7.0 Program Coordination

The Geothermal Technologies Program coordinates research, development, and demonstration activities with international agencies and associations, industry and trade associations, academia, Federal agencies, national laboratories and other Program offices within DOE. This section describes how GTP coordinates research, development, and demonstration efforts.

7.1 International Coordination

DOE has found that international externalities in the energy industry are too consequential for an isolationist energy policy. High fuel prices, climate change, and energy security are all issues that affect every nation. The U.S. government has prioritized collaborative work with other governments in order to overcome the aforementioned challenges. The GTP participates in two international memorandums of understanding (MOUs): the International Partnership for Geothermal Technology and the International Partnership for the Energy Development in Island Nations.

International Partnership for Geothermal Technology (IPGT): The United States and the inaugural IPGT partners including Iceland and Australia signed the IPGT MOU on August 28, 2008. The IPGT provides a framework for international cooperation in geothermal energy technology, policy and model development. The IPGT seeks to realize the promise of geothermal energy by facilitating the accelerated deployment of geothermal technologies at a rate consequential to impact energy security and climate challenges.

The IPGT facilitates the development of advanced, cost-effective geothermal energy technologies to accelerate the availability of these technologies internationally, and to identify and address wider issues related to geothermal energy. IPGT activities include promoting the appropriate technical, political, financial, and regulatory environments for EGS development and EGS deployment.

Priority areas discussed at the IPGT inaugural meeting include:

- Zonal Completion-multilateral wells;
- Packers;
- HT Downhole Tools;
- Stimulation Procedures;
- Seismic Risk;
- HTHV Lifting and HPHV Surface Pumping;
- Rock/Fluid Interactions;
- CO2 as Heat Transfer Fluid;
- Air Cooling;
- O&M Benchmarking;

- Existing Federal and State Practices;
- Geothermal Lexicon;
- Hydraulic Hammer;
- Temporary Sealing;
- Revolutionary and Low Cost Drilling;
- Alternative Working Fluids;
- Selection of Cycles;
- Optimum Size of Units/Modularity;
- Methods to Reduce Exploration Well Drilling Costs;
- Education/University Competitions;
- Best Practices; and
- Data Repository.

The United States, New Zealand, and Iceland recently established the International Partnership for Energy Development in Island Nations (EDIN). The EDIN Partnership provides a framework for international cooperation to advance the development and deployment of renewable energy and energy efficiency technologies in island nations or territories within their jurisdiction. Participant Nations or territories will strive to deploy the maximum amount of renewable energy and energy efficiency possible, and endeavor to attain nation-specific measurable clean energy targets (such as providing 70 percent of primary energy from clean energy sources within one generation, which is the State of Hawaii's goal).

Figure 7.1. Puna, Hawaii Geothermal Site[27]

27 Geothermal National Action Plan, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, Geothermal Technologies Program, 2008

The EDIN Partnership will leverage resources; share knowledge and research findings; bring together intellectual skills and talents to work towards optimal policy and regulatory strategies; and advance technology deployment. It also aims to foster public-private collaboration that addresses the technological, financial, and institutional barriers to a cost-competitive and environmentally benign clean energy economy.

The EDIN Partnership will engage in the deployment of:

- **Renewable Energy Technologies** – Participants will promote the development and adoption of cost-competitive renewable energy technologies and strategies for deployment.
- **Energy Efficiency Technologies** – Participants will advance the utilization of energy efficiency technologies, with an emphasis on the built environment.
- **Grid integration and Storage Technologies** – Participants will advance reliable grid integration and storage technologies and policies that are critical to achieve high penetration levels of renewable energy (especially intermittent wind and solar resources).
- **Sound Policy** – Participants remove barriers to clean energy development and establish policies that provide incentives for growth.
- **Financing Mechanisms** – Participants will attract private capital to islands for development of renewable energy and energy efficiency projects.

7.2 Industry and Trade Associations

The Program works in partnership with industry to establish geothermal energy as an economically competitive contributor to the U.S. energy supply. Additionally, the Program collaborates with potential geothermal investors and developers to reduce institutional barriers associated with project financing. Table 7.1 lists potential investors and developers who participated in the 2008 GEA Finance and Development Workshop in New York City.

Table 7.1. Potential Investors / Developers	
Participants in Geothermal Finance and Development Workshop in NYC, 2008	
• Advanced Technology Ventures	• Alcoa Inc. (Fortune 500)
• Capstar Partners	• AltaRock Energy Inc.
• Dundee Securities	• Bechtel Enterprises
• GE Energy Financial Services	• Calpine Corporation (Fortune 500)
• Glitner Capital Corporation	• ConocoPhillips (Fortune 500)
• Google.org (Fortune 500)	• EGS, Inc.
• International Finance Corporation (World Bank)	• Geothermex, Inc.
• JP Morgan Capital Corporation (Fortune 500)	• Ormat
• Khosla Ventures	• Thayer Gate Energy
• Kleiner Perkins Caufield & Byers	• ThermaSource L.L.C.
• Merrill Lynch (Fortune 500)	• UTC Power
• New Energy Finance	• Vulcan Power Company
• RBC Capital Markets	• Western GeoPower Corporation
• Vulcan Capital	

Other businesses that are potentially relevant to geothermal data development and management include: Black and Veatch, Davis Power Consultants, Jacobs, Schlumberger Consulting and Data Services, KEMA, Inc. and Quanta Technology.

The Program also collaborates with trade associations to promote the development and utilization of geothermal resources. Trade associations present industry views to governmental organizations, compile and maintain statistical data about the geothermal industry, and conduct education and outreach efforts. Trade associations also provide a forum for the industry to discuss important issues and problems regarding geothermal energy while encouraging research and development to improve geothermal technologies. Table 7.2 lists key geothermal trade associations.

Table 7.2. Geothermal Trade Associations	
Agency/ Association	**Function/Expertise**
Geothermal Resources Council	Develops educational functions on a variety of topics that are critical to geothermal development; convenes special meetings, workshops, and conferences on a broad range of topics pertaining to geothermal exploration, development and utilization; publishes a periodical Bulletin, which features articles on technical topics and geothermal development issues, as well as commentaries and news briefs; maintains the most comprehensive geothermal technical library in the world.
International Geothermal Association	Encourages research, development, and utilization of geothermal resources worldwide through the compilation, publication and dissemination of scientific and technical data and information, both within the geothermal community and the general public.
Geothermal Energy Association	Supports the expanded use of geothermal energy and development of geothermal resources worldwide for electrical power generation; advocates for public policies that promote the development and utilization of geothermal resources; provides a forum for the industry to discuss issues and problems, encourages research and development to improve geothermal technologies, and presents industry views to governmental organizations; compiles statistical data about the geothermal industry, and conducts education and outreach projects.

7.3 Academia

The GTP encourages collaborations with universities in cost-shared RD&D. For example, work with the University of Utah and Southern Methodist University has resulted in new and important information and developments critical to the geothermal industry.
The Energy and Geoscience Institute (EGI) at the University of Utah is a not-for-profit research organization with a 25-year record of conducting multidisciplinary projects worldwide. Through cooperative agreements with universities and research institutes, government agencies and laboratories, and national energy companies worldwide, the Institute undertakes a broad range of projects on all seven continents. EGI is focused on developing new technology for exploration, reservoir delineation, and production of resources in the western United States, Latin America, and Southeast Asia.

Southern Methodist University's Geothermal Lab in SMU's Dedman College of Humanities maps geothermal resources, providing information on the potential for geothermal energy production in regions where geothermal data had previously been unreliable or unavailable. SMU mapping also illustrates the potential for tapping geothermal energy from existing oil and gas wells.

As academic institutions (colleges, universities, and trade schools) across the nation expand new capabilities in geothermal technology, the Program will work with these leaders to implement the Program Plan while drawing on the existing core strengths of long standing geothermal institutions.

7.4 Other Federal Agencies

Interagency collaboration and cooperation are essential to increasing investment in geothermal resources, particularly EGS. Through cooperative efforts, each agency achieves greater operational efficiencies, enhanced resource management and protection, and better serves the stakeholder community. The Program is establishing a Geothermal Inter-agency Working Group to support the development of EGS and to provide a forum to discuss and address geothermal institutional and technology barriers. This interagency working group will support the expansion of geothermal energy resources and provide the guidance and management necessary to support our nation's energy security and emissions reduction goals.
Anticipated co-leaders of the Geothermal Inter-agency Working Group are the Geothermal Technologies Program Office Lead at the Department of Energy and the Bureau of Land Management, Geothermal Technologies Program Officer. Members of the interagency working group include representatives from: the Department of Defense, Environmental Protection Agency, National Science Foundation, Department of Interior (including the U.S. Geologic Survey, Bureau of Indian Affairs, Bureau of Land Management, Minerals Management Service, National Park Service, and Fish and Wildlife Service) and other Federal agencies whose activities may be leveraged to further geothermal development.[28]

According to the 2008 U.S. DOE Energy Efficiency and Renewable Energy National Geothermal Action Plan, four goals of the interagency working group will be to:

- Identify research priorities for the next decade that will release the potential of geothermal energy resources with the least disruption to the environment and the greatest impact to energy security and emissions reductions.
- Oversee the management of the National Geothermal Database for effective resource management and planning.
- Recommend and manage studies that will contribute to the development of this resource and promote its management and stewardship similar to that of other natural resources in the United States.
- Provide leadership for environmentally sound energy development, including transmission and other related infrastructure.

Government agencies are integrated in the identification, exploration, drilling and production phases of a geothermal investment, and play an important role in facilitating geothermal development. The Geothermal Technologies Program continues to focus on important RD&D of EGS technology innovations for long-term geothermal expansion, and directly assists industry which is the crucial driver of the exploration and development process.

7.5 Intra-Agency – DOE Offices

In addition to U.S. government interagency efforts, the Program also fosters U.S. DOE intra-agency cooperative working relationships with the Offices of Electricity Delivery and Energy Reliability, Science, and Fossil Energy and DOE national laboratories. Leveraging these close working

28 National Geothermal Action Plan, Geothermal Technologies Program, 2008

relationships enables the Program to best represent the entire resource base of the DOE while leading actions of the interagency working group.

The GTP plans to partner with other DOE offices, whenever practical to leverage DOE geothermal RD&D investments. GTP may build upon or co-fund efforts of other DOE programs where technology goals are similar but require a different focus and application. These program can be found within the Offices of Science, Civilian Radioactive Waste Management (OCRWM), Environmental Management (EM), and Fossil Energy (FE).

EM and OCRWM support earth sciences modeling, tracers, and microseismic analysis research topics important to EGS development. Other common areas of interest between the GTP and EM and OCRWM are in wastewater management and fluid loss management. All of these research areas are crucial to the success of geothermal subsurface development involving reservoir creation, operation, and maintenance.

The GTP is currently co-funding R&D with the Office of Science in the study of coupled mineral-water-gas reactive transport in unsaturated porous media. A wide range of processes in differing geologic environments are covered, including infiltration/evaporation processes in the soil zone, reactive transport processes in fractured rock under boiling conditions, injection of COivt2 in deep aquifers, and hydrothermal alteration in geothermal systems. Although reactive transport modeling and code development are the predominant activities, the Office of Science is also active in planning the analysis and drilling activities for underground thermal experiments, laboratory experiments, and field studies of geothermal systems and natural analogues for nuclear waste isolation.

Although much of the work is focused on predicting thermally-driven processes accompanying the proposed emplacement of high-level nuclear waste at Yucca Mountain, Nevada, the group has expanded its efforts to studies of geothermal systems, CO2 sequestration, and modeling of stable isotope variations. Potential collaboration with others in EM may address essential pieces of the problem, including hydrological processes in the unsaturated zone, thermodynamics and kinetics of geochemical processes, and isotopic effects.

Additional examples of R&D funded by other DOE programs with potential relevance include:

- Simulation and analysis of an ongoing large-scale underground thermal test, and planning of future drilling and sampling efforts.
- Prediction of coupled thermal-hydrological-chemical processes around potential waste emplacement tunnels to evaluate changes in water and gas chemistry, mineralogy, and flow.
- Analysis of geochemical and isotopic data from Yucca Mountain, including Cl-36 as a bomb-pulse tracer, to constrain models of flow and transport in the unsaturated zone.
- Development of models for reactive transport in unsaturated systems and co-developers of the reactive transport code TOUGHREACT.
- Evaluation and development of improved thermodynamic and kinetic databases for water-rock interaction modeling, including new relations for CO2 solubility to model CO2 sequestration.
- Research on natural analogue sites, including (a) analysis and modeling of continuously cored intervals from the Yellowstone geothermal system to assess effects of mineral

alteration on fracture and matrix permeability; (b) study of flow, transport, and secondary mineralization at Peña Blanca, Mexico; and (c) study of anthropogenic analogues, such as those at the Idaho National Engineering and Environmental Laboratory.

- Modeling of CO2 sequestration in saline aquifers, including the impact of acid gas components, H2S and SO2, and interactions with shale confining beds.
- Modeling hydrothermal alteration in geothermal systems.
- Simulation of the effects of scaling and acidulation on permeability in geothermal injection wells at the Tiwi geothermal field, Philippines.
- Study of chemical interaction between formation waters, injected waste fluids, and host rock during deep well injection.
- Development of a Pitzer-type geochemical reactive transport model and simulation of high-ionic-strength groundwater contamination.

7.6 DOE National Laboratories

In 2008 the DOE GTP funded geothermal research, development, and analysis at Lawrence Berkeley National Laboratory (LBNL), Sandia National Laboratories (SNL), Idaho National Laboratory (INL), and National Renewable Energy Laboratory (NREL). Geothermal areas of excellence within the national laboratories offer interdisciplinary core capabilities that provide the program with intellectual continuity and a bridge for facilitating the transfer of developing technologies between academia, industry and other laboratories. The laboratories provide a level of programmatic continuity and synergy that is difficult, for institutional reasons, to sustain at universities or private organizations. To ensure long-term success, the GTP has identified four areas where the national laboratories can and should be involved to support the program: Planning and Analysis, Technology Support to DOE Funded Research Grants, National Laboratory Direct Research and Development, and Support to EGS field demonstration projects.

The laboratories have a long and successful history of working with industry addressing short-term industry needs and long-term R&D efforts. For example, short-term efforts include the Geothermal Drilling (GDO) and Geothermal Technology Organizations (GTO), formed to facilitate laboratory and industry collaboration on short-term R&D projects such as (1) the first use of well re-drilling technologies to minimize the cost of mitigation and (2) the first deployment and interpretation of MEQ sensors to monitor the impact of reinjection into declining resource reservoirs. Long-term R&D efforts include, but are not limited to: advanced methods to reduce drilling flat time; new geophysical approaches for imaging the movement of fluids in the subsurface; and development of predictive modeling capabilities for geothermal reservoir management. The R&D efforts, particularly the long-term projects, reap the benefits of being heavily leveraged by the broad scientific and engineering capabilities that exist at the laboratories, particularly with respect to science and engineering activities supported by other sponsors (e.g. the DOE Office of Science, NNSA, other governmental agencies such as DARPA, and private concerns) as previously mentioned.

Science and engineering capabilities developed and supported by DOE at the national laboratories also assist the GTP in defining and evaluating broad national scientific and engineering needs

pertaining to geothermal energy development. In 2008, the laboratories were vital in peer reviewing GTP's evaluation of the MIT-led panel conclusions regarding the potential for EGS.

Technical Support to GTP Funded Research Grants: In order to attract industry participation through competitive funding opportunities, industry-focused R&D efforts should address shorter-term aspects of the R&D needs; experience suggests that it is unlikely industry will pursue long-term research given uncertain payback. By exploiting the synergies of R&D, the historic knowledge of the laboratories, and the commercial focus of industry, technology can be brought to market faster.

National Laboratory Directed Research and Development: While focusing on industry partners is appropriate, there are aspects of the R&D program where the laboratories can assist GTP at both a programmatic and technical level. Additional information regarding program management and operations follows in **Section 8.2.3 Program Execution**. Where high-risk, fundamental research is required to meet the long-term GTP goals, national laboratories can build programs around core fundamental research efforts to support the long-term R&D program required to make EGS successful.

Success in conquering the challenges of EGS will not only require the incorporation of industry participants, but will also require maintaining a core capability to ensure continuity of the program. The laboratories offer a centralized source of knowledge with institutional missions aligned to meet the programmatic needs of the GTP. The laboratories are capable of providing multidisciplinary teams over long periods of time to ensure the continued progress that is required for program success: Lawrence Berkeley National Laboratories possesses core capabilities in the geosciences in the areas of geophysics, hydrogeology and geochemistry with an emphasis on subsurface geophysical imaging of structures and fluids and hydrologic/reactive transport modeling; and Sandia National Laboratories provides core capabilities in geo-engineering with an emphasis on developing well construction and completion technologies, such as high-temperature/high reliability electronics, drilling technologies, and advanced downhole tools and telemetry systems. There is synergistic overlap between these two labs in areas such as remote sensing, rock mechanics, advanced materials, and nanotechnologies.

Support to EGS Field Demonstration Projects: The objective of planned field demonstration projects is to demonstrate the capability for stimulating a volume of rock to serve as an efficient long-term heat exchanger. To this end, existing and developing technologies will be deployed to evaluate the success of the stimulation and to develop tools for optimizing EGS reservoir creation, management and operation. Operating in collaboration and in parallel with industry, the laboratories provide expertise in many areas relevant to a successful demonstration program. This expertise has been developed through support from the GTP and synergy with various DOE and other governmental programs. Involving the laboratories will ensure that the field demonstration projects provide the best laboratory for developing and testing new R&D concepts and moving fundamental research from the lab to widespread use by industry. The field demonstration projects will lead to the identification of new technologies that will be required to move EGS forward and provide a mechanism for testing new and developing technologies, new tools, and concepts that industry may not be in a position to pursue, even on a cost-shared basis, due to limited resources or institutional interests. The core capabilities of the laboratories provide the DOE with an avenue to ensure that demonstration projects maximize benefits. The laboratories are unique in their ability to couple real-world understanding of industry needs with requirement of researchers and are a necessary partner in the field demonstration projects.

The DOE's Entrepreneur-in-Residence pilot program is furthering real-world understanding by bringing industry to work in the national laboratories. The National Renewable Energy Laboratory, the Sandia National Laboratories, and the Oak Ridge National Laboratory participated in the pilot program in 2008. Venture capitalist firm Kleiner, Perkins, Caufield & Byers is sponsoring an entrepreneur at NREL under its new Entrepreneur-in-Residence Program. The entrepreneur will help identify opportunities for spin-off companies based on NREL-developed technologies. The entrepreneur will then help develop business plans for these promising technologies using a "venture-friendly" license agreement.

Figure 7.2 lists the current geothermal capabilities of the DOE national laboratories.

Figure 7.2 Current Geothermal Capabilities of the DOE National Laboratories

Primary Capability
Significant Capability
Capability
Historic Capability, No Current Expertise or Contracts

	Data and Analysis	Site Selection	Reservoir Characterization	Reservoir Creation	Reservoir Validation	Interwell Connectivity	Reservoir Scale Up	Reservoir Sustainability	Energy Conversion
NREL									
LBNL									
LANL									
SNL									
INEL									
BNL									
ORNL									
LLNL									
PNNL									

10-20 FTE in general area of interest or contract value greater than 10M specifically related to geothermal
= Red shading indicating that the subject area is a primary strength of the lab

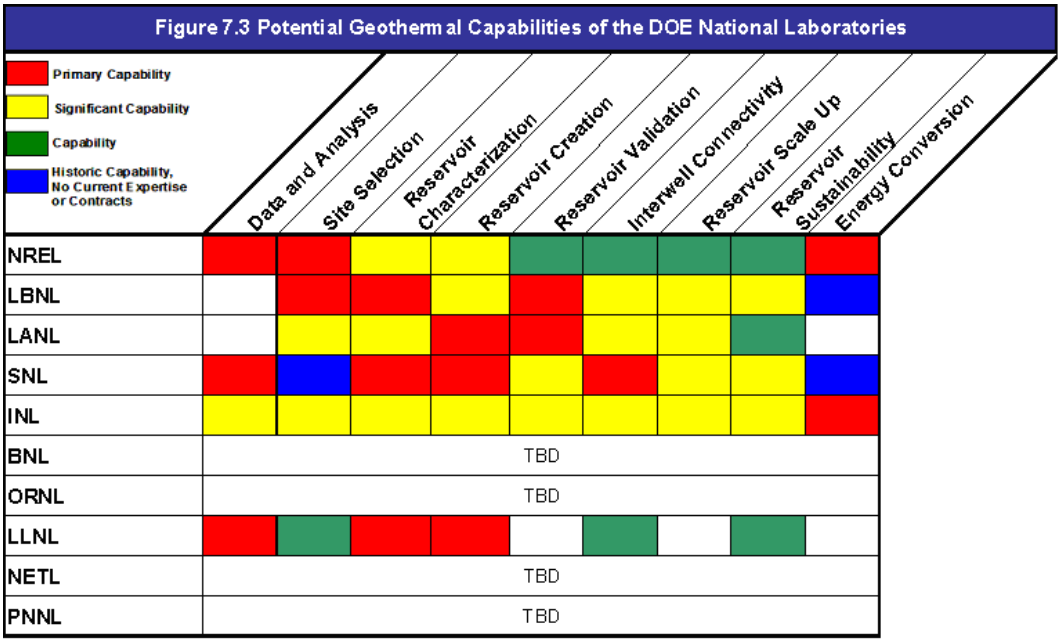
5-10 FTE in general area of interest or contract value greater than 1M specifically related to geothermal Present
= Yellow shading indicating capability

1-5 FTE in general area of interest or contract value greater than 100K specifically related to geothermal
= Green shading indicating capability

Historic Capability no current expertise or contracts = Blue

Figure 7.2. Geothermal Capabilities of the DOE National Laboratories

Figure 7.3 lists the potential geothermal capabilities of the DOE national laboratories.



10-20 FTE in general area of interest or contract value greater than 10M specifically related to geothermal = Red shading indicating that the subject area is a primary strength of the lab

5-10 FTE in general area of interest or contract value greater than 1M specifically related to geothermal = Yellow shading indicating capability

1-5 FTE in general area of interest or contract value greater than 100K specifically related to geothermal = Green shading indicating capability

Historic Capability no current expertise or contracts = Blue

Figure 7.3. Potential Geothermal Capabilities of the DOE National Laboratories

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