Geothermal technologies

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DOE has selected seven additional geothermal exploration projects to find, test, and define previously unutilized geothermal resources under the Geothermal Resource Exploration and Definition II (GRED II) program. This program is a follow-on to the successful initial GRED program that sponsored seven projects in four states (California, Nevada, New Mexico, and Utah), resulted in the drilling of seven test wells, and contributed to the addition of significant new resources. These new GRED II projects will directly contribute toward the goals and objectives of the DOE Geothermal Technologies Program. They will offer a wide geographic and geologic diversity that will promote development of this resource in new areas and ultimately increase the amount of geothermal energy available for electric power generation. DOE is planning to provide $3.5 million over the first two years, with additional funding in later years, to GRED II projects in Arizona, California, Idaho, Nevada, and New Mexico. The new projects are outlined below.

Advanced Thermal Systems, Inc. will perform geophysical testing to site a well and then drill and test the resource at Fly Ranch Hot Springs in Nevada. A seismic reflection survey will be used to define the subsurface stratigraphy of the thermal system in this part of the Hualapai Flat area and locate faults and fractures at depth. The resource potential will be confirmed by slim-hole drilling to a depth of 1500-2500 ft and subsequent testing of the target.

AmeriCulture, Inc. will complete a test well at Lightning Dock in the Animas Valley of New Mexico. The location of this well was targeted under previous enhanced geothermal systems (EGS) funding, resulting in a well drilled to 910 ft to test a shallow resource. Under GRED II funding, this same well will be continuously cored to 1500-2100 ft to test a deeper resource in a fractured limestone hydrothermal reservoir. Drilling will be followed by well testing and reservoir assessment.

Calpine Corporation will site and drill a test well at Arnica Sink near Medicine Lake in California. Arnica Sink, which is just west of Glass Mountain, had been tested in 1984 with a deep well that was plugged back to 4650 ft by a previous owner. In this project, the well will be re-entered, sidetracked, and drilled to a depth of 9000 ft. Flow testing would follow to assess the reservoir.

Layman Energy Associates, Inc. will apply geophysical methods to optimize well siting and then drill and test the resource at Truckhaven in the Imperial Valley of California. This project, located on the western edge of the Salton trough, will use an extensive program of gravity, MT, and EM geophysics to site well locations. Slim-hole drilling to a depth of approximately 3000 ft will be used to confirm the resource.

Noramex Corporation will drill a second exploration and test well at its Blue Mountain site in Nevada. The first well was drilled under a GRED project in 2002 and tested a major fault from the valley side. Based on those results, it appears that the optimum target is on the Blue Mountain side of the fault along a second set of young faults at a depth of about 3000 ft. A slim-hole, continuously cored well will confirm the resource.

Northern Arizona University will explore the San Francisco Volcanic Field in Northern Arizona for prospective geothermal sites. They will use new geologic mapping, argon age dating, and re-evaluation of existing geophysical data (seismic, gravity, and magnetics) to define the potential for a significant geothermal resource in this region. These studies should lead to the identification of a high-priority drilling target.

U. S. Geothermal, Inc. will test and evaluate a geothermal resource at Raft River, Idaho, that has been drilled into, but has never achieved commercial production. The project consists of a series of well inspections and tests to confirm the production potential of the existing wells on the site. Based on these results, the generating potential of the site will be assessed, operational constraints will be identified, and the design of a power plant will be started if well conditions warrant.

(continued on page 2)

In addition to these new projects, work is continuing on drilling and/or testing at three of the original GRED sites. These include ongoing work at Fourmile Hill (***Calpine Corporation***), preparation for drilling at Lightning Dock (***Lightning Dock Geothermal, Inc.***), and final testing of the well at Blue Mountain (***Noramex Corporation***).

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Field Tests for While-Drilling

Efforts to improve drillstring communication began more than half a century ago. For the past 20-plus years, a rudimentary technology called measurement-while-drilling (MWD) has sent downhole data to the surface. Data are transmitted via pressure pulses in the stream of mud that circulates in the well, but the information travels relatively slowly, almost always under 10 bits per second, compared with common computer modems, which transfer data at 57,000 bits/second. MWD systems are expensive and the technology fails at high temperatures, so they are little used for geothermal drilling.

Sandia National Laboratories Geothermal Research Department is developing a new technology, Diagnostics-While-Drilling (DWD), which will bring high-speed, real-time data up the hole, combine it with measurements made at the surface, and integrate and analyze these measurements to advise the driller. Sensors near the bit will measure such things as pressure, temperature, and vibration and will show whether the bit is turning smoothly. With DWD, the driller will know immediately when problems arise, in time to take corrective action. DWD's ability to anticipate problems should greatly reduce "flat time," the industry term for the time the rig is not advancing the hole.

DWD System Design

The system requires four principal technologies: the downhole measurement sub, the format in which data will be transmitted, the data link between surface and downhole, and the surface data display.

Downhole Measurement Sub. Of the many possible downhole measurements, we have focused on those forces and accelerations that are relevant to bit dynamics. The complete list of measurements made comprises:

- Three-axis acceleration
- High-frequency axial acceleration
- Angular acceleration
- Magnetometer (rotary speed)
- Weight on bit, torque on bit, bending moment
- Drill pipe and annulus pressure
- Drill pipe and annulus temperature

The sub is a tubular tool, 7-in diameter by approximately 85-in long, with a central electronics/sensor package suspended by three-legged supports (Figure 1). Strain gauges for torque on bit (TOB), bending, and weight on bit (WOB) are bonded to the outer case and covered with protective shells, while the other sensors are mounted in the central package.

Downhole electronics accept analog signals from the sensors, condition them, convert them to digital format, and transmit them uphole. Sandia designed and fabricated all the electronic circuits, some of them based on previous work in MWD. Mechanical parts of the tool were designed by collaboration between Sandia and a contract engineering service, and were fabricated by a machine shop in Houston. After the metal parts were completed, Sandia personnel fit-checked the parts, and strain gauges were mounted and calibrated at the contractor's facilities. Following the strain gauge work, all components were shipped to Sandia for final assembly and checkout.

Data-Transmission Format. All data sent uphole is in a stream of digital, bi-phase encoded frames. Each major frame comprises 16 minor frames, each of which contains twelve 16-bit words. Each of these words represents one data sample from the list of measurements given above, but not all the measurements appear in each minor frame. The minor frames are sent at the rate of 1041.7 times a second, with some of the highly transient signals (acceleration, strain gauge) sampled in each frame (high-frequency axial acceleration is sampled twice in each minor frame) and other, less transient, signals sampled every 2 to 16 minor frames. That is, the various measurements are sampled at rates from ~2080 times/second to 65 times/second.

The frame stream is decoded, or decommutated, by "decom" hardware and software at the surface, where a computer stores the raw numerical data in a binary file. The raw data are also sent to display hardware and software that apply engineering units, show a real-time moving plot of selected measurements, and also show results of some manipulated measurements (e.g., real-time Fast Fourier Transforms of acceleration measurements).

Data Link. Because the digital data rate is approximately 200,000 bits per second, conventional (mud pulse) data transmission from downhole is inadequate. Other possible data links include methods that have been researched by Sandia, such as acoustic transmission through the drill pipe, optical fiber, and wired pipe (with the signal medium embedded in the drill pipe), but for demonstration of the DWD principle, we chose a commercially available data link called "wet-connect wireline." The wireline is a conventional single-conductor cable

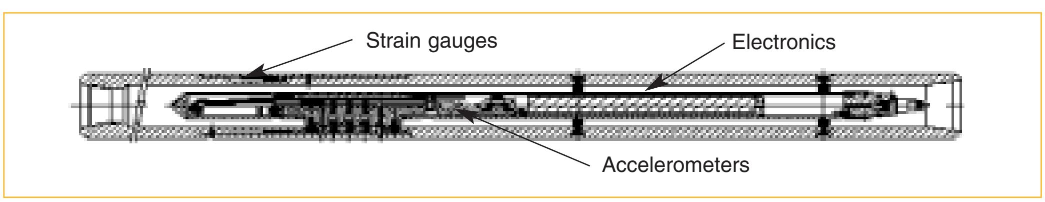

Figure 1. Layout of DWD measurement sub.

with connections that can be made and broken while immersed in drilling fluid, and with an electrical swivel that allows the lower part of the cable to rotate relative to the upper part while maintaining electrical continuity.

A wireline system has at least two major advantages in addition to its commercially available status: the downhole electronics can be powered from the surface, obviating need for downhole batteries, and the wireline can be quickly extracted from the drill string for any required maintenance or repair. This technology was demonstrated in preliminary tests to verify that its electrical performance and data-carrying capacity were adequate for the DWD drilling tests.

Surface Display. An essential feature of the DWD system is integration of surface and downhole data, so our goal is to display a user-selectable set of downhole and surface measurements easily accessible to the driller. Time and budget limitations to date have not allowed complete integration of these displays, so the display used for preliminary testing had two screens of downhole data from the measurement sub and two screens of data from surface measurements. Any combination of the previously specified downhole data measurements could be displayed on their two screens, subject to considerations of readability for the display size.

One surface-data display was the standard screen used by Catoosa for their drilling tests; it includes digital displays of: weight on bit, torque, rotary speed, standpipe pressure, flow rate, bit depth, hole depth, rate of penetration, and statistical manipulation of some of these quantities. The values on this screen represent sampling the various quantities 300 times per second and then displaying a running average of those samples. The other surface-data screen used a Sandia-developed routine in LabView software that took the same raw analog data, sampled at 10 times/second, as the Catoosa screen and displayed selected measurements graphically with current values plus the 5-minute history of those values. This gave an immediate sense of trends in the surface-data measurements.

Field Tests

After preliminary testing in vibration and drilling laboratories, the DWD system experienced its first field drilling at the GTI Catoosa Test Site in the Proof-of-Concept (POC) tests during July and August of 2002.

The underlying principle of these tests was to drill two identical holes with identical polycrystalline diamond compact (PDC) bits (Figure 2), eliminating as many variables as possible, so that test data analysis could focus on the effect of DWD on drilling performance. In general, the factors that affect PDC bit performance are bit design, cutter design (including material), bottom-hole assembly (BHA), formation being drilled, and drilling parameters such as weight on bit, rotary speed, and drilling fluid flow. DWD's initial application is to control drilling parameters, so all the other quantities were held constant to eliminate their effect.

The Catoosa test site has a well-known formation called "The Wall," which is an interval of hard (compressive strength > 35 ksi) limestone below about 1300-ft depth. Both holes through this interval used identical PDC bits and identical packed bottom-hole assemblies.

Our strategy for Phase 1 was to have an experienced driller get as far as possible through The Wall using traditional surface instruments, but without benefit of the downhole data being provided by DWD. Starting with the PDC test bit at approximately 1100-ft depth, and with the consistently hard formation beginning at approximately 1385 ft, the driller was able to reach a final depth of 1492 ft (total bit life of approximately 390 ft) before an experienced drilling engineer judged that the bit was at the end of its useful life. Although the driller began to see some vibration on the rig floor, downhole measurements showed violent bit bounce and vibration shortly before the bit's final failure.

In Phase 2, engineers in the doghouse used the real-time downhole data to coach the driller on when to change weight-on-bit (WOB), to lift off bottom, or to change rotary speed. By avoiding vibration, bit whirl, and stick-slip, the driller was able to reach a final depth of 1615 ft, and only stopped at that point because no more time was available in the drill rig's test schedule. Total PDC bit life in Phase 2 was approximately 515 ft, or 32 percent more than in Phase 1. More important, bit life after beginning penetration of The Wall increased from approximately 105 ft to at least 230 ft, or 120 percent improvement.

Results and Conclusions

System Performance. The principal components of the DWD system worked very well. The downhole measurement sub survived more than 1400 ft (and 26 hours) of drilling with no serious problems. There were no leaks into the electronic package and there was no serious erosion from drilling fluid flow through the tool, both of which had been concerns before the field tests.

The wet-connect wireline system was adequate for high-rate data transmission, as we had demonstrated in preliminary tests, but it suffered longevity problems during extended periods of drilling. There were two kinds of failure: a break in the center conductor, causing an open circuit, and either complete failure or severe data interruption in the electrical swivel. The first problem was more common in Phase 1, but was greatly alleviated by building some slack into the conductor at the top of the wireline spear and by providing more support with a longer housing. There were fewer instances of this failure mode in Phase 2 than Phase 1, in spite of the longer drilling interval. The swivel problem was more surprising, because this equipment is commonly used for directional drilling in many locations, and the swivel is off-the-shelf equipment. There were fewer swivel problems in Phase 1 than in Phase 2, although the reason for this is unclear. Sandia is working with industry to improve this system for follow-on testing.

Figure 2. PDC test bit.

Software and data acquisition worked well, with virtually all data successfully recorded, although there were brief intervals when all the displays did not operate at the same time. A major goal for controlling drilling with this display is to reduce the total number of quantities shown by eliminating the measurements that do not appear critical (all measurements would still be recorded, but not displayed to the driller or analyst). The eventual goal is to have a monitor with only a few measurements in front of the driller. He would then have a relatively simple set of instructions outlining the changes in data that should cause him to react in a specific way.

Bit Damage and Life. At each bit inspection, the condition of the bit and its individual cutters (24 each x 19-mm-diameter stud-mounted face cutters; 9 each x 13-mm-diameter cylindrical gage cutters) was examined and documented. Damage is the principal measure of bit life, but the damage does not have to be obviously catastrophic to degrade performance enough to end the bit's useful life. As an example, a few broken cutters at approximately the same radius can leave a ridge of rock that prevents further bit advance even though all of the other cutters are relatively undamaged. Comparison of bit condition between Phase 1 and Phase 2 emphasized the point that simple observation of bit condition may be difficult to interpret in terms of actual performance.

Rate of Penetration. Another important measure of drilling efficiency is rate of penetration (ROP), and many drillers use this as their primary feedback because bit life or damage is often difficult to assess from surface measurements only. ROPs in the two phases were reasonably comparable, although Phase 2 ROP was often less than in Phase 1, especially notable in the 1420-1481-ft interval. It is not completely clear why this should be, but possible explanations include:

- A near-bit stabilizer was between the measurement sub and the bit. Because of deviation in the upper part of the Phase 2 hole, it is possible that drag on the stabilizer affected the downhole WOB reading, especially in the 1230-1275-ft interval when the drill collars were still in the bent part of the hole. This would mean that, even with downhole measurements, the bit was not actually bearing the indicated load.

- In Phase 2, we knew from Phase 1 experience that the 1420-1481-ft interval was difficult to drill and, in fact, caused the failure of the previous bit. Consequently, we were very cautious and signaled the driller many times to pick up off bottom while we reached consensus on proper drilling conditions. Even though this time off bottom was not included in the ROP calculation, the interruptions prevented reaching an equilibrium drilling condition. This is a natural effect of being on a learning curve, and the learning was shown to be effective by the increased bit life compared to Phase 1.

- Bit inspection showed more damage at 1420 ft in Phase 2 than in Phase 1; this damage could have affected the ROP. The reasons for the increased damage are unclear, but it is possible that the bit was damaged by drilling cement in the upper part of the hole, even though there was no visible sign when the bit was inspected before starting the test interval.

Downhole Data Compared to Surface. Downhole data clearly showed vibrations and oscillations that were not apparent at the surface. This was the key assumption from the beginning of the DWD project, along with the idea that real-time drilling control to avoid or mitigate those forces would improve bit performance. For an example of this phenomenon, see Figure 3, which compares surface and downhole measurements of WOB when the driller was getting back to bottom to resume drilling. Surface indications are that weight is building relatively smoothly as the driller uses the prescribed procedure for setting the bit on bottom, but downhole measurements clearly show significant vibration and bounce. The bit is apparently losing contact with the hole bottom, creating impact loading. This event occurred during Phase 1, when DWD feedback was not being used for drilling control, so engineers allowed the driller to continue with his drilling procedure based only on surface data.

High-Speed, Real-Time Data. The technology for sending high-speed, real-time data from downhole is viable, although the system used for these tests is not "field-ready" and some of its components need improvement. Because the recent work described here was designed to prove a concept, it has always been clear that this system—downhole sub, wireline, and surface display—was only a prototype that would enable us to explore the concept of real-time control. To that end, it performed admirably, acquiring essentially all the data required by the test plan, but the highest priority is replacement of the wet-connect wireline system with a data link that is more transparent to the drilling operation.

Bit Dysfunctions. Different bit dysfunctions can be distinguished in the downhole measurements. Among the downhole conditions that we wish to avoid are bit whirl, drill collar oscillations, stick-slip, and bit bounce. These are often difficult to impossible to sense and distinguish with surface measurements, at least quickly, and corrective action can be different for each phenomenon. Accordingly, the ability to see them in real time, and to react in the proper way, is extremely important. It was also clear in post-test processing that combining downhole measurements with surface measurements is more effective than using either alone.

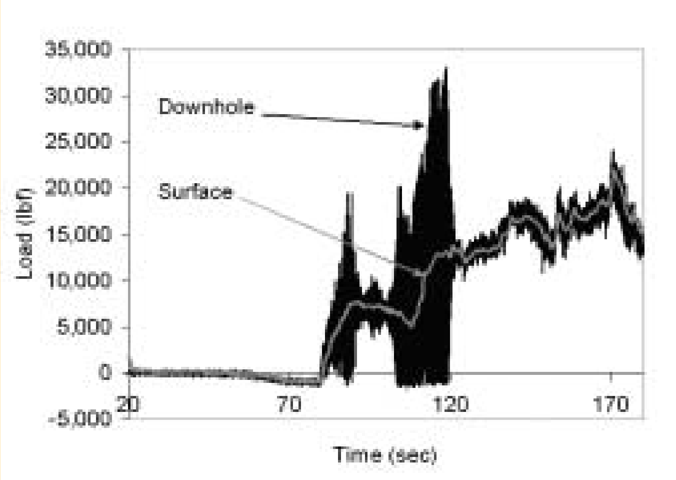

Figure 3. Comparison of surface and downhole WOB measurements.

Measurement Choice. In general, the correct measurements to control drilling with bit dynamics criteria were chosen. Because there were and are different viewpoints on which dynamic measurements are most important to control drilling performance, our original approach was to take as many measurements as possible, at as high a sampling rate as possible. (Post-processing also shows that real-time bit displacement relative to the rock face appears to be possible and could be useful.) This combination of criteria was limited by the maximum data rate that could be driven by the downhole electronics over a given length of wireline. A high priority is to refine the measurement set by eliminating certain measurements or by lowering the sample rate, but we do not yet have data from enough different drilling conditions and formations to make those choices. It will also be important to distinguish between the data and displays that could be used as research tools by engineers and analysts, and the display that should be presented to the driller for real-time control.

Learning Curve. Effective use of this new kind of data involves a significant learning curve. This is related to the previous point; the driller or the engineer can view a large number of measurements, both surface and downhole, but choosing the set that will be most effective to control drilling may not be immediately obvious. It may also be that the optimum measurement set will vary with the formation being drilled, the type of bit being used, or the depth. Using downhole data can also be a way of training the driller, in that he can see instantaneously when the bit is on bottom and doesn't have to "feel" his way down. Similarly, he can learn the acceptable limits to which he can "drill off," or let the WOB decrease, without causing bit bounce or whirl. Many of the corrective actions that should be taken when various bit dysfunctions occur are counter-intuitive; for example, it is often necessary to increase WOB to suppress downhole vibration when one might think that decreasing it would be better. Downhole measurements can show immediately whether the corrective action being used is effective.

Summary. The general conclusion from the Proof-of-Concept test was that the concept is proved. All drilling objectives were met and performance of the DWD system was, especially for a new piece of equipment with no history of drilling in an actual hole, outstanding.

Potential Benefits

"Flat time" is that time when the rig is over the hole but is not drilling ahead. Data from more than 20 geothermal wells and more than 200 oil and gas wells show that flat time ranges between approximately 60 percent and 85 percent of total time on the well. Clearly, reduced flat time could represent a significant cost saving. The top five causes of flat time, with the percentage of total drilling time each could represent, are the following:

- Trouble–12-25%
- Casing installation–12-21%
- Tripping–10-12%
- Formation evaluation–5-18%
- Completion–5-10%

DWD could improve performance in at least the first four of these categories, principally in avoiding trouble and increasing bit life (i.e., avoiding tripping).

As an example, Sandia's drilling cost model was used to estimate the potential savings that DWD could produce in a well at The Geysers. The model is based on an actual well in which casing was set to approximately 5000 ft and then branches were drilled out of that casing until sufficient steam was produced. The well was planned as a two-branch completion, but the first branch produced no steam at all, so it turned out to require three branches total drilling. This well had a below-average amount of flat time—about 60 percent —so it seems that improvements in drilling rate would be especially important here. There was also an average amount of trouble (stuck pipe, twist-off) time. In the model, four cases are considered: (1) actual well, (2) DWD improves drilling rate by using PDC bits, (3) DWD also eliminates some trouble, and (4) better LWD or seismics-while-drilling allows better definition and steering to target, which makes one of the branches unnecessary. In evaluating the improved drilling rate, PDC bits are assumed to drill at twice the ROP with the same bit life (in hours, i.e., twice the footage) as roller-cone bits. ROP and bit life for the roller-cone bits are taken from actual well records. Roller-cone bit costs from well records and PDC bit cost estimates from a bit manufacturer are used in the model. The day rate for the rig was relatively low ($12,000), but there were additional expenses for air compressors ($2,200/day, below 5,000 ft) and BHA rental ($1,400/day).

A summary of the results is that, starting with a well cost of $2.87 million, improved drilling rate saved approximately $150,000, reducing trouble in the 3-branch well saved another $150,000, and in the most optimistic case, both of the above plus eliminating one branch saved a total of approximately $733,000, or 26 percent of the original cost.

If drilling can be made cheaper, then many benefits accrue. We can:

- identify new resources with lower-cost exploration,
- improve productivity from existing resources with more accurate directional drilling and multi-lateral completions,
- reach previously inaccessible resources by drilling deeper at reasonable cost, and
- gain the capability to enhance geothermal reservoirs that are not now productive.

Although DWD technology is very early in development, it offers a possibility to revolutionize drilling.

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orking Group

More than 30 representatives from utilities, industry, universities, tribes, and DOE attended the August Arizona kick-off meeting for GeoPowering the West, hosted by the Western Area Power Administration. Jim Witcher of New

Mexico State University provided participants with a comprehensive overview of Arizona's geothermal resource. Susan Norwood, national coordinator for GeoPowering the West, and Curtis Framel of DOE (Seattle Regional Office) gave background on the program and its goals. Ray Williamson of the Arizona Corporation Commission reviewed the Arizona Renewable Portfolio Standard and discussed the omission of geothermal in that standard. George Brooks of the Gila River Tribe, Mike Pasqualetti of Arizona State University, and Paul Morgan of Northern Arizona University (NAU) gave their perspectives on the types of geothermal energy available in Arizona and some current uses. Steve Munson of Vulcan Power discussed power generation possibilities in the state.

The meeting concluded with Roger Hill from Sandia and DOE staff leading a discussion on forming a statewide working group and identifying issues that could be addressed by the group. Tom Acker from NAU and Amanda Ormond from the Ormond Group will act as leads for the working group. Several issues were identified:

- There is a substantial amount of data quantifying Arizona's geothermal resource, most of it public record.
- Water may be a critical issue for development of geothermal resources in Arizona. The Arizona Department of Water Resources should be invited to join the group, and the group must understand the regulatory framework for geothermal development.
- The group needs to understand Arizona-specific law related to drilling.
- Institutional barriers need to be identified.
- A list of potential sites should be developed.
- It would be helpful to develop materials that present advantages of geothermal energy, water consumption, potential environmental impacts, and social and spiritual issues.
- The group could work with the Western Governor's Association on education as well as with National Association of Regulatory Utility Commissioners (NARUC), National Association of State Energy Officials (NASEO), National Conference of State Legislatures (NCSL), and Association of State Energy Research and Technology Transfer Institutions (ASERTI).
- DOE may have a geothermal solicitation next year for which the group may be able to submit a proposal.
- The group could work to identify field sites for field investigations.
- There is a lack of awareness among the general public, policy makers, and industry about geothermal energy. A public education campaign could raise awareness of and interest in geothermal.
- To ensure an understanding of land use issues, the group should involve the BLM, the Forest Service, and State Land Department.
- Economic benefits from development of geothermal energy should be communicated to economic development agencies, tribes, and municipalities.
- The Arizona Corporation Commission should be encouraged to include geothermal in the Portfolio Standard when it comes up for review.

For more information about the Arizona Working Group, please contact Roger Hill, rrhill@sandia.gov, 505.844.6111.

orking Group

An Idaho Geothermal Energy Working Group meeting was held in Boise on October 10, 2002, and attended by 26 people. The agenda included national/regional updates, state/local geothermal energy projects information, industry updates, and subcommittee reports. In addition, the Idaho Geothermal Energy Strategic Plan was formally accepted. Most subcommittees have identified their members and begun work on their action plans.

Items of major interest from the meeting include the following. Russ Hendricks, Idaho Farm Bureau, reported on opportunities for geothermal energy projects provided in the 2002 Farm Bill by loan guarantees and grants, although funding is limited to $23 million/year FY03-FY07. Gordon Bloomquist, Washington State University, indicated that prospects for district heating projects in Lava Hot Springs and in Cascade are poor due to economics, although those economics would be helped by grants, low-interest loans, or cascaded uses. Doug Glaspey, U.S. Geothermal, reported that he expects his company will have a 10-MWe power plant operating at Raft River by late 2004 or early 2005. The Idaho Department of Water Resources—Energy Division reported on an Idaho geothermal trade mission to Nevada in November. Plans included visiting geothermal applications in the Reno vicinity and meeting with Nevada legislators. Bill Eastlake, Idaho Public Utilities Commission, reported on two pieces of proposed Idaho legislation. A new section of Idaho Code will be proposed that will provide income tax credits for capital investment in alternative energy sources. Also proposed is the Alternative Energy Power Act of 2003, which would require utilities to purchase power from alternative power production facilities at a rate equal to the avoided cost plus one cent per kWh under 12-20-year-duration contracts. Julie Warner, Maverick Energy, discussed her company's efforts to sell renewable energy certificates to promote renewable energy investments in Idaho.

In response to a suggestion made at the working group's October meeting, Bob Neilson of the Idaho National Engineering and Environmental Laboratory and Kevin Rafferty of the Geo-Heat Center are developing an agenda for a one-day workshop to provide a "how to" overview for people who want to do something with their well or spring, as well as to help educate state energy personnel, county commissioners, economic development agencies, etc. The workshop would help identify potential applications, provide enough technical information to determine if potential applications appear doable (or not), and suggest next steps for technical and economic feasibility evaluation. While this workshop would be held in Boise as a state working group activity, it would be advertised to a regional audience. The workshop is proposed for Spring 2003.

Roger Hill and Bob Neilson participated in the Idaho Geothermal Trade Mission to Nevada on November 18-19, 2003. The purpose of this trade mission was to familiarize Idaho legislators, county economic development officials, and others with the utilization 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. Idaho Senator Joe Stegner, who is the author of the draft Idaho Renewable Energy Act of 2003 legislation, was one of the trade mission participants as was Senator Sheila Sorensen. Other Idaho legislators participating included State Representatives Bert Stevenson, Jack Barraclough, and Scott Bedke. A total of forty people attended the trade mission tours and meetings, including twenty-one people representing Idaho and nineteen Nevada participants.

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owering the West – Utah

Gordon Bloomquist (Washington State University), Bob Neilson (Idaho National Engineering and Environmental Laboratory), and Steve Palomo (DOE Denver Regional Office) met with personnel from the Utah Geological Survey, Bureau of Land Management, and others in Salt Lake City in November to discuss the formation of a Utah Geothermal Energy Working Group. The eight Utah representatives agreed to serve as the nucleus for the group and will meet in March 2003 to develop a roadmap.

For more information, please contact Gordon Bloomquist, bloomquistr@energy.wsu.edu, 760.956.2016.

The Great Basin Center for Geothermal Energy at the University of Nevada, Reno, through a cooperative grant via the DOE Idaho Operations Office and the Idaho National Engineering and Environmental Laboratory, is conducting research on geothermal systems in the Great Basin. As a result of this and related research, center personnel made nine presentations at the annual Geothermal Resources Council meeting in Reno in September 2002. Center researchers also recently authored or co-authored ten full-length papers in the GRC Transactions discussing the progress of funded geothermal projects in the Great Basin. Researchers were recently awarded more than $500,000 in a grant to collaborate with Presco Energy and Florida Canyon Mine to help expand the known geothermal resource to be put online at the Rye Patch power plant. This new research grant also will be used to evaluate the lifetimes of geothermal systems in the extensional environments typical in Nevada. Details of Center goals and activities were published in a recent GRC Bulletin (v. 31(5), pg. 179-182).

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ower Conference

Expanded use of geothermal energy and other so-called "green power products" is no longer driven by emotion but by solid economics. Many large energy producers and consumers now recognize green power, not merely as an environmentally benign alternative energy source, but as a stabilizing influence in highly volatile energy markets. It's not just the "right" thing to do; it's the smart thing.

So said David Garman, U.S. Department of Energy's Assistant Secretary for Energy Efficiency and Renewable Energy. Garman was a keynote speaker at the Seventh National Green Power Marketing Conference recently convened in Washington, D.C. Other speakers echoed his view. Pat Wood, chairman of the Federal Energy Regulatory Commission, stated that the price-stabilizing function is the "key attribute of renewable energy." He went on to point out that diversifying electric power sources stimulates competition, promotes fair prices, and provides customer choice.

The conference was sponsored by several government and electric utility organizations, and drew attendees from across the country. Its purpose was to promote the greater use of renewables through sound economics and vigorous marketing. Arlene Juracek, a utility executive from Chicago, emphasized the importance of customer pull instead of regulatory push. "It may be a green market, but it's still a market. It's the market that makes sustainable renewable energy work." She added that the bottom line for a utility is always reliable service at reasonable prices, and renewables can help meet that goal.

Green power marketing is a fairly recent phenomenon, stimulated largely by the on-going deregulation of the electric power industry. Over the past few years, a coherent, well-organized effort has evolved to increase the amount of electric power generated by renewable energy technologies, and to sell this power to consumers through established electric utilities. The original intent was to offer "freedom of choice" to electricity customers who want alternatives to fossil and nuclear fuels; but now, as noted above, green power provides distinct economic as well as environmental benefits.

There is no official or standard definition of green power, but the term generally means electricity generated by renewable energy resources and technologies: geothermal, wind, solar, biomass, and hydropower. Greater use of renewables offers the potential to reduce the environmental footprint of the electric generation sector, the leading contributor to the nation's air quality problems. According to the U.S. Environmental Protection Agency, the sector emits 67% of all sulfur dioxides, 25% of nitrogen oxides, 40% of man-made carbon dioxide, and 34% of mercury in the United States.

There are two distinct markets for green power in the United States. In regulated electricity markets, a franchise utility may provide a green power option to its customers through "green pricing," an optional service or tariff through which customers can support a greater level of utility company investment in renewable energy technologies by voluntarily paying a slight premium for their electricity. Many utilities now offer green pricing to build customer loyalty and expand business lines and expertise. More than 95 utilities in 31 states offer green pricing or are in the process of preparing programs.

In competitive (sometimes called restructured) electricity markets, customers can elect to buy their electricity from a number of different suppliers, some of which may offer green power. Electricity markets are now open to such competition in nearly a dozen states, and several others are phasing in competitive choice slowly. As in regulated markets, a slight premium is usually charged for green power.

In addition, a new type of green power product called "renewable energy certificates" or "green tags" is emerging. These "certificates" are conceptual, not literal, and they represent the environmental, economic, and security benefits of producing electricity from renewable resources, such as better air quality, diversification of risk, and reduced dependence on imported petroleum. They can be "sold" in both regulated and competitive markets, and are "bought" by the consumer from green power providers for the express purpose of supporting development of renewable energy and lessening the use of fossil and nuclear fuels. They are, in effect, another way of paying the slight premium charged for green electricity.

Ultimately, speakers concluded, renewable energy must stand on its own feet in the marketplace. Several speakers reiterated the need to "re-brand" renewables primarily as a price hedge against wild market fluctuations, not just as a "feel good gesture toward the environment." Renewables need to be more widely understood as a competitive energy supply option, not merely as a niche market alternative for the eco-sensitive. Cost reduction through better technology is the key to competitiveness, according to David Garman, and this is the principal goal of DOE's renewable energy research and development program, which has already brought down costs appreciably.

For more information, go to www.eren.doe.gov/greenpower/conference.

Geothermal energy was at the forefront of discussions at the *International Energy Conference and Exposition* in Reno, Nevada, in November, where the state's vast geothermal resources were the subject of intense interest for greater development.

The conference theme, "Breaking Down Barriers," focused on facilitating access to the energy sources found on and under federal lands in the West. Chaired by national coordinator Susan Norwood, the U.S. Department of Energy's GeoPowering the West program presented one of the best-attended workshops offered in the two-and-a-half day conference held at the Reno-Sparks Convention Center, and DOE's Geothermal Technologies Program had a prominent display in the exhibit hall.

The conference keynote speaker was Richard E. Moorer, DOE's Deputy Assistant Secretary for Technology Development, Office of Energy Efficiency and Renewable Energy (EERE). Moorer described EERE's new Strategic Plan that had just been released by his boss, Assistant Secretary David K. Garman. The plan lays out a vigorous and streamlined effort by DOE to "revolutionize how we approach energy efficiency and renewable energy technologies, to leapfrog the status quo, and to pursue dramatic environmental benefits." The Plan commits EERE to be "agents of change, forging a prosperous future where energy is clean, abundant, reliable, and affordable."

A principal goal of the Plan is to "increase the viability and deployment of renewable energy technologies"—including geothermal, solar, wind, biomass, and hydro. This goal will be pursued through two strategies:

1. Improve the performance and reduce the costs of renewable energy technologies by investing in high risk, high pay-off R&D, followed by field tests; and

2. Facilitate market adoption of renewable energy technologies by partnering with private companies to demonstrate technologies in commercial energy systems.

DOE's GeoPowering the West program contributes to this goal through activities in 17 western states that increase awareness of the availability and benefits of geothermal energy, identify barriers to expanded use of geothermal, and work closely with stakeholders to eliminate these barriers.

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