



# GRANT REQUEST FORM (GRF)

## A) New Agreement # EPC-19-019 (to be completed by CGL office)

B) Division	Agreement Manager:	MS-	Phone
ERDD	Chuck Gentry	43	916-327-1528

C) Recipient's Legal Name	Federal ID Number
Lawrence Berkeley National Laboratory	94-2951741

D) Title of Project
Joint Time-Lapse Acquisition and Inversion of Passive Seismic and Magnetotelluric Data for Monitoring Reservoir Processes at the Geysers Geothermal Field

## E) Term and Amount

Start Date	End Date	Amount
6/1/2020	3/29/2024	\$ 1,661,032

## F) Business Meeting Information

ARFVTP agreements \$75K and under delegated to Executive Director

Proposed Business Meeting Date 5/13/2020  Consent  Discussion

Business Meeting Presenter Chuck Gentry Time Needed: 5 minutes

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

### Agenda Item Subject and Description:

LAWRENCE BERKELEY NATIONAL LABORATORY. Proposed resolution approving agreement EPC-19-019 with Lawrence Berkeley National Laboratory for a \$1,661,032 grant to demonstrate the advantages of concurrently acquiring time-lapse magnetotelluric and passive seismic data over a producing geothermal reservoir. The data will be jointly inverted for enhanced images of structural features and dynamic properties of the geothermal reservoir. Ultimately, these images can be used for more accurate reservoir modeling and monitoring which will lead to more accurate placement of production wells. A field demonstration at The Geysers will be carried out to evaluate the value added by applying this technology. (EPIC Funding) Contact: Chuck Gentry.

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

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

Yes (skip to question 2)

No (complete the following (PRC 21065 and 14 CCR 15378)):

Explain why Agreement is not considered a "Project":

2. If Agreement is considered a "Project" under CEQA:

a)  Agreement **IS** exempt.

Statutory Exemption. List PRC and/or CCR section number:

Categorical Exemption. List CCR section number: Cal. Code Regs., tit 14, § 15304 ; Cal. Code Regs., tit 14, § 15306

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



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Explain reason why Agreement is exempt under the above section: This project is exempt under 15304 because it consists of passive data collection and does not involve any construction or changes to the existing landscape.

This project is exempt under 15306 because it consists of data collection for the purposes of resource evaluation research which does not result in a disturbance to the environmental resource.

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

Check all that apply

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

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

Legal Company Name:	Budget
Array Information Technology	\$ 372,700
United States Geological Survey	\$ 279,870
Jarpe Data Solutions, Inc.	\$ 45,000
	\$
	\$

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

Legal Company Name:

### J) Budget Information

Funding Source	Funding Year of Appropriation	Budget List Number	Amount
EPIC	18-19	301.001F	\$1,661,032
			\$
			\$

R&D Program Area: EGRO: Renewables

TOTAL: \$ 1,661,032

Explanation for "Other" selection

Reimbursement Contract #: Federal Agreement #:

### K) Recipient's Contact Information

1. Recipient's Administrator/Officer

Address: 1 Cyclotron Rd

Name: Betsy Quayle



STATE OF CALIFORNIA

# GRANT REQUEST FORM (GRF)

CEC-270 (Revised 12/2019)

CALIFORNIA ENERGY COMMISSION

City, State, Zip: Berkeley, CA  
94720-0001

Phone: 510-486 -7391

E-Mail: BEQuayle@lbl.gov

## 2. Recipient's Project Manager

Name: David Alumbaugh

Address: 1 Cyclotron Rd

City, State, Zip: Berkeley, CA  
94720-0001

Phone: 510-486-6346

E-Mail: dlalumgaugh@lbl.gov

### L) Selection Process Used

Competitive Solicitation      Solicitation #: GFO-19-303

First Come First Served Solicitation Solicitation #:

### M) The following items should be attached to this GRF

- |   |   |                                   |
|---|---|-----------------------------------|
| 1. Exhibit A, Scope of Work                         | <input checked="" type="checkbox"/>     | Attached                          |
| 2. Exhibit B, Budget Detail                         | <input checked="" type="checkbox"/>     | Attached                          |
| 3. CEC 105, Questionnaire for Identifying Conflicts | <input checked="" type="checkbox"/>     | Attached                          |
| 4. Recipient Resolution                             | <input checked="" type="checkbox"/> N/A | <input type="checkbox"/> Attached |
| 5. CEQA Documentation                               | <input checked="" type="checkbox"/> N/A | <input type="checkbox"/> 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 <sup>1</sup>	Task Name
1		General Project Tasks
2		Passive Seismic Data Acquisition and Imaging for Reservoir Properties
3	X	Magnetotelluric Data Acquisition and Imaging for Reservoir Properties
4		Joint Inversion of Seismic and Magnetotelluric Data for Improved Imaging of Reservoir Properties
5		Correlation Analysis of Geophysical Imaging Results and Geothermal Reservoir Model
6		Evaluation of Project Benefits
7		Technology/Knowledge Transfer Activities

#### B. Acronym/Term List

Acronym/Term	Meaning
3D	Three Dimensional
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CPR	Critical Project Review
MT	Magnetotelluric Electromagnetic Geophysical Method
P- and S-wave	Pressure Wave and Shear Wave
TAC	Technical Advisory Committee
Vp	Velocity of the Seismic Pressure Wave
Vs	Velocity of the Seismic Shear Wave
Vp/Vs	Ratio between the pressure wave velocity and the shear wave velocity

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

#### A. Purpose of Agreement

The purpose of this Agreement is to fund joint time-lapse acquisition and inversion of passive seismic and magnetotelluric data for monitoring reservoir processes at the Geysers Geothermal Field, a research project that will demonstrate the advantages of concurrently acquiring and jointly inverting magnetotelluric and passive seismic data in a time-lapse sense over a producing geothermal reservoir. The resulting images of subsurface electrical resistivity and seismic velocity will be used for more accurate reservoir modeling and monitoring, as well as for more accurate placement of production and injection wells for future reservoir development. This technology can play an important role in assuring the continued growth of California's geothermal operations, as required by SB 350.

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<sup>1</sup> 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

In operating geothermal fields, it is inherently difficult to image the movement of water and steam in a fractured geothermal reservoir in time and in three-dimensional space. Tracer tests provide ground-truth information about inter-well connectivity, but they do not directly reveal the flow paths in the regions between the wells. Microseismicity mapped in three-dimensions can provide valuable information about fluid movement, but it is possible for water and steam to move through the fractured rock mass without triggering microseismicity, as well for microseismicity to be triggered without fluids.

#### Solution

This project will demonstrate the advantages of concurrently acquiring magnetotelluric and passive seismic data over a producing geothermal reservoir in a time-lapse sense, jointly inverting these time-lapse data for images of resistivity and seismic velocities using workflows and algorithms that enforce structural similarity constraints between the different physical properties. The spatio-temporal information in the jointly inverted geophysical images will subsequently be correlated to existing reservoir models. These results will ultimately provide added detail to update these existing models and help guide reservoir operators' daily operations and future reservoir development. The technical advancements of this project are provided via concurrent monitoring of time-lapse changes in both resistivity and seismic velocity and the joint inversion of the multi-physics data. A field demonstration at the project site will be carried out to evaluate the value added by applying this technology.

### C. Goals and Objectives of the Agreement

#### Agreement Goals

The goal of this Agreement is to advance the current state for imaging subsurface flow paths, barriers and heterogeneity, and delineating steam and water saturated zones in operating geothermal reservoirs through an integrated approach that combines time-lapse acquisition and advanced processing of magnetotelluric and passive seismic data.

Ratepayer Benefits:<sup>2</sup> This Agreement will result in the ratepayer benefit of lowering the cost of geothermal energy, a non-greenhouse gas (GHG) emitting source of clean energy. This reduction in cost is realized by this technology providing improved accuracy in the location of productive areas for siting wells and by avoiding drilling hazards.

Technological Advancement and Breakthroughs:<sup>3</sup> 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 assisting the continued growth of California's broad portfolio of renewable energy, including geothermal, as required to achieve the goals of SB 350. This growth can be accelerated through the development of innovative technologies and by narrowing the gap of these technologies to commercialization. This project will demonstrate the advantages of concurrently acquiring magnetotelluric and passive seismic data over a

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<sup>2</sup> 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](http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/167664.PDF)).

## EXHIBIT A Scope of Work

producing geothermal reservoir in a time-lapse sense, jointly inverting these time-lapse data for images of resistivity and seismic velocities using workflows and algorithms that enforce structural similarity constraints between the different physical properties, and subsequently correlating the spatio-temporal information in the joint-inversion geophysical images to working reservoir models to update these models and to adjust injection and production rates.

### **Agreement Objectives**

The objectives of this Agreement are to:

- Concurrently acquire magnetotelluric and passive seismic data in a time lapse sense three times at one-year intervals;
- Jointly invert magnetotelluric and passive seismic data for structurally similar images of resistivity and seismic velocity; and
- Correlate the constrained images of resistivity and seismic velocity to Calpine's reservoir model to better estimate rock properties at depth, provide for more accurate reservoir modeling and monitoring, and optimize the placement of production and injection wells.

### **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.

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

## **EXHIBIT A**

### **Scope of Work**

#### 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.

- **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.

## EXHIBIT A Scope of Work

### 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

## **EXHIBIT A**

### **Scope of Work**

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

## **EXHIBIT A**

### **Scope of Work**

- 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

## EXHIBIT A Scope of Work

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**)

## **EXHIBIT A**

### **Scope of Work**

- 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.

## EXHIBIT A Scope of Work

### 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 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,

## EXHIBIT A Scope of Work

- 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:

## **EXHIBIT A**

### **Scope of Work**

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

#### **Products:**

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

#### **Subtask 1.11 TAC Meetings**

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

## EXHIBIT A

### Scope of Work

#### The Recipient shall:

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

#### The TAC shall:

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

#### 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: PASSIVE SEISMIC DATA ACQUISITION AND IMAGING FOR RESERVOIR PROPERTIES

The goals of this task are to acquire, process, and invert passive seismic data collected at three one-year time intervals using about 126 seismic stations that are currently installed at the Geysers geothermal field. The travel time data will be inverted employing three dimensional (3D) joint inversion for microearthquake hypocenter locations and velocity structure ( $V_p$ ,  $V_s$  and  $V_p/V_s$ )<sup>4</sup> to determine spatio-temporal variation of the velocity structure with previously

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<sup>4</sup>  $V_p$ : Velocity of the seismic pressure wave.  $V_s$ : Velocity of the seismic shear wave.  $V_p/V_s$ : Ratio between the pressure wave velocity and the shear wave velocity.

## **EXHIBIT A**

### **Scope of Work**

unattainable resolution at the reservoir-wide scale. The aim will be to generate improved locations of micro-earthquake locations and the necessary input for joint inversion of seismic and magnetotelluric electromagnetic geophysical method (MT) data in Task 4 as well as tomographic images for correlation analysis in Task 5.

#### **The Recipient shall:**

- Acquire the seismic data throughout the duration of the project using seismic stations currently installed at The Geysers geothermal field. The data acquisitions and data processing will be conducted on a quarterly basis and will involve the following subtasks:
  - Swap-out memory cards on all stations and perform maintenance on stations as needed.
  - Download the acquired data from the memory cards to computers.
  - Process the downloaded data for pressure wave and shear wave (P- and S-wave) phase picks and preliminary hypocenter locations.
  - Conduct preliminary 3D joint inversion for hypocenter locations and P- and S-wave velocity structure.
- Invert the seismic travel time data of the first, second and third year for images of P- and S-wave velocity as well as microearthquake locations. Calculate a Vp/Vs image for each time period using the separate P- and S-wave velocity results.
- Prepare *Passive Seismic Data Acquisition and Processing Report #1* that includes:
  - Results of P- and S-wave phase picks and preliminary hypocenter locations
  - Results of preliminary 3D joint inversion for hypocenter locations and P- and S-wave velocity structure
  - Images of P- and S-wave velocity and microearthquake locations and associated calculations and images.
- Prepare *Passive Seismic Data Acquisition and Processing Report #2* that includes updated information similar to report #1.
- Prepare *Passive Seismic Data Acquisition and Processing Report #3* that includes updated information similar to reports #1 and 2.

#### **Products:**

- *Passive Seismic Data Acquisition and Processing Report #1*
- *Passive Seismic Data Acquisition and Processing Report #2*
- *Passive Seismic Data Acquisition and Processing Report #3*

### **TASK 3: MAGNETOTELLURIC DATA ACQUISITION AND IMAGING FOR RESERVOIR PROPERTIES**

The goals of this task are to acquire, process, and invert magnetotelluric data collected using about 52 stations at three one-year time intervals at the Geysers geothermal field. The MT data will be inverted using the three-dimensional magnetotelluric modeling and inversion software (Egbert et al., 2012; Kelbert et al., 2014) code. The inversions will produce 3D models of the electrical resistivity in the reservoir, which will be analyzed for the spatio-temporal variations. The aim will be to generate the necessary input for joint inversion of seismic and MT data in Task 4, as well as tomographic images for correlation analysis in Task 5.

#### **The Recipient shall:**

- Acquire the MT data using four acquisition systems owned by the United States Geological Survey. Each acquisition will occupy the same station locations. It is

## **EXHIBIT A**

### **Scope of Work**

estimated that each of the three data acquisitions will take two weeks of field time. Data acquisition at each station will involve the following subtasks:

- Laying out 50m of wire for two orthogonal electric field dipole measurements and connecting the wires on each end to porous pot electrodes that have been appropriately deployed to provide adequate electrical connection to the earth.
- Installing two orthogonal horizontal magnetic field measurement sensors.
- Connecting the MT acquisition system to the sensors and scheduling the data acquisition to occur over night.
- After the data acquisition has completed for each system, download the data and collect all sensors that were employed for redeployment at the next site.
- Process the MT data at each site for estimates of the MT impedance tensors as well as other parameters.
- For each of the three data sets, invert the MT data for all sites to produce a 3D image of resistivity.
- Prepare *MT Data Acquisition and Processing Report #1* that includes:
  - Estimates of the MT impedance tensors and other parameters
  - 3D Image of resistivity from the inverted MT data
- Prepare *MT Data Acquisition and Processing Report #2* that includes updated information similar to report #1.
- Prepare a *CPR Report* in accordance with subtask 1.3 (CPR Meetings).
- Participate in a CPR meeting.
- Prepare *MT Data Acquisition and Processing Report #3* that includes updated information similar to reports #1 and 2.

#### **Products:**

- MT Data Acquisition and Processing Report #1
- MT Data Acquisition and Processing Report #2
- CPR Report
- MT Data Acquisition and Processing Report #3

#### **TASK 4: JOINT INVERSION OF SEISMIC AND MAGNETOTELLURIC DATA FOR IMPROVED IMAGING OF RESERVOIR PROPERTIES**

The goals of this task are to employ a joint inversion workflow to invert the seismic and MT data by invoking independent iterations of seismic traveltimes and MT data inversion using a cross-gradient operator. During this work we will conduct synthetic test cases, designed according to a priori information of the field site at The Geysers, to fine-tune the workflow. The aim will be to generate improved images of the reservoir properties such as water and steam saturated zones, flow path and barriers that satisfy both the seismic and MT data and that will be used in the correlation analysis in Task 5.

#### **The Recipient shall:**

- Generate synthetic MT and seismic traveltimes data sets using prior information from the Geysers geothermal field.
- Select three seismic data subsets that have a sufficiently high number of earthquakes and that are correlated in time with the MT data sets.
- Fine tune the joint-inversion workflow using the synthetic data set.
- Apply the tuned joint inversion workflow to each of the three time-lapse MT and passive seismic data sets

## **EXHIBIT A**

### **Scope of Work**

- Generate time-lapse images from the three joint inversion results.
- Prepare a *Joint Inversion of MT and Passive Seismic Report* that includes:
  - Description of the process for selecting data and fine tuning the joint-inversion workflow
  - Time-lapse images from the joint inversion results

#### **Products:**

- Joint Inversion of MT and Passive Seismic Report

#### **TASK 5: CORRELATION ANALYSIS OF GEOPHYSICAL IMAGING RESULTS AND GEOTHERMAL RESERVOIR MODEL**

The goals of this task are to develop an approach for assessing and identifying temporal and spatial geophysical anomalies within the geological reservoir modeling software package workflow. The anomalies, which are spatial in nature can be fit using surfaces for correlation analysis with the existing 3D geological reservoir model. Understanding the spatio-temporal relationship between the geophysical response anomalies and the geological and hydrological reservoir parameters will help to determine if the response is a function of geologic structure and/or the temporal changes of steam or water within that zone in the reservoir. This knowledge will provide operators the necessary insight to optimize geothermal operations.

#### **The Recipient shall:**

- Evaluate current 3D geologic reservoir model to evaluate existing features.
- Develop workflow to import seismic Vp, Vs, Vp/Vs and MT inverted images as voxet grids.
- Compare seismic and MT results through a spatial trend analysis for consistency.
- Develop workflow for comparing time-series inverted images to geologic structure and apply to all time vintages to determine if the geophysical anomalies are associated with spatio-temporal steam or water changes and to determine the control on the water/steam movement.
- Prepare a *Correlation Analysis of Geophysical Imaging Results and Geothermal Reservoir Model Report* that includes:
  - Evaluation of 3D model
  - Comparison of seismic and MT results
  - Resulting images and conclusions

#### **Product:**

- Correlation Analysis of Geophysical Imaging Results and Geothermal Reservoir Model 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 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*.

## EXHIBIT A Scope of Work

- 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.
    - GHG 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.

## EXHIBIT A Scope of Work

- 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 7: TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES

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

## **EXHIBIT A Scope of Work**

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.

STATE OF CALIFORNIA

STATE ENERGY RESOURCES  
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION - RE: Lawrence Berkeley National Laboratory

**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-19-019 \$1,661,032 grant to demonstrate the advantages of concurrently acquiring time-lapse magnetotelluric and passive seismic data over a producing geothermal reservoir. The data will be jointly inverted for enhanced images of structural features and dynamic properties of the geothermal reservoir. Ultimately, these images can be used for more accurate reservoir modeling and monitoring which will lead to more accurate placement of production wells. A field demonstration at The Geysers will be carried out to evaluate the value added by applying this technology; and

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

**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 CEC held on May 13, 2020.

AYE:

NAY:

ABSENT:

ABSTAIN:

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Cody Goldthrite  
Secretariat