Reducing Exploration Risk for Undiscovered Hydrothermal Resource Plays through Advanced Geophysical Imaging

FULL PROPOSAL DUE DATE: MONDAY April 20, 2020 by 5:00 PM EASTERN

Overview and Purpose

Over the past five years, the U.S. Department of Energy's Geothermal Technologies Office (GTO) sponsored R&D to adapt the Play Fairway Analysis (PFA) technique to the geothermal industry, targeting the identification of undiscovered or "hidden" hydrothermal systems and incorporating the regional or basin-wide distribution of known geologic factors that control the occurrence of a particular geothermal system. By conducting PFA in unexplored or underexplored regions, or by using new play concepts in basins with known geothermal potential, GTO investments can quantify and reduce uncertainty in geothermal exploration—ultimately yielding a potential 30 gigawatts of additional power from energy hidden deep in the Earth (Williams, 2008). The highly successful PFA effort yielded many favorable prospects that require further study.

In FY 2020, the GTO Hydrothermal Program will continue its emphasis on discovering hidden geothermal systems through a multi-pronged approach that includes the following RD&D paths:

(1) Improving the understanding of heat source and occurrence for certain hidden play types that have not yet been demonstrated in the U.S.
(2) Development of subsurface imaging technology, and
(3) Validation of recently developed play-based exploration methods, including through drilling (outside the scope of this call, see funding opportunity DE-FOA-0002219)

This lab call focuses on (1) and (2) above, specifically for areas where traditional temperature gradient drilling cannot be used to identify a resource. Geothermal plays of interest under this lab call present a significant challenge in resource exploration and confirmation due to the high cost of deep exploratory wells as compared to shallower temperature gradient drilling, and the relatively higher risk profile for projects drilling fewer, more expensive wells. In addition, shallow temperature manifestations of the potential for heat from certain geothermal plays may be masked by shallow aquifers and this significantly limits the utility of commonly-used conventional exploration methods.

Significant progress has been made in recent years adapting advanced geophysical techniques from oil and gas into certain geothermal settings. Direct transfer of technology may not be possible for all play

types, as subsurface features in geothermal settings are often much more difficult to image using seismic methods when compared to oil and gas plays. The cost of certain advanced geophysical surveys may also approach that of drilling a slim well, thus this approach to lowering risk will be most advantageous for plays where exploration and confirmation drilling is expected to be relatively high cost.

Lab Call Description – Key Considerations and Area(s) of Interest

Key Considerations

- *EXPECTED AWARD PERIOD OF PERFORMANCE*: up to 3 years
- *EXPECTED # OF AWARDS:* 1-2 awards
- *ANTICIPATED FUNDING*: $2.5-2.9M in total for all awards
- *LIMIT ON NUMBER OF APPLICATIONS*: 1 full application per laboratory
- *CRADAS AND FOA AWARDS:* The Area of Interest (AOI) below may overlap with existing awards in which the lab is a prime or sub-recipient. Labs with CRADAs or FOA awards addressing the AOI should describe that work in their submitted proposals to demonstrate existing capability and lever existing partnerships with industry and other partners. However, labs are not expected to renegotiate existing CRADA or FOA awards for inclusion of the AOI. If the proposal is not selected for funding under this lab call, the work under the CRADA or FOA award will continue – there is no additional risk to the provision of DOE funding. New CRADA agreements and industry collaborations are encouraged where appropriate. Applications must also state if the proposed work is currently being funded through other sources, and how the proposed work differs from what is currently being funded.
- All projects must take a phased approach, with a go/no-go decision point every 12-18 months. GTO anticipates making awards for 1 or 2 phases at this time, or up to a maximum 3 years of work. Projects that are anticipated to require follow-on funding for subsequent phases should describe those requirements in the proposal, to the greatest extent possible. Projects must have at least one SMART annual milestone and quarterly progress measures.
- To the extent possible and appropriate, DOE seeks lab projects that involve industry engagement or industry partners. Academic partners are also encouraged. Cost share is not a requirement under the lab call.

Areas of Interest

Research Objectives

Having the ability to image structural features or other controls on permeability in geothermal systems would provide geothermal explorers a critical constraint on the distribution of temperature and fluids in the subsurface. RD&D resulting in new imaging capabilities is expected to greatly improve the ability to target exploration wells, thereby improving drilling success rates and lowering overall development costs. Currently, the lack of geophysical methods and technologies to reliably image these features makes exploration and development of geothermal systems particularly challenging and costly. The ultimate

goal of this effort will be to develop methods that reduce the total number of wells that are needed to locate and confirm hidden geothermal resources (see proposal requirements below).

GTO is interested in projects that will:

- Reduce the cost and risk to future exploration drilling efforts through the provision of high-resolution subsurface imagery at locations in certain promising geothermal settings. Imaging techniques involving the integration of multiple geophysical data types are also allowed but not required.
- Advance the state of the art in tools and techniques for accomplishing the same;
- Build on recent GTO-funded work to improve the understanding of heat source and occurrence for certain hidden play types that have not yet been demonstrated in the U.S.; and
- Where possible, support the estimation of resource size to aid in prioritizing and justifying further exploration investments.

Proposal Requirements

- R&D shall focus on the development of subsurface imaging techniques, potentially involving multi-physics data, that will improve well targeting at prospects where temperature gradient holes and other conventional exploration techniques cannot easily delineate a potential resource
- Projects shall investigate prospect(s) associated with one or more of the three following hidden play types:
    - Conduction-dominated intracratonic basin (sedimentary) play of the type described by Allis[1]
    - Convection-dominated magma-hydrothermal plays, specifically:
        - ocean-island volcanic types as described by Lautze[2];
        - types associated with volcanic arc settings in the Cascades or Aleutians as described by Forson[3] and Shevenell[4]
- Resource types outside of those indicated above are not of interest for this lab call.
- Selection of study areas shall be informed by an existing Play Fairway Analysis or other study to high-grade potential prospects for the play type being studied. Final site selection will be subject to GTO approval.

[1] Allis, Rick, et al. "Will Stratigraphic Reservoirs Provide the Next Big Increase in US Geothermal Power Generation." Geothermal Resources Council Transactions 39 (2015): 389-397.
[2] Lautze, Nicole, et al. "Play fairway analysis of geothermal resources across the State of Hawaii: 1. Geological, geophysical, and geochemical datasets." Geothermics 70 (2017): 376-392.
[3] Forson, C., et al "Geothermal Play Fairway Analysis of Washington State Prospects." Geothermal Resources Council Transactions, 39 (2015), 701-710.
[4] Shevenell, Lisa, et al. "Geothermal Potential of the Cascade and Aleutian Arcs, with Ranking of Individual Volcanic Centers for their Potential to Host Electricity-Grade Reservoirs." No. DE-EE0006725. ATLAS Geosciences, Inc., Reno, NV (United States), 2015.

- Applicants shall develop and propose performance metrics for tracking progress against the technology development objectives listed above, and clearly describe the current baseline and end-of-project targets for those metrics in the proposal.
- The U.S. DOE Geothermal Technologies Office (GTO) requires all data generated as a result of an award to be uploaded to the DOE Geothermal Data Repository (DOE-GDR). Further, GTO requires, to the extent practicable, that data generated under the award be structured according to applicable subject matter templates.
- Any new imaging capabilities developed must be made freely available to DOE and national labs.

Full Application Format and Content

General Proposal Requirements

Individual proposals must be submitted in PDF or MS Word format as a single file (do not bundle multiple, unique proposals in a single file). Total length shall not exceed 20 pages. Multiple project sites may be submitted in a single proposal, per the discretion of the applicant. Please conform to the following filename convention:

[Filename] = *ImagingLabCall-Lab Name-Project Title-Principal Investigator.pdf*

Proposal Format and Content

Proposal content aligns with content required in the EERE AOP project forms, with additional information to assist in merit review.

Technical Narrative

The technical narrative should reflect careful consideration of the current state of the art (including previous research in this field as well as ongoing DOE- and industry-funded work), and the scope and tasks necessary to achieve the goals of the project as outlined in the objective. Within the project period and with funding made available by the lab call, the technical narrative should describe a scope which:

- Clearly conveys the potential impact of the proposed work and how it supports GTO research objectives
- Clearly builds upon previous (and ongoing) work without redundancy or extraneous efforts;
- Describes specific R&D challenges and the approach taken to address each one;
- Efficiently progresses towards yearly and final project milestones

General Information

This section summarizes the basic information about the proposed project:

- Title

- Principal Investigator with contact information
- Project Partners with contact information

Project Overview

This section should contain a concise narrative that captures the problem statement, the major R&D challenges, and any context needed to provide the reader with a complete understanding of the project and how it supports the energy system and the National Interest.

Project Objectives

This section should describe the project-specific goals, objectives, and expected outcomes. Details on the technical aspects of the goals, objectives, and outcomes should be included in this section to explain the specific technical areas to be addressed and the scientific merit of the work. The proposer should include the technology barriers addressed by the work and how the project addresses them. The proposal should include a technology maturation plan that describes a path for the technologies under development to be deployed in actual geothermal applications.

Project Approach/Tasks/Milestones

This section should list the key tasks and provide brief descriptions for each task, including roles and responsibilities of any partners. A cost estimate (total) for each task should be provided here, with an indication of the total costs for the project. If this is a multi-investigator project, this section should include a description of each investigator's role and responsibility for each task and subtask.

This section should also define the key milestones which include: at least one annual SMART milestone functioning as a Go/No-Go decision point, three quarterly progress measures, and a final success metric. Each key milestone needs to have a specific descriptions of what will be accomplished, and address key technical risks and the steps to be taken to minimize those risks. Each key milestone must also have a date the milestone will be accomplished.

Addendum for Additional required Information

THE ADDENDUM SHOULD BE NO LONGER THAN ONE PAGE, AND INCLUDE THE FOLLOWING:

- Describe capabilities of Principal Investigator to complete the work.
- Fully describe inter-lab collaboration and teaming arrangements/partnerships not otherwise captured in the technical narrative.
- Indicate technical partners from industry or academia, their roles, and responsibilities.
- Thoroughly describe the various facilities to be used in the completion of the work.
- Describe the data management plan and explain how it will support validation of research results.

Project Management Plan

The project management plan (PMP) should accurately reflect the scope, tasks, milestones and other details described in the Technical Narrative above. The PMP should include the following sections: project

timeline, quarterly milestone log, go/no-go decision points, and budget information. Those sections are described below.

Project Timeline

Provide a timeline of the project (similar to a Gantt chart) broken down by each task and subtask, as described in the Technical Narrative. The timeline should show interdependencies between tasks and include the milestones that are identified in the Milestone Log (below).

Quarterly Milestone Log

Provide quarterly milestones for the project. Each milestone should include a title and planned completion date. Milestones should be quantitative and show progress toward yearly Go/No-Go Decision points. Format for the milestone log should be as follows:

[Milestone title]
[Description]
[Responsible individual or partner]
[Planned completion date]
[Deliverable and milestone verification method]

All milestones should be captured or coordinate with an overarching Gantt chart.

Go/No-Go

Provide Go/No-Go criteria for each Go/No-Go Decision Point in the project, for each phase of the entire project. The criteria should be objective and stated in terms of specific, measurable, and repeatable data. Usually, the criteria pertain to desirable outcomes, results, observations from the project, and map to the success metric of the overall project.

Budget

Provide a table that shows, by year, spending planned for all phases by all participating entities with associated tasks. This table will align with the fields represented in the EERE Lab AOP SharePoint site.

Merit Review and Selection Process

The merit review and selection process will be aligned with the principals of the DOE Merit Review Guide available at:
http://energy.gov/sites/prod/files/2016/02/f29/Merit%20Review%20Guide%20FINAL%20JULY%202013.pdf .
Proposals submitted to the appropriate e-mail address will receive a return e-mail confirming receipt. Upon receipt and review for initial compliance with requirements, all proposals received by the deadline will undergo a thorough technical review. DOE will collect and collate review scores and comments for use in making final project selections. The Selection Official will consider the merit review results to make the final project selections.

Technical Review Criteria

Below are the specific technical review criteria against which the full applications will be reviewed.

Criterion 1: Technical Merit, Innovation, and Impact (Weight: 50%)

- 1(a) Extent to which the proposed technology or process has clear impact to the energy system and/or economy;
- 1(b) Degree to which the current state of the technology and the proposed advancement are clearly described;
- 1(c) Extent to which the application specifically and convincingly demonstrates how the applicant will move the state of the art to the proposed advancement; and
- 1(d) Sufficiency of technical detail in the application to assess whether the proposed work is scientifically meritorious and revolutionary, including relevant data, calculations and discussion of prior work in the literature with analyses that support the viability of the proposed work

Criterion 2: Project Approach (Weight: 30%)

- 2(a) Relevance and appropriateness of the approach and description of key tasks, metrics (including baseline), and SMART milestones
- 2(b) Degree of likelihood that the work plan will succeed in meeting project goals.
- 2(c) Identification of key technical risks and the quality of management and mitigation strategies to address them.
- 2(d) the level of suitability of the Data Management Plan for the proposed research and the extent to which it supports the validation of research results.
- 2(e) Reasonableness of budget and spend plan for proposed project and objectives.

Criterion 3: Team, Resources, and Facilities (Weight: 20%)

- 3(a) Capability of the Principal Investigator(s) and team to address all aspects of the work – qualifications, expertise, specialized regional knowledge, and time commitment of the team.
- 3(b) Sufficiency of the facilities to support the work (if applicable).
- 3(c) Degree to which the team demonstrates the ability to facilitate and expedite further development of the proposed technologies (or wider implementation of the proposed deployment activity), as appropriate.
- 3(d) Level and appropriateness of partnerships (including local stakeholders, where necessary), and the clarity in the description of roles and responsibilities.

Timeline and Process Logistics

Tentative Timeline

- *LAB CALL RELEASE DATE:* MONDAY March 16, 2020
- *FULL PROPOSAL DUE DATE:* MONDAY April 20, 2020 by 5:00 PM EASTERN
- *SELECTION NOTIFICATIONS:* July 2020

Process Logistics

- *DISTRIBUTION LIST:* Potential Applicants should send an email to subsurface@ee.doe.gov designating a point of contact for your organization
- *PROPOSAL SUBMISSIONS:* Lab leads or their designee(s) must submit all proposals via e-mail to subsurface@ee.doe.gov
- *QUESTIONS DURING OPEN LAB CALL PERIOD:* Specific questions about this lab call should be submitted via e-mail to subsurface@ee.doe.gov. DOE will provide responses via periodic e-mail communications to those who have signed up as described above.
- *NOTIFICATION OF SELECTION/NON-SELECTION:* When selections are finalized, applicants and lab leads/designee(s) will receive an email from subsurface@ee.doe.gov.

Questions and Answers

1. Favorable locations for hidden play types of interest might not have been a part of PFA funded projects. Is it the case that only locations with an existing PFA will be eligible for this? No. Projects funded under this lab call must focus on areas that have seen some previous study (such as PFA) that supports continued exploration. For example, the play type described by Allis is not part of any PFA study that GTO is aware of, however the work cited in note [1] will suffice as a "study to high-grade potential prospects for the play type being studied". It may be allowable, however, to also include some work in a well-understood field outside of the prescribed areas to use for comparison with more greenfield study areas.
2. Does the site where new imaging technology is demonstrated have to be in USA? Yes
3. What level of industry funding, if any, will be required? Industry cost share is encouraged and viewed favorably, but not a strict requirement
4. Should the new proposals use the current Play Fairway Analysis project sites as the study areas? The PFA projects identified many suitable sites, but please see answer to # 1 above
5. What geophysical data are available under the current Play Fairway Analysis projects? This question is best answered by reviewing the PFA data submissions and reports on the DOE Geothermal Data Repository. What new data will be acquired? This is to be determined by the applicant.
6. Which Play Fairway Analysis project sites contains the following hidden play types: Conduction-dominated intracratonic basin (sedimentary) play, conduction-dominated intracratonic basin (sedimentary) play and volcanic arc settings in the Cascades or Aleutians? This question is best answered by reviewing the PFA data submissions and reports on the DOE Geothermal Data Repository.
7. Does it require/allow collaboration among national labs, academia, and industry? Collaboration is absolutely encouraged and viewed favorably, but is not a strict requirement.
8. Will Basin and Range be included? One play type listed is associated with the Basin and Range; in addition, a separate funding opportunity is focused on Basin and Range plays (DE-FOA-0002219).

9. Would certain innovative remote sensing or geochemical techniques (e.g. spectral, InSAR, soil-gas, etc.) qualify as advanced geophysical techniques? No, however, these complementary techniques are allowable to the extent that they support the objectives of this call.
10. As there are significant potential study areas that fall outside "existing PFA projects or other comprehensive studies", might this limitation exclude prospective areas? See answer to #8.
11. How is the lab call different from the FOA? This lab call is focused mostly to play types located outside of the Basin and Range (except for the deep sedimentary play), and it is limited to pre-drilling characterization in preparation for future drilling.