Geothermal technologies

Vol. 8 Issue 1
June 2003

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Meet Our New Program Director—
Roy Mink

Roy Mink has rejoined the Department of Energy as the new Geothermal Technologies Program Director. Roy brings energy, good ideas, and a solid background to DOE's efforts to lead geothermal energy into the competitive mainstream.

Roy Mink, DOE's new Director of the Geothermal Technologies Program.

Mink received his B.S. in math/science education from Idaho State University (1965), and his M.S. in hydrology (1971) and Ph.D. in geology (1973) from the University of Idaho. He was a hydrogeologist with the Idaho Bureau of Mines and Geology, and associate professor of hydrogeology at Boise State University. He was a research geo-hydrologist for the EPA in Las Vegas, and spent four years with DOE as a geo-thermal energy project manager in Washington, D.C., and Idaho Falls. He was hydrologist/project engineer for Morrison-Knudson Company in Boise, working in the areas of mining, energy, and environmental and hazardous waste remediation. He came to the University of Idaho as professor of hydrogeology and director of the Idaho Water Resources Research Institute in 1989. Dr. Mink also served as co-director of the Center for Hazardous Waste Remediation Research at the University of Idaho. He has served on the Board of Directors of the National Institutes for Water Resources and the University Council on Water Resources, and was president of NIWR in 1995-96.

(continued on page 2)

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Energy Efficiency and Renewable Energy
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Geothermal Technologies: What do you believe are the current priorities for the Program?

Roy Mink: We want to continue our research efforts in geoscience, drilling, and energy conversion. By concentrating our research on the biggest bottlenecks to development, we can best help industry get geothermal energy into more widespread use. We need better resource definition to reduce the risk of drilling dry holes. We should collaborate with the oil and gas industry to increase exploration success without having to drill so many exploratory wells. Our Enhanced Geothermal Systems projects will enable us to use currently non-productive resources—resources that have heat but no water or rapidly declining water. We also need an updated resource assessment, and I hope to work with the USGS to get that accomplished. There are many medium- and low-temperature resources that can provide energy benefits to western communities and light industrial processes, both in electricity generation and non-electric uses.

Geothermal Technologies: And future priorities you've been thinking about?

Roy Mink: I'd like to see some of the longer-term, basic research be coordinated by entities like the National Science Foundation and universities. We need to convince them to undertake this research so that DOE can concentrate on the more applied research with our limited budget.

We need to work with utilities and public education programs to show them how geothermal energy can help them with base load power. Rural co-ops could use smaller turbines for base load, which would eliminate a lot of need for transmission lines. I'd like to see some small turbines that can run on lower-temperature resources. We have a lot of rural sustainability possibilities associated with the Farm Bill. Wind and biomass have been successful with their efforts, and it's time geothermal got into the game.

Contact Roy at 202.586.5348, roy.mink@ee.doe.gov.

DOE and BLM Issue Report on Sites with Good Potential for Near-Term Development

DOE and BLM, through a GeoPowering the West partnership, have issued a report identifying 35 public-land sites in the West as having good potential for near-term development of geothermal power. After analyzing existing data, ten sites were identified in Nevada, nine in California, seven in Oregon, and three each in New Mexico, Utah, and Washington. Jointly released by DOE Assistant Secretary for Energy Efficiency and Renewable Energy David Garman and Assistant Interior Secretary Rebecca Watson, the report is "part of a broader effort to reduce U.S. dependency on foreign energy," said Watson. The report, titled, "Opportunities for Near-Term Geothermal Development on Public Lands in the Western United States," was prepared by BLM and DOE through the National Renewable Energy Laboratory. Two-thirds of the 35 sites either have been environmentally reviewed or are currently under review. Nevada Senator Harry Reid, a long-time supporter of geothermal energy, said at the press conference, "I have been saying for years that Nevada is the Saudi Arabia of geothermal energy, and I am pleased that the Interior and Energy Departments have reinforced that claim."

The DOE/BLM geothermal report is a companion to a broader DOE/BLM report titled, "Assessing the Potential for Renewable Energy on Public Lands." The purpose of that report is to help federal land managers make decisions on prioritizing land-use activities that will increase development of renewable energy resources on public lands in the West (except Alaska). BLM and the National Renewable Energy Laboratory prepared the report. In announcing the report, Energy Secretary Spencer Abraham said, "The Department of Energy is pleased to provide the technical renewable energy expertise of our national laboratories to the Bureau of Land Management. Federal agencies can lead by example to improve America's energy security by helping renewable industries bring domestic energy resources to market." Sources of renewable energy addressed in the report include wind, solar (photovoltaic and concentrating), biomass, and geothermal. The report found that 63 BLM planning units in 11 western states have high potential for power production from one or more renewable energy sources. Twenty BLM planning units in seven western states have high potential for power production from three or more renewable energy sources.

For a copy of the renewable energy report, go to http://www.nrel.gov/docs/fy03osti/33530.pdf.

For a downloadable copy of the geothermal report on the 35 highest-potential sites, including its many full-color maps, charts, and posters, please go to http://www.eere.energy.gov/geothermal/geopressroom.html.

For more information, please contact Barbara Farhar, co-author of the report, National Renewable Energy Laboratory, 303.384.7376, Barbara_farhar@nrel.gov.

Coating Technology Saves Industry Thousands of Dollars

How can geothermal power plants and chemical refineries save many thousands of dollars a year? By coating heat exchangers and other process equipment with a revolutionary material developed by the National Renewable Energy Laboratory (NREL) and Brookhaven National Laboratory (BNL) geothermal programs. The coating prevents corrosion and inhibits buildup of scale from mineral-rich geothermal brines and caustic industrial fluids, reducing maintenance and capital expenditures.

Keith Gawlik of NREL and Toshi Sugama of BNL have already won an R&D 100 Award and a Federal Laboratory Consortium award for the coating, and industry is beginning to reap the benefits. Refineries throughout the U.S. had installed tens of thousands of heat exchanger tubes coated with the material by mid-2002, and that number may be in the hundreds of thousands by now.

Testimonial letters confirm that the companies are very pleased with the results they're getting. One executive writes, "Our tubes were failing an average of every 17 weeks. We've now used the coating for 13 months at 350 degrees F with no tube failure or loss of heat transfer. We've recovered the cost of the coating application many times over."

Research and development on the coating began as an effort to reduce the cost of geothermal electricity.

The remains of a steam vent pipe made of uncoated carbon steel, after 5 years of exposure to corrosive water vapor and gases at the Cove Fort geothermal power plant in Utah.

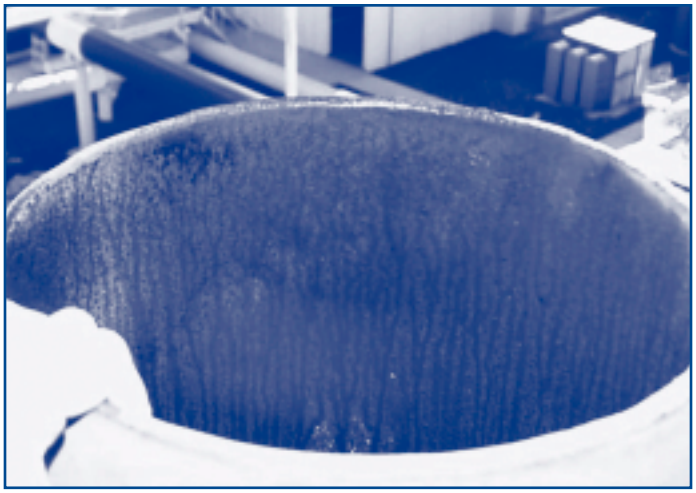
Geothermal power plant heat exchangers have traditionally used expensive stainless steel or other corrosion-resistant materials, such as titanium, to withstand aggressive environments. These materials would provide corrosion protection, but no resistance to scaling. NREL and BNL tested polyphenylenesulfide (PPS) with different fillers, such as carbon fiber, silicon carbide, teflon, and calcium aluminate, in a variety of harsh geothermal environments on relatively inexpensive carbon tubing.

After years of exposure testing in a number of different environments, the formulations were developed such that the tubes were virtually new-looking at the end of a test. Formulations can be developed for abrasion resistance, thermal conductivity enhancement, and scale inhibition.

To launch the coating system into the commercial arena, researchers worked closely with Curran International (formerly Bob Curran and Sons), an established company that had been successful with epoxy and phenolic coatings. After learning basic techniques of working with the new PPS coating, Curran went on to develop their own innovative techniques and perfected large-scale application of the coating system, which they have trademarked as CurraLon™.

Only the slow rate of new geothermal power plant construction has prevented more widespread application of the coating in geothermal environments.

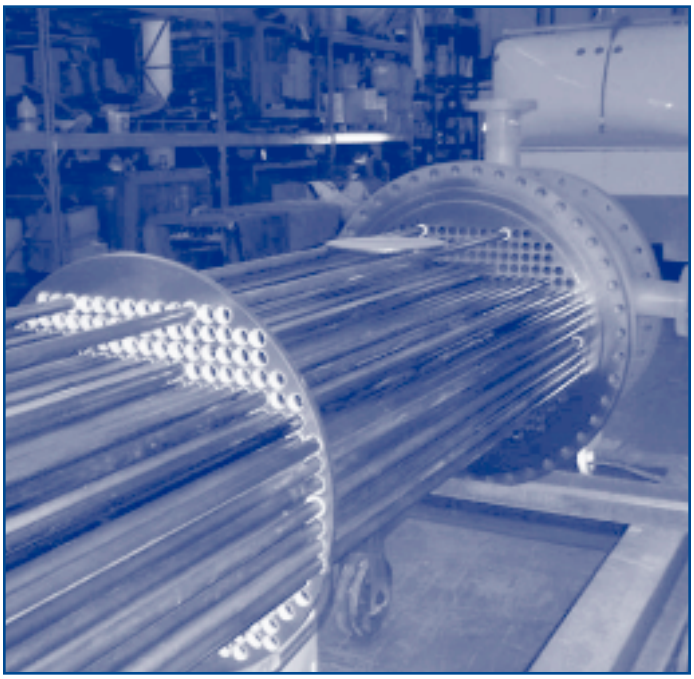
Installation of the new steam vent pipe made of carbon steel coated internally and externally with the polyphenylenesulfide (PPS) system.



The new pipe after seven months of operation, showing no damage. (Rivulets are condensed acidic steam.) Uncoated pipe would have begun to show extensive general corrosion by now.

The coating has, however, been used in the replacement of failed components at existing geothermal plants.

Coating technology R&D continues at NREL and BNL. Gawlik and Sugama are testing PPS formulations in extremely high-temperature geothermal brines, thus making the coating suitable for all known geothermal resources, in acidified and non-acidified fluids, and even in low-temperature applications plagued by algae buildup, such as cooling towers. Research is beginning on development of a new low-temperature organometallic polymer coating that would protect steel tubing with aluminum fins, commonly used in air-cooled geothermal plants, from attack by brine sprays, a proposed method of increasing the power output of these plants during hot weather.



An example of a shell-and-tube heat exchanger being assembled, with the PPS coating shown on the outside of the tubes.

The graph below compares life-cycle cost estimates of a typical geothermal heat exchanger in which the tubes and other wetted components are made of PPS-coated carbon steel, uncoated carbon steel, stainless steel, and titanium. The cost differences are dramatic, and foretell a strong future for this coating technology.

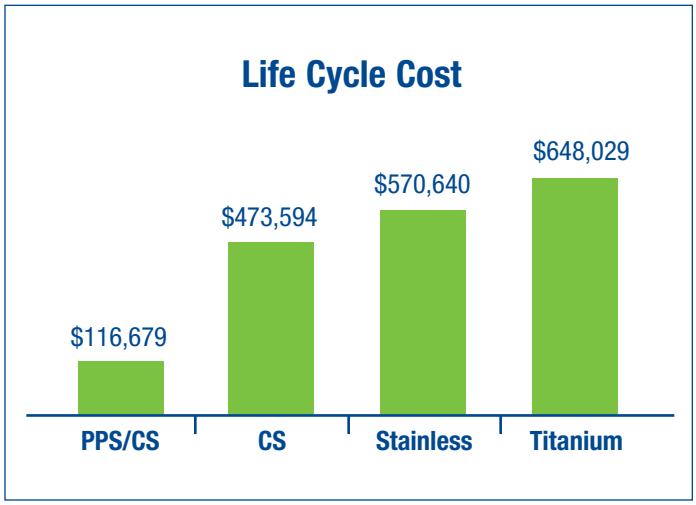


Figure 1. Life cycle cost comparison between the new coating technology and traditional corrosion-resistant materials for a typical brine/working fluid heat exchanger having 800 40-foot-long tubes and a 30-year life cycle. Cleaning and repair costs are estimated.

For more information, please contact Keith Gawlik, National Renewable Energy Laboratory, 303.384.7515, Keith_gawlik@nrel.gov.

Hard-Rock Drilling Performance of PDC Bits and DWD

The goal of Sandia National Laboratories' Hard-Rock Drill Bit Technology Project is to reduce the cost of drilling by promoting development and acceptance of advanced drill bits. The primary objective is to demonstrate the performance capabilities of state-of-the-art drag bits that incorporate polycrystalline diamond compact (PDC) and/or thermally stable polycrystalline (TSP) diamond cutters for drilling into hard-rock formations encountered at geothermal sites.

Several drag bits were recently tested in conjunction with a prototype diagnostics-while-drilling (DWD) system to demonstrate performance in a relatively well-controlled field environment. Three of the four participating drill bit companies have completed their tests. Engineers from each of the three companies were universally enthusiastic about the results.

BACKGROUND

Drag bits offer distinct advantages over traditional rollercone drill bits. A drag bit is equipped with multiple synthetic-diamond cutters that feature thin sintered-diamond layers bonded to tungsten carbide substrates. These cutters are rigidly attached to the bit body and break rock in a shearing process that is inherently more efficient than the crushing action induced by a rollercone bit. The absence of moving parts in a drag bit eliminates the pervasive problems of bearing and seal failures during high-temperature drilling in hard rock with rollercone bits.

Sandia's early contributions to the advancement of drag-bit technology included a geothermal drilling demonstration conducted in the 1980s that showed encouraging results with early PDC bit designs. While drag-bit designs and materials have evolved dramatically since the introduction of this technology, no comparable demonstration has been carried out in recent times to assess the performance of modern drag bits in hard rock. The present work addresses this deficiency by means of field-based drilling demonstrations of baseline and advanced drag bits.

For this task, Sandia formed a multi-partner Cooperative Research and Development Agreement (CRADA) with the following four bit manufacturers:

- ReedHycalog, A Grant Prideco Company (ReedHycalog was formerly a part of Schlumberger Technology Corporation);
- Security DBS, a Product Service Line of Halliburton Energy Services, Inc.;
- Smith Bits—GeoDiamond; and
- Technology International, Inc.

All four participating companies are dedicated to bringing PDC and/or TSP bit technologies to the marketplace as economically competitive options for drilling in awide range of challenging geologic formations.

The initial CRADA work generated baseline hard-rock drilling data for conventional drag bits operated without (Task 1) and with (Task 2) DWD feedback to the driller.

Sandia provided all data from these initial tests to the participating bit companies to support development of their "best effort" hard-rock PDC bit designs and DWD-based drilling strategies. Task 3 of the CRADA involves the field demonstration of these new designs and strategies under the same conditions as the drilling conducted during Tasks 1 and 2.

WORK SCOPE

The heavily instrumented drilling tests in Task 3 are intended to demonstrate the performance of these bits and strategies in a field environment, and simultaneously acquire additional test experience with the prototype DWD measurement system. (See *Geothermal Technologies*, Vol. 7, Issue 4, December 2002 for additional information on DWD.) This parallel approach leverages the limited public and private funding available to support these efforts. In the Task 3 demonstration, the results for the various drag bits provided by the participants are compared to each other and to the Task 1 and 2 benchmark data acquired for conventional PDC (Security DBS, Model PD 5) bits.

Detailed time-resolved measurements of surface and downhole data have been obtained using available rig instrumentation and the DWD system, which features a sophisticated downhole measurement tool (i.e., sub). This DWD sub continuously transmits data to the surface via a wireline connection. Conventional surface-acquired information, including weight-on-bit (WOB), drillstring torque, rotational rate (RPM), rate of penetration (ROP), and mud parameters, have been recorded along with the newly available downhole DWD data for multi-axis acceleration (linear and rotational), WOB, TOB, bending strains, and internal/external mud temperature and pressure. This extensive measurement and analysis effort will yield further improvements in bit design and DWD software and hardware.

The drilling site for the CRADA tests, which is managed by the Gas Technology Institute (GTI), formerly the Gas Research Institute (GRI), at Catoosa, OK, features a uniform, well-characterized hard-rock lithology with a particularly difficult interval known as "The Wall" that is commonly used by industry for bit validation tests. An experienced, test-oriented crew operates the on-site drilling equipment.

FIELD TESTING

To date, CRADA Task 3 testing has been completed with the "best effort" bits supplied by three of the four participating companies. Testing of the fourth "best effort" bit is awaiting completion of the bit as well as modifications of the DWD tool to address a vibration-induced failure mechanism.

An entire week of rig time at the GTI Catoosa Test Facility was scheduled for each "best effort" bit demonstration. During its designated week, each bit company provided one state-of-the-art drag bit along with an on-site team of one or more engineers to control the drilling process for its bit. Prior to initiation of Task 3 activities, Sandia implemented a number of

improvements in the DWD software and display features, and each bit-company team met individually with Sandia staff to define its own "customized" display of DWD data.

In every case to date during Task 3 work, the bit-company drilling engineers paid close attention to the real-time displays of DWD data, and routinely used it to make decisions regarding adjustments in operating conditions. Their acceptance and application of this new capability for downhole diagnostics was unanimous, despite some intermittent wireline/swivel problems. In fact, all teams freely elected to forego opportunities to continue drilling "blind" (i.e., without downhole data) during wireline outages; instead, they chose to await the necessary repairs at the expense of additional time on bottom. Encouragingly, the "best effort" bits coupled with DWD feedback have consistently, and significantly, outperformed the baseline PD 5 results (obtained with and without DWD feedback) in terms of both ROP and bit life.

After its week of testing, each company was presented with a full set of the DWD and surface data acquired for its particular bit by Sandia. Under the terms of the CRADA, this detailed information will not be shared with third parties, including the other CRADA participants. Overall comparative results are currently being documented on an anonymous basis in a summary report for public release. This report will be finalized upon completion of Task 3 drilling with the fourth commercial CRADA partner.

For more information, please contact Jack Wise, Sandia National Laboratories, 505.844.6359, jlwise@sandia.gov.

Nevada GeoPowering the West Working Group: Nevada Legislature "Renewable Energy Day"

GeoPowering the West stakeholders attended the Nevada Legislature's Renewable Energy Day in April, with exhibits hosted by government agencies, renewable energy developers and suppliers, and the power company. A lunchtime "mix and mingle" was well attended by both legislators and geothermal stakeholders. A bill placing new fees on geothermal power producers was heard after lunch, and opposition to the bill was presented by several heavyweights in the geothermal industry—Mack Shelor, Shuman Moore, Mike Stewart, Dan Schochet, Ellen Allman, and others.

For more information, please contact Gerry Nix, National Renewable Energy Laboratory, 303.384.7566, Gerald_nix@nrel.gov.

Idaho GeoPowering the West Working Group

During the last meeting of the working group, which was held on October 10, 2002, subcommittees were established to identify and begin implementing activities to support the objectives of the Idaho Geothermal Energy Development Strategic Plan.

The Idaho Energy Division and the working group hosted a geothermal trade mission to Nevada on November 18-19, 2002. The purpose of this trade mission was to familiarize Idaho legislators, county economic development officials, and others with the use and benefits of clean, renewable geothermal energy. The trade mission included a visit to the Brady Geothermal Power Plant and Gilroy Foods, which uses geothermal heat for onion processing. Presentations were made to the group by a number of Nevada legislators and county officials, the Nevada Public Utilities Commission, the Nevada Division of Minerals, and the U.S. Bureau of Land Management. These presentations (and associated question and answer opportunities) provided information on local economic benefits, Renewable Portfolio Standard legislation, Renewable Energy Credit methodology, geothermal well permitting, and geothermal electric power development on federal lands. The trade mission was very successful, with a great deal of information provided

Idaho legislators discuss geothermal development issues with Nevada officials.

to Idaho policy makers who were impressed with the geothermal operations visited and the potential opportunities for geothermal development in Idaho. The information obtained during this trade mission will be useful for the development of policies and legislation promoting geothermal energy in the state.

The working group will co-host a regional geothermal direct use workshop in Boise on September 10, 2003. This workshop will provide information concerning geothermal resources, their applications and benefits, an overview on the technical, economic, and regulatory aspects of making an application "happen," and guidance on how to proceed. Case studies will be used to illustrate successful projects and potential problems that can be encountered during direct use application development.

During the Harvesting Clean Energy/Idaho Ag Summit in Boise on February 10-11, 2003, Leo Ray, Fish Breeders of Idaho, received an award from Governor Kempthorne recognizing Leo's contributions to geothermal aquaculture. Leo is a member of the Idaho working group.

For more information, please contact Bob Neilson, Idaho National Engineering and Environmental Laboratory, 208.526.8274, rmn@inel.gov.

New Mexico GeoPowering the West Activities

Sandia National Laboratories in Albuquerque and New Mexico State University have been active partners in forming a network of geothermal stakeholders in New Mexico. Many activities have been undertaken to develop New Mexico's geothermal resource. A geothermal resource map of New Mexico was recently completed, and the State Energy Office has undertaken a project to establish, manage, and publicize a Geothermal Information Clearinghouse for New Mexico. Another activity has been strong promotion of direct use applications, capitalizing on New Mexico's hosting of the first- and second-largest geothermally heated greenhouses in the United States. New Mexico's geothermal story was also featured in a recent Geo-Heat Center Quarterly Bulletin. Several potential federal customers are investigating purchasing green geothermal energy. Geothermal stakeholders in New Mexico have been active in developing state energy policy supportive of geothermal development, including the Renewable Portfolio Standard of the Public Regulation Commission. The Jemez Pueblo, with DOE assistance, is evaluating its resources and potential applications, and several geothermal firms have electricity generation projects under consideration.

For more information, please contact Roger Hill, GPW Technical Director, 505.844.6111, rrhill@sandia.gov.

Utah GeoPowering the West Working Group

The first meeting of the Utah Geothermal Energy Working Group was held in Salt Lake City on March 4, 2003. The meeting was organized and hosted by the Utah Division of Natural Resources—Utah Geological Survey (UGS). Thirty-three people representing a variety of interests including state and federal agencies, universities, geothermal electric power producers and vendors, direct use (agriculture, aquaculture, spas, and space heating), and the Utah Clean Energy Alliance attended.

The meeting included presentations on the proposed purpose of the Utah Geothermal Working Group and current geothermal projects at UGS. A DOE State Energy Program grant currently funds work to update geothermal resource data (completed) and to prioritize high-temperature geothermal resources in Utah; a subsequent phase will promote direct use development. Nine high-temperature resources with potential for geothermal electric production have been identified in Utah; work is proceeding to identify and evaluate issues associated with their development.

The presentations were followed by a group discussion on issues associated with geothermal development in Utah and potential activities for the Utah Geothermal Energy Working Group. As a result of these discussions, a policy subcommittee was formed; an education subcommittee may also be formed to promote public education and outreach. Bob Blackett, UGS, agreed to serve as the lead for the Utah Geothermal Energy Working Group.

For more information, please contact Bob Neilson, Idaho National Engineering and Environmental Laboratory, 208.526.8274, rmn@inel.gov.

Arizona GeoPowering the West Activities

On January 30, a GPW meeting was held in Phoenix at Arizona State University. Under Arizona Corporation Commission proceedings, approval has been granted for geothermal to be allowed as a variance to the Environmental Portfolio Standard. Roger Hill reported on GPW organizational activities, and Steve Munson of Vulcan Power, Paul Morgan of Northern Arizona University, and Jim Witcher of New Mexico State University all reported on Arizona geothermal resources and activities.

The group spent some time discussing how to get further organized, and two primary tasks were

identified: collecting all of the current operations and resource documentation, and focusing on the activities beneficial to the state in the future. Amanda Ormand (asormnd@msn.com) has agreed to lead GPW activities in Arizona.

For more information, please contact Roger Hill, GPW Technical Director, 505.844.6111, rrhill@sandia.gov.

National Geothermal Collaborative Update

The National Geothermal Collaborative (NGC), with support from the DOE Geothermal Technologies Program, has formed a steering committee, which has met several times to organize work groups around various issues.

The purpose of the NGC is to bring industry, government, environmental, and other interest groups to consensus on issues relating to geothermal development. They will do this by identifying issues that impede the use of geothermal power, establishing dialogue with key stakeholders, and catalyzing activities to overcome obstacles to appropriate development. Projects underway include a report entitled *Creating Geothermal Markets: Evaluating Experience with State Renewable Portfolio Standards* and a findings document on *Access Impediments to Geothermal Development on Federal and Tribal Lands*.

A first draft of the Renewable Portfolio Standards report has been reviewed by the work group, and will be submitted to the Steering Committee for consideration as a consensus document. The Access Impediments report work group is analyzing existing documents and synthesizing impediments to siting geothermal development on Federal and Tribal lands, then will summarize recommended actions. The work group anticipates using the final report as the basis for a workshop or series of workshops to refine options to reduce access impediments and improve the leasing and permitting process.

For more information, please contact Susan Norwood, GPW National Coordinator, 202.586.4779, susan.norwood@ee.doe.gov.

Upcoming Geothermal-Related Events

June 24-25
Renewable Energy Investor Conference, San Francisco, CA

August 8-10
Second Annual 2003 Southwest Renewable Energy Conference, Flagstaff, AZ
www.swrec.org/

August 26-28
Nevada Energy Showcase, Elko, NV
Michael Canty, 202.586.8119

September 9
GeoPowering the West State Summit, Boise, ID
Gordon Bloomquist, bloomquistr@energy.wsu.edu

September 10
Direct Use Workshop (sponsored by the Idaho GPW State Working Group), Boise, ID
Bob Neilson, rmn@inel.gov

September 11
Idaho GPW State Working Group Meeting, Boise, ID
Bob Neilson, rmn@inel.gov

September 13-16
Western Governor's Association (Annual Meeting), Big Sky, MT, *www.westgov.org/*

September 14-17
International Geothermal Conference, Reykjavik, Iceland
www.jardhitafelag.is/igc/

September 18
Arizona State Working Group Meeting, Phoenix, AZ
Curtis Framel, curtis_framel@ee.doe.gov

October 1-3
Sustainable Energy Expo & Conference, Los Angeles, CA
www.sustainableexpo.com/

October 12-15
Geothermal Resource Council Annual Meeting, Morelia, Mexico
www.geothermal.org/

How to Reach Us

U.S. Department of Energy
Geothermal Technologies Program
1000 Independence Ave., S.W.
Room 5H-038, EE-2C
Washington, DC 20585
(202) 586-5340
www.eere.energy.gov/geothermal

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