

GRANT REQUEST FORM (GRF)

CEC-270 (Revised 02/13)

CALIFORNIA ENERGY COMMISSION

New Agreement GEO-14-001 (To be completed by CGL Office)

Division	Agreement Manager:	MS-	Phone
Choose Division	Cheryl Closson	45	916-651-0315

Recipient's Legal Name	Federal ID Number
Paulsson, Inc.	26-1151245

Title of Project
Surveying and Monitoring of Geothermal Operations using a Fiber Optic Borehole Seismic Vector Sensor Array

Term and Amount	Start Date	End Date	Amount
	1 / 21 / 2015	3 / 30 / 2017	\$ 883,002

Business Meeting Information
 ARFVTP agreements under \$75K delegated to Executive Director.

Proposed Business Meeting Date	12 / 10 / 2014	<input type="checkbox"/> Consent	<input checked="" type="checkbox"/> Discussion
Business Meeting Presenter	Cheryl Closson	Time Needed:	5 minutes

Please select one list serve. Geothermal

Agenda Item Subject and Description

Possible approval of Agreement GEO-14-001 with Paulsson, Inc. for a \$883,002 grant to build and field test a large aperture borehole seismic vector array that is capable of operating at the high subsurface temperatures and pressures common to geothermal areas, and produce high resolution seismic data, models and maps for two wells at the Geysers geothermal field. The array and the resulting high resolution seismic data and maps will allow for better definition of geothermal subsurface conditions and allow for effective characterization and monitoring of geothermal reservoirs in every phase of field development. (GRDA funding) Contact: Cheryl Closson (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 14 CCR 15301 and 14 CCR 15306 section number:
 Common Sense Exemption. 14 CCR 15061 (b) (3)
 Explain reason why Agreement is exempt under the above section:
 Project work consists of data collection and analyses and research tool development that will be conducted in office conditions and existing laboratories, with field surveys conducted at the Geysers geothermal field in accordance with existing permitted well operations and area use permit conditions.
- 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
Lawrence Berkeley National Laboratory	\$ 75,000
JOT Engineering	\$ 49,520
	\$ 0

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

Legal Company Name:
Lawrence Berkeley National Laboratory
Calpine

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CALIFORNIA ENERGY COMMISSION



Budget Information			
Funding Source	Funding Year of Appropriation	Budget List No.	Amount
GRDA	2013/2014	0497-3360-101-10	\$883,002
Funding Source			\$
R&D Program Area: N/A		TOTAL:	\$883,002
Explanation for "Other" selection			
Reimbursement Contract #:		Federal Agreement #:	

Recipient's Administrator/ Officer				Recipient's Project Manager			
Name:	Bjorn N.P. Paulsson			Name:	Bjorn N.P. Paulsson		
Address:	Paulsson, Inc. 16543 Arminta Street			Address:	Paulsson, Inc. 16543 Arminta Street		
City, State, Zip:	Van Nuys, CA 91406-1745			City, State, Zip:	Van Nuys, CA 91406-1745		
Phone:	310-780-2219	Fax:	- -	Phone:	310-780-2219	Fax:	- -
E-Mail:	bjorn.paulsson@paulsson.com			E-Mail:	bjorn.paulsson@paulsson.com		

Selection Process Used			
<input checked="" type="checkbox"/> Competitive Solicitation		Solicitation #: PON-13-507	
<input type="checkbox"/> First Come First Served Solicitation			

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 type="checkbox"/> N/A	<input checked="" type="checkbox"/> Attached

Agreement Manager _____

Date _____

Office Manager _____

Date _____

Deputy Director _____

Date _____

Exhibit A SCOPE OF WORK

TECHNICAL TASK LIST

Task #	Task Name
1	Administration
2	Build Seismic Data Base for the Project
3	Build the 16 Level 482°F (250°C) Borehole Array
4	Test Array Components in the Lab at 482°F (250°C) and 20,000 psi
5	Record Surveys in Geothermal Areas
6	Process Data, Interpret, and Report Results

KEY NAME LIST

Task #	Key Personnel	Key Sub-contractor(s)	Key Partner(s)
1	Björn Paulsson – Paulsson, Inc.		
2	Björn Paulsson – Paulsson, Inc		Lawrence Berkeley National Laboratory (LBNL), Calpine
3			
4			
5	Björn Paulsson – Paulsson, Inc.		Calpine
6	Björn Paulsson – Paulsson, Inc.		LBNL, Calpine

GLOSSARY

Specific terms and acronyms used throughout this scope of work are defined as follows:

Term/ Acronym	Definition
3C	three-component
3D	three-dimensional
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CPR	Critical Project Review
DOE	United States Department of Energy
ft	Feet
ft/sec	feet per second
Energy Commission	California Energy Commission

Exhibit A SCOPE OF WORK

Term/ Acronym	Definition
Fiber Optic Sensors	Sensors in general that are built around fiber optic technology. Examples include Paulsson vector sensors, acoustic sensors, temperature sensors, and chemical sensors.
Fiber Optic Seismic Sensors	Seismic sensors that are built around fiber optic technology. Examples include the Paulsson vector sensors.
GRDA	Geothermal Resources Development Account; also used as a short title for the Geothermal Grant and Loan Program
Hz	Hertz
LBNL	Lawrence Berkeley National Laboratory
Microseismic	Seismic data and events of small magnitude that are generated by either natural causes, such as tectonic stress, or by production and/or injection of fluids into geologic formations.
°F	degrees Fahrenheit
°C	degrees Celsius
psi	pounds per square inch
P-wave	Primary wave
Recipient	Paulsson, Inc.
RED	Renewable Energy Division
S-wave	Secondary wave
VSP	vertical seismic profiling; where seismic receivers are lowered into a borehole as data is recorded using seismic sources operated on or near the surface of the earth.

Problem Statement:

Safe, environmentally compliant and effective production of geothermal energy is critically dependent on a precise understanding of the complexity of the geologic formations that make up the geothermal reservoirs. Safe, environmentally compliant and successful production also depends on an accurate seismic monitoring program to understand the dynamic processes of the injection of fluids and of producing the geothermal resources. The complex production processes of the geothermal fields will only be understood and managed in detail if robust high-resolution seismic reservoir imaging and monitoring technologies are available to characterize the reservoirs in every phase of the field development. Three-dimensional (3D) vertical seismic profiling (VSP), primary wave (P-wave), and secondary wave (S-wave) images have been shown routinely to have more than twice the spatial resolution than surface seismic images in areas with excellent surface seismic data. In areas with poor to very poor surface seismic data, the 3D VSP technique has been proven to still be able to record the high quality P-wave and S-wave data needed for high resolution P-wave and S-wave imaging and monitoring. Microseismic monitoring using borehole seismic instruments has been shown to be much more sensitive and accurate than microseismic monitoring using surface seismic sensors. High-resolution imaging, including mapping of complex high angle faults and fractures, and microseismic monitoring can only be achieved if large volumes of high quality, high frequency borehole seismic data can be recorded and sampled properly, both spatially and

Exhibit A

SCOPE OF WORK

temporally. This data can only be recorded by deploying large aperture borehole seismic vector arrays placed close to the producing geothermal reservoirs.

Compared with the oil and gas market the geothermal market is small. The small market, combined with the hostile geothermal environment, has limited the development of instruments suitable for geothermal wells and fields. Due to the extreme temperature found in geothermal fields, conventional borehole seismic technologies used for oil and gas fields have not been capable of surveying geothermal fields in the past. High temperature borehole seismic tools must therefore be developed and deployed to allow high resolution imaging and monitoring of geothermal reservoirs.

The hostile environment found in geothermal wells requires specialized instruments manufactured using expensive and difficult to machine corrosion resistant materials. In the past, the geothermal market has been too small to develop the expensive instruments needed to operate effectively. With the help of the United States Department of Energy (DOE), seismic instruments have been designed to operate at 572 degrees Fahrenheit (°F) [300 degrees Celsius (°C)]. For the purposes of this agreement, the next step is to manufacture a 16 level, 482°F (250°C) seismic borehole array and test the instruments in two real geothermal wells in the Geysers geothermal field.

Goals of the Agreement:

The goal of this project is to produce high resolution microseismic images around two pre-selected existing geothermal wells operated by Calpine in the Geysers geothermal field in northern California. In addition to the monitoring of microseismic data, Recipient will record an active seismic source survey in one of the wells drilled into the Geysers geothermal field. Recipient will use the microseismic and active source data to develop a much improved understanding of the structure and dynamics of the geothermal reservoirs in the areas to be surveyed. To achieve these goals, Recipient will build a 16 level borehole seismic vector array capable of being deployed at temperatures of 482°F (250°C) to a drilled depth of 15,000 feet (ft) (4,500 meters) at pressures up to 20,000 pounds per square inch (psi).

Objectives of the Agreement:

There are four primary objectives of this project. The first objective is to provide images of geothermal reservoirs with a resolution of 10 ft. This will require the acquisition of 500 Hertz (Hz) seismic 3D data assuming a reservoir velocity of 20,000 feet per second (ft/sec). Second is to locate microseismic events with a 10 ft accuracy up to 4,000 ft away from the monitor well. The third objective is to locate faults using borehole seismic interferometric imaging. The fourth objective is to locate fracture zones and fracture directions using converted shear wave data. All objectives require the development of a highly accurate velocity model which is only possible by deploying and recording data with large aperture high vector fidelity borehole seismic arrays.

TASK 1 ADMINISTRATION

Task 1.1 Attend Kick-off Meeting

The goal of this task is to establish the lines of communication and procedures for implementing this Agreement. The CAM shall designate the date and location of this meeting and provide an agenda to the Recipient prior to the meeting.

Exhibit A

SCOPE OF WORK

The Recipient shall:

- Attend a “Kick-Off” meeting with the Commission Agreement Manager (CAM), the Commission Agreement Officer (CAO), and a representative of the Energy Commission Accounting Office. The Recipient shall bring its Project Manager, Agreement Administrator, Accounting Officer, and others designated by the Commission Agreement Manager to this meeting.
- Discuss the following administrative and technical aspects of this Agreement:
 - Agreement Terms and Conditions
 - Critical Project Review (Task 1.2)
 - Match fund documentation (Task 1.6). No reimbursable work may be done until this documentation is in place.
 - Permit documentation (Task 1.7)
 - Subcontracts needed to carry out project (Task 1.8)
 - The CAM’s expectations for accomplishing tasks described in the Scope of Work
 - An updated Schedule of Products and Due Dates
 - Monthly Progress Reports (Task 1.4)
 - Technical Products (Product Guidelines located in Section 5 of the Terms and Conditions)
 - Final Report (Task 1.5)

Recipient Products:

- Updated Schedule of Products
- Updated List of Match Funds
- Updated List of Permits

Commission Agreement Manager Product:

- Kick-Off Meeting Agenda

Task 1.2 Critical Project Review (CPR) Meetings

CPRs provide the opportunity for frank discussions between the Energy Commission and the Recipient. The goal of this task is to determine if the project should continue to receive Energy Commission funding to complete this Agreement and to identify any needed modifications to the tasks, products, schedule or budget.

CPRs generally take place at key, predetermined points in the Agreement, as determined by the CAM and as shown in the Technical Tasks and project schedule. However, the CAM may schedule additional CPR meetings as necessary, and any additional meeting costs will be borne by the Recipient.

Meeting participants include the CAM and the Recipient and may include the CAO, Renewable Energy Division or other Energy Commission staff and management as well as other individuals selected by the CAM to provide support to the Energy Commission.

Exhibit A

SCOPE OF WORK

The CAM shall:

- Determine the location, date, and time of each CPR meeting with the Recipient. These meetings generally take place at the Energy Commission, but they may take place at another location, by telephone, or by WebEx.
- Send the Recipient the agenda and a list of expected participants in advance of each CPR. If applicable, the agenda shall include a discussion on both match funding and permits.
- Conduct and make a record of each CPR meeting. Prepare a schedule for providing the written determination described below.
- Determine whether to continue the project, and if continuing, whether or not modifications are needed to the tasks, schedule, products, and/or budget for the remainder of the Agreement. Modifications to the Agreement may require a formal amendment (please see section 8 of the Terms and Conditions). If the CAM concludes that satisfactory progress is not being made, this conclusion will be referred to the Lead Commissioner for Renewables for his or her concurrence.
- Provide the Recipient with a written determination in accordance with the schedule. The written response may include a requirement for the Recipient to revise one or more product(s) that were included in the CPR.

The Recipient shall:

- Prepare a CPR Report for each CPR that discusses the progress of the Agreement toward achieving its goals and objectives. This report shall include recommendations and conclusions regarding continued work of the projects. This report shall be submitted along with any other products identified in this scope of work. The Recipient shall submit these documents to the CAM and any other designated reviewers at least 15 working days in advance of each CPR meeting.
- Present the required information at each CPR meeting and participate in a discussion about the Agreement.

CAM Products:

- Agenda and a list of expected participants
- Schedule for written determination
- Written determination

Recipient Product:

- CPR Report(s)

Task 1.3 Final Meeting

The goal of this task is to closeout this Agreement.

The Recipient shall:

- Meet with Energy Commission staff to present the findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement.

Exhibit A

SCOPE OF WORK

This meeting will be attended by, at a minimum, the Recipient, the CAO, and the CAM. The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be two separate meetings at the discretion of the CAM.

The technical portion of the meeting shall present an assessment of the degree to which project and task goals and objectives were achieved, findings, conclusions, recommended next steps (if any) for the Agreement, and recommendations for improvements. The CAM will determine the appropriate meeting participants.

The administrative portion of the meeting shall be a discussion with the CAM and the CAO about the following Agreement closeout items:

- What to do with any equipment purchased with Energy Commission funds (Options) (if applicable)
- Energy Commission requests for specific “generated” data (not already provided in Agreement products)
- Documentation of Recipient’s disclosure of “subject inventions” developed under the Agreement (if applicable)
- “Surviving” Agreement provisions (if applicable)
- Final invoicing and release of retention
- Prepare a schedule for completing the closeout activities for this Agreement.

Products:

- Written documentation of meeting agreements
- Schedule for completing closeout activities

Task 1.4 Monthly Progress Reports

The goal of this task is to periodically verify that satisfactory and continued progress is made towards achieving the objectives of this Agreement on time and within budget.

The objectives of this task are to summarize activities performed during the reporting period, to identify activities planned for the next reporting period, to identify issues that may affect performance and expenditures, and to form the basis for determining whether invoices are consistent with work performed.

The Recipient shall:

- Prepare a Monthly Progress Report which summarizes all Agreement activities conducted by the Recipient for the reporting period, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Each progress report is due to the CAM within 10 days of the end of the reporting period. The recommended specifications for each progress report are contained in Section 6 of the Terms and Conditions of this Agreement.

Product:

- Monthly Progress Reports

Exhibit A

SCOPE OF WORK

Task 1.5 Final Report

The goal of the Final Report is to assess the project's success in achieving the Agreement's goals and objectives.

The objectives of the Final Report are to clearly and completely describe the project's purpose, approach, activities performed, and results

The Final Report shall be a public document. If the Recipient has obtained confidential status from the Energy Commission for any project tasks and will be preparing a confidential version of the Final Report as well, the Recipient shall perform the following activities for both the public and confidential versions of the Final Report.

The Recipient shall:

- Prepare an Outline of the Final Report, if requested by the CAM.
- Prepare a Draft Final Report following the latest version of the Final Report guidelines which will be provided by the CAM. The CAM shall provide written comments on the Draft Final Report within fifteen (15) working days of receipt. The Draft Final Report must be submitted at least 60 days before the end of the Agreement Term.
- Prepare and submit a Final Report that addresses any comments from the CAM.
- Submit a hardcopy and electronic files (in both MS Word and .pdf formats) of the Final Report to the CAM for final review and formatting prior to Energy Commission publication of the report.
- Work with the CAM as necessary to address any questions about the Final Report or any formatting requirements necessary for Energy Commission publication of the Final Report.

Products:

- Outline of the Final Report, if requested
- Draft Final Report
- Final Report

Task 1.6 Identify and Obtain Matching Funds

The goal of this task is to ensure that the match funds planned for this Agreement are obtained for and applied to this Agreement during the term of this Agreement.

The costs to obtain and document match fund commitments are not reimbursable through this Agreement. Although the Energy Commission budget for this task will be zero dollars, the Recipient may utilize match funds for this task. Match funds shall be spent concurrently or in advance of Energy Commission funds for each task during the term of this Agreement. Match funds must be identified in writing and the associated commitments obtained before the Recipient can incur any costs for which the Recipient will request reimbursement.

Exhibit A SCOPE OF WORK

The Recipient shall:

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the Commission Agreement Manager at least 2 working days prior to the kick-off meeting. Provide in the letter a list of the match funds that identifies the:
 - Amount of each cash match fund, its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied.
 - Amount of each in-kind contribution, a description, documented market or book value, and its 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 shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located.
- Provide a copy of the letter of commitment from an authorized representative of each source of cash match funding or in-kind contributions that these funds or contributions have been secured. For match funds provided by a grant a copy of the executed grant shall be submitted in place of a letter of commitment.
- Discuss match funds and the implications to the Agreement if they are reduced or not obtained as committed, at the kick-off meeting. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide the appropriate information to the CAM if during the course of the Agreement additional match funds are received.
- Notify the CAM within 10 days if during the course of the Agreement existing match funds are reduced. Reduction in match funds must be approved through a formal amendment to the Agreement and may trigger an additional CPR meeting.

Products:

- A letter regarding match funds
- Copy(ies) of each match fund commitment letter(s)
- Letter(s) for new match funds (if applicable)
- Letter that match funds were reduced (if applicable)

Task 1.7 Identify and Obtain Required Permits

The goal of this task 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. Although the Energy Commission budget for this task will be zero dollars, the Recipient shall budget match funds for any expected expenditures associated with obtaining permits. Permits must be identified in writing and obtained before the Recipient can make any expenditure for which a permit is required.

Exhibit A

SCOPE OF WORK

The Recipient shall:

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the Commission Agreement Manager at least 2 working days prior to the kick-off meeting. If there are no permits required at the start of this Agreement, then state such in the letter. If it is known at the beginning of the Agreement that permits will be required during the course of the Agreement, provide in the letter:
 - A list of the permits that identifies the:
 - Type of permit
 - Name, address and telephone number of the permitting jurisdictions or lead agencies
 - The schedule the Recipient will follow in applying for and obtaining these permits.
- Discuss the list of permits and the schedule for obtaining them at the kick-off meeting and develop a timetable for submitting the updated list, schedule and the copies of the permits. The implications to the Agreement 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 the Progress Reports and will be a topic at CPR meetings.
- If during the course of the Agreement additional permits become necessary, provide the appropriate information on each permit and an updated schedule to the Commission Agreement Manager.
- As permits are obtained, send a copy of each approved permit to the Commission Agreement Manager.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the CAM within 5 working days. Either of these events may trigger an additional CPR.

Products:

- Letter documenting the permits or stating that no permits are required
- A copy of each approved permit (if applicable)
- Updated list of permits as they change during the term of the Agreement (if applicable)
- Updated schedule for acquiring permits as changes occur during the term of the Agreement (if applicable)
- A copy of each final approved permit (if applicable)

Task 1.8 Obtain and Execute Subcontracts

The goal of this task is to ensure quality products and to procure subcontractors required to carry out the tasks under this Agreement consistent with the Agreement Terms and Conditions and the Recipient's own procurement policies and procedures. It will also provide the Energy Commission an opportunity to review the subcontracts to ensure that the tasks are consistent with this Agreement, and that the budgeted expenditures are reasonable and consistent with applicable cost principles.

Exhibit A

SCOPE OF WORK

The Recipient shall:

- Manage and coordinate subcontractor activities.
- Submit a draft of each subcontract required to conduct the work under this Agreement to the Commission Agreement Manager for review.
- Submit a final copy of the executed subcontract.
- If Recipient decides to add new subcontractors, then the Recipient shall notify the CAM.

Products:

- Draft subcontracts
- Final subcontracts

TECHNICAL TASKS

TASK 2 BUILD SEISMIC DATABASE FOR THE PROJECT

The goal of this task is to identify, document and evaluate existing active seismic and passive microseismic data which will be used for planning the microseismic and active source surveys in the two Geysers geothermal wells. The existing data is the best predictor of the type and volume of data sought in this project. The existing microseismic data also has a wide areal distribution which will make it complimentary to the higher resolution borehole microseismic data that Recipient will record using a large array of fiber optic seismic sensors.

In order to effectively use the existing data Recipient plans to build a seismic data base of both the active seismic source data and the passive microseismic data. The data will be indexed both in terms of location and in time. Recipient will also correlate the microseismic events with the injection and production history in the area, and use the existing data to plan the structure and sequence of future data collection.

Although this is a collaborative task between Paulsson, Inc., Lawrence Berkeley National Laboratory and Calpine, Recipient is ultimately responsible for delivering the agreed-upon products.

The Recipient shall:

- Prepare a *Seismic/Microseismic Data Collection, Analysis, and Database Development Plan*. The plan shall include, but not be limited to, descriptions of the purpose of the task, subtasks and seismic data, how data will be collected and analyzed, and how the database will be developed and used.
- Identify, collect and analyze reasonably accessible and relevant existing active seismic source data, per the *Seismic/Microseismic Data Collection, Analysis, and Database Development Plan*.
- Prepare a written *Active Seismic Source Data Report* discussing the purpose of the subtask, the analysis of the active seismic data collected, and any imaging or velocity models developed using the data.

Exhibit A

SCOPE OF WORK

- Identify, collect and analyze reasonably accessible and relevant existing passive microseismic source data, per the *Seismic/Microseismic Data Collection, Analysis, and Database Development Plan*.
- Prepare a written *Passive Microseismic Source Data Report* discussing the purpose of the subtask, the analysis of the passive microseismic data collected, and any imaging or velocity models developed using the data.
- Build the seismic database, per the *Seismic/Microseismic Data Collection, Analysis, and Database Development Plan*, using the existing active seismic and passive microseismic data collected and analyzed.
- Prepare a *Seismic Database Report* describing the database, development of the database and its anticipated use.

Products:

- *Seismic/Microseismic Data Collection, Analysis, and Database Development Plan* (no draft)
- *Active Seismic Source Data Report* (no draft)
- *Passive Microseismic Source Data Report* (no draft)
- *Seismic Database Report* (no draft)

TASK 3 - BUILD THE 16 LEVEL 482°F (250°C) BOREHOLE ARRAY

The goal of this task is to manufacture a 16 level, three-component (3C) array that is capable of operation in wells that are up to 482°F (250°C) to a depth of 15,000 ft and at pressures up to 20,000 psi. The array will be manufactured using the designs and components that were developed and purchased on several DOE contracts.

The Recipient shall:

- Prepare a *Seismic Borehole Array Construction and Testing Plan*. The plan shall include, but not be limited to, descriptions of the purpose and function of the array as well as identification of each array development step, the purpose of each step, and the actions to be taken in each step. Array development steps to be completed may include:
 - Test the 15,000 ft long telemetry fiber tube with 15 fibers.
 - Spool the completed 15,000 ft lead-in fiber tube onto the existing field spools.
 - Test 48 fiber optic seismic sensors using existing sensor design.
 - Test the 48 sensors for output amplitude, uniformity and vector fidelity.
 - Test 16 fiber optic seismic three-component sensor pods using existing sensor design.
 - Test the telemetry fiber tube with the sensor pods.
 - Install the fiber optic seismic sensor into 16 sensor pods.
 - Test 16 sensor pod housings using existing sensor pod housing designs.
 - Test 16 clamping mechanisms using an existing design.
 - Install the clamping mechanism into the sensor pod housings.

Exhibit A

SCOPE OF WORK

- Assemble the components into a borehole seismic array with a pod spacing of 25 ft and capable of being deployed to 15,000 ft.
- Manufacture, construct and test the borehole array and components in accordance with the *Seismic Borehole Array Construction and Testing Plan*.
- Prepare a *Seismic Sensor Test Results Report* documenting the results from testing the 48 fiber optic seismic sensors for output amplitude, uniformity and vector fidelity.
- Prepare a *Seismic Sensor Installation Report* documenting the results and installation of the 48 fiber optic seismic sensor into 16 sensor pods.

Products:

- *Seismic Borehole Array Construction and Testing Plan* (no draft)
- *Seismic Sensor Test Results Report* (no draft)
- *Seismic Sensor Installation Report* (no draft)

TASK 4 TEST ARRAY IN THE LAB AT 482°F (250°C) AND 20,000 psi

The first goal of this task is to confirm that the array is functional at high temperatures and pressures. The second goal is to verify that that array has a high seismic output and records high fidelity data.

The Recipient shall:

- Generate a *Fiber Optic Seismic Sensor Test Plan* for the laboratory tests. The test plan shall include, but not be limited to:
 - Description of the instruments to be tested.
 - A rationale why the tests are required.
 - Predicted performance based on modeling.
 - Test objectives and technical approach.
 - A test matrix showing the different tests.
 - Description of the facilities, equipment, and instrumentation required to conduct the tests.
 - Description of test procedures.
 - A description of the data analysis procedures.
 - A description of quality assurance procedures.
 - Contingency measures to be considered if the test objectives are not met.
- Provide a *Written Notification of Laboratory Testing* prior to the array acceptance test indicating that the sensors mounted into the sensor pods are ready for testing at both temperature and pressure.
- Test the sensors and sensor pods at 482°F (250°C) AND 20,000 psi to assure that the system will perform as designed during the field survey when they are exposed to high temperatures.
- Compare the fiber optic seismic sensors with industry standard geophones to evaluate the sensors and bench mark them relative to the industry standard sensor.

Exhibit A

SCOPE OF WORK

- Prepare a *Laboratory Test Report* on the findings of the laboratory tests. The test report shall include:
 - A summary of the testing process.
 - Test data and results.
 - Analysis.
 - Conclusions.
 - Recommendations for system improvements or adjustments.
 - Diagrams and photographs as appropriate.
- Participate in a Critical Project Review Meeting per Task 1.2

Products:

- *Fiber Optic Seismic Sensor Test Plan* (no draft)
- *Written Notification of Laboratory Testing* (no draft)
- *Laboratory Test Report* (no draft)

TASK 5 RECORD SURVEYS IN GEOTHERMAL AREAS

The goal of this task is to deploy the 16 level 3C array into two pre-selected wells operated by Calpine in the Geysers geothermal field and record seismic data. The data recorded will include passive seismic source data from two wells and active seismic source data from one well.

The Recipient shall:

- Generate a *Field Survey Test Plan* for the microseismic and active seismic source field surveys. The survey test plan shall include, but not be limited to:
 - Description of the instruments to be used.
 - Survey objectives and technical approach.
 - A rationale for the survey plan.
 - Predicted performance based on modeling.
 - A matrix showing the different survey steps.
 - Description of the facilities, equipment, and instrumentation required to conduct the survey.
 - Description of the specific steps necessary to deploy the borehole seismic array system into a geothermal well.
 - Description of survey procedures.
 - A description of the survey analysis procedures.
 - A description of quality assurance procedures.
 - Contingency measures to be considered if the survey objectives are not met.
- Provide *Written Notification of Field Surveys* regarding the array acceptance test that the sensors mounted into the sensor pods are ready for being deployed into the geothermal wells.

Exhibit A

SCOPE OF WORK

- Deploy the borehole seismic array system to the field in accordance with the *Field Survey Test Plan*.
- Record microseismic data in two wells in accordance with the *Field Survey Test Plan*.
- Record active seismic source data in one well in accordance with the *Field Survey Test Plan*.
- Generate a *Field Report* for the field surveys and data processed in the field that will be analyzed for data quality and consistency. The Field Report shall include, but not be limited to:
 - Detailed descriptions of the deployment of the fiber optic borehole seismic system to the field.
 - Information on the microseismic data recorded in two wells.
 - Information on the active seismic source data recorded in one well.

The Field Report shall also include, but not be limited to, descriptions of any:

- Transport issues.
- Deployment issues including time to deploy.
- Data quality issues.
- Safety issues.
- Functions issues with the equipment.
- Recommendations for improvement in any aspect of the field work.

Products:

- *Field Survey Test Plan* (no draft)
- *Written Notification of Field Surveys* (no draft)
- *Field Report* (no draft)

TASK 6 PROCESS DATA, INTERPRET, AND REPORT RESULTS

This task includes several goals. The first is to generate a highly accurate velocity model using active and passive seismic source data. The second is production of highly accurate 3D maps of microseismic data as well as a highly accurate 3D image using active source data. The third goal is mapping of faults and fractures using interferometric imaging. Finally, the Recipient shall prepare a plan for the dissemination of project results to the scientific community or the public.

The Recipient shall:

- Generate a detailed *Data Processing and Model Development Plan*, including but not limited to:
 - Description of the data to be processed.
 - A rationale for the data processing approach.
 - 3D velocity modeling and 3D maps purpose and development requirements.
 - Predicted results.

Exhibit A

SCOPE OF WORK

- Processing objectives and technical approach.
- A processing matrix showing the different processing approaches.
- Description of the facilities, equipment, and instrumentation required to conduct the processing.
- Description of processing procedures.
- A description of quality assurance procedures for the processing.
- Contingency measures to be considered if the processing objectives are not met.
- Provide a *Written Notification of Data Processing*, including a list and description of the data to be processed.
- Generate a highly accurate *3D Velocity Model*.
- Generate highly accurate *3D Maps of Microseismic Data*.
- Generate a highly accurate *3D Image of Geology* around the well used for active source imaging.
- Generate a *Final Interpreted Data Report*, including interpretation of the active source images as well as the microseismic volumes.
- Prepare a *Plan for Dissemination of Project Results* identifying the steps to be taken to present the results from the project at conferences or publish the results in geophysical, engineering, geothermal or other publications.
- Provide copies of conference presentations or articles on the results of the project that are completed or published within the term of the agreement.

Products:

- *Data Processing and Model Development Plan* (no draft)
- *Written Notification of Data Processing* (no draft)
- *3D Velocity Model* (no draft)
- *3D Maps of Microseismic Data* (no draft)
- *3D Image of Geology* (no draft)
- *Final Interpreted Data Report* (no draft)
- *Plan for Dissemination of Project Results* (no draft)
- Copies of presentations or publications on the project results that are completed or issued within the term of the agreement (no drafts)

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION - RE: PAULSSON, INC.

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

RESOLVED, that the Energy Commission approves Agreement GEO-14-001 with **Paulsson, Inc.** for a **\$883,002** grant to build and field test a large aperture borehole seismic vector array that is capable of operating at the high subsurface temperatures and pressures common to geothermal areas, and produce high resolution seismic data, models and maps for two wells at the Geysers geothermal field. The array and the resulting high resolution seismic data and maps will allow for better definition of geothermal subsurface conditions and allow for effective characterization and monitoring of geothermal reservoirs in every phase of field development; 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 December 10, 2014

AYE: [List of Commissioners]

NAY: [List of Commissioners]

ABSENT: [List of Commissioners]

ABSTAIN: [List of Commissioners]

Harriet Kallemeyn,
Secretariat