Geothermal technologies
U.S. Department of Energy

Geo-Heat Center Helps Double the Growth of Direct-Use Applications

Over the past quarter century, the University of Oregon's Geo-Heat Center (GHC) in Klamath Falls has helped to more than double the growth rate of geothermal direct use in the United States. The U.S. Department of Energy's Office of Wind and Geothermal Technologies funds GHC's Technical Assistance Program, which assists developers with new, low-temperature projects and solves operational problems with existing projects.

In recent years, GHC has been particularly active on new projects in north-eastern California, which boasts substantial geothermal resources, and this activity is now paying big dividends. Schools have been especially hard hit by higher energy prices, and in some cases are cutting academic programs to cover surging utility costs. But thanks to GHC, a number of schools in the area are much less concerned about energy costs than they might have been, *were it not for their geothermal heating systems!* GHC provided feasibility studies and/or initial technical assistance to Cedarville High School, Cedarville Elementary School, Alturas High School, Susanville High School, and Yreka High School. Another GHC-assisted system is under construction at Alturas Middle and Elementary Schools, and an elementary school in Canby may be connected to the Canby district heating system (with which GHC has been working for the last 2 years), if additional well capacity is developed.

Assisting geothermal system owners with expansion plans and solutions to operating problems are also GHC services. In the Imperial Valley of California, GHC assisted the California Desert Fish Farm in Niland with production well problems, and evaluated the need for a new well for expansion. The farm was designed to produce 400,000 pounds of Tilapia annually, but was constrained by limited fluid flow from its single production well. The farm has

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100-ft.-diameter grow-out ponds at California Desert Fish Farm, Niland, California, using paddle-wheel-type aeration.

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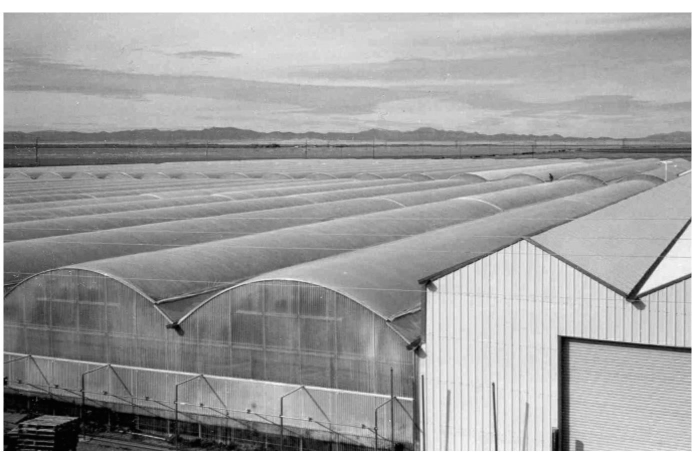
Tilapia harvest operations at California Desert Fish Farm, Niland, California.

now successfully modified the design of its first well and added a second production well.

In California, Calistoga Water Bottling Company consulted GHC for assistance in determining the cause of repeated well pump failures. After providing the company with a procedure for measuring the alignment of their well, GHC staff identified the problem as stemming from the well, not the pump. This led to installation of a submersible pump more suitable for the situation.

Milgro Nursery, Inc. in Newcastle, Utah, is one of the largest geothermal greenhouses in the United States and has consulted the GHC many times over the years, most recently for their injection well design. Milgro is the largest potted plant producer in the United States, and their geothermal operation has grown from 2 acres to more than 18 acres.

Because geothermal direct-use projects are typically small in size and investment, geothermal resources are widely distributed, and only a limited engineer/contractor infrastructure exists capable of serving would-be developers, a large and mutually supportive direct use "industry" has not evolved, as it has with geothermal power or geothermal heat pumps. DOE's support of GHC, which efficiently



Exterior view of two geothermally-heated greenhouse "ranges" at the Milgro greenhouse facility at Newcastle, Utah.

Bench-top production of potted plants at Milgro greenhouse facility, Newcastle, Utah. Geothermal heating tubes are installed below the bench surface.

supports a large number of projects over a wide area, provides the critical catalyst for greater use of these resources. The evidence is persuasive: Prior to GHC's Technical Assistance Program, growth in geothermal direct use was approximately 3.5% per year. In the last 5 years, this rate of growth has more than doubled to approximately 8.3% per year, significantly expanding the use of this clean and indigenous energy resource.

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The Geothermal Resource Exploration and Definition (GRED) program is a collaboration between the U. S. Department of Energy's Office of Wind and Geothermal Technologies and the U. S. geothermal industry. The program's purpose is to promote geophysical exploration, leading to discovery and definition of new geothermal resources. The overall goal is to aid in developing geographically diverse geothermal resources, thereby increasing geothermal electricity generation in the U.S.

DOE budgeted $900,000 for the program in fiscal year 2000, and made six awards totaling $624,449. In fiscal year 2001, $2,000,000 was budgeted.

GRED projects are divided into three phases: (1) exploration, (2) drilling a test well, and (3) evaluating well performance. In Phase I, awardees perform sufficient geophysical surveys to select an optimum drill site. Some projects were already sufficiently advanced so that no geophysics work was required, and only an exploration report was needed to document the site potential. In Phase II, a test well will be drilled, cored, logged, and otherwise evaluated. In Phase III, detailed testing of the resource will be performed. Several of the projects are completing Phase I and are beginning negotiations for

Phase II. The location and brief description of the projects are as follows:

Rye Patch, Nevada. Mt. Wheeler Power, Inc., is developing a high-temperature site at Rye Patch, Nevada. A well will be drilled through a shallow limestone target and then drilled directionally to attempt to intercept the Rye Patch fault at greater depth. The Rye Patch site has a partially completed power plant that could enable rapid development of this resource if the drilling program is successful. An exploration report has been completed (no additional geophysics were required), a well site has been selected, and Phase II negotiations are nearing completion.

Blue Mountain, Nevada. The Noramex Corporation has completed Phase I reporting with no additional geophysics required, and negotiations for Phase II have begun. A 600-meter well will be drilled to confirm the existence of a high-temperature geothermal reservoir associated with overlapping spontaneous potential, resistivity, and shallow temperature gradient anomalies, and to determine the reservoir's production characteristics.

Cove Fort-Sulphurdale, Utah. The Utah Municipal Power Agency is in Phase I exploration to locate and drill a 900-meter well to explore the western extension of the Cove Fort-Sulphurdale geothermal area. Geophysical exploration consists of resistivity, ground magnetic, and microgravity surveys. The Agency has a power plant at Cove Fort with additional capacity available, so the western extension of the reservoir could be used immediately.

Steamboat, Nevada. SB Geo, Inc., is investigating a shallow boiling reservoir in the northern Steamboat Hills and Steamboat Springs area of Nevada. Phase I is complete (no additional geophysics work was required), and a 760-meter well will be drilled to verify an extension of the Steamboat Springs resource, if sufficient funding is available. Given the existing power plants and grid structure in the area, additional geothermal power could be brought online quickly if this project is successful.

Under Steamboat, Nevada. Another project in the Steamboat area (named U-Boat, for Under Steamboat) is being conducted by the Coso Operating Unit of Yankee Caithness Joint Venture, LLC. Phase I geophysical exploration of the deep geothermal resource beneath the Steamboat Hills region is underway, using seismic and gravity studies. These results, combined with data from micro-earthquake studies, will be used to locate the deep fault system and productive zone at U-Boat.

Lightning Dock, New Mexico. Ormat International, Inc., is investigating a deep, high-temperature resource in the Lightning Dock Known Geothermal Resource Area. Extensive Phase I work includes seismic, gravity, and resistivity surveys to determine the strike of the Animas Valley Fault in southwestern New Mexico. The geophysical data, combined with existing information, will enable siting an exploratory well. The well will then be tested to assess the geothermal capacity of the resource.

In summary, three of the projects have completed Phase I work, and negotiations are underway to develop Phase II projects, subject to the availability of DOE funds. The objective is to bring these projects through all three phases, and therefore define new geothermal capacity in Nevada, Utah, and New Mexico. Depending on future funding levels, a second GRED solicitation may be issued to define additional geothermal resources.

For more information, please contact Norm Warpinski at Sandia National Laboratories, 505.844.3640, nrwarpi@sandia.gov.

ormations

Sandia National Laboratories, with funding from DOE, has worked with DynaFlow, Inc., and Security DBS to develop a polycrystalline diamond compact (PDC) drill bit with five passive jet nozzles (no moving parts) that emit self-resonating, pulsating mud streams. These cavitating jets both "pre-weaken" the rock surface and clear rock debris for more efficient cutting. The addition of mudjets makes PDC bits very attractive for use in the high-temperature, hard, abrasive formations encountered in geothermal drilling.

Roller cone bits have been most widely used in geothermal drilling, but the seal and bearing assemblies that allow rotation of the cones are prone to fail at the high temperatures characteristic of geothermal formations. Furthermore, roller cone bits often suffer from slow penetration rates in these hard formations. The maturity of this bit technology offers little promise for major technological improvements. On the other hand, PDC bits are used extensively in oil and gas drilling. The lack of moving parts, high-temperature resistance, and aggressive cutting structure of PDC bits make them an attractive alternative for geothermal drilling. However, hard geothermal formations induce large forces on the cutters of the PDC bit, which can lead to high wear rates on the cutters. Hard rock also presents problems with impact-type failures in the PDC cutters if significant bit vibration occurs within these formations. Both of these concerns are addressed with the Sandia mudjet PDC bit by reducing the forces on the PDC cutters at the rock interface.

To reduce the magnitude of the forces, high-pressure jets augment the rock removal process. Mudjets allow PDC cutters to penetrate rock more efficiently by two mechanisms. First, the jets keep the rock/cutter interface clean of rock cuttings, thereby increasing the penetrating stresses in the rock. Second, the high-pressure fluid can enter and hydraulically extend fractures created by the cutter, thereby pre-weakening the rock.

The mudjet nozzles pulsate passively due to a resonance set up in a tuned chamber upstream of the nozzle orifice. DynaFlow's tuned organ pipe nozzle design produces vortex-shedding jets that cavitate more effectively and at greater wellbore depths than jets produced by conventional nozzles. These pulsating jets are also more effective than conventional jets in eroding a rock surface because the collapsing cavities spawn microjets that produce very high impact pressures. The jet pulsations assist with lifting the rock cuttings off the bottom where they are held down under large hydrostatic well pressures.

The bit is intended to use readily available rig pressures, i.e., up to 5000 psi. Sandia analyzed an 8-1/2" diameter Security DBS bit and selected those cutters for augmentation that would provide the greatest improvement in bit performance. DynaFlow conducted laboratory testing to specify the organ pipe and orifice configurations. Security DBS integrated the organ pipe and orifice configurations into their matrix-body PDC bit, and manufactured the bit following a project-team design review. A computer model produced by Security DBS showing the flow geometry for the tuned organ pipes housed within the bit is shown in Figure 1. A face view of the actual bit with the nozzles directed at the bit blades is shown in Figure 2. The bit design features removable nozzle assemblies such that it can be used with either cavitating or conventional nozzles to allow the relative benefits of high-pressure jets to be evaluated with a single bit.

DynaFlow encountered erosion in the orifices during laboratory testing using conventional orifice materials (tungsten carbide, stainless steel, and sapphire), all of which experienced significant erosion leading to a reduction in nozzle performance. Sandia then began work to identify an orifice material with improved abrasion resistance. Tungsten carbide-supported polycrystalline diamond was chosen for its erosion resistance. Sandia employed specialized fabrication techniques to create the required profile in the throat of the orifice. The orifices are brazed into individual nozzle assemblies that are subsequently threaded into the bit body.

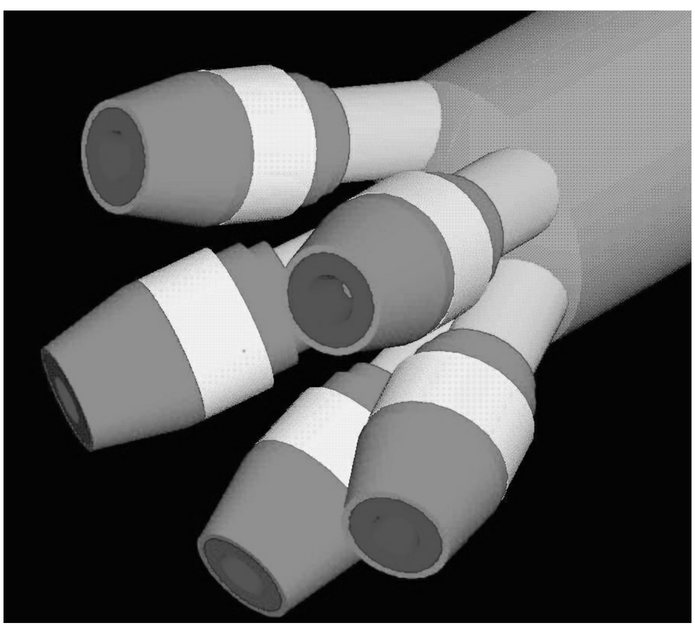

Figure 1. Computer model of organ pipe geometry and flow sections within the bit.

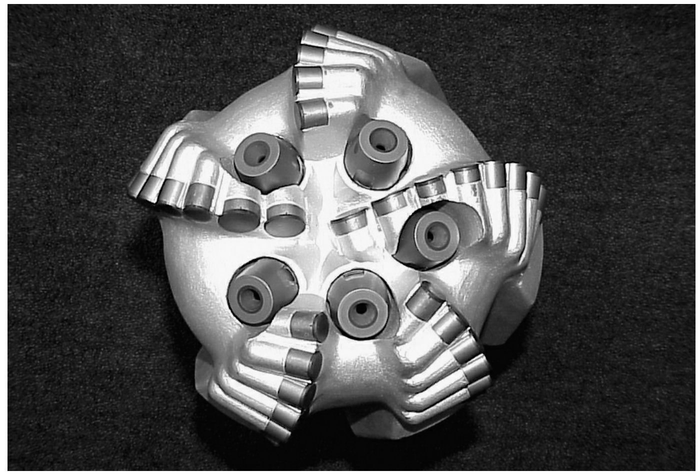

Figure 2. Face view of the mudjet-augmented PDC bit showing the cavitating jet nozzles/orifices augmenting each blade of the bit.

The nozzles/orifices were flow-tested to confirm erosion resistance to cavitation. Post-test inspection showed negligible erosion in the throat of the orifice, although marginal pitting was seen at the entrance to the orifice. (This erosion could be addressed by redesigning the orifice entrance.) During part of the flow-testing, the nozzles were allowed to impinge upon a sample of Nugget sandstone for 30 seconds, resulting in significant rock erosion. The bit was thereby qualified for subsequent drilling tests.

The mudjet-augmented PDC bit was then tested at the Drilling Research Laboratory at TerraTek, Inc., in Salt Lake City. The bit was tested with both standard nozzles and the cavitating jet nozzles in Crab Orchard sandstone, a rock representing the upper compressive strength for PDC bits currently used in production drilling. A conventional roller cone bit was also tested for comparison. As shown in Figure 3, the PDC bit drilled more than twice as fast as the roller cone. Furthermore, the rate of penetration of the

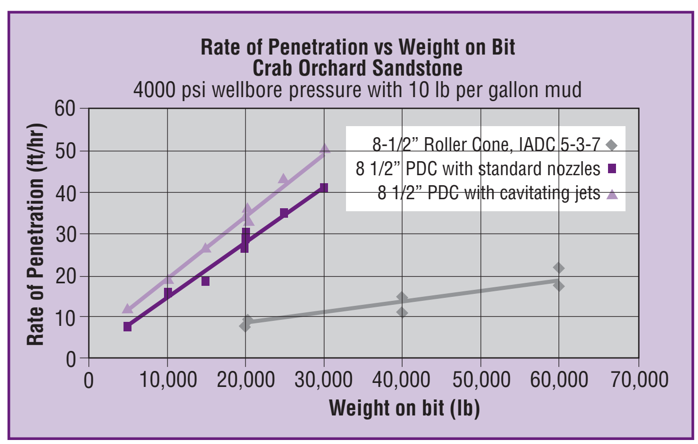

Figure 3. Results of the demonstration testing of the mudjet-augmented PDC bit. The unaugmented PDC bit drills at twice the penetration rate of a current-technology roller cone. Cavitating jets to augment the cutting action further improve penetration rate and reduce the weight on bit requirements for a PDC bit.

PDC bit with jet-augmentation increased up to 30 percent over that achieved with standard nozzles. At a given penetration rate, the jet augmentation reduced the requisite weight on bit, and hence the component cutter forces, by 20 percent or more. The PDC bit was also used with both cavitating and conventional nozzles to drill Sierra White granite, a rock occurring in geothermal formations, at rates in excess of 30 feet per hour.

Jet augmentation is just one of the directions Sandia is pursuing to extend the use of PDC bits to geothermal well development.

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orkshop

Allan Jelacic, geothermal team leader in DOE's Office of Wind and Geothermal Technologies, presented DOE's Geothermal Energy Program goals in the opening session of the Stanford workshop on January 29, 2001:

- Double the number of states with geothermal electric power facilities to eight by 2006.
- Reduce the levelized cost of generating geothermal power to 3-5 cents/kWh by 2007.
- Supply the electrical power or heat energy needs of 5 million homes and businesses in the United States by 2010.

He stressed the three "E's" of the program in attaining these goals:

- Energy—use indigenous geothermal power to balance the national energy portfolio.
- Economics—use geothermal energy to capture domestic and international markets.
- Environment—limit the impacts of geothermal power production.

In the 1990s, there were no new domestic installations and virtually no growth in U.S. geothermal power production. Jelacic presented several reasons:

- Competition with fossil fuels—particularly natural gas until recent price increases
- Financing—concerns about small capitalization and perceived risk
- Long project lead times—the Glass Mountain example
- Siting and permitting—two- to five-year approval periods
- Obvious sites already taken—exploration is needed
- Industry focus overseas—because of weak U.S. activity

To overcome the lack of growth in domestic geothermal power production, partnership is essential. DOE's program structure contains national laboratories, universities, and most important—industry partnerships. Geoscience and supporting technologies, drilling, and energy systems research are the three components of this program structure.

Current projects involving DOE-industry partnerships include resource exploration, enhanced geothermal systems, and small-scale field verification. For FY 2000, seven DOE project awards for resource exploration and definition totaled $827,000; nine awards for enhanced geothermal systems totaled $1,736,000; and five awards for field verification totaled $750,000.

Jelacic concluded that while the outlook for geothermal energy was cautiously optimistic, some challenges remain, such as the cost of electricity, defining new resources for development, access to public lands, stakeholder involvement, and electric utility restructuring.

Brookhaven National Laboratory (BNL) conducts research on durable, cost-effective materials for use in geothermal energy applications. Specialized materials are required to handle aggressive geothermal environments encountered during drilling, well completion, power production, and reinjection. BNL's interests include developing materials to better withstand high-temperature corrosive brines; optimal use of existing materials and technologies through improved basis for selection; reduction of capital, operation, and maintenance costs; life extension of equipment; and non-destructive testing. BNL's research program integrates experimental characterization of material properties, numerical modeling to predict *in situ* behavior, and field-testing in collaboration with industry. Materials investigated include cements, polymers, elastomers, composites, and corrosion-resistant alloys.

Recent successful research projects include heat exchanger tube coatings (Geothermal Technologies Vol. 5, No, 4, 2000), thermally conductive grouts for geothermal heat pumps (Geothermal Technologies Vol. 4, No, 4, 1999), and calcium phosphate well cements (Geothermal Technologies Vol. 5, No, 3, 2000). Brief descriptions of other recent and current projects follow:

MICROBIOLOGICAL ATTACK OF CONCRETE

BNL has been working on prevention of microbiologically influenced corrosion (MIC) of concrete in cooling towers used in geothermal power plants. MIC of concrete is typically induced by sulphur-oxidizing, nitrifying, iron, or heterotrophic bacteria. In the case of cooling water, sulphur-oxidizing and nitrifying bacteria are probably of greatest concern. Sulphur-oxidizing bacteria such as *Thiobacillus thiooxidans* and *Thiobacillus ferrooxidans* produce sulphuric acid which is aggressive toward concrete. Nitrifying bacteria (e.g., *Nitrosomonas* and *Nitrobacter*) can cause nitric acid degradation of concrete.

BNL's research has examined the resistance of different surface-applied coatings and mortars to sulphur-oxidizing bacteria. The influence of concrete mix design on durability has also been investigated. Laboratory tests were performed in which specimens were exposed to *Thiobacillus ferrooxidans* and then analyzed for deterioration. Epoxy coatings and calcium aluminate mortars exhibited the best performance. Use of silica fume in concrete was found to enhance resistance to attack. Specimens of epoxy-coated concrete, mortars, and silica-fume-modified concrete underwent 8 months of exposure in an Indonesian cooling tower in collaboration with Unocal. The field tests confirmed the laboratory findings. Figure 1 compares the surfaces of plain and silica-fume-modified concrete after exposure. Evident in the plain concrete is severe etching, revealing coarse and fine aggregate. The degree of attack on the silica-fume-modified concrete is significantly less. It was concluded that design of future cooling towers that may be prone to MIC should consider using silica fume and protective coatings to prevent degradation. Existing structures can be protected with epoxy coatings or calcium aluminate mortar.

WELL CASING REMEDIATION AND DESIGN CRITERIA FOR WELL CEMENTS

Geothermal well casings experience excessive deformation, which could result in production losses. Formation movement is suspected to be the primary cause of casing damage. Remediation of geothermal wells is a cost-effective alternative to plugging and abandonment. Remediation involves milling the deformed casing, and cementing a liner into place. BNL is developing candidate patch cements for well casing remediation. The influence of additives and fiber reinforcement on pertinent material properties at elevated temperatures is under investigation.

Material characterization studies are combined with numerical modeling to evaluate the cement patch/formation interaction. The primary loads considered are pressure and temperature. Finite element models incorporating the liner and various cement formulations were developed. In addition, all existing casing, as well as the surrounding formation, are included in the modeling studies. Parametric studies are conducted that consider variations in materials and loading conditions. The project initially used 2D models, and then 3D models were employed to validate the assumptions made. Results demonstrate that stresses become high in the vicinity of the remediated zone. Furthermore, part of such stresses is tensile. While cements deform plastically at higher strains under compression, their tensile capability needs to be increased to respond to the demand shown by the analysis.

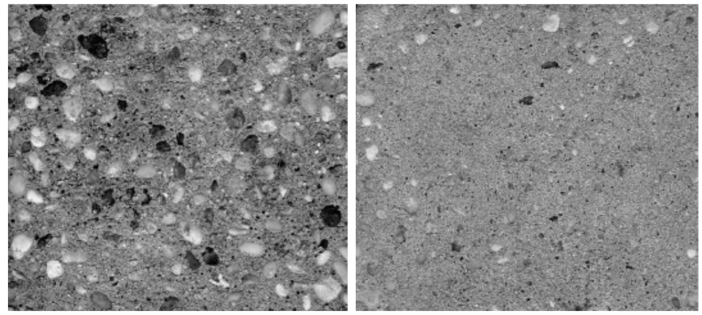

Figure 1. Comparing the surfaces of plain (left) and silica-fume-modified concrete after 8 months of exposure in a cooling tower.

Extended research is planned to address broader issues of cement design criteria and structural response analysis for completion cements. Currently, compressive strength is the only mechanical property considered for geothermal well cements. However, this consideration is largely irrelevant for the types of stresses encountered during well operation. Our studies clearly demonstrate the importance of other mechanical properties in maintaining cement integrity. BNL is investigating foam, latex-modified, and fiber-reinforced cements because they offer control of specific mechanical properties and potential enhancement of long-term performance. Through the use of finite element analysis of the cemented wellbore and surrounding formation, it is possible to predict the system response for different cement and formation properties and thereby assist in development of cements with optimal functionality.

NON-DESTRUCTIVE TESTING OF CORROSION- AND EROSION-INDUCED DAMAGE IN GEOTHERMAL PIPING SYSTEMS

A new project has been initiated to investigate improved non-destructive testing (NDT) methods for monitoring damage induced by corrosion and erosion in piping. Typically, ultrasonic techniques are used to measure wall thickness and thereby detect loss of metal. Disadvantages of such techniques are the point-source nature of measurements, insulation removal requirements, and high labor costs. Alternatives that can be used for on-line, long-range flaw detection with insulation intact are desirable. BNL is examining the relative attributes of current and developmental NDT methods that have potential for more reliable and cost-effective monitoring of piping condition. Emphasis is being placed on dynamic response measurements and guided-wave ultrasonic techniques. The feasibility of using these techniques in geothermal piping systems is investigated through combined experimental work and numerical modeling. The usefulness of the proposed alternative NDT methods will be validated through field tests. Means of integrating NDT with risk assessment and condition-based maintenance will be investigated, along with improved NDT of other components such as heat exchanger tubes.

INDUSTRY PARTICIPATION

Collaboration with the geothermal industry on materials-related issues is an important component of BNL's program. Expansion of this collaboration is sought, particularly on the new NDT project. Suggestions for future research to solve industry problems are welcome at all times.

For more information, please contact Dr. Marita Berndt, BNL, 631.344.3060, allan@bnl.gov.

In February, DOE sponsored an exhibit on geothermal energy at the First Renewable Energy Technologies Fair in San Pedro Sula, Honduras, sponsored by the Honduras Ministry of Natural Resources and Environment (SERNA) and the General Energy Directorate. The three-day fair drew 150 industry and government participants from Central America and other countries. DOE/National Renewable Energy Laboratory (NREL) provided the only exhibit on geothermal energy.

DOE also sponsored two speakers at the fair. Dr. Marcelo Lippmann of Lawrence Berkeley National Laboratory gave a primer on geothermal energy, emphasizing geothermal resources and projects in Central America (see Table 1). Dr. Tsvi Meidav of Transpacific Geothermal Corporation (representing the Geothermal Energy Association) spoke about economic advantages of developing the abundant geothermal resources of the region. In addition to their technical presentations, both were kept busy at the exhibit answering questions and distributing literature. The exhibit included a continuously running Spanish version of the Geothermal Education Office/DOE's geothermal video.

Dr. Lippmann reported that the exhibit "was a hit! We could have used twice the printed materials. We informed the audience about advantages of geothermal energy, the large geothermal resources of Central America, and the technical capabilities of DOE and US industry. Seven companies talked to us about developing power plants and direct-use applications in their countries." The Geo-Heat Center and NREL will coordinate follow-up.

Proceedings of the fair will be put on CD-ROM by SERNA, and may later be available at SERNA's Web site (http://www.serna.gob.hn).

U.S. Senator Larry Craig and the
U.S. Department of Energy
invite you to the

Idaho Geothermal Energy Stakeholders Workshop

Boise, Idaho

Home of the Oldest Geothermal District Heating System in the United States

Thursday, May 31 – 8:00 a.m. to 5:00 p.m.
Workshop for All Attendees

Friday, June 1 – 8:00 a.m. to 12:00 noon
Planning Session for the Idaho Geothermal Working Group

For information or to register:
www.eren.doe.gov/geopoweringthewest

The U. S. Geological Survey estimated that already-identified geothermal systems hotter than 150 degrees C are capable of producing about 22,000 megawatts of electricity for 30 years (Muffler, 1979). Additional geothermal systems estimated to be awaiting discovery are capable of producing from 72,000 to 127,000 MW.

Table 1. Electricity and Geothermal in Central America (data in MWe)

Country	Installed(1) Electrical Capacity (1999)	Installed Geotherrmal Electrical Capacity (February 2001)	Geothermal Potential: Range Mentioned In Publications	Geothermal Potential: Most Probable(2) Values
Costa Rica	1565.0	162	400–3500	1000
El Salvador	959.3	161	400–4140	465
Guatemala	1359.2	29	800–4000	1000
Honduras	857.6	—	25-500	130
Nicaragua	614.4	70	300–4000	2500
Panama	1093.8	—	25–200	>50
Totals:	**6449.3**	**422**	**1950–16340**	**>5145**

(1) According to the Sistema de Información Económica Energética (SIEE) of the Latin American Organization of Energy (OLADE).
(2) Based on recent personal communications.

The current status of geothermal exploration has been likened to that of the oil and gas industry in the early 20th century. The oil industry was drilling wells based on surface oil seeps, similar to the geothermal industry targeting hot springs. Advances in exploration technology have enabled the oil industry to pursue exploration projects with no surface manifestations and targets at great depths. The geothermal industry still has only limited ability to target hidden systems.

DOE conducts research on exploration methods and the geologic settings of existing systems to assist the geothermal industry in discovering these hidden systems. National laboratories and universities are developing improved geophysical tools and interpretation methods for exploration. High temperature logging tools are under development at Sandia National Laboratories, and an electromagnetic logging tool is being developed with ElectroMagnetic Instruments, Inc., the California Energy Commission, and researchers at Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory, the University of Wisconsin, and the University of Utah. This tool will be able to withstand the elevated temperatures of geothermal systems and determine whether fractures are present near a well bore, indicating viable access to the hot water. Laboratory geochemists also are investigating the possibility that minor concentrations of rare earth elements or carbon dioxide gases in soils may be indicators of hidden geothermal systems.

DOE is also producing innovative methods for characterizing geothermal resources and ascertaining changes in reservoirs during production. As fluid is produced from a reservoir, mass is lost and the gravity signal decreases. Newly developed gravimeters allow more rapid and precise measuring of gravity, allowing researchers to monitor changes in fluid content in a reservoir over time to ensure maximum productivity. Withdrawal of fluid from a reservoir during production may allow the reservoir to compact, lessening production with a consequent change in the surface elevation of the reservoir. Space-based imaging systems allow rapid, remote sensing of these changes which then can be correlated with areas of subsurface fluid withdrawal.

Also under development are new tracers for monitoring fluid flow. Tracers and improved numerical, subsurface flow simulators are important tools for characterizing geothermal reservoirs so that the resource is used most effectively. DOE researchers are leaders in developing these new numerical techniques.

Future projects will continue development of new tools and exploration methods to reduce the risk associated with exploration. Predicting the presence of a geothermal field without drilling is the ultimate goal.

An Alternative Energy Symposium, sponsored by the U.S. Department of Energy's Office of Power Technologies, was held on December 4 and 5, 2000, in Albuquerque, New Mexico, to highlight the important role that renewable energy technologies can play in meeting the state's and the nation's power needs. Symposium co-sponsors were the New Mexico Department of Energy, Minerals and Natural Resources; the Public Service Company of New Mexico; and DOE/Sandia National Laboratories.

Symposium participants included members of the New Mexico legislature; regulators and other state officials; geothermal, wind, and solar developers and manufacturers; DOE and national laboratory representatives; and clean energy stakeholder organizations. Keynote speakers Governor Gary Johnson and DOE Deputy Assistant Secretary Robert Dixon described existing and potential contributions that geothermal, solar, and wind resources can make toward increasing supplies of electricity and heat, and to overall economic development.

Participants identified opportunities for and obstacles to renewable energy development and use in New Mexico, and agreed to establish a state renewable energy forum. The forum will include representatives from federal, state, local, and tribal government; private renewable energy businesses; non-profit organizations; public interest and environmental groups; and private citizens. The forum objective is to assist in expediting and furthering renewable resource development in New Mexico by participating in appropriate regulatory rule-making processes, establishing market-based incentives, identifying and removing barriers to development of renewables, and education and outreach programs.

In conjunction with the Alternative Energy Symposium, the U. S. Department of Energy, New Mexico Energy, Minerals and Natural Resources Department, and Sandia National Laboratories convened the New Mexico Geothermal Working Group's second meeting. The Working Group was formed in August 2000 to address issues hampering development of New Mexico's abundant geothermal resources. During the half-day meeting, topics of discussion included initiating geothermal projects with funding from the state Systems Benefits Program, land availability and leasing, outreach needs and opportunities, New Mexico electric utility restructuring, resource mapping and database requirements, and production tax credits.

For more information, please contact Susan Norwood, U.S. Department of Energy, at 202.586.4779, or by email at susan.norwood@hq.doe.gov.

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