Geothermal technologies
U.S. Department of Energy

Vol.5 Issue 3
September 2000

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DOE Announces 21 Partnerships to Develop Geothermal Energy in the West

Secretary of Energy Bill Richardson has announced 21 partnerships between the Department of Energy and private industry to support development and use of geothermal energy throughout the western United States, primarily millions of homes and businesses in California, New Mexico, Nevada, and Utah. DOE and industry will share funding of the projects over a three-to-five-year period. The total value of the 21 partnerships is $43 million. The announcement was made in Nevada with Senator Harry Reid. "Today's projects move us one step closer toward our goal of providing 10 percent of the electricity needs of the western states with geothermal resources by 2020," said Secretary Richardson. "Clean, reliable, and renewable energy sources such as geothermal energy can become a significant contributor to the energy mix in the West, at a time when parts of the region are experiencing power supply shortages."

DOE will provide first-year funding of $3.5 million for 21 projects. R&D will be conducted in three areas. The first, Field Verification of Small-Scale Geothermal Electric Power Plants, will verify the operating and economic characteristics of small-scale power plants in a variety of field locations. Each plant will produce between 300 kilowatts and one megawatt of power. The second area is Enhanced Geothermal Systems Technology. These projects will seek to improve the electricity-generating potential of geothermal systems at existing sites by increasing production and extending their operating life. The third area, Geothermal Resource Exploration and Definition, will include developing collaborative efforts with industry to support exploration and development of new or previously undiscovered geothermal resources. Activities will focus on surface exploration, exploratory well drilling, and well testing.

In January, Secretary Richardson launched GeoPowering the West, an initiative to expand the production of geothermal energy activities in 19 western states. The goals of the initiative include:

- Supplying at least 10 percent of the electricity needs of the West by 2020 with 20,000 megawatts of geothermal energy installed;
- Supplying the electric power or heating needs of at least seven million homes through geopower by 2010; and
- Doubling the number of states with geothermal electric power facilities to eight by 2006.

A listing of the Department of Energy geothermal power contracts is included on page two.

Project Area	Private-Sector Partners	Location	Funding	Funding	Funding
Small-Scale Geothermal Electric Power Plants	Empire Energy LLC, Empire Nevada	Empire, NV	$150,000 prior year money	$1,600,000/4 years	$600,000
	Energy, Inc., Hayward, CA	Cotton City, NM	$150,000 prior year money	$1,700,000/4 years	$1,600,000
	Milgro Newcastle, Inc., Newcastle, UT	Newcastle, UT	$150,000 prior year money	$1,100,000/4 years	$1,400,000
	ORMAT International, Inc., Sparks, NV	Lordsburg, NM	$150,000 prior year money	$1,596,000/4 years	$1,604,000
	Vulcan Power Company Bend, OR	Radium Springs, NM	$150,000 prior year money	$500,000/4 years	$1,900,000
Enhanced Geothermal Systems Technology	Americulture, Inc., Los alamos, NM	Animas Valley, NM	$177,000	Funding being awarded through evaluation*	
	Drilling, Observation and Sampling of Earth's Continental Crust, Inc., Salt Lake City, UT	The Geysers, Santa Rosa, CA	$199,917`	funding being awarded through evaluation*	
	Maurer Engineering, Inc., Houston, TX	The Geysers, Santa Rosa, CA	$194,554	Funding being awarded through evaluation*	
	Northern California Power Agency, Middleton, CA	The Geysers, Santa Rosa, CA	$174,584	Funding being awarded through evaluation*	
	ORMAT International, Inc., Sparks, NV	Animas Valley, NM	$200,000	Funding being awarded through evaluation*	
	Power Engineers, Inc., Hailey, ID	Roosevelt Hot Springs, UT	$191,615	Funding being awarded through evaluation*	
	Steamboat Envirosystems, LLC, West Palm Beach, FL	Reno, NV	$199,805	Funding being awarded through evaluation*	
	ThermaSource, Inc., and RES Company, Santa Rosa, CA	The Geysers, Santa Rosa, CA	$198,630	Funding being awarded through evaluation*	
	University of Utah, Salt Lake City, UT	The Geysers, Santa Rosa, CA	$199,973	Funding being awarded through evaluation	
Geothermal Resource Exploration and Definition	Calpine Siskiyou Geothermal Partners Limited Partnership, Middletown, CA	Glass Mountain, CA	$202,371	$1,102,371/3 years	$275,593
	Coso Operating Company of Caithness Resources, Inc., Ridgecrest, CA	U-boat, NV	$300,000	$1,875,000/3 years	$500,000
	Mount Wheeler Power Company Ely, NV	Rye Patch, NV	$20,000	$1,620,000/3 years	$405,000
	Noramex Corporation, Carson City, NV	Blue Mountain, NV	$21,600	$656,736/3 years	$164,184
	ORMAT International, Inc., Sparks, NV, and Lightning Dock Geothermal Inc., Las Cruces, NM	Animas Valley, NM	$245,000	$913,000/3 years	$245,500
	SB Geo, Inc., Reno, NV	Steamboat Springs, NV	$14,792	$269,792/3 years	$67,448
	Utah Municipal Power Agency, Spanish Forks, UT	Cove Fort-Sulphurdale, UT	$23,057	$366,057/3 years	$91,514

*Nine contracts are being evaluated to develop conceptual design for Enhanced Geothermal Systems Technology power plants. Two of the projects will be selected for full final design and installation testing at a cost of approximately $10 million for each project.

Workshop: GeoPowering Nevada and the West July 6, 2000—

Hosted by: Senator Harry Reid (D-Nev); U.S. Department of Energy (DOE); University of Nevada, Reno; and the Geothermal Energy Association

Dan Reicher, Assistant Secretary of Energy for Energy Efficiency and Renewable Energy, opened this GeoPowering the West workshop by saying that "although California is now the No. 1 producer of geothermal-powered energy at 2,500 megawatts of the 2,800 megawatts produced nationwide, Nevada has the potential to generate at least that much." More than 125 industry representatives, scientists, and Federal and regional government officials attended the workshop to hear presentations and discuss ways to tap the vast geothermal resources in Nevada and throughout the West.

Geothermal power has a strong role in economic competitiveness, and opportunities abound. Costs have trended dramatically downward since 1980—from 15 to 5–8 cents per kWh. Reicher said that along with generating power, geothermal heat also is being used in the production of dried garlic and onions, and in gypsum-based products such as cat litter and oil absorbents.

Sen. Harry Reid predicted that Nevada has the potential to become a national leader in geothermal power production. "The United States should be the world leader in geothermal energy use, and Nevada should be the nation's leader in producing this non-polluting source of power," Reid said.

"In California, 6 percent of all electricity is generated by geothermal energy. We here in Nevada have much more potential than California," he said.

Reid praised Energy Secretary Bill Richardson for launching the "GeoPowering the West" initiative in January, providing $4.8 million in research grants for developing geothermal power in the western states. "GeoPowering the West," administered by DOE's Office of Geothermal and Wind Technologies, is a commitment to dramatically increase the use of geothermal energy in the western United States. Its goal is to have 10 percent of the western states' electricity needs provided by geothermal energy by the year 2020. "That amount of power would be about twice what Nevada produces today," said Dan Schochet, an executive with Ormat International, a geothermal equipment manufacturer in Sparks, Nevada. Schochet added that technology now allows power generation from lower-temperature reservoirs than in the past.

Reid and Reicher said that it is necessary to educate

Robert Dixon *(Deputy Assistant Secretary, DOE Office of Power Technologies),* ***Lou Capuano*** *(President, Geothermal Resources Council),* ***Dan Reicher*** *(Assistant Secretary, DOE Office of Energy Efficiency and Renewable Energy),* ***Peter Goldman*** *(Director, DOE Office of Geothermal and Wind Technologies),* ***Dan Schochet*** *(ORMAT International), and* ***Allan Jelacic*** *(Geothermal Team Leader, DOE Office of Geothermal and Wind Technologies).*

energy producers and show them that they don't have to rely solely on coal and oil to power their generators, and it is necessary to persuade Congress to encourage geothermal research and development through tax incentives. They said wind energy production has exceeded that of geothermal primarily because better tax breaks are available.

Robert Dixon, DOE's Deputy Assistant Secretary for Power Technologies, closed the workshop by stating, "In geothermal, we have a clean and green technology. DOE is committed to geothermal energy production, and realizes that it is a long-term activity."

The U.S. Department of Energy (DOE) recently announced seven grants to small businesses for research and development (R&D) in advanced geothermal technologies. These grants are made under the annual Small Business Innovation Research (SBIR) program, under which small businesses with strong research capabilities in science or engineering are invited to submit competitive applications for government funding in a broad range of topic areas. This year's geothermal-related topics are "High-Temperature Electronics Development for Geothermal Applications" and "High-Temperature Electronics for Geothermal Drilling." The Geothermal Energy Program administration welcomes suggestions for future topics for this annual program.

The SBIR program is divided into three sequential phases. Phase I is to evaluate the scientific or technical merit and

feasibility of innovative ideas, approaches, or concepts that appear to have commercial potential. Awards are limited to a maximum of $100,000 for a project period of about 6 months. Phase II constitutes the principal R&D effort and is competitively available to Phase I awardees whose results have shown sufficient promise to warrant further effort. Phase II grants are in amounts up to $750,000 and cover a period of up to 24 months. Under Phase III, non-Federal capital is used by the small business to pursue commercial applications of the R&D. Federal agencies may also award follow-on grants for products or processes that meet the mission needs of those agencies, or for further R&D.

HIGH-TEMPERATURE ELECTRONICS DEVELOPMENT FOR GEOTHERMAL APPLICATIONS (PHASE I AWARDS)

Advancements in high-temperature electronics are critical to a number of industries, including aircraft and automotive engine manufacturing, natural gas production, and geothermal well drilling. This topic seeks to speed the transition of newly developed high-temperature electronics out of the laboratory and into high-temperature commercial applications in the geothermal industry. Grant applications under this topic were accepted only for the following subtopics: **(a) Solid-State Temperature Sensor**—to develop a simple, lower-cost solid-state electronic device that measures temperature as a function of current; and **(b) Pressure/Temperature Tool—**to develop a lower-cost tool that is capable of operating unshielded in a geothermal well in temperatures greater than or equal to 250 degrees C with an accuracy less than or equal to 2 degrees C, and at pressures greater than or equal to 8000 psi with an accuracy within 5 percent of the full-scale reading of 10,000 psi.

Phase I awards under this topic were made to:

1. LEL Corporation, Cresskill, New Jersey (in collaboration with Rutgers University)
   Project Title: *Advanced Geothermal Optical Transducer (AGOT)*

2. Accusol, Inc., Oak Lawn, Illinois
   Project Title: *Resistive Temperature Device for Two-Wire, Downhole Temperature Measurement as a Function of Current*

3. E-Spectrum Technologies, Inc., San Antonio, Texas
   Project Title: *A Pressure/Temperature Tool for Geothermal Drilling Applications Based on a High-Temperature Universal Logging Computer*

4. PhotoSonic, Inc., Blacksburg, Virginia
   Project Title: *Low-Cost, High-Temperature Logging Tool for Geothermal Wells*

HIGH-TEMPERATURE ELECTRONICS FOR GEOTHERMAL DRILLING (PHASE II AWARDS)

Sensing, communication, and process control are becoming commonplace functions of geothermal drilling operations. However, unlike oil and gas well drilling, geothermal wells have a unique and harsh environment in which the instrumentation for these processes must survive. Electronic devices and sensors (to control and optimize the geothermal drilling operation) are needed that operate at the high temperatures (greater than 300 degrees C) in geothermal wells. These devices and sensors would eventually become components in high-temperature-capable systems such as measurement-while-drilling systems, logging-while-drilling systems, data telemetry systems, and process control systems.

Phase II awards under this topic were made to:

1. Silicon Designs, Inc., Issaquah, Washington
   Project Title: *A High-Temperature MEMS Inclination Sensor for Geothermal Drilling*

2. Sigma Technologies International, Inc., Tucson, Arizona
   Project Title: *Capacitors for Extreme Temperature Applications*

3. Linear Measurements, Inc., San Diego, California
   Project Title: *High-Temperature Oscillator and Digital Clock*

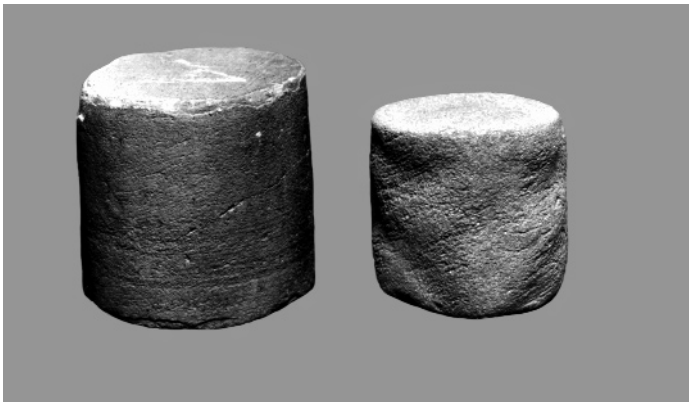
For information regarding the Department of Energy's SBIR program as it relates to geothermal energy, please call Raymond LaSala at (202) 586-4198, or email him at raymond.lasala@hq.doe.gov.

For information regarding the SBIR program in general, please visit the SBIR Web site at http://sbir.er.doe.gov/SBIR or call the SBIR Hotline at (301) 903-5707.

ell Cement

Dr. Toshifumi Sugama of the U.S. Department of Energy's Brookhaven National Laboratory has won an R&D 100 award for developing a high-performance cement for geothermal wells. The calcium aluminate phosphate (CaP) cement substantially extends the lifetime of geothermal wells, in which hypersaline brines, high carbon dioxide content, high levels of acidity, and extremely high temperatures (200°C—320°C at depths up to 1700 meters) create a harsh, hostile environment that rapidly degrades conventional well cements. Indications are that this new cement may increase useful well life by a factor of 20 or more, thereby greatly reducing the costs of well maintenance and remediation. Total savings are estimated to be $150,000 per well per year over a 20-year lifetime of the well.

The prestigious R&D 100 awards are given annually by R&D Magazine, published by Cahners Publishing Company of Chicago, to the world's one hundred most commercially significant new technologies. Named as co-winners for the CaP cement were Lawrence Weber, PE, of Unocal, and Lance Brothers, PE, of Haliburton. The awards will be



Portland cement (right) shows deterioration, while ThermaLock cement (left) is virtually unaffected by the harsh environment in geothermal wells.

presented on September 27, 2000, at Chicago's Museum of Science and Industry.

Brookhaven originally developed the cement under research sponsored by DOE's Geothermal Energy Program. The laboratory then partnered with Unocal and Haliburton for further development and field testing, which led to full-scale tests and a field-workable cement.

In September 1997, Unocal emplaced the cement in a geothermal well in Northern Sumatra, Indonesia. Four wells were later completed using this new cement, all of which are functioning in good condition. As a result of the very promising full-scale field demonstration in Indonesia, Haliburton commercialized the CaP cement in February 1999 under the trade name, "ThermaLock Cement." The following April, they exported 32 tons of ThermaLock Cement to the Japan Petroleum Exploration Co. (JAPEX), which were used to complete geothermal steam-producing wells on the island of Kyushu, Japan. This job was the first commercial application of CaP cement. JAPEX engineers were so impressed with its performance that they used 84 more tons to complete their next well in October 1999, and an additional 60 tons for other geothermal jobs in April 2000. Cost of the commercial product was 83 cents per pound, which is moderately priced compared to conventional cements.

Brookhaven's CaP cement provides five significant benefits to cementing operators:

- It greatly reduces concerns about the long-term effects of CO_2 on the well;
- It saves on the costs of remedial operations;
- It saves on the costs of abandonment, redrilling, or recompletion;
- It does not require special cementing equipment or technologies; and
- It greatly expands an operator's cementing options and opportunities for other applications.

Examples of other applications of this award-winning cement include: cementing and plugging highly CO_2-contaminated and acidic oil and gas wells; paving roads, airport runways, bridge decks, and buildings with steel-reinforced concrete; manufacturing precast concrete products such as pipe, slab, floor panel, and block that are exposed to acid attack; and remediating heavy-metal-contaminated soils.

The CaP cement has four chemical components: calcium aluminate cement; fly ash, a recycled byproduct of coal combustion; sodium polyphosphate (a fertilizer intermediate); and water.

When a cement slurry of these components is exposed to geothermal environments, three principal reactions occur: calcium aluminate reacts with sodium polyphosphate to form hydroxyapatite, a hard, biocompatible ceramic found in human bones and teeth. The remaining aluminum hydrates form boehmite. Sodium from sodium polyphosphate reacts with the aluminum silicate in the fly ash to form zeolitic analcime.

In the mineralogical chemical-reaction composite, the major component is hydroxyapatite; zeolitic analcime and boehmite comprise most of the rest. Hydroxyapatite strengthens the cement, and also provides excellent adherence to casing steel pipes. The phosphate inhibits corrosion of the casing pipes. The cement system is therefore essentially a ceramic that is much less susceptible to attack by CO_2 and acid.

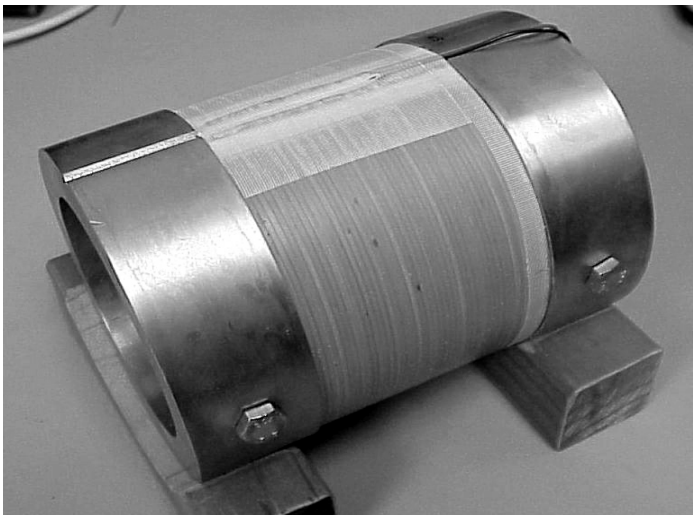
As this new geothermal cement becomes more widely used, its cost-reduction and O&M benefits will facilitate acceptance of geothermal energy within the power industry.

For further information, please call Dr. Toshifumi Sugama at Brookhaven National Laboratory, at (631) 344-4029.

While-Drilling echnology

Down-hole communication systems are needed by drilling companies to gather real-time data for both navigation and formation evaluation. Traditionally, this activity has been called "measurement-while-drilling." Researchers at the U.S. Department of Energy (DOE) Sandia National Laboratories, with funding from DOE's Geothermal Energy Program, have developed an acoustic telemetry tool—a communication system that uses extensional stress waves in steel drill pipe to transmit encoded data. This tool allows transmission of data back to drill rig operators from instruments housed in the drill string near the drill bit. The much greater data capacities that are possible with this tool will allow deployment of additional sensors in a system that will more appropriately be called "diagnostics-while-drilling."

Today, the only economical option for down-hole data transmission in worldwide commercial use is mud-pulse telemetry, wherein data are transmitted as a sequence of



The heart of Sandia's acoustic telemetry tool is this lead/zirconium/titanate (PZT) transmitter, capable of transmitting an acoustic signal more than 14,000 feet. This device directly converts electrical energy into axial pipe vibrations. It is only 5 inches long, but in combination with a power amplifier, it operates at 25% efficiency—about 100 times better than a typical home stereo system.

pressure pulses in the well mud. Often, drilling must cease during transmission. Mud-pulse telemetry was first commercialized by Teleco Oilfield Services in the 1980s. Teleco's effort was a great success, the first in an industry that has grown to multi-billions of dollars per year. But mud-pulse has limited application, particularly in geothermal projects, because it is a mechanical system susceptible to high temperatures and drilling mud properties (if the driller is even using mud). Also, the telemetry signal can be degraded by the presence of very small amounts of gas in the mud. Moreover, without the aid of sophisticated data compression methods, mud-pulse systems can only transmit data at the incredibly slow rate of 1 bit/second. (The computer file for this article contains about 220,000 bits of data. It would take more than 2.5 days to transmit it at that rate.) Sandia's new acoustical telemetry system bypasses these problems because it is primarily an electrical device with no moving parts. Also, it is unaffected by mud conditions because it communicates through the steel tubulars. A 10-watt transmitter can easily communicate at 10 to 100 bits/second, even without employing data compression methods, which typically can boost the actual data transfer rates by 4 to 8 times beyond the basic uncompressed rate.

Sandia recently completed a successful joint project with Baker Oil Tools to develop an acoustical telemetry tool with a transmission range of about 14,000 feet. As a result of that joint effort, Baker Oil Tools acquired a license to operate the tool as a monitor in oil and gas production wells. Although this tool has a relatively flexible pressure housing that is not designed for drilling, it survived a workover drilling operation during its initial field test. With continued support from DOE, Sandia's industry partners ABB Vetco Gray and Passband Downhole Communications, and the University of Texas at Austin, Sandia is now developing a new tool capable of withstanding drilling operations.

The ultimate goal of this R&D is to develop a measurement-while-drilling tool for the geothermal industry. Such a tool will help geothermal operators reduce drilling costs. The laboratory and its partners are currently assembling and testing a prototype that will allow drillers to determine when they encounter a fluid-producing fracture. This new tool uses high-temperature electronics, which allow it to operate at 200 degrees C and survive 300 degrees C. Because of its mechanical simplicity, it is inherently more reliable and less expensive than conventional mud-pulse tools. Initially, the prototype will monitor the temperature and fluid pressure in the well-bore annulus. Other data channels will be available for any future measurements the drilling operator might need. A field test program will commence next year; several companies are negotiating agreements to participate.

For more information, contact D.S.Drumheller, Sandia National Laboratories, (505) 844-8920 or email: dsdrumh@sandia.gov.

Numerical modeling has become an integral part of geothermal reservoir engineering. It provides tools for data analyses, forecast of future steam production, and optimization of field operations designed to enhance reservoir performance. While numerical simulation capabilities have reached a high degree of sophistication, taking into account coupled processes of steam and water flow as well as heat transport through fractured-porous rocks, a lack of characterization data severely reduces the reliability of model predictions. Lawrence Berkeley National Laboratory (LBNL), with funding from DOE's Geothermal Energy Program, has developed a simulation program that automatically calibrates reservoir models against measured data. The purpose of the program is to reduce the uncertainty of subsequent model predictions.

Even though certain parameters, such as permeability and porosity, can be measured on core samples in the laboratory or inferred from well tests, these parameters may not represent field-scale behavior. A numerical model simplifies many of the geological features and thermo-dynamic processes. Such a model requires a set of effective, model-specific parameter values to produce meaningful numerical modeling results.

One way to estimate input parameters is to calibrate the model against production data, such as measured steam rate, enthalpy, or pressure. Data from observation wells may be matched at the same time, increasing the data basis for reservoir characterization. However, such history matching is usually a tedious, trial-and-error procedure. Engineers adjust the input parameters by hand, using their

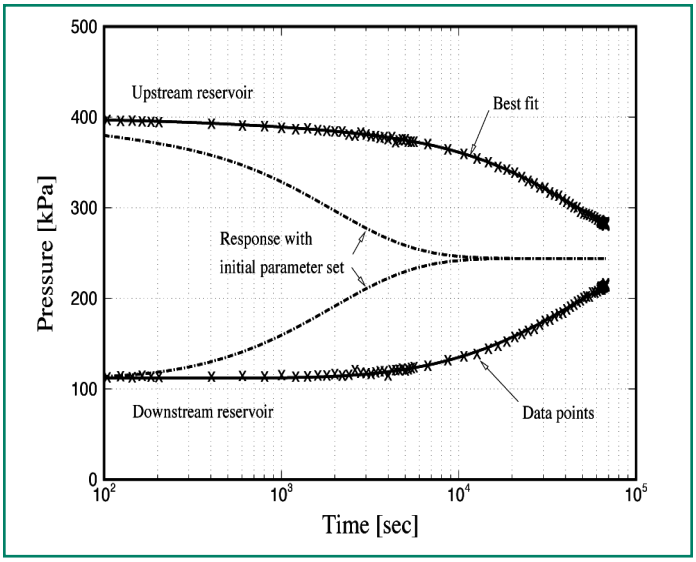


Figure 1. Gas pressure data are automatically matched.

intuition and understanding of a system. The model runs many times with different trial parameters, eventually improving the fit to the data.

History matching, however, can be regarded as the solution to an optimization problem. LBNL research has focused on mathematical strategies for automatically updating the trial parameter sets. These methods have been linked to the geothermal reservoir simulator TOUGH2, resulting in the iTOUGH2 code for inverse modeling, sensitivity, and uncertainty propagation analyses. The flexibility and accuracy of numerical simulation can now be made available for data analysis from laboratory experiments and field tests. Furthermore, geothermal reservoir models can be directly calibrated, providing model-related parameters that reflect the scale and processes relevant to geothermal reservoir engineering.

Figure 1 shows how gas pressure data, measured during a laboratory experiment, are automatically matched. This determines permeability and porosity of an extremely tight plug taken from a Geysers graywacke core. Figure 2 demonstrates how pressure predictions for a geothermal well can be significantly improved by calibrating a non-isothermal multiphase flow model to wellhead data during an earlier production period.

Automatic model calibration is an effective and efficient characterization method. A variety of data measured under different conditions can be analyzed simultaneously, providing the input needed for sophisticated geothermal reservoir models. The iTOUGH2 code is available to the public. The following reports describe its usage: *iTOUGH2 User's Guide*, *iTOUGH2 Command Reference*, and *iTOUGH2 Sample Problems*.

For more information, visit LBNL's iTOUGH2 Web site at www.esd.lbl.gov/iTOUGH2, or contact Stefan Finsterle with LBNL at (510) 465-5205 or SAFinsterle@lbl.gov.

orld Geothermal

The World Geothermal Congress 2000 (WGC2000), convened by the International Geothermal Association and the Japanese Organizing Committee for WGC2000, opened on May 28, 2000, with the theme "Sustaining Geothermal Energy into the 21st Century." DOE's Office of Geothermal and Wind Technologies participated with an exhibit and financial assistance. More than 1,800 geothermal professionals from 61 countries attended. The WGC, held once every five years since 1970, is the largest international conference on geothermal energy. This was the first time the WGC has been held in Asia. Kyushu (Beppu) and Tohoku (Morioka), two geothermal regions in Japan, were venues for the WGC2000.

At the opening ceremony in Beppu, Oita Prefecture, Ladislaus Rybach, Chairman of the Organizing Committee for WGC2000, urged participants to make the public and governments aware of the benefits of geothermal energy

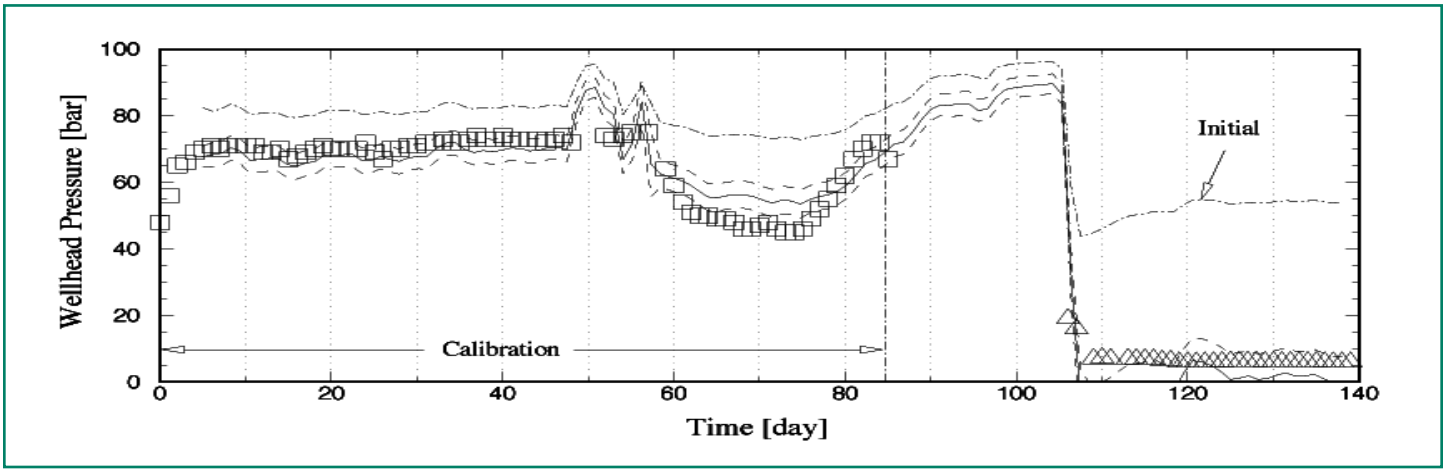
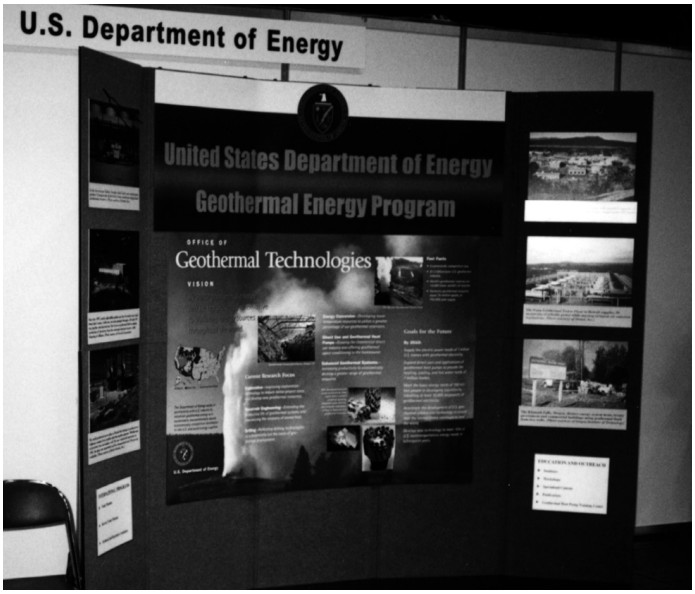


Figure 2. Pressure predictions are improved by calibrating a model to data.

One of several presentations at WGC2000.

because it can be found almost anywhere in the world, and can be sustained and expanded into the 21st century. Phillip M. Wright, Honorary Co-Chairman of WGC2000, stressed the importance of collaboration among geothermal groups because geothermal technology is developing and changing so rapidly that there is a critical need to share information.

Gerald W. Huttrer, Geothermal Management Co., Inc., USA, presented "The Status of World Geothermal Power Generation 1995 – 2000." He discussed global generation of geothermal power from 1995 to 2000. Many countries are now harnessing this energy to generate electricity. Referring to the latest information and related pictures, he explained the growing situations in countries such as Costa Rica, El Salvador, Ethiopia, France, Guatemala, Kenya, Mexico, Nicaragua, Portugal, Thailand, and Turkey. He also touched on the increasing competitiveness of geothermal energy because of the recent sharp increase in oil prices and the need for environmentally friendly energy to reduce the emission of greenhouse gases. Privatization of power-generating entities and the growing demand for renewable energy in rural areas also have contributed to this growth.



DOE's Geothermal Energy Program exhibit at WGC2000.

Derek H. Freeston, Geothermal Institute, New Zealand, summarized worldwide direct use of geothermal energy in the past five years. The number of countries using heat from geothermal energy has increased from 31 to 55, more than 1,000 new geothermal wells have been drilled, and direct investment exceeds US$841 million. Freeston also listed examples of geothermal use, including heating of greenhouses in Russia and Hungary; industrial use in New Zealand and China; space heating in China, Iceland, and Turkey; and geothermal heat pumps in the U.S., Sweden, and Switzerland.

Phillip M. Wright, President, International Geothermal Association, introduced the host country for WGC2005, saying that although many proposals had been received from various countries, the one from the Turkish Geothermal Association (TGA) was the most appealing. Orhan Mertoglu, Chairman of the TGA, welcomed the participants to the WGC2005, saying it was an invaluable privilege and honor. He showed a video presentation of the city of Antalya, host city of WGC2005, and clips of geothermal facilities in Turkey. The Anatolia region is a very important tourist site, where WGC2005 participants will be able to enjoy the historical richness and beauty of the area.

Turkey is the 7th largest geothermal producer in the world, and 5th in non-electrical geothermal resource use.

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