California Energy Commission
May 8, 2025 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 Amendment Request Form
3. Scope of Work

[PROPOSED]

RESOLUTION NO: 25-0508-03d

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 amendment 1 to agreement EPC-21-012 with Swift Solar Inc. to revise the Scope of Work (SOW) to remove both the development of curved perovskite tandem modules as well as their integration into onboard electric vehicle (EV) charging applications. The revised SOW now focuses on the development of flat perovskite tandem modules for residential, commercial, and utility solar applications; 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 May 8, 2025.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

_____
Kristine Banaag
Secretariat

STATE OF CALIFORNIA

GRANT AMENDMENT REQUEST FORM (GARF)

CEC-277 (Revised 01/2024) CALIFORNIA ENERGY COMMISSION

Original Agreement # EPC-21-012 Amendment # 1

Division	Agreement Manager:	MS-	Phone
ERDD	Michael Ferreira	51	510-364-8808

Recipient's Legal Name	Federal ID #
Swift Solar Inc.	82-3547302

Revisions: (check all that apply)	**Additional Requirements**
☐ Term Extension New End Date:	Include revised schedule and complete items A, B, C, & F below.
☐ Budget Augmentation Amendment Amount: $ 0	Include revised budget and complete items A, B, C, D, & F below.
☐ Budget Reallocation	Include revised budget and complete items A, B, C, & F below.
☒ Scope of Work Revision	Include revised scope of work and complete items A, B, C, E, & F below.
☐ Change in Project Location or Demonstration Site	Include revised scope of work and complete items A, B, C, E, & F below.
☐ Novation/Name Change of Prime Recipient	Include novation documentation and complete items A, B, C, & F below.
☐ Terms and Conditions Modification	Include applicable exhibits with bold/underline/ strikeout and complete items A, B, C, & F below.

A) Business Meeting Information

Business Meeting approval is not required for the following types of Agreements:

☐ Minor amendments delegated to Executive Director per December 2013 Resolution

Proposed Business Meeting Date 5/8/2025 ☒ Consent ☐ Discussion

Business Meeting Presenter N/A Time Needed: 0 minutes

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

Agenda Item Subject and Description:

Swift Solar Inc. Proposed resolution approving amendment 1 to agreement EPC-21-012 with Swift Solar Inc. to revise the Scope of Work (SOW) to remove both the development of curved perovskite tandem modules as well as their integration into onboard EV charging applications and adopting staff's recommendation that this action is exempt from CEQA for the reasons adopted in the January 26, 2022, business meeting. The revised SOW now focuses on the development of flat perovskite tandem modules for residential, commercial, and utility solar applications. (EPIC Funding) Contact: Michael Ferreira

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

Legal Company Name:	Budget
	$
	$

C) List all key partners: (attach additional sheets as necessary)

Legal Company Name:

D) Budget Information (only include amendment amount information)

Funding Source	Funding Year of Appropriation	Budget List Number	Amount
			$

R&D Program Area: TIEB: EDMF TOTAL: $ 0

Explanation for "Other" selection

Federal Agreement #:

E) California Environmental Quality Act (CEQA) Compliance

1. Is Agreement considered a "Project" under CEQA?
   ☒ Yes (skip to question 2)
   ☐ No (complete the following (PRC 21065 and 14 CCR 15378)):

   Explain why Agreement is not considered a "Project":

2. If Agreement is considered a "Project" under CEQA:
   a) ☐ Agreement **IS** exempt.
   ☐ Statutory Exemption. List PRC and/or CCR section number:
   ☒ Categorical Exemption. List CCR section number: Cal. Code Regs., tit. 14, § 15301

   This project is exempt from CEQA for the reasons adopted by the CEC at the January 26, 2022 business meeting, which noted the project was exempt under Cal. Code Regs., tit. 14, sect. 15301. Testing will involve limited driving in recipient's parking lot and possibly local streets to measure solar output at different orientations. For these reasons, this project will have no impact on the environment and fits within section 15301. Therefore, the project still falls within section 15301 and will not have a significant effect on the environment.

   The project 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.

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

Explain reason why Agreement is exempt under the above section:

b) ☐ Agreement **IS NOT** exempt. (consult with the legal office to determine next steps)

Check all that apply

☐ Initial Study
☐ Negative Declaration
☐ Mitigated Negative Declaration
☐ Environmental Impact Report
☐ Statement of Overriding Considerations

F) Is this project considered "Infrastructure"? No

G) The following items should be attached to this GARF (as applicable)

1. Exhibit A, Scope of Work/Schedule	☐ N/A	☒ Attached
2. Exhibit B, Budget Detail	☒ N/A	☐ Attached
3. CEQA Documentation	☒ N/A	☐ Attached
4. Novation Documentation	☒ N/A	☐ Attached
5. CEC 105, Questionnaire for Identifying Conflicts		☒ Attached

Michael Ferreira **Agreement Manager**	3/5/2025 **Date**
Anthony Ng **Branch Manager**	3/14/2025 **Date**
Anthony Ng for Jonah Steinbuck **Director**	3/14/2025 **Date**

EXHIBIT A
Scope of Work
Swift Solar Inc.

I. TASK AND ACRONYM/TERM LISTS

A. Task List

Task #	CPR[1]	Task Name
1		General Project Tasks
2		Module Prototype Line Planning
3		Module Prototype Development
4	X	Module Prototype Testing
5		Module Prototype Development and Testing – 2nd Generation
6		~~Vehicle Prototype Integration~~ **Energy Yield and Levelized Cost of Electricity Evaluation**
~~7~~		~~Vehicle Prototype Testing~~
7~~8~~		Evaluation of Project Benefits
8~~9~~		Technology/Knowledge Transfer Activities

B. Acronym/Term List

Acronym/Term	Meaning
c-Si	**Crystalline Silicon**
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CEC	California Energy Commission
CPR	Critical Project Review
EV	Electric Vehicle
NREL	National Renewable Energy Lab
PV	Photovoltaic
TAC	Technical Advisory Committee

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

A. Purpose of Agreement

The purpose of the Agreement is to further develop perovskite-silicon tandem photovoltaic (PV) technology, integrate the technology into **modules for installation in utility, commercial and residential systems**~~, an onboard Electric Vehicle (EV) charging application~~, and test the system for efficiency, ~~shade tolerance~~, durability, **and commercial viability** ~~ease of integration, and aesthetics~~.

[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.

B. Problem/ Solution Statement

Problem

Today's dominant solar cell products are limited in both efficiency and application. Current silicon single junction technology will reach its practical commercial efficiency ceiling of approximately 25% within the next 5-10 years. ~~This limited efficiency leads to larger footprints for PV applications, or alternatively, lower power output. In addition, current silicon PV is heavy and rigid, making it difficult to apply PV to many consumer applications. This restricts common applications to large solar fields and rooftops, and leaves emerging applications such as electric mobility and consumer electronics lacking easily integrated solar power options.~~ As demand for electricity continues to grow~~,~~ **at a fast pace as a result of electrification of transportation and industry, as well as an increase in data center power demand,** all California communities and consumers need more efficient and affordable PV that can be more practically integrated into a wide range of products.

Solution

The recipient has developed highly efficient perovskite-silicon tandem solar cells that raise the theoretical photovoltaic efficiency limit to over 45% with a practical commercial limit of 35%. This compares to today's silicon-based PV technology with a practical commercial limit of 25%.

The recipient's core perovskite technology will result in cells and modules that resemble conventional silicon PV cell and modules in cost and format, but at a considerably higher efficiency and power production rate. Choosing the recipient's high efficiency modules over conventional modules, while keeping the rest of the system the same, will enable developers to rapidly meet the high pace of power demand growth. What used to require three PV power systems to be installed might now only require two power systems to be installed, saving developers time and capital. ~~Swift's core perovskite technology also provides the additional benefits of being lighter, more durable, more easily applied to curved surfaces, and aesthetically superior to silicon technology. These attributes allow PV to be integrated into new applications such as EV and consumer electronics for which practical application of solar PV is currently highly limited.~~

As a proof of concept, the recipient proposes to further develop its perovskite technology to increase efficiency and integrate the cells into a conventional format PV module ~~an onboard EV charging station~~. This ~~automotive~~ application is considered to be a particularly **important one because it represents the largest use case for solar and places high demands on the technology:** ~~demanding proof of concept because of the rigors of engineering and consumer requirements~~:

- High efficiency: PV efficiency is critical to **drive system level cost savings in labor, racking, and land use**. ~~increase EV range and time between charging. As documented in several studies, range is a primary barrier to EV adoption.~~
- ~~Curved surfaces: In order to meet the aerodynamic requirements of auto manufacturers and maximize usable surface area, PV solutions must be able to be applied to curved surfaces.~~
- **Durability: Modules must perform efficiently over at least 25 years over a range of harsh climates to be commercially viable. The utility and commercial (buildings) applications targeted with these modules are extremely sensitive to the return on investment into the PV system and hence have a very high requirement for reliability in the field. To finance a utility scale PV system, banks**

must also sign off on the technology, requiring further proof of reliability.
- **Cost: These are some of the most cost sensitive applications. Hence it is critical for the cell and module making steps to be as similar as possible to existing steps used by the crystalline silicon (c-Si) industry - this allows the recipient to leverage existing manufacturing equipment and processes.**
- ~~Weight: In order to increase vehicle efficiency, automakers demand lighter solutions.~~
- ~~Durability: PV products must be able to withstand the day-to-day rigors of the road, including vibration, exposure to moisture, and varying temperatures.~~
- ~~Aesthetics: Today's automobiles carefully integrate form and function. To be successful, any integrated PV technology must meet the aesthetic requirements of both OEMs and consumers.~~

Given the current growth in demand for clean energy sources, developing "drop in" modules with higher efficiency than existing c-Si technology is likely the most compelling path towards commercializing the Recipient's tandem technology. This enables the recipient to directly address the largest market, have the largest impact on greenhouse gas emissions, and build high volume manufacturing capabilities in California. The technical development performed here will also translate to other use cases, such as Low Earth Orbit satellites, Electric Vehicles, and residential rooftop solar.

~~Swift believes that an EV proof of concept will help establish its next-generation perovskite technology for use in other applications, including consumer electronics and aerospace, and also facilitate transition of the technology into established PV markets such as rooftop solar.~~

C. Goals and Objectives of the Agreement

Agreement Goals

The goals of this Agreement are to:

- Improve the efficiency and applications of the recipient's perovskite solar cell technology by:
  - Increasing the power conversion efficiency to over 28%
  - ~~Making them suitable for integration into curved surfaces such as car parts~~
  - **Making them suitable for integration into PV modules for installation in utility and commercial scale PV systems**
  - Verifying real-world reliability and energy production
- Develop prototype perovskite tandem modules that
  - **Achieve a power conversion efficiency of at least 23%**
  - **Leverage existing manufacturing techniques**
  - **Meet reliability targets required for 25 year operation across the US**
  - ~~Are curved~~
  - ~~Can replace car parts like the roof~~
  - ~~Are shade tolerant~~
  - ~~Meet established aesthetic requirements~~
- Demonstrate **tandem modules operating in the field and** ~~solar charging in an electric vehicle using Swift Solar's perovskite tandem technology and~~
  - ~~o~~ Verify that the power output is the highest per area of any **field deployed PV technology** ~~solar charging car~~
  - Model the lifetime financial, energy, and carbon emissions benefits to the customer and the California grid

- ~~Evaluate the viability of prototype solar charging solutions for EVs in terms of~~
  - ~~Efficiency~~
  - ~~Robust integration on curved surfaces~~
  - ~~Weight~~
  - ~~Durability~~
  - ~~Aesthetics~~

Ratepayer Benefits:[2] This Agreement will result in technological advancements that will reduce reliance on IOU supplied electricity, lower costs, and increase safety. We estimate that the successful integration of the recipient's cell technology will result in:

- Greater access to clean energy: Successful development and deployment of perovskite PV technology into the existing rooftop PV market will increase solar electricity output by 25%, ceteris paribus. However, perovskite technology could also increase the number of sites for which solar PV is accessible and/or cost effective. Moreover, perovskites will enable robust application of PV into consumer applications that are not practical with existing technologies. This includes but is not limited to EVs, consumer products, and specialized applications such as portable or off-grid power, and will spur innovation for further applications.
- Lower costs: Though cost-effectiveness will depend on the application, perovskite technology can generally enable lower overall costs than today's silicon-based technology due to increased efficiency. ~~Swift calculates that integration of perovskite-silicon tandems into EVs can reduce a typical CA driver's annual electricity costs by up to $405 and yield a net 10-year cost savings of up to $2700. For eventual application in rooftop solar, the~~ **For utility, commercial and residential applications, the** higher efficiency of the recipient's perovskite tandems will enable system-level cost savings and reduce the levelized cost of electricity by ~~10%~~ **over 5-15% depending on location and application**.
- Increased safety and reliability: Distributed solar generation will alleviate burden on the state's complex transmission grid and help prevent tragic accidents such as the devastating fires caused by aging infrastructure. Moreover, onsite electricity generation combined with battery storage (e.g., from solar-charged EVs) will increase reliability, even during periods of grid strain.
- Benefits to low-income and disadvantaged communities: Due to increased efficiency, ease of integration, and lower cost of ownership, the recipient's perovskite technology will help low- income and disadvantaged communities have greater access to cost-effective, clean energy. Perovskite tandems can produce 25% more electricity in rooftop applications than current silicon technology, which is particularly important in high-density urban applications where usable roof area is highly limited. **By reducing the levelized cost of electricity in utility scale applications, the recipient's modules have the potential to further lower ratepayer electricity pricing while reducing CO2 emissions.** ~~In addition, as documented by UCLA for the California Air Resources Board, access to charging stations is a significant~~

[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).

~~barrier to EV adoption by low-income communities.[3] Moreover, as documented by the International Council on Clean Transportation, public charging is 2–3x more expensive than home charging, leading to greater EV operating costs for low-income drivers who have limited access to home charging.[4]~~

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 the perovskite tandem cell technology and integrating it into **modules that can be installed in large scale PV system to produce more power at a lower cost and potentially at a faster rate (with more power per system, fewer permits and less construction are required)** ~~an EV~~. The recipient's perovskite tandem technology will increase the mid-term practically attainable power conversion efficiency of commercially available solar cells from 26% to 35%. By enabling prototyping capabilities, **and performing field demonstrations and testing,** the recipient will have the potential to penetrate the solar market and further accelerate the use of efficient tandem PV in EVs and buildings~~, and consumer electronics~~.

Agreement Objectives

The objectives of this Agreement are to:

- Develop a prototype tandem cell with greater than **28% efficiency**, ability to **be integrated into large modules suitable to utility scale power generation, and suitable reliability for 25 year lifetime and cost effective operations in the US** ~~conform to curved surfaces, and suitable reliability for integration into electric vehicles~~
- ~~Integrate Swift Solar's perovskite solar cell technology into a consumer EV; and~~
- Test and validate prototype manufacturing facilities and processes
- **Test and validate module performance and reliability in the field**
- ~~Test the practical application of Swift's perovskite solar cell technology on a consumer EV~~

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.

[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.

EXHIBIT A
Scope of Work
Swift Solar Inc.

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, and other CEC staff relevant to the Agreement. The Recipient's Project Manager and any other individuals deemed necessary by the CAM or the Project Manager shall participate in 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., Teams, Zoom), with approval of the CAM.

  The Kick-off meeting will include discussion of the following:
  - The CAM's expectations for accomplishing tasks described in the Scope of Work;
  - An updated Project Schedule;
  - Terms and conditions of the Agreement;
  - Invoicing and auditing procedures;
  - Travel;
  - Equipment purchases;
  - Administrative and Technical products (subtask 1.1);
  - CPR meetings (subtask 1.3);
  - Monthly Calls (subtask 1.5)
  - Quarterly Progress reports (subtask 1.6)
  - Final Report (subtask 1.7)
  - Match funds (subtask 1.8);
  - Permit documentation (subtask 1.9);
  - Subawards(subtask 1.10);
  - Technical Advisory Committee meetings (subtasks 1.11 and 1.12);
  - Agreement changes;
  - Performance Evaluations; 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 1.8) *(if applicable)*
- Permit Status Letter (subtask 1.9) *(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 may 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 may 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. A determination of unsatisfactory progress This may result in project delays, including a potential Stop Work Order, while the CEC determines whether the project should continue.
- 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 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* 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 quarterly *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:

o 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* received on the Executive Summary. For each comment received, the recipient will identify in the summary the following:
  - Comments the recipient proposes to incorporate.

o **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
- 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 1.12.
- 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.

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* for each TAC Meeting 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

IV. TECHNICAL TASKS

TASK 2 MODULE PROTOTYPING LINE PLANNING

The goal of this task is to (1) identify, purchase, and install all equipment needed for module and product integration while obtaining best-value.

SUBTASK 2.1 Identify and Source all Necessary Equipment

The goals of this subtask are to (1) identify and source all manufacturing equipment specific to making PV modules ~~for EVs~~ and (2) establish components of the manufacturing process.

The Recipient shall:

- Work with equipment manufacturers to specify processes and equipment for the prototyping line. This explicitly excludes equipment involved in the cell manufacturing, since this has already been specified and paid for by the Recipient before the start of the project. Example equipment includes but is not limited to:
  - ~~Autoclave and laminator for curved module lamination~~
  - Module testing equipment for testing under simulated and outdoor conditions
  - Mechanical testing equipment
  - ~~Equipment for working on car body parts~~
  - ~~Electrical equipment for battery and high voltage work~~
- Prepare a *Consolidated List of Equipment*. The List will accumulate information on all equipment purchases. It is expected that the information may include the name of the equipment, the vendor's name, and a brief description of the equipment. The consolidated List will provide CEC with a brief yet informative overview of the equipment being used in the manufacturing process.
- Create a *Materials Procurement Summary* that includes but is not limited to:
  - Material descriptions and volumes;
  - Delivery timeline; and
  - Any identified risks/issues and resolutions.
- Create a *Production and Sourcing Plan* that summarizes the main components of the prototype manufacturing process

Products:

- Consolidated List of Equipment
- Materials Procurement Summary
- Production and Sourcing Plan (draft and final)

SUBTASK 2.2 Qualify Equipment

The goals of this subtask are to (1) install and (2) integrate all purchased equipment at the Recipient's laboratory facilities.

The Recipient shall:

- Assemble all equipment for pre-delivery qualifications.
- Arrange for training on proper usage of equipment, and pre-delivery equipment qualifications. Install equipment on site.

- Test equipment functionality by fabricating appropriate samples.
- Prepare a *Test Plan for Qualification of New Equipment*. The Test Plan will evaluate the loss of cell and module efficiency compared to R&D equipment, evaluate throughput and yield, determine order of magnitude material usage, and develop an equipment maintenance schedule.

Products:

- Test Plan for Qualification of New Equipment

TASK 3 MODULE PROTOTYPE DEVELOPMENT

The goals of this task are to (1) establish a manufacturing plan, (2) refine the design, and (3) build the module for the first proof-of-principle prototypes of PV **modules made from tandem cells** ~~integrated into EV parts~~. The cell efficiency target is greater than 28% for 6-inch cells.

SUBTASK 3.1 Establish The Design

The goal of this subtask is to establish a ~~customizable PV module design for EVs~~ **flat glass/glass PV module design for commercial and utility applications** so the recipient can finalize materials, processing, and equipment choices.

The Recipient shall:

- Develop a Module Specification sheet ~~developed with an EV partner~~ focusing on
  - Electrical output specifications;
  - Mechanical specifications to facilitate **system** integration;
  - Dimensions;
  - ~~Aesthetic requirements~~; and
  - Reliability requirements.
- ~~Perform Mechanical design and provide:~~
  - ~~Description and/or schematics of the proposed vehicle integration methods and module dimensions including size and curvature.~~
- Perform Electrical design and provide:
  - Spec sheet documenting cell and module level electrical outputs.
- Perform Module level design and provide:
  - Description and/or schematics of the proposed lamination strategy
- Prepare a *Design Report* including, but is not limited to:
  - The Module Specification sheet;
  - Assembled schematics and documents from above;
  - List of processes to be used in module manufacturing; and
  - List of new manufacturing equipment required (e.g., laminators).
- **Prepare a *Flat Panel Design Report* including, but is not limited to:**
  - **The Module Specification sheet;**
  - **Assembled schematics and documents from above;**
  - **List of processes to be used in module manufacturing; and**
  - **List of new manufacturing equipment required (e.g., laminators)**.

Products:

- Design Report
- **Flat Panel Design Report**

SUBTASK 3.2 Establish The Manufacturing Plan
The goal of this subtask is to plan the manufacturing processes of the basic cell and module technology. There is some overlap with **3.4** and **3.5** in time, as results from those subtasks will feed into the Manufacturing Process Report.

The Recipient shall:

- Create a *Manufacturing Process Report* that includes but is not limited to:
  - An overview of the manufacturing workflow;
  - Success criteria and results for process evaluations, excluding process details; and
  - Any identified risks/issues and resolutions.
- Integrate individual processes into a functional and optimized process flow including:
  - Developing standard protocols for sample transfer between separate processes;
  - Standard protocols for sample storage between processes;
  - Identifying key process steps that influence manufacturing yield; and
  - ~~Developing protocols for handling and transferring large curved module glass between processes.~~

Products:

- Manufacturing Process Report

SUBTASK 3.3 Establish Cell Manufacturing Processes On The Prototyping Line
The goal of this subtask is to validate the manufacturing of the Recipient's perovskite solar cell technology for tandem cell applications. This task will bring the Recipient's cell technology from small R&D size to commercially relevant sizes with a target to improve the cell level efficiency to greater than 28%.

The Recipient shall:

- Optimize each cell manufacturing process step for
  - High efficiency tandem cell performance, as judged according to the testing plan (Task 4);
  - Throughput; and
  - Yield.
- Optimize raw material sources and usage
- Develop processes that enable:
  - Aesthetically pleasing perovskite-silicon tandems by optically hiding electrical connections;
  - Flexible and crack tolerant perovskite-silicon tandem cells by engineering of the front and rear electrodes and choice in silicon sub-cell; and
  - Shade tolerance by integrating cell-level electronics.
- Provide a *Preliminary Evaluation Report* of the cells every 6 months including
  - Initial performance data;
  - Dimensions of the cells;
  - Statistical distribution of cell performance data over time operating the prototyping line; and
  - Pictures of the cells.
- Continuously iterate on and improve the cell manufacturing process by using the Preliminary Evaluation Reports

Products:

- Preliminary Evaluation Reports

Subtask 3.4 Develop Manufacturing Quality Monitoring System

The goals of this subtask are to (1) document the equipment Standard Operating Procedures (SOP); and (2) develop process quality control of each process in the prototyping line

The Recipient shall:

- Create SOP that ensure the cell prototype manufacturing line meets power conversion efficiency and stability requirements transferred from the R&D line.
- Establish metrologies for stabilizing operations using data collection and analysis, including keeping a running log of peak, mean, and standard deviations of power conversion efficiency of each process batch along with measured stoichiometry.
- Establish process quality control, data collection, and tracking for the various manufacturing processes.
- Create a *Quality Monitoring Report* that includes but is not limited to:
  - SOP documented for tool operation;
  - Defined metrics and tracking of key parameters to maintain tool operations;
  - Corrective and preventative actions for manufactured prototypes that fall below established metrics; and
  - Any other tools and information to assist the technical personnel in successfully maintaining process quality.

Products:

- Quality Monitoring Report (draft and final)

Subtask 3.5 Develop Module Prototypes

The goal of this subtask is to develop a prototype PV module**s, starting with small format modules and ending with** ~~according to~~ the design laid out in **Subtask 3.1**.

The Recipient shall:

- Optimize the process associated with each piece of equipment and all materials required including:
  - ~~Formatting cells for curved panels~~;
  - Layout of cells and electrical interconnections into module format;
  - Lamination of **flat** ~~curved~~ glass panels;
  - ~~Integration of smart electronics (DC-DC converters, maximum power point trackers) for shade tolerance;~~
  - ~~Develop aesthetically pleasing modules, hiding electrical connections and emphasizing uniform color;~~
  - ~~Developing module electrodes for simple vehicle integration; and~~
  - **De-risk** ~~Develop~~ automated processes around module integration.
  - **The recipient shall perform these tasks above on 1-cell and 4-cell mini-modules to de-risk the processes without sacrificing large numbers of cells. These mini-modules will be the basic test structure for stability testing as well. Success must be achieved with these before full modules are made.**
- Send cells **to** ~~for~~ third party module prototyping **groups (e.g., Fraunhofer)** ~~by the~~

~~EV partners on the project~~ with the goal to de-risk the module development phase and maximize learning.

- Create a *Prototype Manufacturing Report* that includes but is not limited to:
  - Total units produced during the process;
  - Pictures of the prototypes; and
  - Key performance results and conclusions.

Products:

- Prototype Manufacturing Report

TASK 4 MODULE PROTOTYPE TESTING

The goals of this task are to develop a testing plan and then to use that plan to verify (1) performance, (2) reliability, and (3) aesthetics of the modules.

SUBTASK 4.1 Develop Testing Plan

The goal of this subtask is to prepare testing plans for both cells and modules that verify performance, reliability, and aesthetics.

The Recipient shall:

- Prepare a*Testing Plan* including
  - Protocols for performance testing, established with EV partner, including tests for
    - Cell prototypes: focused on efficiency and temperature coefficient, to be validated by an independent third party; and
    - Panel prototypes: focusing on efficiency and W/m2 produced under relevant parking conditions, to be validated in line with industry standards.
  - Protocols for reliability testing, established with EV partner, including tests to evaluate some or all of the following:
    - Cell and module level reliability, determined by preset thermal and atmospheric stressing conditions;
    - Cell and module reliability under high heat and bright sunlight unique to vehicle conditions;
    - Module shade tolerance;
    - Aesthetics of the module, determined by metrics to evaluate shape, color, uniformity;
    - Shock and vibration tolerance of the module as determined by tests designed to delaminate the module or induce cracking and breakage;
    - Outdoor performance of modules at the Recipient's facility and at an independent third party testing lab; and
    - List of new required testing equipment.
  - Schedule for sample exchange with EV partners
  - Schedule for external validation of cell results at an independent test facility
  - Schedule for external validation of module results by independent labs equipped for testing curved modules - e.g. the EV partners
- **Prepare a *Flat Testing Plan* including**
  - **Protocols for performance testing, including tests for**
    - **Cell prototypes: focused on efficiency and temperature**

coefficient, to be validated by an independent third party; and

- **Panel prototypes: focusing on efficiency a**~~nd W/m2 produced under relevant parking conditions~~**, to be validated in line with industry standards.**

- **Protocols for reliability testing, mirroring those published by the Photovoltaic Accelerator for Commercializing Technologies** ~~established with EV partner~~**, including tests to evaluate some or all of the following:**
  - **Cell and module level reliability, determined by preset thermal and atmospheric stressing conditions;**
  - **Cell and module reliability under high heat and bright sunlight equivalent to >10 years in the field**
  - **Outdoor performance of modules at the Recipient's facility and at an independent third party testing lab; and**

- **Schedule for external validation of cell results at an independent test facility**
- Develop a Performance Model by:
  - Developing a model predicting energy output, financial benefit to the user, and amount of CO2 saved over the module's lifespan.
- Create a *Performance Model Report* that describes the model methodology and the model results, including the forecasted performance of f**lat modules made of tandem cells** ~~EVs with the prototype panels in varying locations.~~

Products:

- Testing Plan
- Flat Panel Testing Plan
- Performance Model Report

SUBTASK 4.2 Conduct Testing for Cells and Modules

The goals of this subtask are to (1) evaluate cells and modules relative to the metrics set in the testing plan (2) improve the testing plan as required based on new findings. This task will be ongoing throughout the project.

The Recipient shall:

- Evaluate cells according to the testing plan.
- Evaluate modules according to the testing plan.
- Prepare *Initial Test Results* document summarizing outcomes of initial testing.
- **Prepare *Flat Panel Test Results document summarizing outcomes of initial testing.***
  - Compare results to the desired specifications.
  - ~~Send cells and modules to EV partners for feedback and independent validation.~~
  - Send cells to an independent third party for performance certification.
  - Make a *List of Proposed Improvements* for the cell, module, and testing plan.
  - **Make a *Flat Panel List of Proposed Improvements* for the cell, module, and testing plan.**
  - Prepare *CPR Report* and participate in a CPR meeting in accordance with subtask 1.3

Products:

- Initial Test Results

- **Flat Panel Test Results**
- List of Proposed Improvements
- **Flat Panel List of Proposed Improvements**
- CPR Report

SUBTASK 4.3 Evaluate Testing

The goals of this subtask are to evaluate the results of the testing.

The Recipient shall:

- Prepare *Report on Proof of Principle (RPP)* including
  - Comparison of technical results to specification sheet
  - **Evaluation by 3rd party test laboratories**
  - ~~Summary of feedback based on evaluation by EV partners~~
  - ~~Results of product integration including:~~
    - ~~Pictures~~
  - Field validation testing - e.g., energy generated per day of a module placed outside
    - ~~Evaluation by partner qualification teams~~

Products:

- Report on Proof of Principle

TASK 5 MODULE PROTOTYPE DEVELOPMENT AND TESTING – 2ND GENERATION

The goals of this task are to develop and test improved module prototypes compared to those developed in Task 3 using the evaluation from Task 4.

SUBTASK 5.1 Establish Design Improvements

The goal of this task is to use the Report on Proof of Principle to improve on the first generation module.

The Recipient shall:

- Generate a *2ND Generation Design Report* including:
  - Improvements to the electrical design; and
  - Improvements to mechanical design.
- Generate a *Revised Manufacturing Plan.*

Products:

- 2nd Generation Design Report
- Revised Manufacturing Plan

SUBTASK 5.2 Develop 2ND Generation Module Prototypes

The goal of this subtask is to develop a 2ND generation prototype PV module according to the design laid out in Subtask **5.1**.

The Recipient shall:

- Improve the process associated with each piece of equipment and all materials as required by Subtask **5.1**, example areas for improvement being:

  - ~~Formatting cells for curved panels~~;
  - Layout of cells and electrical interconnections into module format;
  - Laminating **flat** ~~curved~~ glass panels;
  - ~~Integrating smart electronics (DC-DC converters, maximum power point trackers) for shade tolerance;~~
  - ~~Developing aesthetically pleasing modules, hiding electrical connections and emphasizing uniform color;~~
  - ~~Developing module electrodes for simple vehicle integration; and~~
  - Developing automated processes around module integration
- Send cells for third party module prototyping **with module** ~~by the EV~~ partners ~~on the project~~ with the goal to de-risk the module development phase and maximize learning.
- Create an *2ND Generation R&D Prototype Manufacturing Report* that includes but is not limited to:
  - Total units produced during the process;
  - Pictures of the prototypes
  - Key performance results and conclusions, highlighting improvements over the first-generation prototypes

Products:
- 2ND Generation R&D Prototype Manufacturing Report

SUBTASK 5.3 Testing 2nd Generation Prototypes
The goals of this subtask are to validate the performance, reliability, and aesthetics of the module prototypes developed in Subtask **5.2.**

The Recipient shall:
- Update the testing plan based on learnings from Subtask **4.2.**
- Evaluate modules according to the testing plan.
- Compare results to the desired specifications.
- Send cells and modules to ~~EV~~ partners for feedback and independent validation.
- Generate a *2ND Generation Test* Report including:
  - Performance data from in house and external measurements;
  - Reliability data; and
  - Summary of feedback from evaluation by **3rd party** ~~EV~~ partners.

Products:
- 2ND Generation Test Report

TASK 6 Energy Yield and Levelized Cost of Electricity Evaluation
The goal of this task is to evaluate the test results and compare them to performance and cost models in order to predict energy yield and the levelized cost of electricity over the panel's lifetime.

SUBTASK 6.1 Comparison to performance model
The goal of this subtask is to compare the energy output of panels installed in the field from Task 4 and 5 to the performance model.

The Recipient shall:

- **Generate plots of energy conversion efficiency over a range of weather conditions and compare these to those predicted by the model**
- **Evaluate the rate of degradation of the panels and compare it to the rate predicted by in-house accelerated test results**
- **Update the performance model**
- **Generate a *Report on Energy Yield* including the results of the updated performance model and the implications in at least three US climates.**

Products:

- ***Report on Energy Yield***

SUBTASK 6.2 Determine the Levelized Cost of Electricity
The goal of this subtask is to determine the levelized cost of electricity for a few model locations in the US.

The Recipient shall

- **Use the updated performance model and a cost model developed internally to determine the expected levelized cost of electricity of the tandem modules developed in this project**
- **Write a *Cost Model Report*, including breakdown of manufacturing costs, cost per module, and the cost of levelized electricity in various climates.**

Products:

- **Cost Model Report**

~~**TASK 6 VEHICLE PROTOTYPE INTEGRATION**~~
~~The goal of this task is to perform the first demonstration of Swift's perovskite-silicon tandem technology integrated into electric vehicles.~~

~~**SUBTASK 6.1 Establish Integration Plan**~~
~~The goals of this subtask are to (1) establish a plan for integration and (2) prepare for integration.~~

~~**The Recipient shall:**~~

- ~~Identify specifications for vehicle to be used focusing on~~
  - ~~Energy efficiency of the vehicle;~~
  - ~~Battery capacity of the vehicle;~~
  - ~~Suitability for simple solar module integration - e.g. already has a large glass roof; and~~
  - ~~Ability to incorporate large area solar panels (e.g. the entire roof and / or hood) for maximum solar charging benefit.~~
- ~~Develop an *Integration Plan* including an overview of:~~
  - ~~Procurement of a best-value vehicle following the specifications above~~
  - ~~Identification of a suitable local Auto Body Shop to execute mechanical and electrical integration work as required~~
  - ~~Development of general procedures for integration, in partnership with a local Auto Body Shop, focused on:~~
    - ~~Preparing the car for integration~~

- Removing the existing roof
- Exposing battery management system

- Mechanical integration, including structural work
- Electrical integration
- A schedule for integration
- Identification of risks and unknowns along with mitigation measures

Products:

- Integration Plan

SUBTASK 6.2 Mechanical Integration of Module Into EV

The goals of this subtask are to mechanically integrate the prototype modules into EVs, working together with a local Auto Body Shop.

The Recipient shall:

- Procure an EV
- Prepare the EV as necessary, including
  - Mechanical disassembly of the roof; and
  - Preparing the roof mounting fixtures as required.
- Mount the module into the roof.
- Integrate the panel to the battery management system.
- Create an *Integration Report* including an overview of:
  - Procedures as they are iterated on;
  - Unforeseen problems and solutions; and
  - High Quality Digital Photographs of the cell and EV.

Products:

- Integration Report

SUBTASK 6.3 Electrical Integration of Module Into EV

The goal of this task is to perform the electrical integration of the prototype modules into EV demonstrations, working together with a local Auto Body Shop.

The Recipient shall:

- Prepare the EV as necessary, including
  - Exposing the charging infrastructure; and
  - Adapting the battery management system.
- Integrating wiring from the panel to the battery management area.
- Integrate the module wiring with the battery management system.
- Integrate software to track solar charging behavior.
- Create an *Electrical Integration Report* including an overview of:
  - Procedures as they are iterated on;
  - Unforeseen problems and solutions; and
  - High Quality Digital Photographs of the cell and EV.

Products:

- Electrical Integration Report

~~TASK 7 VEHICLE PROTOTYPE TESTING~~

~~The goals of this task are to (1) test the module once integrated into the EV and (2) test the charging performance of the demonstration vehicle.~~

~~SUBTASK 7.1 Prepare a Testing Plan for Solar Integrated Vehicles~~

~~The goal of this subtask is to establish testing protocols to evaluate the performance of the module and of the solar charging behavior of the vehicle.~~

~~The Recipient shall:~~

- ~~Prepare an *Integration Testing Plan* including an overview of:~~
  - ~~Protocols for module performance testing, established with EV partner, including tests for~~
  - ~~Power conversion efficiency when integrated into the vehicle~~
  - ~~Determining temperature coefficient when integrated~~
  - ~~Determining aesthetics of the integrated module in terms of color, uniformity, "seamlessness" of the integration~~
  - ~~Shade tolerance of the module~~
- ~~Develop protocols for testing the battery charging infrastructure including~~
  - ~~Validating electrical safety of the system; and~~
  - ~~Charging efficiency.~~
- ~~Develop protocols for testing vehicle performance including~~
  - ~~Solar charging rates over several typical days in a California city;~~
  - ~~Solar charging rates under varying shade conditions; and~~
  - ~~Monitoring vehicle temperature.~~
- ~~Agree upon metrics that 3rd party testing (by EV partners) and the recipient will use to:~~
  - ~~Benchmark the results to improve on the performance model; and~~
  - ~~Incorporate information on shading~~
- ~~Incorporate new metrics into an Improved Performance Model and create *Improved Performance Model Report* summarizing results from updated model.~~

~~Products:~~

- ~~Integration Testing Plan~~
- ~~Improved Performance Model Report~~

~~SUBTASK 7.2 Conduct Testing for Modules Integrated in EV~~

~~The goal of this subtask is to evaluate vehicle integration relative to the metrics set in the testing plan~~

~~The Recipient shall:~~

- ~~Evaluate integrated modules and vehicles according to the testing plan.~~
- ~~Compare results to the desired specifications.~~
- ~~Interface with EV partners for 3rd party validation of the test results.~~
- ~~Develop a *List of Proposed Improvements* for integration and testing plan.~~
- ~~Summarize test data in an *Integration Test Report*.~~

~~Products:~~

- ~~List of Proposed Improvements~~
- ~~Integration Test Report~~

~~**SUBTASK 7.3 Evaluate Testing**~~
~~The goals of this subtask are to evaluate the results of the testing~~

~~**The Recipient shall:**~~
- ~~Prepare *Report on Proof of Principle of Integration (RPPI)* including~~
  - ~~Comparison of results to specification sheet~~
  - ~~Summary of feedback from evaluation by EV partners~~
  - ~~Results of product integration including~~
    - ~~Pictures~~
    - ~~Results and implications of the performance model~~
    - ~~Evaluation by partner qualification teams~~
- ~~Prepare a *Report of Viability* including:~~
  - ~~A high-level summary of the technical specifications that were met or that were not met;~~
  - ~~Cost model results showing projected module integration cost ranges; and~~
  - ~~Summary of EV partners' interest in proceeding to production.~~

~~**Products:**~~
- ~~Report on Proof of Principle of Integration~~
- ~~Report of Viability~~

TASK 7 ~~8~~: 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 8~~9~~ TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES

The goal of this task is to conduct activities that will accelerate the commercial adoption of the technology being supported under this agreement. Eligible activities include, but are not limited to, the following:

- Scale-up analysis including manufacturing analysis, independent design verification, and process improvement efforts.
- Technology verification testing, or application to a test bed program located in California.
- Legal services or licensing to secure necessary intellectual property to further develop the technology
- Market research, business plan development, and cost-performance modeling.
- Entry into an incubator or accelerator program located in California.

The Recipient Shall:

- Develop and submit a *Technology Transfer Plan* that identifies the proposed activities the recipient will conduct to accelerate the successful commercial adoption of the technology.
- Present the draft *Technology Transfer Plan* to the TAC for feedback and comments.
- Develop and submit a *Summary of TAC Comments* that summarizes comments received from the TAC members on the Draft Technology Transfer 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 with and explanation why.
- Submit the final *Technology Transfer Plan* to the CAM for approval.
- Implement activities identified in final *Technology Transfer Plan*.
- Develop and submit a *Technology Transfer Summary Report* that includes high level summaries of the activities, results, and lessons learned of tasks performed relating to implementing the Final Technology Transfer Plan. This report should not include any proprietary information.
- When directed by the CAM, develop presentation materials for an 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:

- Technology Transfer Plan (draft and final)
- Summary of TAC Comments
- Technology Transfer Summary Report (draft and final)
- High Quality Digital Photographs

V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.