STATE OF CALIFORNIA

# GRANT REQUEST FORM (GRF)

CEC-270 (Revised 10/2015) CALIFORNIA ENERGY COMMISSION

New Agreement EPC-18-024 (To be completed by CGL Office)

| Division | Agreement Manager: | MS- | Phone |
|---|---|---|---|
| ERDD | Bryan Lee | 43 | 916-327-1414 |

| Recipient's Legal Name | Federal ID Number |
|---|---|
| Element 16 Technologies, Inc | 81-3026272 |

| Title of Project |
|---|
| Large-Scale Sulfur Thermal Battery Demonstration for Enhanced Grid Flexibility and Increased Renewable |

| Term and Amount | Start Date | End Date | Amount |
|---|---|---|---|
| | 6/28/2019 | 3/30/2023 | $ 3,000,000 |

**Business Meeting Information**

☐ ARFVTP agreements under $75K delegated to Executive Director.

| | | | |
|---|---|---|---|
| Proposed Business Meeting Date | 6/12/2019 | ☐ Consent | ☒ Discussion |
| Business Meeting Presenter | Qing Tian | Time Needed: | 5 minutes |

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

**Agenda Item Subject and Description**

ELEMENT 16 TECHNOLOGIES, INC. Proposed resolution approving Agreement EPC-18-024 with Element 16 Technologies, Inc. for a $3,000,000 grant to demonstrate a sulfur thermal battery technology for stationary storage and power generation, and field test converting the stored thermal energy to electricity in real-time, and adopting staff's determination that this action is exempt from CEQA. (EPIC funding) Contact: Qing Tian (Staff presentation: 5 minutes)

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

2. If Agreement is considered a "Project" under CEQA:
   ☒ a) Agreement **IS** exempt. (Attach draft NOE)
   ☐ Statutory Exemption. List PRC and/or CCR section number:
   ☒ Categorical Exemption. List CCR section number: Cal. Code Regs., tit 14, § 15301
   ☐ Common Sense Exemption. 14 CCR 15061 (b) (3)
   Explain reason why Agreement is exempt under the above section:
   This project is exempt under Cal.Code Regs.,tit 14, § 15301. This grant will fund design, development, installation and testing of sulfur thermal battery technology in existing manufacturing and testing facilities which will result in minor alteration of the existing facilities and involve negligible expansion to use and will not have a significant effect on the environment.

   ☐ b) Agreement **IS NOT** exempt. (Consult with the legal office to determine next steps.)
   Check all that apply
   ☐ Initial Study ☐ Environmental Impact Report
   ☐ Negative Declaration ☐ Statement of Overriding Considerations
   ☐ Mitigated Negative Declaration

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

| Legal Company Name: | Budget |
|---|---|
| Exponent Engineering, P.C. | $ 90,000 |
| Brad Alan LLC. | $ 95,000 |
| | $ |
| | $ |
| | $ |

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| **List all key partners:** (attach additional sheets as necessary) |
|---|
| Legal Company Name: |
| |
| |
| |
| |

| **Budget Information** | | | |
|---|---|---|---|
| **Funding Source** | **Funding Year of Appropriation** | **Budget List No.** | **Amount** |
| EPIC | 17-18 | 301.001E | $262,119 |
| EPIC | 18-19 | 301.001F | $2,737,881 |
| | | | $ |
| | | | $ |
| | | | $ |
| | | | $ |
| R&D Program Area: ESRO: ETSI | | TOTAL: | $3,000,000 |
| Explanation for "Other" selection | | | |
| Reimbursement Contract #: | | Federal Agreement #: | |

| **Recipient's Administrator/ Officer** | | | | **Recipient's Project Manager** | | | |
|---|---|---|---|---|---|---|---|
| Name: | Hamarz Aryafar | | | Name: | Hamarz Aryafar | | |
| Address: | 2038 Buckingham Pl | | | Address: | 2038 Buckingham Pl | | |
| City, State, Zip: | Glendale, CA 91206-1401 | | | City, State, Zip: | Glendale, CA 91206-1401 | | |
| Phone: | 619-254-4270 / | Fax: | - - | Phone: | 619-254-4270 / | Fax: | - - |
| E-Mail: | hamarz@e16tech.com | | | E-Mail: | hamarz@e16tech.com | | |

| **Selection Process Used** |
|---|
| ☒ Competitive Solicitation Solicitation #: GFO-18-304 |
| ☐ First Come First Served Solicitation |

| **The following items should be attached to this GRF** | | |
|---|---|---|
| 1. Exhibit A, Scope of Work | | ☒ Attached |
| 2. Exhibit B, Budget Detail | | ☒ Attached |
| 3. CEC 105, Questionnaire for Identifying Conflicts | | ☒ Attached |
| 4. Recipient Resolution | ☒ N/A | ☐ Attached |
| 5. CEQA Documentation | ☐ N/A | ☒ Attached |

| Agreement Manager | Date | Office Manager | Date | Deputy Director | Date |
|---|---|---|---|---|---|

# EXHIBIT A
# Scope of Work

## I. TASK ACRONYM/TERM LISTS

### A. Task List

| Task # | CPR[1] | Task Name |
|---|---|---|
| 1 | | General Project Tasks |
| 2 | | System Performance and Cost Modeling |
| 3 | X | Design Optimization |
| 4 | | Construction of Pilot Module |
| 5 | X | Installation, Testing, and Data Analysis |
| 6 | | Commission and Demonstrate the Low-Cost Sulfur Thermal Battery System |
| 7 | | Measurement and Verification |
| 8 | | Market Analysis and Economic Impact |
| 9 | | Evaluation of Project Benefits |
| 10 | | Technology/Knowledge Transfer Activities |

### B. Acronym/Term List

| Acronym/Term | Meaning |
|---|---|
| BOS | Balance of System |
| CAM | Commission Agreement Manager |
| CAO | Commission Agreement Officer |
| CPR | Critical Project Review |
| Disadvantaged Community | Communities defined as areas representing census tracts scoring in the top 25 % in CalEnviroScreen 3.0. (https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30) |
| GHG | Greenhouse Gas |
| HTF | Heat Transfer Fluid |
| LCOS | Levelized Cost of Storage [$/kWhe] |
| TAC | Technical Advisory Committee |
| TRL | Technology Readiness Level |

## 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 optimization, construction, installation, and demonstration of a low-cost (less than the DOE goal of $15/kWht) sulfur thermal battery that can store and discharge electricity for the purpose of energy savings, electricity bill savings, greenhouse gas (GHG) emissions reductions and water use reductions.

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

# EXHIBIT A
# Scope of Work

## B. Problem/ Solution Statement

**Problem**
Stationary electrical energy storage plays several important roles in the electricity system to enhance grid reliability and flexibility, and these are expected to grow as the grid continues to evolve with increased penetration of highly variable renewable sources such as wind and solar. Pumped hydroelectric energy storage is by far the largest source of stationary electricity storage on the grid today. However, installation of this technology is severely limited by geographic location and difficulties in permitting new sites and financing larger projects. Compressed air energy storage systems also suffer from the same challenges. Electrochemical batteries, especially Li-ion, are being researched the most for deployment on the grid, but their high cost limits their viability in large-scale and long duration applications. Thermal energy storage presents the best option of competing with pumped hydroelectric energy storage but the current state-of-the-art two-tank molten salt thermal storage concept is cost prohibitive for wide scale adoption.

**Solution**
This project will optimize design, construct, install, and demonstrate a low-cost sulfur thermal battery technology at up to 400 kWhe for discharge duration of approximately 8-12 hours that represents approximately >40% higher scale up in energy from the previously awarded Energy Commission project. The sulfur thermal battery will be demonstrated in an existing facility, a manufacturing space served by Southern California Edison or other suitable site as approved by the CAM. Sulfur provides a low-cost energy storage solution due to its low/negative cost, simple chemical composition, and high heat transfer rates. The recipient's sulfur thermal battery technology can be deployed and operated independently of geographic condition. In addition, the charge rate, discharge rate and storage capacity can be independently scaled to maximize benefits. The thermal battery technology can fulfill the requirements of both daily-cycling (daily energy time shift applications with typical discharge time of 8 to 10 hours, 'black-start' capacity with typical discharge duration ~ minutes to 1 hour) and non-daily cycling (back-up power applications with typical discharge time > 10 hours). Installation and demonstration of the storage system at the aforementioned scale and in an actual operating environment exceeds the solicitation's target and will advance the technology to a state where it can attract significant interest and investment from the private sector.

## C. Goals and Objectives of the Agreement

**Agreement Goals**
The goals of this Agreement are to optimize design, construct, install and demonstrate a low-cost sulfur thermal battery technology for electricity storage and power. This proposed project will demonstrate the technology at up to 400 kWhe (1500 kWht) for discharge duration of approximately 8-12 hours, which would represent >40% higher scale up in energy of the recipient's technology. The recipient's previous pilot demonstrations involved development and testing of sulfur thermal storage over 1110 °F and a 30-$kWh_t$ pilot demonstration of the storage system integrated with a concentrating solar power dish system.

Ratepayer Benefits:[2] This Agreement will result in the ratepayer benefits of greater electricity reliability, lower costs and increased safety by:

[2] California Public Resources Code, Section 25711.5(a) requires projects funded by the Electric Program Investment Charge (EPIC) to result in ratepayer benefits. The California Public Utilities Commission,

a. *Reliability*: The integration of low-cost distributed energy storage can help prevent blackouts and smooth overall grid operation (by functioning as non-spinning reserves) and provide long-lasting backup power during outages. It mitigates grid transmission congestion and secure stable electricity supply. This demonstration will pave the way for California industrial facilities to reduce their electricity usage during peak demand times, thus reducing the load placed on the California electrical grid, help with the duck curve, and seasonal over-generation or under-generation of renewables.

b. *Lower Cost*: The low-cost sulfur thermal battery technology can reduce peak demand charges and on-peak electricity consumption, and provide energy arbitrage by accessing electricity when it is cheapest, thereby ensuring customer bill savings. With the ability to capture excess electricity from renewables for later use, the thermal battery technology can allow renewable generation plants to operate at the optimal efficiency and deliver on-peak electricity at a lower cost than gas-fired Peaker plants.

*c.* *Increased Safety*: By capturing excess renewable energy generation for later use, the sulfur thermal battery technology reduces or avoids the curtailment of renewable energy and displaces the use of fossil fuels to generate electricity. The technology also minimizes the need to build conventional generation and peaking plants to serve as backup to California grids that use an increased amount of renewable energy. This will greatly reduce GHG emissions from the fossil-fueled power plants and improve air quality.

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 developing and deploying a low-cost sulfur thermal battery for electricity storage and power generation. Specifically, the development of this low-cost sulfur thermal battery technology will enhance grid resiliency, support the transmission and distribution infrastructure, and will provide low-cost, long-duration electric storage capacity to the California grid. This directly addresses adoption of energy storage procurement mandate for investor owned utilities to install 1325 MW (addition of a supplementary 500 MW target) of storage before 2024 for a reliable and affordable electricity supply. Electrically charging the low-cost sulfur thermal battery gives rise to system flexibility with respect to coupling to different types of energy sources and will drive the expansion of intermittent renewable sources such as wind and solar in California (California Energy Commission 2015-2017 EPIC Investment Plan, *S15 Strategic Objective: Demonstrate Advanced Energy Storage Interconnection Systems to Lower Costs, Facilitate Market and Improve Grid Reliability*).

**Agreement Objectives**

The primary objectives of this Agreement are to:

A. Demonstrate novel, low-cost sulfur thermal battery technology for electricity storage and generation to achieve a Technology Readiness Level (TRL) of 9 and prime the technology for commercial investment from investors.

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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.

B. Demonstrate the use of sulfur thermal battery to provide back-up power for the facility to reduce its dependence on the grid.
C. Demonstrate the economic benefits, electricity savings, peak load reduction and shifting, energy cost reductions, greenhouse gas emission reductions, and efficiency improvements of integrating sulfur thermal battery in a facility located within a Disadvantaged Community.

## 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).** 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 Energy Commission's 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 or CD-ROM.

The following describes the accepted formats for electronic data and documents provided to the Energy Commission 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.
- Documents intended for public distribution will be in PDF file format.
- The Recipient must also provide the native Microsoft file format.
- Project management documents will be in Microsoft Project file format, version 2007 or later.

o **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 Energy Commission's Information Technology Services Branch to determine whether the exceptions are allowable.

## *MEETINGS*

**Subtask 1.2 Kick-off Meeting**

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

**The Recipient shall:**

- Attend a "Kick-off" meeting with the CAM, the Commission Agreement Officer (CAO), and any other Energy Commission staff relevant to the Agreement. The Recipient will bring its Project Manager and any other individuals designated by the CAM to this meeting. The

administrative and technical aspects of the Agreement will be discussed at the meeting. Prior to the meeting, the CAM will provide an agenda to all potential meeting participants. The meeting may take place in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

The administrative portion of the meeting will include discussion of the following:
- Terms and conditions of the Agreement;
- Administrative products (subtask 1.1);
- CPR meetings (subtask 1.3);
- Match fund documentation (subtask 1.7);
- Permit documentation (subtask 1.8);
- Subcontracts (subtask 1.9); and
- Any other relevant topics.

The technical portion of the meeting will include discussion of the following:
- The CAM's expectations for accomplishing tasks described in the Scope of Work;
- An updated Project Schedule;
- Technical products (subtask 1.1);
- Progress reports and invoices (subtask 1.5);
- Final Report (subtask 1.6);
- Technical Advisory Committee meetings (subtasks 1.10 and 1.11); and
- Any other relevant topics.

- Provide an *Updated Project Schedule, List of Match Funds,* and *List of Permits*, 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:**
- Updated Project Schedule *(if applicable)*
- Updated List of Match Funds *(if applicable)*
- Updated List of Permits *(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 Energy Commission 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 Energy Commission 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 Energy Commission.

CPR meetings generally take place at key, predetermined points in the Agreement, as determined by the CAM and as shown in the Task List on page 1 of this Exhibit. However, the CAM may

schedule additional CPR meetings as necessary. The budget will be reallocated to cover the additional costs borne by the Recipient, but the overall Agreement amount will not increase. CPR meetings generally take place at the Energy Commission, 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 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.
- Submit the CPR Report along with any other *Task Products* that correspond to the technical task for which the CPR meeting is required (i.e., if a CPR meeting is required for Task 2, submit the Task 2 products along with the CPR Report).
- 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* and a *List of Expected CPR Participants* in advance of the CPR meeting. If applicable, the agenda will include a discussion of match funding and permits.
- Conduct and make a record of each CPR meeting. Provide the Recipient with a *Schedule for Providing a Progress Determination* on continuation of the project.
- Determine whether to continue the project, and if so whether modifications are needed to the tasks, schedule, products, or budget for the remainder of the Agreement. If the CAM concludes that satisfactory progress is not being made, this conclusion will be referred to the Deputy Director of the Energy Research and Development Division.
- Provide the Recipient with a *Progress Determination* on continuation of the project, in accordance with the schedule. The Progress Determination may include a requirement that the Recipient revise one or more products.

**Recipient Products:**

- CPR Report(s)
- Task Products (draft and/or final as specified in the task)

**CAM Products:**

- CPR Agenda
- List of Expected CPR Participants
- Schedule for Providing a Progress Determination
- 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 Energy Commission staff to present project findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement. This meeting will be attended by the Recipient and CAM, at a minimum. The meeting may occur in person or by electronic conferencing (e.g., WebEx), with approval

of the CAM.

The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be divided into two separate meetings at the CAM's discretion.

- The technical portion of the meeting will involve the presentation of findings, conclusions, and recommended next steps (if any) for the Agreement. The CAM will determine the appropriate meeting participants.
- The administrative portion of the meeting will involve a discussion with the CAM and the CAO of the following Agreement closeout items:
  - Disposition of any state-owned equipment.
  - Need to file a Uniform Commercial Code Financing Statement (Form UCC-1) regarding the Energy Commission's interest in patented technology.
  - The Energy Commission'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 *All Draft and Final Written Products* on a CD-ROM or USB memory stick, organized by the tasks in the Agreement.

**Products:**

- Final Meeting Agreement Summary *(if applicable)*
- Schedule for Completing Agreement Closeout Activities
- All Draft and Final Written Products

## *REPORTS AND INVOICES*

**Subtask 1.5 Progress Reports and Invoices**

The goals of this subtask are to: (1) periodically verify that satisfactory and continued progress is made towards achieving the project objectives of this Agreement; and (2) ensure that invoices contain all required information and are submitted in the appropriate format.

**The Recipient shall:**

- Submit a monthly *Progress Report* to the CAM. Each progress report must:
  - Summarize progress made on all Agreement activities as specified in the scope of work for the preceding month, including accomplishments, problems, milestones, products, schedule, fiscal status, and an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. See the Progress Report Format Attachment for the recommended specifications.
- Submit a monthly or quarterly *Invoice* that follows the instructions in the "Payment of Funds" section of the terms and conditions, including a financial report on Match Fund 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. The CAM will review the Final Report, which will be due at least **two months** before the Agreement end date. When creating the Final Report Outline and the Final Report, the Recipient must use the 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 *Style Manual* provided by the CAM. *(See Task 1.1 for requirements for draft and final products.)*

**Recipient Products:**
- Final Report Outline (draft and final)

**CAM Product:**
- 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, Style Manual, and Final Report Template provided by the CAM with the following considerations:
  - Ensure that the report includes the following items, in the following order:
    - Cover page (**required**)
    - Credits page on the reverse side of cover with legal disclaimer (**required**)
    - Acknowledgements page (optional)
    - Preface (**required**)
    - Abstract, keywords, and citation page (**required**)
    - Table of Contents (**required**, followed by List of Figures and List of Tables, if needed)
    - Executive summary (**required**)
    - Body of the report (**required**)
    - References (if applicable)
    - Glossary/Acronyms (If more than 10 acronyms or abbreviations are used, it is required.)
    - Bibliography (if applicable)
    - Appendices (if applicable) (Create a separate volume if very large.)
    - Attachments (if applicable)
  - Ensure that the document is written in the third person.
  - Ensure that the Executive Summary is understandable to the lay public.
    - Briefly summarize the completed work. Succinctly describe the project results and whether or not the project goals were accomplished.

        - Identify which specific ratepayers can benefit from the project results and how they can achieve the benefits.
        - If it's necessary to use a technical term in the Executive Summary, provide a brief definition or explanation when the technical term is first used.
    - Follow the Style Guide format requirements for headings, figures/tables, citations, and acronyms/abbreviations.
    - Ensure that the document omits subjective comments and opinions. However, recommendations in the conclusion of the report are allowed.
    - Include a brief description of the project results in the Abstract.
- 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
- Consider incorporating all CAM comments into the Final Report. 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 Final Report 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.
- Submit one bound copy of the *Final Report* to the CAM along with *Written Responses to Comments on the Draft Final Report*.

**Products**:
- Final Report (draft and final)
- Written Responses to Comments on the Draft 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 Energy Commission 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 Energy Commission 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 Energy Commission 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 <u>no permits</u> 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 the 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.

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, and a summary of relevant experience and potential value to the project. The list will be discussed at the Kick-off meeting, and a schedule for recruiting members and holding the first TAC meeting will be developed.
- Recruit TAC members. Ensure that each individual understands member obligations and the TAC meeting schedule developed in subtask 1.11.
- Prepare a *List of TAC Members* once all TAC members have committed to serving on the TAC.
- Submit *Documentation of TAC Member Commitment* (such as Letters of Acceptance) from each TAC member.

**Products:**

- List of Potential TAC Members
- List of TAC Members
- Documentation of TAC Member Commitment

**Subtask 1.11 TAC Meetings**

The goal of this subtask is for the TAC to provide strategic guidance for the project by participating in regular meetings, which may be held via teleconference.

**The Recipient shall:**

- Discuss the TAC meeting schedule with the CAM at the Kick-off meeting. Determine the number and location of meetings (in-person and via teleconference) in consultation with the CAM.
- Prepare a *TAC Meeting Schedule* that will be presented to the TAC members during recruiting. Revise the schedule after the first TAC meeting to incorporate meeting comments.
- Prepare a *TAC Meeting Agenda* and *TAC Meeting Back-up Materials* for each TAC meeting.
- Organize and lead TAC meetings in accordance with the TAC Meeting Schedule. Changes to the schedule must be pre-approved in writing by the CAM.

- Prepare *TAC Meeting Summaries* that include any recommended resolutions of major TAC issues.

**Products:**

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

## 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 SYSTEM PERFORMANCE AND COST MODELING

The goals of this task are to (1) adapt the in-house system design and cost modeling tool of the low cost sulfur thermal battery for the proposed installation and demonstration, and (2) optimize the low cost sulfur thermal battery system sizing and design for high round trip efficiency performance and lower levelized cost of storage (LCOS). The major components of the low-cost sulfur thermal battery system include a thermal battery module, heat exchangers, electric heaters, and a power generation unit.

**The Recipient shall:**

- Adapt thermodynamic in-house system/cost model to incorporate the major components of the low-cost sulfur thermal battery system.
- Simulate the charge and discharge process to calculate the overall electrical efficiency of the low cost sulfur thermal battery system.
- Perform parametric study to explore possible modes for maximizing sulfur thermal battery performance (energy and power) while reducing cost.
- Optimize the charging power, storage capacity and discharging power with the objective of minimizing LCOS.
- Prepare a *System Performance and Cost Modeling Report and Presentation* that describes:
  - The in-house modeling work;
  - A discussion of the thermal battery performance behavior during charge and discharge cycles;
  - A discussion of the round-trip electric efficiency of the thermal battery;
  - The results of the parametric study; and
  - The results of the optimization.

**Products:**

- System Performance and Cost Modeling Report and Presentation (draft and final)

### TASK 3 DESIGN OPTIMIZATION

The goal of this task is to use a computational model of the sulfur thermo-fluidic behavior to optimize the low cost sulfur thermal battery design for maximizing charge and discharge rates.

**The Recipient shall:**

- Develop a *Thermal Battery Computational Design Optimization Test Plan:*
  - Adapt computational model developed in the previous Energy Commission and DOE funded projects to quantify the charge/discharge performance of the low cost sulfur thermal battery to be installed and demonstrated.
  - Conduct sensitivity analysis of various design and operating parameters on charge and discharge rates of the low cost sulfur thermal battery.
  - Optimize the low cost sulfur thermal battery module design for maximum charge and discharge rates.

  - Use the computational tool and results to identify the appropriate sizing of other Balance of System (BOS) Components, including Heat transfer fluid (HTF) pump, HTF electric heater, and HTF heat exchangers.
- Prepare a *Thermal Battery Design and Optimization Report* that describes:
  - The in-house computational modeling work;
  - A discussion of the performance of the thermal battery during charge and discharge.
  - The results of the parametric study.
  - Optimal design of the thermal battery.
  - Procurement strategy of the thermal battery and BOS components.
- Participate in a CPR meeting in accordance with Task 1.3 and prepare CPR Report #1

**Products:**
- Thermal Battery Computational Design Optimization Test Plan (draft and final)
- Thermal Battery Design and Optimization Report (draft and final)
- CPR Report #1 (draft and final)

**TASK 4 CONSTRUCTION OF PILOT MODULE**
The goal of this task is to construct the newly optimized low cost sulfur thermal battery module.

**The Recipient shall:**
- Develop final low cost sulfur thermal battery system design based on results of Task 3.
- Purchase all required components for the manufacturing of the low cost sulfur thermal battery module.
- Determine lead times for construction.
- Develop tentative schedule for assembly and construction.
- Catalogue components as they arrive.
- Construct the optimized low cost thermal battery module.
- Prepare *Sulfur Thermal Battery Fabrication Report* that describes the materials used for construction and the fabrication procedure.

**Products:**
- Sulfur Thermal Battery Fabrication Report (draft and final)

**TASK 5 INSTALLATION, TESTING, AND DATA ANALYSIS**
The goal of this task is to install the thermal battery module constructed in Task 4 and Balance of System (BOS) components namely, heat transfer fluid (HTF) pump, HTF electric heater, and HTF heat exchangers that are procured from off-the-shelf materials, develop the controller architecture, and install and test the performance of the thermal battery module to establish its performance.

**The Recipient shall:**
- Purchase all required BOS components (oil pump, oil electric heater, oil heat exchanger) off-the-shelf:
- Determine lead times for installation.
- Develop tentative schedule for assembly and construction.
- Catalogue components as they arrive.
- Develop and build the controller framework for the low cost sulfur thermal battery module.

- Develop a *Thermal Battery Test Plan* to measure and characterize the thermal battery performance.
- Carry out tests and research the module and BOS capabilities and performance.
- Analyze data and compare module performance to computational model (Task 2).
- Prepare *Thermal Battery Performance Report* that describes the thermal battery module and BOS commissioning procedure, testing procedure and scenarios that were tested, and charge and discharge performance.
- Prepare a *CPR Report* #2 in accordance with subtask 1.3 (CPR Meetings) and participate in a CPR meeting.

**Products:**

- Thermal Battery Test Plan (draft and final)
- Thermal Battery Performance Report (draft and final)
- CPR Report #2 (draft and final)

**TASK 6 COMMISSION AND DEMONSTRATE THE LOW-COST SULFUR THERMAL BATTERY SYSTEM**

The goal of this task is to integrate the low cost sulfur thermal battery module and the BOS with a procured power generation unit, and demonstrate the low cost sulfur thermal battery system capability to store and generate electricity. The demonstration will be located in and benefit a Disadvantaged Community as defined.

**The Recipient shall:**

- Procure power generation unit.
- Develop *Demonstration Test Plan* for:
  - Integrating the low-cost sulfur thermal battery module and BOS equipment to the power generation unit and commission the system.
  - Carrying out tests on the complete thermal battery to demonstrate performance and functionality.
- Prepare *Demonstration System Performance Report* that describes the integration and commissioning procedure, testing procedure and scenarios that were tested, data collection and analysis, charge and discharge performance.

**Products:**

- Demonstration Test Plan (draft and final)
- Demonstration System Performance Report (draft and final)

**TASK 7 MEASUREMENT AND VERIFICATION**

The goal of this task is to independently verify the performance, electricity and thermal savings, and GHG reductions of the sulfur thermal battery system.

**The Recipient shall:**

- Create a *Measurement and Verification Plan* to verify the performance, electricity and thermal savings, and GHG reductions of the sulfur thermal battery system.
- Implement the *Measurement and Verification Plan* by:
  - Taking pre-installation measurements at the demonstration site.

  - Measuring the capabilities of the low cost sulfur thermal battery system components before installation.
  - Taking post-installation measurements over the course of at least six months or reasonable time period as determined by the CAM to characterize system performance.
- Have all results, data and analysis verified by an independent third party subcontractor.
- Prepare a *Measurement and Verification Report* to summarize the results of demonstration and M&V.

**Products:**
- Measurement and Verification Plan (draft and final)
- Measurement and Verification Report (draft and final)

**TASK 8 MARKET ANALYSIS AND ECONOMIC IMPACT**
The goals of this task are to demonstrate the importance of recipient's optimized low cost sulfur thermal battery technology to potential strategic industry partners and evaluate the impact of widescale adoption of the technology in industrial plants throughout the state of California.

**The Recipient shall:**
- Interview 5 to 10 potential utility and industry partners to gather information on annual electricity usage, frequency and duration of electricity outages, etc. in order to:
  - Calculate potential economic impact and environmental impact of the optimized low cost sulfur thermal battery technology.
  - Formulate go-to-market strategy for the optimized low cost sulfur thermal battery technology.
  - Disseminate information regarding the optimized low cost sulfur thermal battery technology and project successes.
  - Find further deployment locations of the optimized low cost sulfur thermal battery technology at larger scale in both energy and power.
  - Develop the implementation plan for large-scale adoptability and manufacturability.
- Prepare *Potential Market Impact Report* that describes the electricity and cost savings, grid efficiency improvements and the potential GHG emissions reductions from large scale implementation of the technology.

**Products:**
- Potential Market Impact Report (draft and final)

**TASK 9 EVALUATION OF PROJECT BENEFITS *(Mandatory task)***
The goal of this task is to report the benefits resulting from this project.

**The Recipient shall:**
- Complete three Project Benefits Questionnaires that correspond to three main intervals in the Agreement: (1) *Kick-off Meeting Benefits Questionnaire*; (2) *Mid-term Benefits Questionnaire*; and (3) *Final Meeting Benefits Questionnaire*.
- Provide all key assumptions used to estimate projected benefits, including targeted market sector (e.g., population and geographic location), projected market penetration, baseline

and projected energy use and cost, operating conditions, and emission reduction calculations. Examples of information that may be requested in the questionnaires include:

- For Product Development Projects and Project Demonstrations:
  - Published documents, including date, title, and periodical name.
  - Estimated or actual energy and cost savings, and estimated statewide energy savings once market potential has been realized. Identify all assumptions used in the estimates.
  - Greenhouse gas and criteria emissions reductions.
  - Other non-energy benefits such as reliability, public safety, lower operational cost, environmental improvement, indoor environmental quality, and societal benefits.
  - Data on potential job creation, market potential, economic development, and increased state revenue as a result of the project.
  - A discussion of project product downloads from websites, and publications in technical journals.
  - A comparison of project expectations and performance. Discuss whether the goals and objectives of the Agreement have been met and what improvements are needed, if any.
  - Additional Information for Product Development Projects:
    - Outcome of product development efforts, such copyrights and license agreements.
    - Units sold or projected to be sold in California and outside of California.
    - Total annual sales or projected annual sales (in dollars) of products developed under the Agreement.
    - Investment dollars/follow-on private funding as a result of Energy Commission funding.
    - Patent numbers and applications, along with dates and brief descriptions.
  - Additional Information for Product Demonstrations:
    - Outcome of demonstrations and status of technology.
    - Number of similar installations.
    - Jobs created/retained as a result of the Agreement.
- For Information/Tools and Other Research Studies:
  - Outcome of project.
  - Published documents, including date, title, and periodical name.
  - A discussion of policy development. State if the project has been cited in government policy publications or technical journals, or has been used to inform regulatory bodies.
  - The number of website downloads.
  - An estimate of how the project information has affected energy use and cost, or have resulted in other non-energy benefits.
  - An estimate of energy and non-energy benefits.
  - Data on potential job creation, market potential, economic development, and increased state revenue as a result of project.

  - A discussion of project product downloads from websites, and publications in technical journals.
  - A comparison of project expectations and performance. Discuss whether the goals and objectives of the Agreement have been met and what improvements are needed, if any.
- Respond to CAM questions regarding responses to the questionnaires.

The Energy Commission may send the Recipient similar questionnaires after the Agreement term ends. Responses to these questionnaires will be voluntary.

**Products:**

- Kick-off Meeting Benefits Questionnaire
- Mid-term Benefits Questionnaire
- Final Meeting Benefits Questionnaire

**TASK 10 TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES *(Mandatory task)***

The goal of this task is to develop a plan to make the knowledge gained, experimental results, and lessons learned available to the public and key decision makers.

**The Recipient shall:**

- Prepare an *Initial Fact Sheet* at start of the project that describes the project. Use the format provided by the CAM.
- Prepare a *Final Project Fact Sheet* at the project's conclusion that discusses results. Use the format provided by the CAM.
- Prepare a *Technology/Knowledge Transfer Plan* that includes:
  - An explanation of how the knowledge gained from the project will be made available to the public, including the targeted market sector and potential outreach to end users, utilities, regulatory agencies, and others.
  - A description of the intended use(s) for and users of the project results.
  - Published documents, including date, title, and periodical name.
  - Copies of documents, fact sheets, journal articles, press releases, and other documents prepared for public dissemination. These documents must include the Legal Notice required in the terms and conditions. Indicate where and when the documents were disseminated.
  - A discussion of policy development. State if project has been or will be cited in government policy publications, or used to inform regulatory bodies.
  - The number of website downloads or public requests for project results.
  - Additional areas as determined by the CAM.
- Conduct technology transfer activities in accordance with the Technology/Knowledge Transfer Plan. These activities will be reported in the Progress Reports.
- When directed by the CAM, develop *Presentation Materials* for an Energy Commission-sponsored conference/workshop(s) on the project.
- When directed by the CAM, participate in annual EPIC symposium(s) sponsored by the California Energy Commission.
- 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.
- Prepare a *Technology/Knowledge Transfer Report* on technology transfer activities

conducted during the project.

**Products:**

- Initial Fact Sheet (draft and final)
- Final Project Fact Sheet (draft and final)
- Presentation Materials (draft and final)
- High Quality Digital Photographs
- Technology/Knowledge Transfer Plan (draft and final)
- Technology/Knowledge Transfer Report (draft and final)

## V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.

**RESOLUTION NO: 2019-0612-15c**

**STATE OF CALIFORNIA**

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

RESOLUTION - RE: ELEMENT 16 TECHNOLOGIES, INC.

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

**RESOLVED,** that the Energy Commission approves Agreement EPC-18-024 with Element 16 Technologies, Inc. for a $3,000,000 grant to demonstrate a sulfur thermal battery technology for stationary storage and power generation, and field test converting the stored thermal energy to electricity in real-time, and adopting staff's determination that this action is exempt from CEQA; and

**FURTHER BE IT RESOLVED,** that the Executive Director or his/her designee shall execute the same on behalf of the Energy Commission.

## ***CERTIFICATION***

The undersigned Secretariat to the Commission 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 California Energy Commission held on June 12, 2019.

AYE: [List of Commissioners]
NAY: [List of Commissioners]
ABSENT: [List of Commissioners]
ABSTAIN: [List of Commissioners]

Cody Goldthrite,
Secretariat