### 1.3.6 Research and Development Implementation Plan.

The "Research and Development Implementation Plan" enfranchises the "Project Vision" which is to construct an internationally recognized in-situ research facility centered around two (initially) directionally drilled wells in Central Utah. This well-characterized and controlled field laboratory will enable developing, testing, optimizing and validating technologies that will expedite EGS implementation in commercial settings elsewhere. The Project Vision and the aligned Research and Development Implementation Plan explicitly align with GTO's goals and objectives. In particular, the laboratory development and the supplementary research solicitations are designed to:

- Develop field testing data that demonstrates best practices for initiating, reopening, reactivating and extending natural and latent fracture networks and hydraulically comminuting virgin basement rock.
- Assess sustainability of hydraulic conductivity and thermal deliverability. If either of these are jeopardized assess technologies for remediation or restoration.
- From these field data, fundamental scientific comprehension is collaterally developed.
- During well construction, identify technology gaps related to drilling and completion, and implement solutions where applicable. After commissioning of the experimental laboratory, test stimulation technologies, monitoring methodologies, develop fluid handling and sampling methods at surface, assess alternative working fluids and energy transfer technologies, verify and validate numerical simulation methods, test logging and monitoring methods.

Procedures are described for effectively incorporating R&D activities with site activities in a safe and scientifically successful manner. Logistical, administrated, and techno-analytical support is described for site operation and for soliciting, reviewing and selecting research programs after commissioning of the laboratory. Procedures are outlined for evaluation of the FORGE project to ensure that the objectives of the GTO are met and research is fairly, logically and transparently solicited, administered, evaluated, implemented and reported. This is incumbent on the Project Management Team (PMT) and the Science and Technology Analysis Team (STAT). The concepts of the charters and compositions for both of these teams are outlined, with particular emphasis on avoidance of conflict of interest (COI).

***Project Vision***

The overarching purpose of Utah FORGE is to bring EGS to commercial viability and national visibility. The project will create a well-characterized and controlled environment where the most talented and creative scientists and engineers in the field can develop and optimize EGS technologies. The laboratory will function as a venue for technical interaction and public education to support the widespread adoption of EGS as an energy source.

Utah FORGE builds on recent successful EGS demonstration projects in Idaho and an ongoing project in Korea, as well as research conducted throughout the US and Europe during the last 50 years. These projects demonstrate that to extract useful heat over prolonged periods we need a better understanding of how to stimulate, maintain and quantify fracture networks in crystalline basement rocks.

Previous successful EGS stimulation experiments (e.g., Desert Peak, Geysers, Landau, Soultz and Raft River) have all relied on interaction with pre-existing structures. Tests at locations without such structures (e.g., Newberry) have been discouraging. The Utah FORGE site includes areas suitable for studying the fundamental geologic conditions for successful heat extraction, and for developing engineering protocols that will increase the number of potential sites for EGS energy development.

The R&D Implementation program at Utah FORGE is focused on addressing the following questions:

- What pre-existing fracturing and stress states of the reservoir rocks are necessary for EGS development? A corollary is, "If fractures are sparse, are there conditioning procedures (aggressive perforation, propellant, cyclic thermal or cryogenic injection,) that can overcome these limitations?"
- What techniques can stimulate targeted reservoir rocks to create long-lived dilation and a heat exchange surface area sufficient to support EGS circulation? What technologies can be effectively used to characterize permeability, fracture interconnectivity and other key properties required for EGS system deployment?

In order to achieve rapid progress, the Utah FORGE Research and Development Implementation Plan requires high-level collaboration between geoscientists and engineers. The Utah FORGE Project Management Team (PMT) will support the research with staff professionals to facilitate progress. Aspects of the plan pertaining to Phase 2C will be implemented as early as possible so as to involve the community of geothermal researchers in the laboratory development.

The Project Management Team (PMT) will administer the FORGE R&D Implementation Plan. The managing and administrative staff will be housed at EGI and led by the Utah FORGE Managing PI, Dr. Joseph Moore. The PMT will consist of three additional members: Dr. Rick Allis, Dr. John McLennan, and Dr. Philip Wannamaker. The PMT will take primary responsibility for day-to-day technical and financial management of Utah FORGE R&D, its cooperative agreements, educational and transitioning programs that it develops, agreements on intellectual property (IP) and addressing the management of conflicts for participating members. EGI and the University of Utah have extensive experience in operating large, federal research centers and conducting collaborative research with US federal laboratories, other universities, government organizations, and the oil and gas and geothermal communities.

The process of involving the wider geothermal community will be described below. The result will be a program with the following goals:

1. Drill and steer highly deviated wells into granitic rocks with a temperature of ~175-225°C in the 1.5-4 km depth range.
2. Solicit, develop and test innovative technologies for reservoir stimulation, monitoring and testing.
3. Create a network of highly conductive fluid pathways connecting the wells (without short-circuiting), demonstrate long-term reservoir sustainability and monitor performance and thermal extraction efficiency.
4. Characterize the reservoir volume (productive, sustained surface area), fracture morphology, directions, surface area and interconnectivity; formulate and validate reservoir and site models.

5. Provide a facility where high-temperature logging and fracture imaging tools and equipment can be tested, and expert teams can visit and test novel stimulation and heat exchange techniques.
6. Provide a site that showcases EGS technologies to the public, stakeholders, and the energy industry; demonstrating that they are viable and have the potential to contribute significantly to power generation and direct use applications.
7. Provide educational and research opportunities at all levels - from grade school to graduate programs, as well as the general public, national and international specialists and laypersons.

***Pre-Selection Technical Plan (Phases 1, 2A and 2B)***

Utah FORGE activities will evolve through the project timeline. In Phase 1, we have demonstrated that the laboratory site meets the technical requirements established by the DOE for temperature, rock type and depth. Temperatures, rock distributions, large-scale tectonic structures, background seismicity, stress directions, representative matrix rock strength and permeability were established. Based on the analysis of legacy and newly acquired data (refer to Task 1.1 and 1.2), a ~5 $km^2$ site area has been selected for the deep drilling venue. No environmental issue that would constrain FORGE activity has been identified thus far.

The activities of Phase 2 will progressively improve our understanding of the deep well site. In Phase 2A, we (the Utah FORGE PMT, its contractors, and consultants) will:

- Augment seismic data that have been collected since 1980. Dr. Kristine Pankow (University of Utah Seismographic Stations) and Dr. Jim Rutledge (Schlumberger) will lead the seismic monitoring activities.
- Establish the baseline information necessary to ensure that any site activities present no conditions incompatible with the site, and that all necessary environmental permitting and NEPA requirements be met in an adequate timeframe to satisfy the programmatic needs of the DOE. Ms. Anna Carter (private consultant) will serve as the Environmental Manager of Utah FORGE.
- Continue outreach and communication program initiated in Phase 1 including public meetings, science fairs, and use of website and social media. Dr. Anthony Butterfield and his students (University of Utah) will conduct K-Gray activities throughout Utah and the material developed will be made available nationally through electronic media.

In Phase 2B, we will undertake non-invasive geologic and geophysical surveys and thermal gradient drilling in order to reduce uncertainty by better constraining the top of the granite, the subsurface locations of faults, and the temperature distribution beneath the deep drill site. Seismic monitoring will continue. Background data on ground motion and deformation will be collected from ground motion detectors, tiltmeters, geodetic surveys. The new data will allow us to further refine the target location. In Phase 2B, we will:

- Achieve full NEPA compliance.
- Fully instrument the site for surface and subsurface investigations. The team will bring the site to full readiness for R&D technology testing and evaluation.

- Initiate non-invasive characterization of the site. Activities will be directed toward further characterization of subsurface geology and stress regime, the hydrologic system and the thermal regime and preparing for acquiring surface representations of hydraulic stimulation in future stages. Utilize the data to refine the drilling and testing program for the Phase 2C test well.
- Continue ongoing seismic monitoring to record seismic background in this historically quiescent region of Utah. Microearthquake data will be incorporated into a finalized Induced Seismicity Mitigation Plan. This plan will include a Probabilistic Seismic Hazard Analysis, delineate Criteria for Damage and Vibration, and specify Mitigation Actions appropriate for future field testing.
- Continue outreach and communication activities initiated in Phase 2A. The intent is to engage stakeholders and inform the public and DOE about ongoing activities. The full list of activities is included in the Project Management Plan and SOPO.
- In concert with the DOE, establish the STAT as described subsequently in this R&D Implementation Plan.

***Post-Selection Technical Plan (Phases 2C and 3)***

***Phase 2C***

In Phase 2C, a 1525 m vertical testing/reservoir characterization wellbore will be drilled to the granitic reservoir in addition to drilling wells for microseismic monitoring. The test hole will be drilled and a complete suite of openhole logs will be run to determine petrophysical properties and delineate natural fracture systems. Core will be taken from the granitic reservoir and the physical and mechanical properties of the rocks will be determined. Measurements will be carried out to determine in situ stresses using microhydraulic fracturing (see for example, McLennan, 1980[1]) and, in combination with the mechanical property data, used to calibrate the acoustic logs. At least two of small volume injections will be performed in the test hole to provide data to infer the behavior of the reservoir rock during future stimulation and to aid in developing a geothermal model of the reservoir. This well will be cased and cemented. A string of geophones will be installed for seismic monitoring and fracture mapping during and after stimulation of the deep wells drilled in Phase 3. Inferences of permeability will be made by well testing in naturally fractured regions (if present) and/or in conjunction with the microhydraulic fracturing. The procedures will be similar to Diagnostic Fracture Injection Testing (DFIT) adopted in the petroleum industry, with pre- and post-closure assessments. The geologic, geophysical, and mechanical properties data will be consolidated into a geomodel representing the thermal reservoir. Natural fractures and faulting will be important components of this geologic model – as inferred from field mapping, seismic and image logging Numerical modeling will assist in predicting the effects of potential stimulation activities.

There is also some possibility of incorporating a well of opportunity. The Acord-1 is a legacy well in the area. If funds allow, that well would be re-entered and cleaned out. It would then be available for testing new technologies by R&D Performers – for example, thermal stability of logging tools and isolation technologies.

[1] McLennan, J.D. 1980. Hydraulic Fracturing: A Fracture Mechanics Approach, Ph.D. Dissertation, University of Toronto, November.

While carrying out all of these activities, the Utah FORGE team will closely coordinate with technical and management specialists on the Science and Technology Analysis Team (STAT). The STAT will be established and convened to assess the "state of the art" (e.g. exploration and testing, drilling and completion, stimulation, production, reservoir management, and sustainability) and define R&D directions. The first solicitation for R&D investigations will be prepared and issued at the beginning of Phase 3. The STAT will contribute to the development of the stimulation program and its metrics.

***Phase 3***

Phase 3 will involve full implementation of FORGE, including drilling, stimulation, flow and pressure transient analysis, and monitoring to achieve incremental as well as substantial additions to the important findings from earlier field demonstrations, domestically and internationally. R&D projects will be solicited, reviewed, selected and tested. These projects will be designed to develop new and novel tools and methods for the drilling, stimulation and maintenance of EGS reservoirs. We anticipate that emphasis will be placed on the development of tools capable of withstanding elevated temperatures for long periods of time. Tools are needed to increase the Rate of Penetration (ROP), improve geosteering and perform Logging While Drilling (LWD) in these extreme environments. New technologies that can substantially improve EGS development include smart tracers and other fracture mapping/quantification methods, geophysical and well testing techniques for reservoir monitoring, and new reservoir models and simulation methodologies.

During Phase 3, two wells will be drilled and interconnecting hydraulic fracturing will be undertaken. The facility will allow will allow development, testing, refinement and comparison of different EGS stimulation, monitoring, prediction, mapping, extraction, and prediction technologies. While protocols are not finalized, based on our present understanding of the drilling environment, we propose to drill two or more wells vertically to a depth of approximately 1800 m and complete them with legs drilled to the southeast at approximately 60$^{o}$ or more from the vertical.[2] We anticipate drilling the deviated legs of these wells not more than 100 m apart. More insights are provided below. As discussed below, we propose a staged stimulation program beginning at the toe of the first well drilled, rather than attempting to stimulate the entire reservoir section at one time. This will allow implementation of some additional simulation and completion methods uphole from the initial fractures. All data generated by the project will be made available to the public through the National Geothermal Data System.

EGI has an MOU with Southwest Petroleum University in Chengdu City, China. We have been sharing information related to their deep EGS drilling and stimulation program in South Korea. One of the key messages from that program is the difficulty in breaking down deep granitic reservoirs. The recent results of attempted stimulation in this South Korean setting - which was designed to develop an EGS reservoir in granite - demonstrate that even high pressure (in excess of 90 MPa at the surface) could not break down the toe of the active well, precluding the immediate opportunity to produce the distributed fracture network required for EGS

[2] Consultation with various service providers indicates that horizontal drilling would be possible but setting isolation tools may be less problematic at a slightly smaller inclination.

development. Those researchers tried aggressive injection, cycling and prolonged maintenance of elevated pressures. No significant injectivity was created in the 100 m of open hole despite the high pressures. These data, as well as the results of other EGS experiments suggest two important considerations:

1. Incorporation of existing zones of weakness (veins, fractures) into the isolated zone in the wellbore, with an added requirement of closely spaced stimulations will likely be required unless the natural fracture frequency is high.
2. Implementation of breakdown procedures (e.g. perforating in openhole, multiple perforation runs, propellant, aggressive abrasive slotting, and/or cryogenic fluids[3]) will be required in addition to hydraulic stimulation.

In order to achieve interconnected wells, we propose the following general approach. This is based on our experience and current understanding of the reservoir environment. At this point, we DO NOT recommend that the entire wellbore length is hydraulically fractured. Only two zones at the toe of the "active" well will be treated. This allows future research in terms of stimulation methodology to be assessed in the R&D phase:

1. In Year 1 of Phase 3, drill and case the "active"[4] well. The well be cased and cemented (it may be a cemented liner that is later tied back), leaving a 20 m barefoot section below the casing shoe (7-inch casing is being currently considered). This section will allow us to evaluate openhole hydraulic fracturing.
2. Where possible log the entire hole. Temperature may require cooldown.
3. Carry out a Diagnostic Fracture Injection Test (DFIT) at the toe to assess if measures need to be taken to promote breakdown. Interpret pre- and after-closure data. Determine in-situ stress conditions, permeability, skin, degree of natural fracturing and suitability for stimulation (without near-wellbore conditioning to assist breakdown).
4. Stimulate one or two additional zones within the cased portion of the well. At the present time, plug-and-perf techniques will be used because of their relative simplicity. Short segments of the lateral will be isolated, likely with only one perforation cluster although this is an area of open discussion. Currently, the preferred treating fluid will be slickwater (water with biocide, friction reducer and corrosion inhibitor) on the premise that proppant will not be initially pumped. In fact, these zones could be refractured subsequently to specifically evaluate the effectiveness and longevity of bauxite (see EGI DOE-Proppant study The Role of Geochemistry and Stress on Fracture Development and Proppant Behavior in EGS Development)).
5. There are other permutations for treating these lower zones that will be evaluated prior to stimulation. For example, low rate injection of cold water has proven to be effective at Raft River. Is shear induced conductivity sustainable? Customized treating schemes could be conceived to allow rates to increase at constant or decreasing pressure.
6. After stimulation, continue, low rate injection of cold water.

[3] Application is unlikely because of need for specialized metallurgy in the injection tubing, but it is not out of the question. There could also be risks to isolation equipment.

[4] For arbitrary delineation of the two wells, the initial well is termed the active well. The second well is termed the passive well. The implication is that the active well will be hydraulically fractured and the passive well drilled to intersect the fractures.

7. Using installed monitoring equipment, monitor the direction and extent of the fractures that are created.
8. Drill the second well in Year 2. The deviated leg of this well will be directionally drilled to optimally intersect the fracture networks determined from Well 1 stimulations. Intersection can be confirmed by several methods including pressure transient testing resistivity surveys, and tracer breakthrough.
9. Different stimulation techniques will be tested during the stimulations. Potential techniques could include the use of proppant, cold water injection, propellant, and abrasive slotting.
10. Conduct a long-term test to establish the efficiency of the EGS system, Characterize the temperature,, fracture volume, fracture interconnectivity, and heat sweep evolution of the system with time. Monitor fracture growth, seismicity and pressures using surface monitoring equipment, the seismic network, Distributed Temperature Sensors, and downhole logs (e.g. Temperature-Pressure-Spinner logs) to validate model predictions. Test the effects of potential enhancement techniques such as repeated stimulations, changing fluid pressures and temperature.

The Project Management Team will ensure that the logistical administrative, analytical and technical support required for on-site operations will be available and will facilitate data sharing, access. All data generated by the project will be made available to the public through the National Geothermal Data System.

***R&D Implementation Plan***

The R&D Implementation Plan has been designed to develop new technologies and to provide the flexibility required to address the evolving needs of the project. Fifty percent of the funds provided by DOE will be used for R&D subcontracts; the remainder will be attributed to drilling, stimulation and related activities, operations and management, and routine periodic or continuous monitoring activities. R&D activities will be generated, funded and managed through a recurring series of Funding Opportunity Announcements (FOAs). The mechanisms and protocols that will be used to address R&D needs throughout all phases of the Utah FORGE project are described in the following R&D Implementation Plan. Proposals submitted outside the scope of the FOAs will be considered based on the level of funding available, the needs of the project, their impact on ongoing activities, and the STAT's assessment of their contributions to advancing EGS application and viability. R&D projects will not be limited to topics addressed by the FOAs

The scope of the plan includes:

1. Management of the R&D program,
2. Identification of technologies and research that address FORGE and future EGS needs,
3. Preparation of Funding Opportunity Announcements (FOAs), proposal solicitation,
4. Selection of technical experts to serve on the STAT and STAT obligations to the R&D program.
5. Management of these technology development/validation and research projects
6. Management of conflicts of interest.

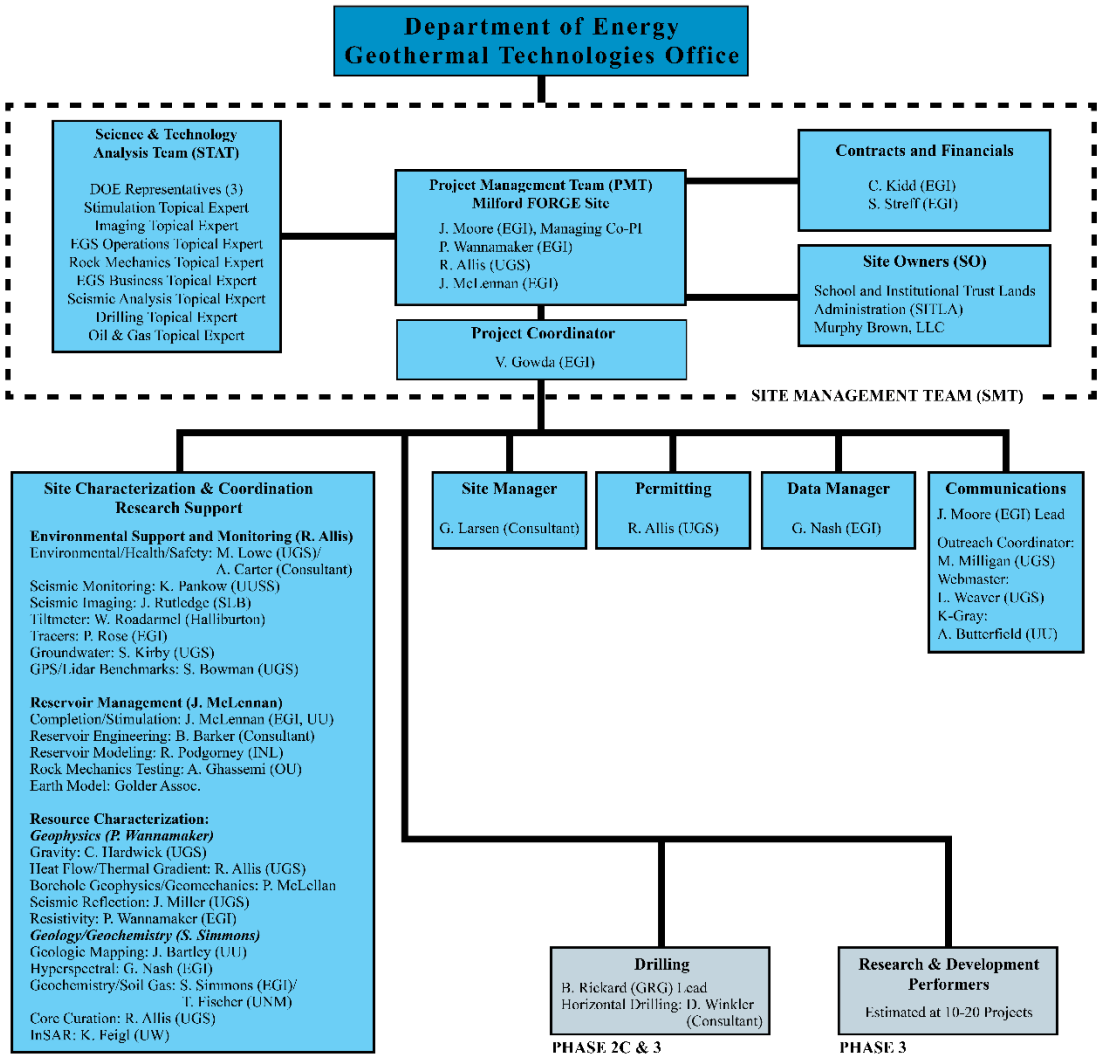
The STAT will consist of DOE representatives, their appointed technical experts, as well as experts from the geothermal, petroleum, and rock mechanics communities; the latter will be appointed by the Project Management Team (PMT). The PMT will oversee all day-to-day operations and management, including administrative and financial activities of Utah FORGE.

### *Management of the R&D Program*

### *Science Technology and Analysis Team*

The STAT will provide technical guidance on research directions, identify specific research topics and ensure continued significance of the FORGE mission throughout Phases 2C and 3. To avoid potential Conflicts of Interest, the STAT will conduct its activities independent of the Utah FORGE Project Management Team (PMT) (Figure 1). The STAT, which will be established in Phase 2C, will:

***Figure 1.*** *Project Management Team Diagram.*



1. Assess and summarize the current state of the art and identify technology gaps,
2. Establish technical baseline information and performance metrics,
3. Determine topics for the initial and subsequent rounds of solicitations during Phase 3
4. Provide a draft of the solicitations for release at the beginning of Phase 3.
5. Review proposals and R&D progress

The membership of the STAT may change as the project objectives evolve. Phase 2C activities will focus on site characterization and the development of the Utah FORGE laboratory, including drilling and stimulation and fluid circulation. Once the wells are drilled and interconnected, the focus will be on reservoir behavior, thermal extraction management and long term assessment. This may require modification of the STAT. The charter and governance structure of the STAT will be established in Phase 2C. It will include provisions for modifying the STAT membership to meet the project's evolving needs.

In order to bridge the gap between the engineering and scientific aspects of the project, members of the STAT will include world class experts in site characterization, drilling and well stimulation, reservoir management and engineering, rock mechanics, and induced seismicity. The STAT members will be drawn from the geothermal and oil and gas industries, national laboratories, research organizations, energy technology companies and academic institutions. The STAT will consist of approximately 10 standing members, up to seven of whom will be selected by the PMT and at least three by the DOE. We have identified a group of experts who can serve on the initial STAT. For example, Eng. Sidney Green, an expert in rock mechanics, Dr. J-C. Rogiers, an expert in rock mechanics and well stimulation, Dr. Roland Horne, an expert in reservoir engineering, and Dr. Norm Warpinski, an expert in microseismic monitoring have agreed to serve on the STAT. In addition, Mr. Nick Goodman, CEO of Cyrq Energy, has agreed to assist in above ground activities. Cyrq currently produces electricity from three geothermal fields. Other experts have been identified to fill the remaining spots and have agreed to serve. We will provide the names of all STAT candidates to the DOE for comment prior to forming the committee. Other world-class experts have indicated their interest in serving on the STAT.

The DOE will choose one member of the STAT to serve as Chairperson. This individual will serve as the primary contact between the STAT and the Managing PI. The Chair will ensure that the goals and objectives of the DOE program are being considered and incorporated into the R&D projects.

The STAT will meet at least twice a year. The STAT, including its governance and charter, will be established within two months of the Phase 2C award. The first meeting of the STAT will be convened in Salt Lake City within the following 2 months (i.e., four months from the start of Phase 2C). At this meeting, the STAT will initiate discussions on:

1. The current state-of-the-technology,
2. Baseline information and performance metrics for Utah FORGE
3. The topics for the first round of solicitations. Writing responsibilities for the first round of solicitations will be assigned.

Solicitations will be issued in the following three EGS lifecycle categories:

- Reservoir characterization (coupled imaging, drilling for interrogation and monitoring, high temperature tools and sensors)
- Reservoir creation (formation access, fracture characterization, zonal isolation stimulation technologies)
- Reservoir sustainability (long-term testing, monitoring, and operational feedback).

Solicitations will be released at month 7. The STAT will meet again at approximately month 10 months to review the proposals submitted under Phase 2C solicitations. We anticipate completing contract negotiations by the start of Phase 3. The solicitation process will be repeated annually in Phase 3 following a similar schedule The STAT will meet during the first quarter to determine topics for the year's solicitations. This meeting will be combined with a Peer Review of activities related to R&D projects, Operations and Maintenance, and projects being conducted by Utah FORGE personnel. The solicitations will be reviewed at the second STAT meeting, which will be convened at approximately month 10, with contract negotiations completed within the following 60 days

***Project Management Team***

The PMT will participate in discussions with the STAT and provide updates on Utah FORGE activities but will not be voting members. The DOE and/or STAT Chairperson will establish the schedule for routine discussions and updates. During Phase 2C, we recommend holding conference calls at least monthly between the PMT and STAT and more frequently during Phase 3 when the wells are being drilled. The PMT will make itself available for impromptu conferences and will initiate conference callsto appraise the STAT of any concerns, issues or variances that could affect the project's objectives. The PMT recognizes the importance of these status updates. During the drilling, completion and stimulation of the Raft River Demonstration well, Dr. Moore, the project's PI, frequently initiated phone calls with DOE's Technical Monitoring Team as often as several times a week. These conversations identified solutions to potential problems and ultimately led to a successful EGS project.

Specific responsibilities of the PMT include:

1. Conducting technical, financial and administrative activities, including oversight of scheduling and engagement of subcontractors for field services; ensuring the safe and cost-effective execution of Utah FORGE and development of EGS technologies. The PMT will be supported by the Finance Manager
2. Oversight of day-to-day site operations and maintenance,
3. Developing and implementing formal procedures for Utah FORGE and for reviewing and awarding funding for R&D technology development and/or validation or conceptual demonstration,
4. Ensuring that all state and federal permits have been acquired and are compliant with NEPA and Protocols for Induced Seismicity Associated with Enhanced Geothermal Systems. The PMT will be supported by the Technical Lead on Seismic Monitoring,
5. Maintaining effective communication with the DOE and interested stakeholders on project activities and technical results. The Managing PI will serve as the primary point of contact with the DOE and assume overall responsibility for communication and outreach activities. He will be supported by the Outreach Coordinator,

6. Making FORGE data available through a dedicated node on the National Geothermal Data System (NGDS). The PMT will be supported by the Data Manager, and
7. Preparation of an annual operating plan (AOP) in Phase 3 for approval by the DOE.

The PMT will be supported by the Project Manager, Financial Manager and Office Manager, as well as the Office of Sponsored Research, and the Legal Department at the University of Utah. The Project Manager will serve as a liaison between the PMT, the R&D projects, the Site Manager and investigators conduction operational activities.. The Financial Officer will monitor all financial aspects of the Utah FORGE project, including disbursement of funds and submission of all required financial statements. The Office of Sponsored Research at the University of Utah will assist in negotiations with contractors, consultants and R&D performers and any subsequent contractual matters that may arise.

Research and daily activities in the field will be supported by the Site Manager, Mr. Garth Larson. The project will maintain a Site Office for conducting daily operations, receiving visitors and equipment, for safety indoctrination and for training. The office will provide work space for scientists, contractors and staff. This office will be located close to the deep drill site. The office facility will be equipped with a fiber optic cable, telephones, and computer facilities necessary to transmit data from ongoing operations to EGI and the Utah FORGE website. Two-way radios will be available to maintain contact with personnel working in the field and to communicate effectively and safely with the well site. Mr. Garth Larsen, was the former Site Manager of the Blundell Geothermal Plant. He will oversee access to the site, the safety of all personnel, and ensure there is adequate security for personnel and equipment. He will be the primary point of contact between the PMT and the field site. All personal will be required to sign in at the field office before proceeding to the drill site. All visitors, contractors and staff members will be required to take a training course once a year before proceeding to the field or drill site. Mr. Larson is familiar with the service industry in Utah and the surrounding states.

During the drilling activities, field operations will be supported by some of the world's most respected and experienced geothermal experts. The drilling program will be led by Geothermal Resources Group and Mr. Duane Winkler, who have drilled more than 450,000 m of horizontal legs for the oil and gas industry. Geothermal Resource Group were significant contributors to the successful Raft River EGS demonstration project. Their staff includes Mr. Bill Rickard (drilling engineer), Dr. Subir Sanyal (principal and founder of GeothermEX, now Schlumberger) and Mr. Dennis Kaspereit (formally a reservoir engineer for Terra-Gen and CalEnergy).

### *Conflict of Interest Among Participants*

Actual or perceived conflicts of interest among participating members of the STAT can have disastrous results. Conflicts of interest are most likely to occur during the solicitation and review process, but can occur at any time during the project. Members of individual review panels will be required to sign conflict of interest statements, indicating the nature of any potential conflicts (see Conflict of Interest form that has been approved by the DOE below). The chairs of the individual review panels will review these statements.

Individuals that do have conflicts of interest are expected them to recuse themselves from the review panels. If the chair concludes that a potential conflict of interest exists, and cannot resolve

the conflict, the PMT will make a determination regarding the suitability of the individual to participate in the solicitation and review process.

We recognize that not all conflicts can be resolved through discussion, although this will always be the first step. In the event conflicts cannot be resolved in this manner, The Managing PI can request the assistance of the University of Utah Legal Department in such determinations.

***Proposed Solicitation Process***

The STAT will advise the PMT on the research and technology requirements based on the overall objectives of the program as discussed above. Proposals will be solicited for research, tool testing and validation, numerical calculations, stimulation and development activities. The specific proposals will be based on the most pressing needs – as determined by the STAT. Proposal development will also recognize anticipated high impact future needs and growth areas.

For each of the three EGS lifecycle categories, a chair will be chosen within the STAT membership to oversee preparation of the solicitation and evaluation of the proposals. The Utah FORGE R&D solicitations will incorporate the evaluation criteria to be achieved. The draft solicitations will be forwarded to the PMT for review and possible recommendations for modification. The PMT will establish a review committee to ensure that each solicitation meets all federal guidelines and requirements.

Each chair will be responsible for recommending the committee members who will serve as reviewers. The committee will nominally consist of three to five voting members in addition to the non-voting chair. Both STAT and non-STAT members will be eligible to serve on these committees, providing there are no conflicts of interest. The review process will comply with all DOE/OMB procedures and protocols.

The solicitations will be announced through DOE's email list, DOE and Utah FORGE websites and in the Commerce Business Daily. The proposals will be ranked by the review committee and prioritized based on their strengths and weaknesses. In some cases, and where funds are available, for example those requiring destruction of core samples, projects that are nondestructive may be given priority over projects that result in sample destruction.

Submitted proposals must address the required milestones and evaluation criteria. The proposals will be assessed using a formalized merit criteria system. The review team will evaluate the proposals, with each member recusing him- or herself from reviewing proposals if a conflict of interest exists. Each reviewer will rank the proposals based on the established review criteria and then all of the ranking scores for each proposal will be summed to provide an overall individual proposal ranking. The results of the reviews and the recommendations by the review committee will be communicated to the PMT by the committee chair, in writing.

In the event that significant issues arise during the review process that cannot be resolved within the committee, the PMT will be notified immediately. The PMT will review the issues and formulate an appropriate response to resolve them. A range of actions may be required. The PMT may, for example, obtain input from additional experts or the STAT, negotiate the addition or removal of specific activities, or conclude that none of the proposals is acceptable.

Research proposals that address existing solicitations will be accepted for review irrespective of the funding source. All proposals will be reviewed and ranked based on the same criteria. Unsolicited proposals that do not address existing solicitations may be submitted throughout the course of the project. These proposals will be reviewed semiannually for relevance to the Utah FORGE project and EGS development. The review will specifically include an assessment of their impact on existing projects and project resources.

***Monitoring R&D Performances***

The period of performance for each project will be defined in the solicitation. These periods will vary based on the needs of the FORGE project the relevance of the proposed work. Research proposals will nominally last for 1 to 2 years, although longer periods may be appropriate for some projects. Each project will consist of two or more phases separated by a GO/NO GO decision at the conclusion of each phase. The evaluation criteria will include, at a minimum:

1. potential impact on the FORGE project and broader impacts on enhanced geothermal system needs, potential for commercialization
2. quality of technical approach and proposal team
3. quality of the results,
4. achievement of milestones, and
5. value of research relative to cost

The GO/NO-GO reviews will include recommendations from the STAT. Projects are not expected to deviate more than 10% from their proposed timelines or category costs. Deviations greater than 10% must be immediately reported to the PMT. Such deviations may result in the immediate cessation of the project unless there is a compelling reason to do so, such as the inability to source equipment or supplies, inability of the researcher to participate and/or inability to book time or other scheduling constraints for the facility.

Each research team will participate in a yearly Program Review. This review may be held in concert with the DOE Peer Review or independently. The review will be open to the public. Each PI will provide a description of the R&D project and progress toward achieving the proposed milestones. After the annual review, a report evaluating the research progress will be compiled by the PMT. A short summary of each research project will be published as part of the Program Review and posted on the Utah FORGE website. The report will also be available through the NGDS and DOE websites.

***Data Dissemination***

All research teams will be responsible for submitting their data to the NGDS in a timely manner as prescribed in their proposal. The FORGE Data Manager will assist as needed to help with this task but the responsibility for compliance will rest with the project PI. The PI will provide all periodic, topical, and final technical and financial reports in accordance with the "Federal Assistance Reporting Checklist" to the PMT.

***Capability to Manage Utah FORGE***

The PMT will conduct ongoing and systematic reviews of the Utah FORGE project and its efforts and members, along with its accomplishments. EGI and the University of Utah have significant experience running a research center and multi-university consortiums, teaming with national laboratories and industry, maintaining close communications with stakeholders, including the DOE, leading topical and wide-reaching consortia, and arranging open events and annual meetings for participants. Success will require a close relationship with program managers at DOE and NETL. This will ensure that the Utah FORGE's work remains relevant to the needs of DOE as a whole. EGI and the University of Utah have extensive experience administering energy-related research awards. In the past 10 years, EGI has administered over $167,000,000 in contracts funded by government agencies and the EGI consortium of oil and gas companies. Significantly, this is the largest university oil and gas consortium in the world. Of those administered contracts, $116,000,000 was funded by DOE and $86,000,000 was specifically targeted towards fossil energy.

EGI and the University of Utah have both staff and systems in place to effectively contract and manage all aspects of the R&D technologies that will be tested and evaluated at the Utah FORGE site. EGI, EGI's Business Office, and the University of Utah's Office of Sponsored Research and its Technology & Venture Commercialization group provide exceptional services related to contractual agreements, administrative assistance, and financial management.

The PMT and STAT will be responsible for ensuring the retention of leading technical experts in the oil and gas and geothermal communities. EGI, in collaboration with these experts from industry, academia, and the National Laboratories have the collective experience, background and insight to high-grade existing technology needs and to develop new ideas and approaches not yet popularized.

***Project Evolution and Teaming***

The Utah FORGE team recognizes that the project requirements will evolve with time. The composition of the STAT and FORGE team will change as necessary to reflect those changing requirements (Table 1). In Phase 2A and B, our activities are designed to achieve NEPA approval and augment existing characterization data with non-invasive studies. In Phase 2C, the focus of work involves refining the temperature and subsurface information (stress, mechanical properties, fractures and faults) in order to improve understanding of the reservoir. Early in Phase 3 the emphasis will be on drilling and stimulation. The later phases of Phase 3 will focus on long term monitoring, reservoir modeling and analysis of early predictions. The mix of technical specialties is illustrated in Table 1.

***Table 1:*** *Evolution of technical specialties*

| Phase | Activity | | Environmental Specialist | Structural Geologist | Geochemist | Rock Mechanic | Geophysician | Reservoir Engineer | Drilling Engineer |
|---|---|---|---|---|---|---|---|---|---|
| 2A | NEPA approval | Non-invasive studies | X | | | | | | |
| 2B | | reflection seismic<br>passive seismic (MEQ)<br>MagnetoTelluric<br>LIDAR<br>hyperspectral imaging<br>precision land surveying<br>gravity<br>soil gas | X | X | X | | X | | |
| 2C | Refine Temp, Stress distributions | Subsurface studies<br>Temp surveys<br>geophysical logs<br>fluid sampling<br>mini-frac tests<br>injection tests<br>core sampling | | X | X | X | X | X | X |
| 3 (early) | Drilling | Stimulation | | | | X | X | X | X |
| 3 (later) | Monitoring | | X | | X | | X | X | |
| | Reservoir modeling | rock & fluid mechanics | | | X | X | X | X | |
| | Analysis | geoscience & economics | X | X | X | X | X | X | X |

We have identified potential STAT and team members who can contribute to these efforts. Over the years, we have worked with many highly qualified individuals from private industry, universities and national laboratories. Some experts identified by the Utah FORGE team have already been approached and offered to participate in our project, even though they are on other teams. It is not appropriate to identify all of them at this point. We propose to nominate some of these individuals to our team.

As part of the R&D Management process (described above) the STAT will meet at least twice each year to review progress and development solicitations. The first meeting will identify research needs for the upcoming year. This meeting will be an appropriate time to recommend adjustments to the membership of the STAT and the review committees. This will allow members whose research interests have changed or who anticipate a developing conflict of interest to change roles for the good of the project. It will also be a natural transition time for the PMT to add new people, ideas and energy to the teams.

# EERE
# INDIVIDUAL CONFLICT OF INTEREST AND NONDISCLOSURE ACKNOWLEDGMENT

This acknowledgment must be completed by individuals prior to receiving any related documentation or information pertaining to, and participation in, the merit review or peer review process. The acknowledgement provides for each reviewer to understand conflict of interest and nondisclosure requirements associated with their participation in these reviews. Individuals with a conflict of interest may not participate in the merit or peer review process or use or disclose information obtained during these reviews, unless DOE has decided that there is acceptable mitigation of the identified conflict.

In anticipation of my participating as a reviewer for the Department of Energy,

I, _____ (Print Name), acknowledge the following:

(a) I understand that during the course of performing merit and/or peer review services, I may obtain access to confidential or proprietary business, technical, or financial information belonging to the Government or other entities, including information relating to the submissions of applications and other information in connection with any Funding Opportunity Announcement (FOA) or peer review;

(b) To the best of my knowledge and belief, no conflict of interest exists that may either:

(1) Result in my participation on a particular matter involving a FOA that will have a direct and predictable effect upon my financial interest;

(2) Diminish my capacity to impartially assist in the review of applications in response to FOAs and project reviews; or

(3) Result in a biased opinion or unfair advantage.

(c) In making the above statement, I have considered all the following factors that might place me in a position of conflict, real or apparent, regarding FOA information or projects during the peer review:

(1) All my stocks, bonds, other outstanding financial interests or commitments;

(2) All my employment arrangements (past, present, and under consideration); and

(3) All financial interests and employment arrangements of my spouse, minor children, and other members of my immediate household as well as my general partners, or any organization in which I serve as an officer, director, or trustee, or with whom I am negotiating for employment.

(4) Any examples of relationships that might create an appearance of a conflict regarding these duties have been provided to me.

(d) I have a continuing obligation to disclose any circumstance that may create an actual or apparent conflict of interest. If I learn of any such conflict, I will report it immediately to the FOA manager/Peer Review Leader and/or the DOE Contracting Officer. I will perform no more duties related to the merit review and/or peer review until I receive instructions on the matter.

(e) I agree to treat this information as proprietary and confidential and comply with agency procedures for the protection of such information (including electronic information) and use my best efforts to safeguard such information. I will not disclose the contents of, nor release, any such information to anyone either during or after the merit and/or peer review evaluation other than:

(1) To individuals within the review process that are directly concerned with the performance of this effort and who have executed this Conflict of Interest and Nondisclosure Acknowledgment;

(2) To other individuals designated by the DOE Contracting Officer, FOA Manager or Peer Review Leader; or

(3) Pursuant to an order from a court of competent jurisdiction.

(f) I shall not accept any invitations or gratuities (e.g., meals, gifts, favors, etc.) from any applicant or project performer. If I am offered any invitations, gratuities, or job offers by or on behalf of any applicant or project performer, I will immediately report to the Contracting Officer or Federal Peer Review Manager.

(g) Whenever DOE furnishes any FOA or project related information to me, I, the reviewer, agree to use such information only for the purpose of conducting the review and to treat the information obtained in confidence. Further, I will not use such information for my own private gain or the private gain of others. This requirement for confidential treatment applies to information obtained from any source, including the submitter, without restriction. Any notice of restriction placed on such information by either DOE or the submitter of the information shall be conspicuously affixed to any reproduction or abstract thereof and its provisions strictly complied with. Upon completion of my duties, I will return all copies to the DOE office that initially furnished such information or I will destroy the files (paper and electronic) and certify to the Contracting Officer, FOA Manager or Peer Review Leader that I have done so.

(h) These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions, requirements, obligations, rights, sanctions, and liabilities created by controlling Executive orders and statutory provisions are incorporated into this agreement and are controlling.

**Signature/Date**: _____

**Name/Title:** _____

**Phone number**: _____

**Email address**: _____

DOCUMENT MUST BE SIGNED AND RETURNED TO DOE POINT OF CONTACT (PROGRAM OR CONTRACTING PERSON WHO IS MANAGING THE REVIEWER PANEL) BEFORE REVIEWER RECEIVES DOCUMENTATION FOR REVIEW.

## EXAMPLES OF POSSIBLE REAL OR APPARENT CONFLICTS

1. AFFILIATION WITH AN APPLICANT/RECIPIENT INSTITUTION
(In this document, "Institution" will be used to mean the inclusive set of all types of institutions, organization, companies, or other entities.)

You may have a conflict, subject to possible mitigation if agreed to by DOE after notification and consideration, if you have/hold/are:

- Current employment at the institution in any capacity
- Other current employment with the institution as a consultant or advisor
- Previous employment with the institution within the last 12 months
- Being considered for employment at the institution
- Formal or informal reemployment arrangement with the institution
- Ownership of securities of companies involved in the application
- Current membership on a visiting committee or similar body at the institution
- Any office, governing board membership, or relevant committee chairpersonship in the institution (Ordinary membership in a professional society or association is not considered an office.)
- Current enrollment as a student at that institution
- Received and retained an honorarium or award from the institution within the last 12 months
- Some other business or financial relationship

2. RELATIONSHIPS WITH AN INVESTIGATOR, PROJECT DIRECTOR, OR OTHER PERSON WHO HAS A PERSONAL INTEREST/ROLE IN THE APPLICATION

- Known family relationship as spouse, child, sibling, or parent
- Business or professional partnership
- Past or present association as thesis advisor or thesis student
- Recent collaboration on a project or on a book, article, report, paper, journal, compendium, or conference proceedings

3. OTHER AFFILIATIONS OR RELATIONSHIPS.

- Interests of the following persons are to be treated as if they were yours: Any affiliation or relationship of your spouse, of your minor child, or a relative living in your immediate household or of anyone who is legally your partner.
- Other relationship (including but not limited to a close personal friendship, a person with whom the reviewer has a longstanding difference, a recent student or teacher, or a former employer) that might cause a reasonable person with knowledge of all the relevant facts to question your impartiality or which you believe might affect your impartiality.