacturing Line Workflow Report
- Draft Cost Model Report

TASK 3 EQUIPMENT ORDERING

The goal of this task is to qualify equipment vendors and place orders for all major equipment required for the cell-to-module conversion LRIP pilot line.

The Recipient shall:

- Qualify vendors by:
    - Creating a vendor list (some vendor information may be confidential) including budgetary quotes, vendor capabilities, and estimated lead times, with a target of 3–4 vendors per step for the initial list.
    - Performing sample exchange to evaluate tools and processes
    - Comparing vendor specifications to the Equipment Specification and Acceptance Criteria Report from Task 2 to then down-select vendors
    - Performing reference checks and site visits
    - Performing further sample exchange to qualify down-selected tools and processes
    - Comparing final vendor specifications to the Equipment Specification and Acceptance Criteria Report from Task 2 and selecting one vendor per step.
- Writing a *Vendor Qualification Report* including a vendor list, budgetary quotes, lead times, summary of key specifications and comparisons to the Recipient's target equipment specifications, results of sample exchange, and final decision on vendors.
- Order tools via the following steps:
    - Complete any design and engineering work
    - Negotiate purchase parameters
    - Place equipment orders: The Recipient will create an *Order Summary* which may include some of the following information—items ordered, specifications, acceptance criteria (factory acceptance test (FAT) and site acceptance test (SAT)), budget and invoices, estimated delivery dates.
    - Review final designs for equipment build, including projected preventative maintenance procedures and spares list
    - Perform a FAT at the completion of the equipment build and submit a *FAT Report*.
- GenerateFATs and SATs for each tool—i.e., a checklist of tests with pass/fail criteria to be performed by the vendor prior to shipment and upon installation in the Recipient's facility, respectively. These tests will
    - validate whether the equipment is performing to the agreed-upon specifications
    - include requirements on documentation, performance, repeatability, and uniformity
- Perform an FAT and SAT with the vendor for each piece of equipment and write an *FAT and SAT Report*, which will be a completed version of the FAT checklist created above.
- Identify hiring needs for operating and maintaining the specified equipment. The equipment specifications and line integration planning will allow us to develop a *Staffing Plan* which includes the number of unique roles, required skill sets per role, and ideal start dates for each role.

Products:

- Vendor Qualification Report
- Order Summary
- Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) Report(s)
- Staffing Plan

TASK 4 SITE PREPARATION, SELECTION AND FACILITATION

The goal of this task is to plan for and prepare the existing facility or secure and prepare a new facility (if needed) if it is determined the current facility cannot accommodate the space requirements for new equipment to house the LRIP pilot line and manufacturing operations.

The Recipient shall:

- Create a *Site Specification Checklist* based on the equipment specifications identified in the Vendor Qualification Report and Integrated Manufacturing Line Workflow Report. The summary will include constraints and specifications such as the required footprint, electrical power, communication/network requirements, cooling water capabilities, plumbing, chemical handling, fume extraction, siting permits, compressed gas, and location.
- Evaluate feasibility of using the current R&D site located in the San Francisco Bay Area and establish a Facility *Modification Plan* to accommodate required changes to the facility.
- If needed, tour >5 facilities together with a general contractor in California and compare them to the Site Specification Checklist, as well as rent terms and rough timelines and costs for required upgrades. A *Facility Comparison Matrix* will be produced.
- If needed, select a facility and negotiate the lease.
    - In the event a change of facility is necessary, the Recipient shall work with the CAM to determine whether an amendment to the grant documentation is necessary.
- Create a *Facilitation Plan* to identify all required upgrades to the facility to enable equipment install and LRIP pilot line operation. This will include initial contractor quotes and timelines.
- Execute facilitation work and track progress of key items in a *Facilitation Execution Report (draft and final),* which will include status of each major item to be completed in the facilitation at a halfway point (draft) and at the targeted completion date.

Products:

- Site Specification Checklist
- Facility Modification Plan
- Facility Comparison Matrix (if necessary)
- Facilitation Plan (if necessary)
- Facilitation Execution Report (draft and final)

TASK 5 EQUIPMENT INSTALLATION AND PROCESS QUALIFICATION

The goal of this task is to receive and install all purchased equipment at the existing facility or at the new facility (if needed), then qualify each process for each tool.

The Recipient shall:

- Receive and install the equipment at the current R&D site located in the San Francisco Bay Area or at the new facility selected by the Recipient pursuant to Task 4 (if needed).
    - In the event the equipment shall be installed at the new facility, the Recipient shall work with the CAM to determine whether an amendment to the grant documentation is necessary.
- Upon installation, the Recipient and vendor shall perform an SAT for each tool and fill out the *SAT Report*, a completed version of the SAT checklist created above.
- Create a maintenance plan, including checklists, schedules, and directly responsible individuals, for each tool. A summary of the maintenance for each tool will be provided in a *Maintenance Plan*.
- Qualify the process for each tool using the Recipient's test structures. An example would be to perform current-voltage and electroluminescence testing on a unit of several

interconnected solar cells to validate the stringing tool. The Recipient will write a *Process Qualification Report* summarizing the process qualification procedure for each tool.
- Generate a set of Standard Operating Procedures (SOPs) for each tool and ensure that at least one Engineer and one Operator are trained on each tool. An *SOP and Training Summary* will be generated.

Products:
- SAT Report
- Maintenance Plan
- Process Qualification Report
- SOP and Training Summary

TASK 6 SECURE MATERIAL SUPPLY CHAIN

The goal of this task is to ensure that the Recipient's material supply chain does not limit the cell-to-module conversion line in terms of throughput, cost, and performance.

The Recipient shall:
- Forecast material volume requirements and timing for each material used in the line in a *Material Volumes Forecast.*
- Generate *Material Specification Sheets* to specify quality control parameters for each material. A few examples of parameters are given below
    - Material purity
    - Mechanical constants
    - Conductivity
- Identify at least two vendors per material and receive samples from each vendor to compare them to the specification. Their performance will be evaluated in the Recipient's PV modules. A primary and secondary vendor will be listed for each material.
- Receive budgetary quotes from each vendor and apply them in a preliminary cost model to determine the cost impacts on future production modules.
- Establish delivery schedules with each vendor to reflect the timing identified in the *Material Volumes Forecast*.
- Develop an incoming material quality assurance / quality control (QA/QC) plan and any necessary procedures to ensure the quality of incoming material continues to meet specification over many shipments.
- Write a *Vendor Summary* that summarizes results of test results relative to the specifications, discusses the impacts of material costs, lists the primary and secondary vendors, and outlines delivery schedules.
- Establish *Material Receiving Procedures* that include unloading, inputting information into a digital material inventory, QA/QC and storage.
- Update the cost model with equipment costs obtained in Task 3 and material costs from Task 6.

Products:
- Material Volumes Forecast
- Material Specification Sheets
- Vendor Summary
- Material Receiving Procedures

TASK 7 MODULE PRODUCTION AND QUALITY MONITORING

The goal of this task is to produce modules at high throughput and monitor module quality.

The Recipient shall:

- Develop a *Test Plan* by which modules will be tested and quality will be quantified. The plan will include testing specifications such as the test conditions (e.g., current-voltage testing at a specified irradiance, spectrum class, sweep rate, temperature), the time associated with each test and throughput implications, which equipment they are performed on, when and on which modules a given test is performed, and how that data is used for process feedback and line performance tracking. This will include initial performance, stability, and reliability testing.
- Train the necessary personnel to operate the line in its first low-volume phase of production. The previously written Staffing Plan, SOP, and Training Summary products will ensure that the right personnel are available and trained appropriately.
- Enter the first phase of module production at a relatively low throughput (1 module per day) to validate the fully integrated line and discover any outstanding issues.
    - An *Initial Production Report* will be written to summarize
        - Progress on staff hiring and training
        - Module performance as laid out in the Test Plan
        - Outstanding issues and plans for resolution, especially as related to performance and throughput
- Enter into the second phase of production with higher throughput (up to 10 modules per day) run at the throughput (modules/hour) required to operate the line at its targeted capacity.
    - A *Production Report* will be written to summarize the
        - Progress on staff hiring and training for the second phase
        - Module performance as laid out in the Test Plan, and tracked over >3 week long operating campaigns operating at the targeted modules/hour throughput
        - Validated throughput and implications for operating a 100MW line
        - Equipment issues and maintenance reports over the timeframe of operating
        - Lessons learned for a future larger line

Products:

- Test Plan
- Initial Production Report
- Production Report

TASK 8 FIELD TESTING AND CERTIFICATION

The goal of this task is to evaluate the performance of the modules produced on the line in real-world conditions.

The Recipient shall:

- Develop design specifications for field testing in open rack utility-style installation as well as for vehicle integration and testing.
    - Installation and testing will be conducted with contract and partner environmental weathering sites located in various climate zones.
    - A *Field Testing Plan* will be generated that includes installation locations, installation design criteria, equipment needs, potential safety issues and solutions, partners involved in the installations and testing, installation procedures and timelines, as well as module testing procedures and a plan for data collection. It will also include a description of 3rd party certifications (e.g., IEC 61215, appropriate UL certifications) to be completed along with the names of the 3rd party test centers.

- Perform the installations according to the Field Testing Plan together with project partners.
    - An *Installation Summary* will be generated to review how the installation was executed relative to the plan and highlight any issues and resolutions in anticipation of larger commercial installations after the end of the project.
- Monitor module performance according to the Field Testing Plan.
    - For the open rack mounted modules, this will consist of collecting power generation and weather data over time, as well as performing occasional ex-situ measurements such as EL imaging.
    - For the vehicle-integrated PV modules, this entails driving and parking the vehicle in different locations and at different times of day, collecting power generation, location, and weather data to fine tune an Energy Yield Model as discussed in Task 9.
    - The data will be summarized in a *Field Testing Report* along with implications for eventual commercial installations. The Outdoor modules will have been outdoors for at least 6 months by the time of the report.
- Submit modules to third-party test sites for IEC and UL certification.
    - Third-party reliability and safety testing is critical for commercial installations. Modules from at least three production days across one month will be sent.
    - A *Certification Report* will be written describing the number of modules sent, results of the tests performed, and evaluation of process reproducibility by comparing certification results across multiple production days.

Products:

- Field Testing Plan
- Installation Summary
- Field Testing Report
- Certification Report

TASK 9 VALIDATE AND UPDATE COST MODEL, ENERGY YIELD MODEL, AND MARKET APPROACH

The goal of this task is to assemble the data gathered through equipment ordering, installation, running the line, and performing field tests to refine the manufacturing cost model, energy yield model, and market approach.

The Recipient shall:

- Collate all capital and operational costs based on having built and operated the LRIP line.
    - This information will be used to update the cost model to generate a *Final Module Cost Model Report*. It will include material costs, equipment costs, personnel costs, and facility costs, allowing the Recipient to compare relative contributions, and identify which step(s) in the line are most cost-limiting. This will inform changes for future lines. Sensitive details may be redacted.
- Use the field testing data from Task 8 to update the Energy Yield model that the Recipient has developed through the BRIDGE project using real outdoor testing data for both vehicle-integrated and traditional PV applications.
    - The model will incorporate factors such as module design, cell performance, operating temperature and temperature coefficients, module degradation rates, and real world-weather data to predict the energy yield in different locations and for different applications. The model will be described and results presented in an *Updated Energy Yield Model* product.

- Use the Energy Yield and Module Cost Models to generate a *System Level Cost Model Report* calculating installed costs and LCOE for utility, rooftop, and vehicle applications. This will be compared to existing solutions to highlight benefits to ratepayers in a *Ratepayer Benefit Report*.
- Refine the market approach by analyzing customer needs, willingness to pay, and technical requirements in light of the updated cost and energy yield models.
    - For example, if the cost model highlights that it is possible to achieve low production costs even at an early stage, the Recipient may choose to favor larger volume, lower price-point customers that represent a larger growth market than a lower volume, higher price-point customer that has limited long-term market size. A table and report comparing the Recipient's initial target markets' requirements to the data gathered throughout the project will be presented in a *Market Analysis*.

Products:

- Final Cost Model Report
- Updated Energy Yield Model
- System Level Cost Model Report
- Ratepayer Benefit Report
- Market Analysis

TASK 10 PLAN FOR GIGAWATT (GW) SCALE

The goal of this task is to use information gathered throughout the project to make a plan for scaling production by 10–100x to GW scale.

The Recipient shall:

- Identify which equipment can be translated to GW scale and which cannot, by:
    - Creating a table listing each step and how the LIRP line translates to GW scale
    - Quantifying equipment costs at GW scale
- Create a *GW Line Plan* including
    - Which equipment is to be translated using the table listed above
    - Example line layout
    - Estimated capital costs
    - Estimated operational costs
- Analyze financing options for a GW line in a *Financing Plan.*

Products:

- GW Line Plan
- Financing Plan

TASK 11 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* by January 31st of 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), 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), and provide *Documentation of Organization Profile on EnergizeInnovation.fund*, including the profile link.

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 12 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

V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.