Geothermal technologies
U.S. Department of Energy

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DOE Reorganization Combines Geothermal and Wind Programs

On September 26, a reorganization of the U.S. Department of Energy's (DOE) Office of Power Technologies went into effect. In accordance with that reorganization, the Office of Geothermal Technologies (OGT) was combined with the Wind Program, creating a new DOE office. Peter Goldman, a DOE career employee and former Wind Program director, will lead the office. We welcome Peter as a new member of the geothermal community and wish him well in his new post.

The reorganization includes the reassignments of Lew Pratsch to the Wind Program and Paul Grabowski to the Biopower Program. Lew managed the drilling program for many years, as well as the geothermal heat pump program for which he became widely known as one of the government's leading experts. Paul ably managed the Geothermal Energy Program's long-term research efforts in advanced drilling and enhanced geothermal systems. Lew and Paul were a credit to the Geothermal Energy Program, and we wish them every success as they move on to new career paths.

Lew's and Paul's Geothermal Energy Program duties will be apportioned among those of us who remain with the Geothermal Energy Program: Marshall Reed, Ray LaSala, Ray Fortuna, and I. Given the magnitude of the staffing changes, I anticipate significant changes in the management and administration of the program as well. Laboratory consolidation, a long-standing issue affecting how we conduct business, has been receiving serious consideration. One or more major new initiatives also may be announced in the near future for the revitalization of the program and better recognition of geothermal as an important energy source. In-depth discussions with industry regarding these new thrusts have already begun.

Obviously, the Geothermal Energy Program has entered a period of substantial, if not dramatic, change as we begin Fiscal Year 2000. And with that change comes a degree of uncertainty about the future. But change also represents opportunity, and I see tremendous opportunities for growth in the use of geothermal energy throughout the country. Growth factors, such as market pull supplied by utility restructuring and technology push provided by research and development, will fuel those opportunities. In the not too distant future, some communities could satisfy their total energy needs from geothermal resources. As never before, the ambitious goals stated in our Strategic Plan seem within reach. We should redouble our efforts to make those goals a reality.

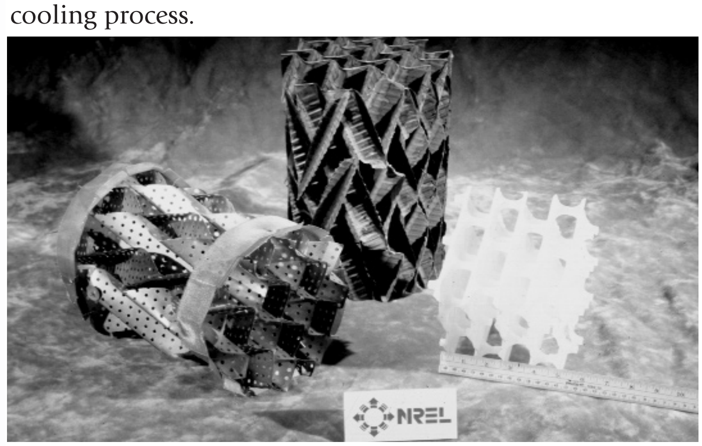
Allan J. Jelacic
Geothermal Energy Program Team

DOE Geothermal Research Wins "R&D 100" Award

Advanced technology for condensing spent steam from geothermal power plants, developed by the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL), earned one of this year's "R&D 100 Awards." *R&D Magazine* gives these prestigious awards to the 100 most commercially promising technical innovations, and it recently honored the developers at a banquet held in the Museum of Science and Industry in Chicago, where the magazine is published.

The award-winning technology, the result of research sponsored by the DOE Geothermal Energy Program, is called Advanced Direct-Contact Condensation (ADCC). It was developed in conjunction with Alstom Energy Systems, Inc. of Easton, Pennsylvania, which has licensed the technology for commercialization. Alstom has already contracted with the national electric utility of Mexico to install an ADCC unit at a new geothermal plant in Mexico.

Conventional steam condensers, known as shell-and-tube condensers, circulate spent steam from electric generating plants around sealed coolant pipes to condense the steam. By contrast, direct-contact condensers mix cooling water directly with the steam in an open chamber, with simple perforated plates inside to provide the surface area on which condensation takes place. NREL's advanced direct-contact condenser design is less expensive than the others, and it increases the efficiency and generating capacity in electric power plants. This increase is accomplished by using sophisticated geometric shapes, called packing structures, to provide the largest surface area for condensation. The ADCC packing structures also channel the steam and water for maximum contact with each other, speeding up the cooling process.



NREL has modeled and tested these packing structures for ADCC technology.

ADCC also offers a major improvement in control of pollution from noncondensable gases in the steam. It does this by a computer program that models the chemical reactions in the spent steam and cooling water, and controls the amount of chemicals needed for emission abatement.

NREL and Pacific Gas and Electric Company (PG&E) demonstrated ADCC technology by refurbishing an existing direct-contact condenser at one of PG&E's geothermal power plants at The Geysers steam field in California. When ADCC went on-line at PG&E's Unit #11, power production efficiency improved by 5%, potential generating capacity dramatically increased by nearly 17%, and chemical cost for emission abatement was cut in half. In an industry where fractions of a percent difference in performance are highly significant, these are outstanding gains. Increased annual revenues at Unit #11 will recover the cost of refurbishment in less than two years.

Market potential for this innovative technology is significant. There are 21 other generating units at The Geysers using direct-contact condensers, as well as many other geothermal power plants worldwide, where retrofit with ADCC could be economically advantageous. With further adaptation, ADCC could also be profitably applied in fossil-fueled power plants, which generally use conventional shell-and-tube condensers. Finally, condensers are common equipment for any industrial process that generates steam or other vapors that subsequently require cooling and condensation. Therefore, ADCC technology could be particularly appropriate for processes such as concentrating fruit juices, for which maintaining low-temperature, low-pressure conditions is important.

When congratulating the NREL winners, Secretary of Energy Bill Richardson said, "These awards are both a tribute to the impressive creativity of the scientists and engineers at our national labs that made these technologies possible, and recognition of the practical contributions that DOE research makes to the country."

ests Reveal Influence

Polycrystalline diamond compact (PDC) bits have yet to be routinely applied to drilling the hard-rock formations characteristic of geothermal reservoirs. Most geothermal production wells are currently drilled with tungsten-carbide-insert roller-cone bits. PDC bits have significantly improved penetration rates and bit life beyond roller-cone bits in the oil and gas industry, where soft to medium-hard rock types are encountered. If PDC bits could be used to double the current penetration rates in hard rock, geothermal well-drilling costs could be reduced by 15% or more.

PDC bits exhibit reasonable life in hard-rock wear tests when using the relatively rigid setups typical of laboratory testing. Unfortunately, field experience indicates otherwise. The prevailing mode of failure encountered by PDC bits returning from hard-rock formations in the field is catastrophic, presumably due to impact loading. These failures usually occur in advance of any appreciable wear that might dictate cutter replacement. Self-induced bit vibration, or "chatter," is one of the mechanisms that may be responsible for impact damage to PDC cutters in hard-rock drilling. Chatter is more severe in hard-rock formations, since they induce significant dynamic loading on the cutter elements.

Chatter happens when the drillstring becomes dynamically unstable and excessive sustained vibrations occur. Unlike forced vibration, the force (i.e., weight on bit) that drives self-induced vibration is coupled with the response it produces. Many of the chatter principles derived in the machine tool industry are applicable to drilling. However, while it is a simple to change a machine tool to study the chatter phenomenon, this is not the case with drilling. Chatter occurs in field drilling due to the flexibility of the drillstring. Therefore, laboratory setups must be made compliant to observe chatter.

Sandia National Laboratories (SNL) modified its Hard-Rock Drilling Facility (HRDF) with the addition of springs, which allow the compliance of field drillstrings for simulation (Figure 1). To represent field-drilling conditions, the range of parameters used in the experimental setup must reflect the conditions typically experienced by a drillstring equipped with a PDC bit. Weight on bit (WOB), rotary speed, and the fundamental vibration modes of the drill-string are important parameters in the experimental design. The penetrating forces and surface speeds for the

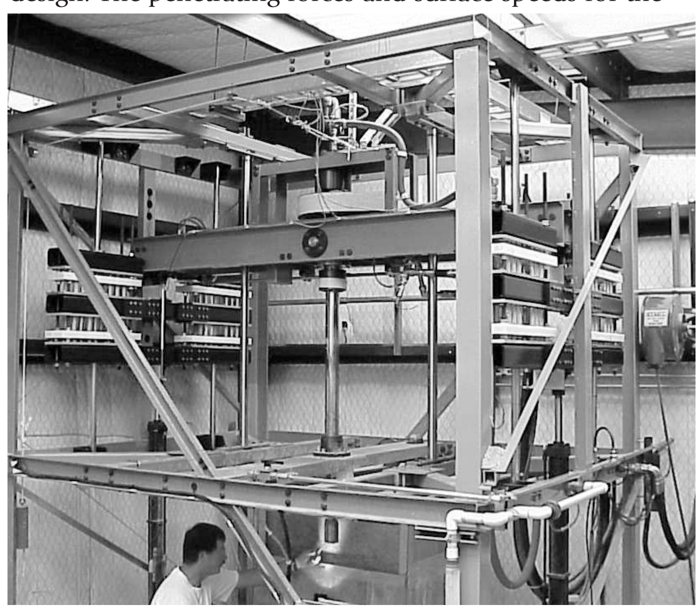


Figure 1. Sandia's Hard-Rock Drilling Facility was modified to include axial compliance.

cutters on the test bit should characterize what cutters experience in the field with comparable formations. The fundamental frequencies of the test fixture were made as low as possible to simulate field drilling. Using this approach, chatter effects observed at the test setup's natural frequency represent the system characteristics at frequencies which may be encountered in the field. Torsional compliance, also inherent in field drillstrings and of particular concern in PDC bit applications, was eliminated in this first phase for simplicity, but it will be addressed in future investigations.

SNL conducted testing in Berea Sandstone, a soft formation, and Sierra White Granite, a hard rock representative of geothermal formations, to determine the conditions under which chatter originates. The tests involved drilling a series of holes at constant WOB and rotary speed while recording drilling parameters for post-test analysis. A displacement transducer monitored the peak-to-peak vibration of the drillstring. Drilling tests were conducted over a range of WOB values and rotary speeds to simulate a variety of conditions.

One measure of chatter severity is the difference between the bit's peak-to-peak vibration and its depth-of-cut per revolution. This parameter, the "out-of-cut distance," is shown in Figure 2 for sandstone. The plot shows the relative amplitude of vibration at various WOB and rotary speed combinations. When the parameter is negative, the bit remains in the cut. Conversely, when the parameter is positive, the bit is bouncing completely out of the cut. The power spectral density has the same general character; it suggests that the out-of-cut parameter is indicative of the vibration energy residing in each of the operating conditions across the measurement range.

The data show that severe chatter occurs in sandstone. This implies that chatter can play a significant role in oil and gas drilling. However, no damage to the PDC cutters was observed throughout the sandstone testing. Like the theory of chatter applied in the machine tool industry, tests

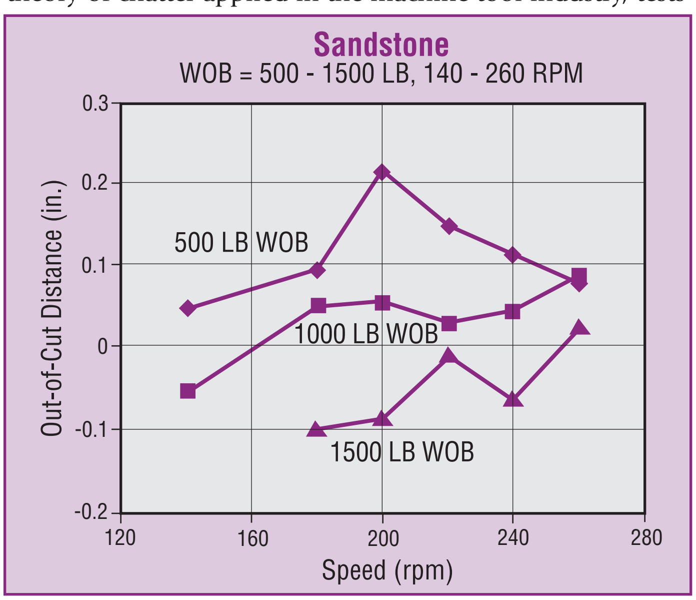


Figure 2. Bit vibration measurements from drilling tests in Berea sandstone.

show that there are pockets of stability (i.e., WOB and RPM pairs) for which the vibration level is reduced. Figure 2 shows that a given WOB has preferential rotary speeds for the drilling configuration represented. Further, although not apparent from the data displayed here, the rate of penetration decreases in the presence of significant chatter. Alternatively, when the chatter level decreases the penetration rate increases. As expected, increasing the WOB at a given rotary speed decreases the chatter. However, even at higher WOB some rotary speeds are better than others. The zigzag nature of the higher WOB data, shown in Figure 2, is due to the excitation of higher-frequency vibration modes at increased WOB.

Important to geothermal drilling, SNL's testing in Sierra White Granite produced chatter with much higher impact loading that led to PDC cutter damage and failure. In fact, the quantity of PDC cutter failures limited the progress of the testing. Figure 3a is a photo of a PDC cutter that drilled 96 feet at 30 feet/hour under stable, non-chatter operating conditions that resulted in the initial stages of wear. Figure 3b shows a cutter that drilled one foot at 10 feet/hour in Sierra White Granite under chatter conditions, resulting in bulk failure of the diamond table and carbide support. These results confirm that chatter is a significant problem when drilling in hard-rock formations. Controlling the level of chatter in the drillstring is crucial when using PDCs for geothermal drilling.

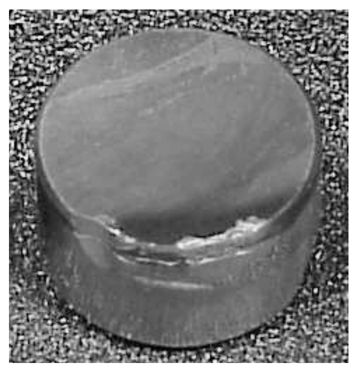


Figure 3a. Lightly-worn PDC at Stable Drilling Condition (96 ft of Sierra White Granite at 30 ft/hr, 2000 lb. WOB and 100 RPM).

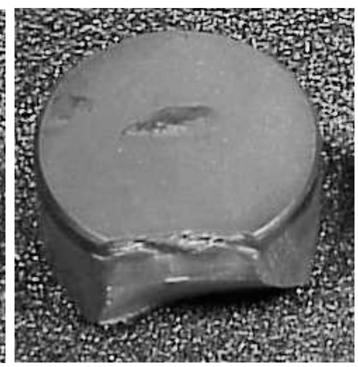


Figure 3b. Failed PDC in Chatter Conditions (1 ft of Sierra White Granite at 10 ft/hr, 1500 lb. WOB and 140 RPM).

SNL is pursuing many ways to reduce chatter. Using a high-speed data link to the bit is one approach. The level of vibration measured at the surface is attenuated from the vibration actually occurring at depth. If accurate dynamic conditions are known downhole, drilling parameters can be modified using feedback control to reduce the chatter level at the bit and improve the drilling process. Another approach is to use a downhole-controllable damper. Such a device would monitor the response of the bit and apply appropriate damping to reduce the chatter level, thereby reducing the impact loading of PDC cutters in hard-rock formations. Yet another approach is to have the HRDF emulate the shock environment that PDC bits must endure under nominal operating conditions. This information will be used to develop advanced cutters that are capable of surviving chatter in the hard-rock formations characteristic of geothermal drilling.

For more information, contact David Raymond, SNL, at (505) 844-8026 or dwraymo@sandia.gov; or Jack Wise, SNL, at (505) 844-6359 or jlwise@sandia.gov. The contributions of Mike Elsayed, University of Southwestern Louisiana, are gratefully acknowledged. SNL is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for DOE under Contract DE-AC04-94AL85000.

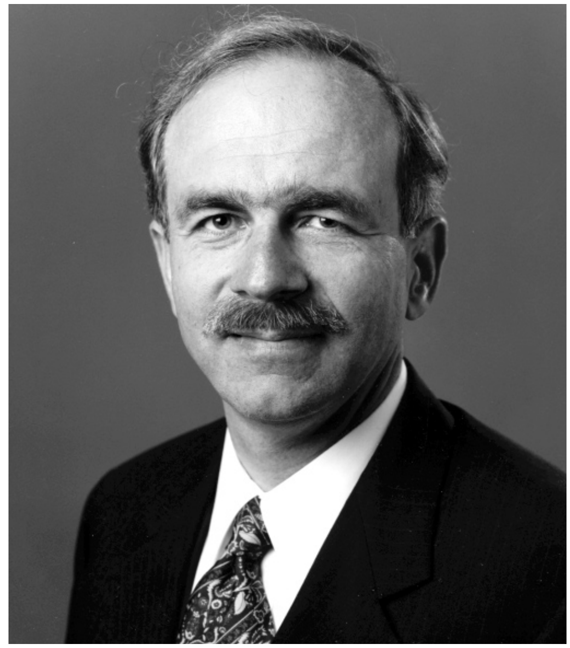
Every research manager dreams of a breakthrough, a major development, a significant contribution to the emergence of an important new technology. The U.S. Department of Energy's (DOE) Geothermal Energy Program had such a manager in Lew Pratsch. His pioneering work that produced the recent growth in the use of geothermal heat pumps (GHPs) fulfills that dream.

Generic heat pump technology is not new, of course; it's basically refrigeration equipment. However, the rapid emergence of energy-efficient, non-polluting GHPs for space heating, cooling, and water heating is, indeed, a phenomenon that is attracting more and more attention. GHPs are increasingly being installed in nearly all types of buildings—from homes, schools, and stores to multistory office complexes. And for the past several years, Lew has been a major player in this process.

But let's back up a bit. Lew is a civil engineer who started his 30-year government career in the field of commuter transportation. First at the U.S. Department of Transportation, and then at DOE, he worked on programs to reduce energy consumption and air pollution by increasing the use of car pools, van pools, and high-occupancy vehicle lanes. And he practices what he preaches: he has driven a commuter van pool between Washington, D.C., and the Virginia suburbs for more than 22 years.

Lew joined the Geothermal Energy Program in 1984 as a program manager for the construction of the experimental 50-megawatt Heber Binary Power Plant in California's Imperial Valley. Soon he was given additional responsibility for the geothermal direct use program, and in this role he became fascinated with the possibilities of GHPs (now called GeoExchange). He was particularly intrigued with the load-leveling benefits that the technology provides to electric utilities. He realized that GeoExchange is a three-way winner: consumers save money on their energy bills, utilities improve their load factors, and the country reduces air pollutants. So, he became an advocate.

To start, Lew brought the fledgling GHP industry together with large, established, influential organizations such as the Edison Electric Institute, the Electric Power Research



Lew Pratsch was manager of DOE's geothermal drilling and heat pump programs.

Institute, the National Rural Electric Cooperative Association, and the U.S. Environmental Protection Agency. He helped educate those organizations' leaders about the exceptional benefits of GHPs, and out of these groups, the Geothermal Heat Pump Consortium was born. The industry has recognized his large contribution to this effort with several awards. And once again, he practices what he preaches: his second home uses GeoExchange. He only paid a dollar a day to heat and cool its 2300 square feet when it was rented.

This was not the end of Lew's contributions to the Geothermal Energy Program. After the Heber plant was completed, he was asked to head up the department's research and development (R&D) program in geothermal drilling. Sandia National Laboratories (SNL) in New Mexico performed much of the technical work in this program, and Lew was instrumental in coordinating SNL's research with the geothermal industry's needs. Through the Industrial Review Panel of the Geothermal Drilling Organization, the Geothermal Resources Council, and the Geothermal Energy Program's annual Program Reviews, he helped shape the R&D agenda to meet industry's highest priority requirements.

He also emphasized the importance of developing drilling technologies for application in the oil and gas industry, since the geothermal drilling market alone often lacks the critical mass required to commercialize innovations. For example, acoustic telemetry technology, as a result of last year's licensing agreement between SNL and Baker Hughes, will be applied first in the oil and gas industry. Then, as the market develops and costs decrease, the technology will be applied in the geothermal industry.

For Lew, there's more to life than work. He, his wife, and two sons are all avid water-skiers, and they love to spend their summer weekends in their ski boat on Lake Anna in

Virginia. His son, Craig, a high school sophomore, is having a great year of achievements: straight A's in school last year, an Eagle Scout award in the spring, and barefoot water skiing last summer.

Under the reorganization of DOE's Office of Power Technologies, Lew is now leaving the Geothermal Energy Program and transferring to the Wind Program. But he's made his mark in geothermal energy and will be remembered for it.

erformance

Boreholes used with geothermal heat pumps (GHPs) require grouting. In the past, minimal attention was given to the selection of grouting material for GHPs. The same bentonite grouts used by the water well industry were also used for GHP applications. Bentonite is a relatively poor thermal conductor, and it is also prone to severe cracking and shrinkage under drying conditions. Interest in GHPs has rapidly expanded in recent years, and this has coincided with efforts to decrease installation costs and improve efficiency.

One way of achieving these goals is to increase the thermal conductivity of grout used to complete boreholes. Dr. Marita Allan and Dr. A.J. Philippacopoulos at Brookhaven National Laboratory (BNL) are conducting research on thermally conductive cementitious grouts for use with GHPs. BNL's research covers experimental characterization of a wide range of grout properties, numerical modeling of grout behavior under thermal loads, field demonstrations, and technology transfer to industry.

INCREASING GROUT CONDUCTIVITY

Thermal conductivities up to three times higher than bentonite and neat cement grouts were achieved through appropriate selection of grout ingredients and mix design. The new BNL grout is called Mix 111. Mix 111 basically consists of cement, water, silica sand, and small amounts of superplasticizer and bentonite. It is simple to mix, cost-competitive, and retains thermally conductive properties in the dry state, whereas conventional grouts undergo dramatic decline in conductivity. By increasing the thermal conductivity, it is possible to reduce the required bore length and thus save on installation costs.

The University of Alabama performed analysis showing that the bore length can theoretically be reduced by up to 22%-35% for a particular test case—depending on various other factors such as soil conductivity and bore diameter—by using the cement-sand grout rather than conventional grouts. Cost calculations predict economic viability of the grout compared with bentonite-sand mixtures. While control of initial costs is important, long-term performance of the grout is essential. Mix 111 has been designed to provide better thermal coupling throughout the service life of a GHP, which decreases the life cycle cost.

SUCCESSFUL FIELD TESTS

Oklahoma State University and Sandia National Laboratories conducted field tests in two different climates and geologies. They confirmed the enhanced performance of BNL's Mix 111. Figures 1 and 2 display the initial results, showing that thermal resistance decreased by 29% and 35% when compared with bentonite grout for the two sites, respectively. Further testing is in progress.

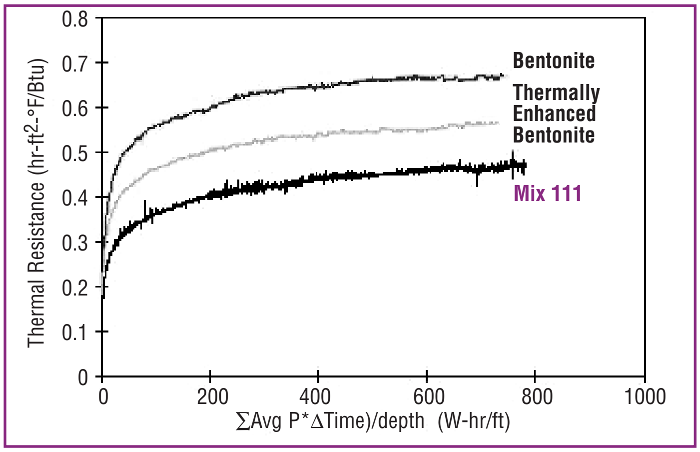


Figure 1. Results of field tests conducted by Oklahoma State University indicating 29% reduction in thermal resistance with Mix 111 compared to bentonite.

WORKING WITH INDUSTRY AND REGULATORS

Besides thermal conductivity, Mix 111 has several other advantages that ultimately resolved some environmental regulatory concerns in New Jersey. The New Jersey Heat Pump Council contacted BNL in search of an alternative to neat cement grout, since permission to use this material had been denied by the New Jersey Department of Environmental Protection (NJDEP). The situation arose due to questionable bond integrity between neat cement

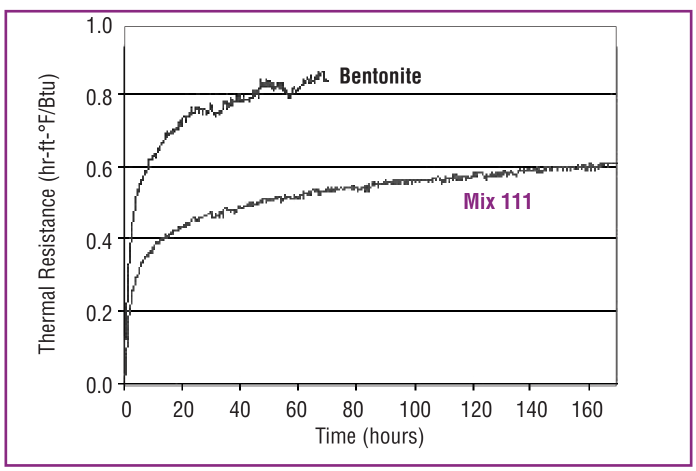


Figure 2. Results of field tests conducted by Sandia National Laboratories indicating 35% reduction in thermal resistance after 70 hours with Mix 111 compared to bentonite.

grout and U-loop, and the possibility of aquifer contamination if channeling occurred at the interfaces. As a result of the injunction, installation of GHPs in consolidated formations in that state halted, and the loss of business was estimated at $3 million in less than one year.

The superior performance of Mix 111—including its reduced coefficient of permeability, lower infiltration rate, shrinkage resistance, and better bond strength to U-loop—convinced the NJDEP that the environmental risk would be minimized by using it rather than neat cement. Finite element analysis of thermal stresses developed in the grouted borehole was used to alleviate concerns of cracking induced by expansion of the U-loop (see Figure 3). Mix 111 was approved for use in both consolidated and unconsolidated formations in November 1998. The New Jersey state permit conditions now include specifications for mixing and pumping Mix 111.

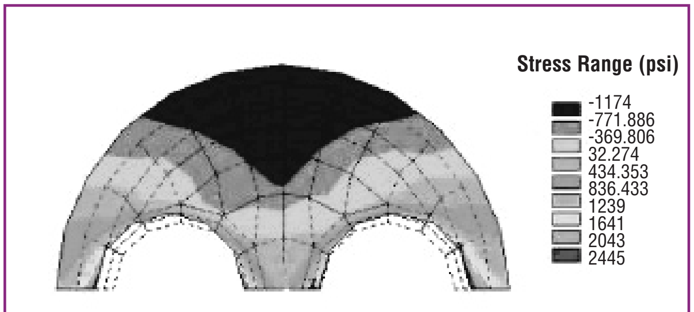


Figure 3. Finite element analysis of thermal stresses in grouted borehole operating in cooling mode. (BNL data)

COMMERCIAL USE

To date, Geothermal Services, Inc., has used Mix 111 on five residential projects in New Jersey, and a test bore was grouted for a future Hilton Hotel project (Figure 4). Based on experience in New Jersey, it has been calculated that bore length reductions of 15% are required for breaking even on Mix 111 material costs, as compared with bentonite grout. This can be achieved given the significantly higher thermal conductivity of Mix 111. Several other commercial projects in New Jersey and other states are pending.

Figure 4. The training session and field demonstration of BNL grout at future Hilton Hotel site in Dover, New Jersey, was conducted in collaboration with NJHPC, Geothermal Resource Group, Geothermal Services, and GPU Energy. (BNL photo)

Enlink Geoenergy Services and Ted Wynne Engineering also used Mix 111 in prepackaged form on the Gallatin Middle School project in Tennessee, which involved 130 boreholes at 300 feet deep. Project engineers were extremely satisfied with Mix 111's high thermal conductivity, consistency from hole to hole of the grout conductivity, independence of performance from the depth of water table, and aquifer protection. Marked improvement in reproducible heat transfer, compared with backfilling the boreholes with soil cuttings, resulted from appropriate grouting techniques and materials. The additional cost of using Mix 111 was nominal and worth the benefits of long-term efficiency and functionality. The grout material costs were only about 2.7% of the overall project costs.

For further information, please contact Dr. Marita Allan at BNL at (516)344-3060.

The U.S. Department of Energy's (DOE) Idaho Operations Office, on behalf of DOE's Geothermal Energy Program, has awarded three cost-sharing grants under the Geothermal Direct Use Drilling Program Solicitation for Financial Assistance.

DOE awarded a $260,000 grant to the Modoc Joint Unified School District in Alturas, California, for drilling an injection well. The direct use project will provide space heating for two schools, Alturas Elementary School and Modoc Middle School, with an enrollment of more than 700 students. Energy savings from the project should allow the school district to realize as much as $73,000 in energy cost savings per year, thereby freeing up funds for enhanced educational programs. Substituting geothermal energy for fuel oil also will eliminate air pollution from hydrocarbon combustion.

Another grant was given to the I'SOT, Inc. geothermal district heating project in Canby, California, for drilling a production well. The developer will retrofit existing propane heating systems to accept heat from a hot water loop. Twenty-nine buildings will be heated and supplied with domestic hot water. In addition to replacing fossil fuels, the developer is planning to create wetlands with the geothermal effluent, which could serve as a habitat for birds on the Pacific flyway. DOE's cost share is $144,000, or 75% of the drilling cost. The California Energy Commission is supporting non-drilling aspects of the project.

Finally, Alex Masson, Inc. received a $296,000 grant for drilling a production well to expand a commercial green-house near Radium Springs, New Mexico. The proposed well, which will target the deep parent reservoir of the Radium Springs geothermal system, is expected to provide heat equivalent to 14,000 barrels of fuel oil, or 85 million cubic feet of natural gas, per year. The new well should double the amount of acreage under cultivation.

Since 1962, the International Association of Business Communicators (IABC) has been honoring the outstanding work of communications professionals. In IABC's 1998-1999 competition, the National Renewable Energy Laboratory (NREL) received the "Award of Merit" for a series of four fact sheets it completed for the U.S. Department of Energy's (DOE) Geothermal Energy Program's Geothermal Heat Pump Program.

The titles of these fact sheets are:

- *Environmental and Energy Benefits of Geothermal Heat Pumps*
- *Geothermal Heat Pumps Score High Marks in Schools*
- *Geothermal Heat Pumps Make Sense for Homeowners*
- *Geothermal Heat Pumps for Medium and Large Buildings.*

They provide an engaging and encouraging overview of geothermal heat pumps as a proven technology well on the way to substantial market penetration and success.

A quote from the judging committee sums things up nicely:

> "An admirable job, given the difficult challenges and limitations characteristic of working in the public sector. The series is thorough and the writing clear. A good example of 'effectiveness on a tight budget.'"

Lew Pratsch, the DOE program manager in charge of the Geothermal Heat Pump Program, supervised the series. Bruce Green and Kara Stewart, both with NREL, performed the research, writing, and development of this award-winning fact sheet series. A fifth fact sheet entitled *Geothermal Heat Pumps for Federal Buildings* has just been printed.

IABC presented NREL with the above 1999 Bronze Quill Award.

urbo-Drill Ready to Field Test

The U.S. Department of Energy's (DOE) Geothermal Energy Program will collaborate with DOE's Office of Fossil Energy (OFE) on a field test of an advanced drilling system, which is applicable to both geothermal and some natural gas wells.

The Geothermal Energy Program, which was then the Office of Geothermal Technologies, originally provided funding to Maurer Engineering for the development of the Turbo-Drill—a down-hole, mud-driven drilling motor. After further refinement, the motor was coupled with a gear reducer to provide better torque. OFE then helped review the initial proposal at its Federal Energy Technology Center in Morgantown, West Virginia.

Maurer is now ready to field test and commercialize the technology, and OFE and the Geothermal Energy Program will cost-share this phase of the project. This latest successful agreement results from the National Advanced Drilling and Excavation Technologies (NADET) Memorandum of Understanding between these offices. Past combined efforts through NADET have included proposal review assistance; the co-funding of research and development for advanced drilling systems; technical advice on strategic planning; and the regular exchange of programmatic information.

The new coupled system is a significant advance in down-hole drilling motor technology. It promises to greatly reduce the costs of drilling the extremely hard rock associated with geothermal and natural gas wells.

For more information, contact Allan Jelacic, DOE, at (202)586-5340.

oward Commercialization

The May 1999 issue of *Geothermal Technologies* reported that Sandia National Laboratories' (SNL) innovative rolling float meter (RFM) was being used to help drill a relief well targeted at a burning gas well near Bakersfield, California. Epoch Wellsite Services, Inc., the mud-logging company for both wells, requested the RFM because of the excellent control it provides for accurate drilling, especially when mated with Epoch's RIGWATCH drilling instrumentation system. It's now time to report that the relief well successfully intercepted the gas well; the fire is out, and the blow-out is capped.

This dramatic field success for SNL's new technology resulted in a request to install another RFM on a Berkeley Petroleum, Inc. well about 20 miles north of Bakersfield. SNL technicians have completed its installation and calibration. The data from the well will be used to evaluate the circulation monitoring system software program, currently under development by Marconi, Inc., for real-time detection of kicks and lost circulation.

Because of these successes, three more companies—Epoch Well Information Services, International Logging Overseas, and Petron—are pursuing the acquisition of RFMs. Industrial procurement of the device will mark the first commercial deployment of this technology.

SNL developed the RFM through the Lost Circulation Technology Program of the U.S. Department of Energy's (DOE) Office of Geothermal Technologies, which is now the Geothermal Energy Program.

For more information, contact Allan Jelacic, DOE, at (202) 586-5340; or SNL's George Staller at (505) 844-9328 or Gary Whitlow at (505) 844-5755. SNL is a multiprogram lab operated by Sandia Corporation, a Lockheed Martin company, for DOE.

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echnology Innovation

The U.S. Department of Energy's (DOE) Geothermal Energy Program recently announced four awards for advanced research in geothermal technology innovation. The awards, which will total about $300,000, were made under a solicitation for proposals issued by DOE's Golden Field Office.

The DOE solicitation sought proposals to identify, examine, and evaluate innovative ideas that have significant potential to reduce the cost of geothermal energy development or increase the availability of economic geothermal resources. All awards require a minimum private partner cost share of 20%.

The awards (see Table 1 below) cover only Phase I of each project: establishing scientific or technical feasibility of the innovative approach or concept. At the conclusion of Phase I, which will last up to 12 months, the Geothermal Energy Program will review final reports and evaluate proposals for Phase II follow-on work, which may last up to 24 months. Total DOE funding is expected to be $1 million, subject to the availability of appropriations, for those projects selected for Phase II.

For more information, contact Jeff Hahn at the DOE Golden Field Office in Golden, Colorado, at (303) 275-4775

Table 1. Phase I Awardees.

Organization	Project Title	Objective
FAS Engineering, Inc.	Improved Energy Conversion for Geothermal Power Plant	Build and test a two-phase reaction turbine
Michigan Technological University	Highly Impact Resistant and Thermally Stable Rock Drill Bits —A Nanometer Diamond Composite and Near-Net Shaped Manufacturing Technology	Develop and advanced drill bit technology for reducing geothermal drilling costs
Technology International, Inc.	Fracture Resistant TSP Diamond Cutters for Drag Bits	Increase the fracture toughness of TSP diamond to improve the penetration and durability of drag bits
Two-Phase Engineering and Research	Brine Enhanced Air-Cooling	Design, fabricate, and test a small-scale system that will use geothermal brine to evaporatively cool the air as it enters the air-cooled condensers