**California Energy Commission**
**October 08, 2025 Business Meeting**
**Backup Materials for SirenOpt 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: 25-1008-XX**

**STATE OF CALIFORNIA**

**STATE ENERGY RESOURCES**
**CONSERVATION AND DEVELOPMENT COMMISSION**

**RESOLUTION: SirenOpt 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-25-030 with SirenOpt Inc. for a $2,395,317 grant. This project will take place in Alameda County and advance innovative battery manufacturing inspection and process control technologies to the pilot-scale demonstration stage; 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 October 08, 2025.

AYE:
NAY:
ABSENT:
ABSTAIN:

Dated:

_____
Kim Todd
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-25-030

## B. Division Information

1. Division Name: ERDD
2. Agreement Manager: Benson Gilbert
3. MS-:51
4. Phone Number: 916-352-0595

## C. Recipient's Information

1. Recipient's Legal Name: SirenOpt Inc.
2. Federal ID Number: 88-0719093

## D. Title of Project

Title of project: Cold Atmospheric Plasma-Based Inspection & Real-Time Process Control of Electrode Materials to Enable High-Performance Battery Manufacturing

## E. Term and Amount

1. Start Date: 10/8/2025
2. End Date: 3/31/2030
3. Amount: $2,395,317.00

## F. Business Meeting Information

1. Are the ARFVTP agreements $75K and under delegated to Executive Director? No
2. The Proposed Business Meeting Date: 10/8/2025 .
3. Consent or Discussion? Discussion
4. Business Meeting Presenter Name: Lindsey Fransen
5. Time Needed for Business Meeting: 5 minutes.
6. The email subscription topic is: Electric Program Investment Charge (EPIC) Program

**Agenda Item Subject and Description:**

SirenOpt Inc. Proposed resolution approving agreement EPC-25-030 with SirenOpt Inc. for a $2,395,317 grant, and adopting staff's recommendation that this action is exempt from CEQA. This project will take place in Alameda County and advance innovative battery manufacturing inspection and process control technologies to the pilot-scale demonstration stage. (EPIC Funding) Contact: Lindsey Fransen

## G. California Environmental Quality Act (CEQA) Compliance

1. **Is Agreement considered a "Project" under CEQA?**
   Yes

   If yes, skip to question 2.

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

**2. If Agreement is considered a "Project" under CEQA answer the following questions.**

a) Agreement **IS** exempt?

Yes

Statutory Exemption?
No

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

PRC section number: None

CCR section number: None

Categorical Exemption?
Yes

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

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

Common Sense Exemption? 14 CCR 15061 (b) (3)
No

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

Cal. Code Regs. (CCR), Title 14, Section 15301 (Existing Facilities) consists of the operation, repair, maintenance or minor alteration of existing public or private structures, facilities, or mechanical equipment involving negligible or no expansion of existing or former use. This project will advance innovative battery manufacturing inspection and process control technologies to the pilot-scale demonstration stage through applied research and development and scalable integration into commercial research and development (R&D) electrode manufacturing (EM) workflows and high-volume EM lines, and by demonstrating how the inline electrode inspection solution will enable real-time process control and process optimization. The project will be carried out in two separate facilities, where work for the project will be moved near the beginning of the project from one facility (located in Oakland, California) to another facility (located in San Leandro, California).

The facility in Oakland, CA is approximately 3,000 square foot (sf) in size and includes combined office and lab space. At this facility there is no permitting required to conduct research and test equipment for this project, or to perform other work for this project as listed within its scope of work (SOW).

The facility in San Leandro, CA is approximately 10,000 sf in size and includes combined office and lab space. At this facility there is no permitting required to conduct research and test equipment for this project, or to perform other work for this project as listed within its SOW.

To support SOW Subtask 3.2, a project partner has committed the use of their facility to support this project. The existing facility is located in Hayward, is approximately 20,818 sf in size, and includes combined office (including conference room, single office, kitchen, and multipurpose), wet lab, dry room, and shop space. Recipient will develop procedures for pairing the inline metrology sensor platform with the digital factory host at the partner's site and evaluate the metrology sensor's performance under relevant electrode manufacturing processing conditions. All performance testing will occur, and all equipment will be placed within the existing facility.

The project will involve negligible or no expansion of use beyond that existing at the time of the lead agency's determination. Specifically, the project includes operation of existing facilities, mechanical equipment, electronic and electrical equipment, and negligible change of use for each location. Additionally, the project will not result in the addition to floorspace of the existing structures, and there will be only minor interior alterations or construction associated with the project.

This project does not involve impacts on any particularly sensitive environment; 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.

For these reasons, the proposed work will not have any significant effect on the environment and falls under section 15301.

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 | $ | **$** |

## 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 |
|---|---|---|
| Microsoft Corporation | $11,250 | $3,750 |
| TBD- Equipment | $0 | $175,000 |
| TBD- Equipment | $0 | $20,000 |
| TBD- Equipment | $0 | $20,000 |
| TBD-Miscellaneous | $10,000 | $0 |
| TBD-Miscellaneous | $19,500 | $1,500 |
| TBD-Miscellaneous | $100,000 | $0 |
| TBD-Miscellaneous | $45,000 | $0 |
| TBD-Miscellaneous | $180,000 | $0 |
| TBD-Miscellaneous | $180,000 | $0 |
| TBD-Miscellaneous | $30,000 | $0 |
| TBD-Miscellaneous | $50,000 | $0 |
| TBD-Miscellaneous | $20,000 | $0 |
| Siemens Corporation | $0 | $11,200 |

## 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 | 24-25 | 301.001L | $ 2,395,317 |

**TOTAL Amount:** $ 2,395,317

R&D Program Area: TIEB: EDMF

Explanation for "Other" selection Not applicable

Reimbursement Contract #: Not applicable

Federal Agreement #:

## M. Recipient's Contact Information

### 1. Recipient's Administrator/Officer

Name: Clementine Honda

Address: 8000 Edgewater Dr Ste 200

City, State, Zip: Oakland, CA 94621-2042

Phone: 916-216-1231

E-Mail: clementine.honda@sirenopt.com

### 2. Recipient's Project Manager

Name: Jared O'Leary

Address: 8000 Edgewater Dr Ste 200

City, State, Zip: Oakland, CA 94621-2042

Phone: 925-330-3249

E-Mail: jared.oleary@sirenopt.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-23-318 |
| 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 | No |
| 5 | Awardee CEQA Documentation | No |

### Approved By

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

**Agreement Manager:** Benson Gilbert

**Approval Date:** 8/21/25

**Branch Manager:** Anthony Ng

**Approval Date:** 8/28/25

**Director:** Jonah Steinbuck delegated to Branch Manager

**Approval Date:** 8/28/25

# Exhibit A
# Scope of Work
# SirenOpt Inc.

## I. TASK ACRONYM/TERM LISTS

### A. Task List

| Task # | CPR[1] | Task Name |
|---|---|---|
| 1 | | General Project Tasks |
| 2 | | Prototype Inline Metrology Sensor on a Small-Scale Roll-to-Roll Electrode Coating Process |
| 3 | | Integration and Demonstration of the Inline Metrology Sensor at Pilot-Scale on at Least One Electrode Manufacturing Process |
| 4 | CPR | Development of Automated Data Acquisition and Machine Learning Pipelines for the Inline Metrology Sensor |
| 5 | | Real-Time Optimization and Control Demonstration Using the Inline Metrology Sensor on Pilot-Scale Electrode Manufacturing Process |
| 6 | | Evaluation of Project Benefits |
| 7 | | Technology/Knowledge Transfer Activities |

### B. Acronym/Term List

| Acronym/Term | Meaning |
|---|---|
| Analytics Suite | Generic term for the recipient's fully automated machine learning software. |
| CAM | Commission Agreement Manager |
| CAO | Commission Agreement Officer |
| CEC | California Energy Commission |
| CPR | Critical Project Review |
| CSI | Control Systems Integration |
| Data Historian | Generic term for the recipient's high-performance data historian. |
| EM | Electrode Manufacturing |
| ESS | Energy Storage System |
| EV | Electric Vehicle |
| LIB | Lithium-ion Batteries |
| Metrology Sensor | Generic term for the recipient's cold atmospheric plasma inspection tool. |
| ML | Machine Learning |
| MPC | Model Predictive Control (advanced multivariable feedback controller) |
| OEM | Original Equipment Manufacturer |
| PID | Proportional-Integral-Derivative Feedback Controller |
| R&D | Research and Development |
| TAC | Technical Advisory Committee |

## 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 pilot-scale demonstrations of the Recipient's real-time, high-resolution, and multi-property electrode inspection solution via

[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.

scalable integration into commercial research and development (R&D) electrode manufacturing (EM) workflows and high-volume EM lines, and to demonstrate how the inline electrode inspection solution will enable real-time process control and process optimization.

### B. Problem/ Solution Statement

**Problem**

While many companies are developing new battery materials, there is a significant opportunity to improve the cost, efficiency, and reliability of battery manufacturing in the near-term– particularly as it relates to process inspection, optimization, and control. As more and more batteries are deployed, the risk that poorly manufactured batteries result in thermal runaway or other failure conditions grows. There is a critical need for breakthrough inspection and real-time process control technologies that can be practically deployed for superior battery production. EM consists of a complex process train with multiple processing steps, each of which can introduce a quality issue on the line, and numerous interrelated parameters. A holistic, data-driven understanding of how process parameters and intermediates affect final cell properties is key to optimizing lithium-ion battery (LIB) production and meeting rising performance demands through scalable, cost-effective methods.

As LIB production continues to scale, inline measurement systems for measuring electrode properties become exponentially more challenging since it is not possible to check the key properties of every electrode at each processing step without compromising throughput. A real-time, inline, multi-measurement electrode metrology strategy is becoming indispensable for implementing smart manufacturing practices and advanced process control solutions to accelerate process optimization and yield ramp, reduce material waste, and result in higher precision and production throughput. Nonetheless, traditional EM metrology solutions rely on individual measurement techniques for different electrode properties (e.g., using lasers for thickness, beta-rays for mass loading, imaging systems for defects, etc.). In addition to being limited to indirectly measuring one property, these techniques often employ spot sizes that are too large (>10 mm) to detect certain defect types, cover a limited portion of the electrode surface, involve cumbersome process integration requirements, and/or cannot measure electrodes with certain chemistries or that are double-sided. There is a significant unmet demand for novel thin-film metrology solutions that enable inline, fast, and noninvasive measurement of electrode properties in manufacturing lithium-ion and next-generation batteries.

**Solution**

The Recipient has invented a thin film metrology platform, based on cold atmospheric plasmas, capable of non-destructively measuring multiple electrode properties simultaneously and in real time. This technology provides LIB manufacturers with critical EM information and functional testing capabilities that are otherwise unobtainable. These include real-time, sub-millimeter resolution, cross-web measurements of electrode mass loading, thickness, density, resistivity, conductivity, chemical composition, surface roughness, contamination levels, and defect identification, as demonstrated on over 45 different micro- and nano-structure materials provided by current and prospective customers.

### C. Goals and Objectives of the Agreement

# Exhibit A
# Scope of Work
# SirenOpt Inc.

**Agreement Goals**

The goal of this Agreement is to demonstrate the recipient's metrology sensor's capability and techno-economic value on pilot electrode production lines in detecting manufacturing issues earlier and with more sensitivity and spatial resolution than state-of-the-art inline electrode inspection methods.

Ratepayer Benefits:[2] This Agreement will result in the ratepayer benefits of:

- **Lower costs:** The metrology sensor can reduce battery cell costs by at least **$10/kWh** by increasing electrode manufacturing yields and reducing electrode-to-electrode variability and thus decreasing battery pack size. Aligned with SB32, SB100, SB 350, and AB 2514, this Project will enable lower cost electric vehicle (EV) and energy storage system (ESS) batteries and reduce scale-up time for next-generation batteries. According to some estimates, the $10/kWh battery cell price reduction projected above can make the median market price of new EVs less than those of median internal combustion engine vehicle prices by 2030.
- **Greater electricity reliability and increased safety:** California ratepayers have become increasingly vulnerable to power outages due to electrical equipment and infrastructure failures during wildfires, earthquakes, and landslides, which are exacerbated by the unreliability of current EV & ESS solutions at scale. Electrode defects, contaminants, and spatial gradients in key material properties such as density, thickness, and resistivity are some of the major causes of thermal runaway and undesirable variability of EV & ESS battery lifespan and performance in the field. These issues have led to multiple EV recalls, and fires and/or explosions at multiple ESS sites, including those sold to or deployed in California. This project will enable the metrology sensor to provide inline monitoring of electrode manufacturing, significantly reducing these risks.
- **Public Health:** Enabling faster EV & ESS adoption and reducing emissions protects the public's health (and especially the health of disadvantaged communities that are disproportionally affected by emissions) and helps the state meet its environmental and renewable energy goals in SB 32, AB 2514, SB 350, and SB 100.

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 enabling faster development of next-generation battery technologies in California. Providing fast, accurate, and otherwise unobtainable material inspection and functional testing capabilities for researchers, process developers, and manufacturers will accelerate the development and scaling of new processes and techniques. As a result, the metrology sensor can enable the commercialization of inherently safer and more reliable next-generation battery technologies such as Lithium-metal, Lithium-sulfur, solid-state, and Nickel-Zinc batteries. These next-generation batteries could

[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.

completely disrupt current cost constraints to widespread battery adoption and thus allow California to achieve its statutory energy goals (e.g., Governor Newsom's 2020 Executive Order to require sales of all new passenger vehicles to be zero-emission by 2035).

**Agreement Objectives**

The broad objectives of this Agreement are to:

- Scale inline metrology sensor technology for deployment in Lithium-ion and next-generation non-Lithium-ion (such as sodium-ion) battery electrode R&D and pilot production to help diversify California's energy storage solutions.
- Define system requirements and roadmap for commercial adoption based on customer feedback.
- Establish manufacturing systems and initial supply chain to enter low-rate production.
- Take the inline metrology sensor system from Technology Readiness Level (TRL) 3 to TRL 7, Manufacturing Readiness Level (MRL) 3 to MRL 8, and Commercialization Readiness Level (CRL) 2 to CRL 4 (as detailed in the Project Narrative).

The specific objectives of this Agreement are to:

- Create and validate a prototype inline metrology sensor on a small-scale roll-to-roll electrode coating process.
- Integrate and demonstrate the inline metrology sensor at pilot-scale on an electrode manufacturing process.
- Develop automated data acquisition and machine learning (ML) pipelines for the inline metrology sensor.
- Demonstrate real-time optimization and control using the inline metrology sensor on a pilot-scale electrode manufacturing process.

## 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, 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 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

***MONTHLY CALLS, REPORTS AND INVOICES***

**Subtask 1.5 Monthly Calls**

The goal of this task is to have calls at least monthly between the CAM and Recipient to verify that satisfactory and continued progress is made towards achieving the objectives of this Agreement on time and within budget.

The objectives of this task are to verbally summarize activities performed during the reporting period, to identify activities planned for the next reporting period, to identify issues that may affect performance and expenditures, to verify match funds are being proportionally spent concurrently or in advance of CEC funds or are being spent in accordance with an approved Match Funding Spending Plan, to form the basis for determining whether invoices are consistent with work performed, and to answer any other questions from the CAM. Monthly calls might not be held on those months when a quarterly progress report is submitted or the CAM determines that a monthly call is unnecessary.

**The CAM shall:**

- Schedule monthly calls.
- Provide questions to the Recipient prior to the monthly call.
- Provide call summary notes to Recipient of items discussed during call.

**The Recipient shall:**

- Review the questions provided by CAM prior to the monthly call
- Provide verbal answers to the CAM during the call.

**Product:**

- Email to CAM concurring with call summary notes.

**Subtask 1.6 Quarterly 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 reporting period, 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. Progress reports are due to the CAM the 10th day of each January, April, July, and October. The Quarterly Progress Report template can be found on the ECAMS Resources webpage available at: https://www.energy.ca.gov/media/4691
- Submit a monthly or quarterly *Invoice* on the invoice template(s) provided by the CAM.

**Recipient Products:**

- Quarterly Progress Reports
- Invoices

**CAM Product:**
- Invoice template

**Subtask 1.7 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 1.7.1 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 Products:**
- Energy Commission Style Manual
- Comments on Draft Final Report Outline
- Acceptance of Final Report Outline

**Subtask 1.7.2 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 requirements as described in the Final Report Template provided by the CAM.
- 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 not 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 SUBAWARDS*

### Subtask 1.8 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. 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 application 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 application 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 1.9 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 1.10 Obtain and Execute Subawards and Agreements with Site Hosts**
The goals of this subtask are to: (1) procure and execute subrecipients and site host agreements, as applicable, required to carry out the tasks under this Agreement; and (2) ensure that the subrecipients and site host agreements are consistent with the Agreement terms and conditions and the Recipient's own contracting policies and procedures.

**The Recipient shall:**
- Execute and manage subawards and coordinate subrecipients activities in accordance with the requirements of this Agreement.

- Execute and manage site host agreements and ensure the right to use the project site throughout the term of the Agreement, as applicable. A site host agreement is not required if the Recipient is the site host.
- Notify the CEC in writing immediately, but no later than five calendar days, if there is a reasonable likelihood the project site cannot be acquired or can no longer be used for the project.
- Incorporate this Agreement by reference into each subaward.
- Include any required Energy Commission flow-down provisions in each subaward, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subaward terms.
- Submit a *Subaward and Site Letter* to the CAM describing the subawards and any site host agreement needed or stating that no subawards or site host agreements are required.
- If requested by the CAM, submit a draft of each *Subaward* and any *Site Host Agreement* required to conduct the work under this Agreement.
- If requested by the CAM, submit a final copy of each executed *Subaward* and any *Site Host Agreement*.
- Notify and receive written approval from the CAM prior to adding any new subrecipient (see the terms regarding subrecipient additions in the terms and conditions).

**Products:**

- Subaward and Site Letter
- Draft Subawards *(if requested by the CAM)*
- Draft Site Host Agreement *(if requested by the CAM)*
- Final Subawards *(if requested by the CAM)*
- Final Site Host Agreement *(if requested by the CAM)*

***TECHNICAL ADVISORY COMMITTEE***

**Subtask 1.11 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 1.12 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 1.13 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

*Products that require a draft version are indicated by marking **"(draft and final)"** after the product name in the "Products" section of the task/subtask. If "(draft and final)" does not appear after the product name, only a final version of the product is required. **Subtask 1.1 (Products)** describes the procedure for submitting products to the CAM.*

### TASK 2: PROTOTYPE INLINE METROLOGY SENSOR ON A SMALL-SCALE ROLL-TO-ROLL ELECTRODE COATING PROCESS

The goals of this task are to design a multi-head inline metrology sensor with tunable spatial resolution and coverage that is compatible with double-sided electrode films and to test the sensor on a roll-to-roll electrode coating process acquired by the Recipient.

#### Subtask 2.1: Conduct Research to Inform Design of the Inline Metrology Sensor

The goal of this subtask is to perform sensitivity studies on the offline metrology sensor to inform design of the inline sensor with respect to the plasma jet geometry, electrode configuration and number of jet heads, and selection of detectors for real-time measurement of the electrical, chemical, and thermal interactions of plasma with an electrode sample.

**The Recipient shall:**

- Interact with stakeholders such as collaborators and customers to characterize common EM process disturbances and define specifications for an inline electrode inspection tool
- Design and conduct experiments on the offline metrology sensor platform to investigate the effects of key characteristics such as:
    - Plasma jet inner diameter, height, and electrode configuration
    - Type, configuration, and alignment of optical emission and infrared spectrometers, as well as waveform electrical measurements
    - Ambient temperature, humidity, and other common EM process disturbances on sensor performance
- Analyze data from the above experiments
- Prepare a *Metrology Sensor Sensitivity and Design Specifications Report* that includes, but is not limited to:

- An executive summary written for a non-technical audience
- A summary of findings from interactions with stakeholders
- A description of experiments performed, including the characteristics evaluated, evaluation methods, and equipment used
- A discussion of the findings from the experiments, including challenges, lessons learned, and next steps for overcoming remaining challenges, if any
- Design specifications for the inline metrology sensor
- This report should not disclose any confidential information

**Products:**

- Metrology Sensor Sensitivity and Design Specifications Report

**Subtask 2.2: Design and Integrate the Inline Metrology Sensor into an In-House Electrode Coating Process**

The goal of this subtask is to design, prototype, and test the inline metrology sensor on a small-scale electrode coating process.

**The Recipient shall:**

- Perform computer-aided design of the plasma sensor head, as guided by the results of Subtask 2.1
- Integrate the metrology sensor into the Recipient's small-scale roll-to-roll electrode coating process in partnership with EM collaborators
- Review and iterate on sensor design and prototyping until the design specifications are met, including evaluation of sensor performance under varying conditions such as different web speeds, tensions, and vibrations/oscillations, and of the influence of the sensor operating protocol on outcomes such as sensor coverage and size
- Prepare an *Inline Sensor Iterative Design and Performance Report* that includes, but is not limited to:
    - An executive summary that is written for a non-technical audience
    - Discussion of the process and computing tools used for designing the metrology sensor inline system
    - Protocols for inline sensor operation and integration into EM processes
    - A list of what disturbances and conditions the sensors were tested against
    - A summary of the results of the design iteration process
    - A discussion of the inline system performance during the electrode coating process, including technical issues experienced, lessons learned, and next steps for overcoming remaining challenges, if any
    - This report should not disclose any confidential information

**Products:**

- Inline Sensor Iterative Design and Performance Report

**Subtask 2.3: Design and Select Computer Hardware, Firmware, and Advanced Control System**

The goals of this subtask are to design computer hardware and firmware for the inline metrology sensor that are compatible with the automated data acquisition and analysis strategies of Task 4, and to design an embedded multivariable control system that will ensure safe and high-

performance inline metrology sensor operation in the presence of process variabilities and disturbances common in EM.

**The Recipient shall:**

- Develop low-level firmware for the Recipient's proprietary plasma control systems that addresses functions such as data collection, data processing, and on-unit model deployment
- Select hardware for functions such as segregated motion control and data coordination systems
- Design a hierarchical control system
- Select industrial-grade computing systems to streamline the data flow and enable real-time execution of ML software
- Design a constrained multivariable feedback control scheme that can automatically regulate the multiple inputs of the plasma sensor head using real-time measurements from the sensor head detectors
- Embed the constrained multivariable feedback control scheme on resource-limited edge hardware to enable safe and fast operation of the inline metrology sensor
- Prepare a *Hardware, Firmware, and Advanced Control System Design Report* that includes, but is not limited to:
    - An executive summary written for a non-technical audience
    - Descriptions of the hardware, firmware, and computing systems selected, including design specifications
    - A description of the advanced control system, including design specifications
    - An overview of the metrics for gauging the performance of the system
    - A discussion of results from embedding the control system on edge hardware, including technical issues experienced, lessons learned, and next steps for overcoming remaining challenges, if any
    - This report should not disclose any confidential information

**Products:**

- Hardware, Firmware, and Advanced Control System Design Report

**TASK 3 INTEGRATION AND DEMONSTRATION OF THE INLINE METROLOGY SENSOR AT PILOT-SCALE ON AT LEAST ONE ELECTRODE MANUFACTURING PROCESS**

The goal of this task is to perform validation testing in electrode coating, drying, and calendering processes at a stakeholder's (e.g., customer's) pilot production facilities.

**Subtask 3.1: Inline Metrology Sensor Demonstration on Pilot-Scale Anode and Cathode**

The goal of this subtask is to evaluate the performance of the inline metrology sensor for real-time anode and cathode inspection in various EM processes, such as coating, drying, and calendering, at the pilot scale.

**The Recipient shall:**

- Develop a validation plan and define success measures with input from a stakeholder(s) (e.g., customer) for the anode manufacturing processes
- Develop a validation plan and define success measures with input from a stakeholder(s) (e.g., customer) for the cathode manufacturing processes

- Install and commission the inline metrology sensor system and train operators at a stakeholder's (e.g., customer's) site
- Execute validation tests that quantify the metrology sensor's performance in the context of the success measures developed in the above bullet points. Example tests may include material property measurement accuracies at different line speeds and environmental conditions (e.g., mass loading accuracy at line speed of 30 m/min at 50% humidity and 25 degrees Celsius).
- Prepare a *Metrology Sensor Pilot Success Measures and Validation Report* that includes, but is not limited to:
    - An executive summary written for a non-technical audience
    - An overview of the success measures used and why they were chosen
    - A summary of the validation process employed
    - A discussion of the findings of the validation tests, including technical challenges experienced, lessons learned, and next steps for overcoming remaining challenges, if any
    - This report should not disclose any confidential information

**Products:**

- Metrology Sensor Pilot Success Measures and Validation Report

**Subtask 3.2: Optimize Factory Host Integration, Data Capture, and Back-End Analytics**
The goal of this subtask is to develop procedures for pairing the inline metrology sensor platform with the digital factory host at a partner's site, and to evaluate the metrology sensor's performance under relevant EM processing conditions.

**The Recipient shall:**

- Develop procedures for the integration of the metrology sensor's data acquisition and ML pipeline with the digital factory host
- Evaluate the pairing of the metrology sensor with the digital factory host
- Design informative experiments with the host
- Perform testing and validation of the inline metrology sensor under diverse process variabilities and disturbances
- Evaluate performance and modify the metrology sensor design and / or inline integration procedures accordingly
- Prepare a *Metrology Sensor Digital Factory Host Integration and Evaluation Report* that includes, but is not limited to:
    - An executive summary written for a non-technical audience
    - A list of digital factory host integration protocols developed
    - A discussion of the findings of the integration evaluation, including technical issues experienced, lessons learned, and next steps for overcoming remaining challenges, if any
    - A summary of the performance assessment experimental design, including performance metrics used and target performance specifications
    - A discussion of experimental outcomes, such as any metrology sensor design or integration procedure modifications made, technical issues experienced, lessons learned, and next steps for overcoming remaining challenges, if any
    - This report should not disclose any confidential information

**Products:**

- Metrology Sensor Digital Factory Host Integration and Evaluation Report

**Subtask 3.3: Develop Detailed Integration Procedure and Safety Protocols for High-Volume Production Lines**

The goal of this subtask is to develop relevant integration procedures and safety protocols to enable fast deployment and scalability to additional high-volume manufacturing lines.

**The Recipient shall:**

- Develop and evaluate procedures for integration of the inline metrology sensor considering features such as wiring, power supply, and sensor positioning in EM lines
- Develop and evaluate protocols for safe sensor deployment in EM lines
- Prepare a *Metrology Sensor Integration Procedures and Safety Protocols Report* that includes, but is not limited to:
    - An executive summary written for a non-technical audience
    - A list of procedures and protocols developed
    - A discussion of the findings from evaluating the procedures and protocols, including technical issues experienced, lessons learned, and next steps for overcoming remaining challenges, if any
    - This report should not disclose any confidential information

**Products:**

- Metrology Sensor Integration Procedures and Safety Protocols Report

**TASK 4 DEVELOPMENT OF AUTOMATED DATA ACQUISITION AND MACHINE LEARNING PIPELINES FOR THE INLINE METROLOGY SENSOR**

The goal of this task is to design and implement a data storage system, edge computing software for data processing, and machine learning (ML) framework to analyze data; and to test and validate these systems on an in-house roll-to-roll electrode coating process.

**Subtask 4.1: Design a High-Performance Data Historian for Real-Time Inline Sensing Applications, Develop Edge Computing Software, and Implement Fully Automated Machine Learning Framework for End-to-End Modeling of Key Performance Indicators from Raw Sensor Data**

The goal of this subtask is to design and implement a robust system for managing high-frequency sensor data in real time; develop lightweight edge computing software to enable efficient, real-time data processing directly at the point of measurement; and develop an automated framework (“analytics suite”) for analyzing key performance indicators based on sensor data, reducing the need for manual intervention.

**The Recipient shall:**

- Design a dual-layer data historian architecture featuring:
    - A cloud-based data lake for long-term data archiving
    - A relational database management system for high-speed access to critical, real-time data
- Develop data ingestion pipelines to ensure low-latency transfer of sensor data from the edge to the historian system

- Implement a ML model registry to facilitate the storage, retrieval, and deployment of trained models
- Create preprocessing pipelines for normalization and feature extraction to streamline data flow to the data historian
- Use frameworks such as TensorRT and ONNX Runtime to optimize model execution for sub-second latency
- Integrate the software with hardware developed in earlier tasks to ensure seamless operation and compatibility
- Validate the software's performance under realistic operating conditions to confirm robustness and efficiency
- Implement modules for feature extraction, ML model training, and hyperparameter optimization
- Integrate the analytics suite with the data historian for seamless ML model deployment
- Validate the framework's ability to analyze and extract actionable insights under real-time constraints
- Prepare a *Sensor Data Storage and Analysis Report* that includes, but is not limited to:
    - An executive summary written for a non-technical audience
    - A description of the data storage system architecture design
    - A discussion of how the ML model registry is implemented in the data storage system, including technical issues experienced, lessons learned, and next steps for overcoming remaining challenges, if any
    - A discussion of the development process for the software, including technical issues experienced, lessons learned, and next steps to overcoming remaining challenges, if any
    - A summary of the results of software performance tests
    - A list of modules included in the ML framework
    - A discussion of the findings from the framework validation efforts, including technical issues experienced, lessons learned, and next steps for overcoming remaining challenges, if any
    - This report should not disclose any confidential information

**Products:**

- Sensor Data Storage and Analysis Report

**Subtask 4.2: Test and Validate the Data Historian and Analytics Suite on In-House Roll-to-Roll Electrode Coating Process**

The goal of this subtask is to test and validate the data historian and the analytics suite as part of the fully integrated metrology sensor ecosystem on a representative manufacturing process.

**The Recipient shall:**

- Integrate all system components, including the data historian, the analytics suite, and edge computing software, into the roll-to-roll electrode coating process
- Debug and refine hardware and software interfaces to ensure seamless operation
- Perform validation tests to evaluate system performance for real-time inline inspections, focusing on accuracy and robustness
- Prepare an *Integrated Software Suite for Inspection of Roll-to-Roll Electrode Coating Process Report* that includes, but is not limited to:

  - An executive summary written for a non-technical audience
  - An overview of the design of validation tests and system performance metrics
  - A discussion of the findings of the validation tests, including technical issues experienced, lessons learned, and next steps for overcoming remaining challenges, if any
  - This report should not disclose any confidential information
- Prepare a *CPR Report*, per subtask 1.3. This report should also summarize system performance, technical challenges, and lessons learned from this project and this specific task (task 4). This report should not disclose any confidential information.
- Participate in a CPR meeting per subtask 1.3

**Products:**
- Integrated Software Suite for Inspection of Roll-to-Roll Electrode Coating Process Report
- CPR Report

**TASK 5 REAL-TIME OPTIMIZATION AND CONTROL DEMONSTRATION USING THE INLINE METROLOGY SENSOR ON PILOT-SCALE ELECTRODE MANUFACTURING PROCESS**

The goal of this task is to demonstrate the ability of the platform to detect and correct various anomalies in the pilot-scale electrode manufacturing process and to develop and demonstrate a self-tuning control system that dynamically optimizes controller parameters.

**Subtask 5.1: Deploy the Analytics Suite for Real-Time Quality Monitoring Using ML-Based Anomaly Detection Methods with a Partner.**

The goal of this subtask is to deploy the analytics suite software to enable real-time anomaly detection for properties like film thickness and mass loading.

**The Recipient shall:**
- Train and optimize anomaly detection models using historical and experimental data from the metrology sensor measurements
- Deploy these models on edge computing hardware at a partner's facility to ensure real-time performance
- Integrate the deployed system with metrology sensor hardware to monitor the manufacturing process and flag deviations for operator intervention
- Prepare a *Real-Time Anomaly Detection in Electrode Manufacturing Report* that includes, but is not limited to:
  - An executive summary written for a non-technical audience
  - An explanation of the training process for detection models
  - A discussion of the integration and performance of the deployed system, including technical issues experienced, lessons learned, and next steps for overcoming remaining challenges, if any
  - This report should not disclose any confidential information

**Products**
- Real-Time Anomaly Detection in Electrode Manufacturing Report

**Subtask 5.2: Develop a Multivariable Feedback Control System and Application to Simultaneously Control Mass Loading and Film Thickness in the Pilot-Scale Electrode Manufacturing Process.**
The goal of this subtask is to implement a multivariable feedback control system using Model Predictive Control (MPC) to regulate both mass loading and thickness simultaneously.

**The Recipient shall:**

- Conduct dynamic experiments to evaluate manipulated variables (e.g., coating gap, drying airflow) and their impact on thickness control
- Develop and tune a Proportional-Integral-Derivative Feedback Controller (PID) control system based on the experimental results and integrate it with the metrology sensor platform
- Test and validate the PID control system under pilot-scale manufacturing conditions to maintain thickness within strict tolerances
- Perform dynamic experiments to generate process data and build system identification models for controlled and manipulated variables
- Develop and implement the MPC framework, accounting for constraints and dynamic interactions between variables
- Validate the integrated MPC system under representative pilot-scale disturbances to ensure real-time feasibility and robust performance
- Prepare an *MPC System for Electrode Manufacturing Report* that includes, but is not limited to:
    - An executive summary written for a non-technical audience
    - A description of the PID framework deployed
    - A description of the MPC framework employed
    - A discussion of findings from pilot-scale deployment and validation of the MPC system, including the validation test design, technical issues experienced, lessons learned, a comparison of PID and MPC performance, and next steps for overcoming remaining challenges, if any.
    - This report should not disclose any confidential information

**Products**

- MPC System for Electrode Manufacturing Report

**Subtask 5.3: Develop and Demonstrate Safety-Aware, Self-Tuning Control Technology for Adaptive Performance Optimization Using Closed-Loop Metrology Sensor Data.**
The goal of this subtask is to develop and demonstrate a self-tuning control system that dynamically optimizes controller parameters using safety-aware Bayesian optimization.

**The Recipient shall:**

- Develop a safety-aware self-tuning optimization algorithm to iteratively refine control parameters using high-resolution metrology sensor data
- Integrate the self-tuning framework into the existing control system and validate its performance under non-stationary process conditions
- Demonstrate the framework's ability to improve control system performance while maintaining compliance with safety constraints
- Prepare a *Control Systems Integration for Electrode Manufacturing Report* that includes, but is not limited to:

- An executive summary written for a non-technical audience
- A discussion of the development process for the iterative, self-tuning control algorithm, including technical issues experienced, lessons learned, and next steps for overcoming remaining challenges, if any
- A review of validation test design and performance metrics used
- A roadmap to commercial adoption for the entire metrology system, which is heavily based on partner feedback in Tasks 2-5.
- This report should not disclose any confidential information

**Products**

- Controls Systems Integration for Electrode Manufacturing Report

**TASK 6: 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 7: 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.