Geothermal technologies
U.S. Department of Energy

Vol. 6 Issue 3
December 2001

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TMAP© Geo: The Key to Geothermal

easibility, Analysis, Design,

Determining the commercial feasibility of geothermal district energy systems is a two-track process. One track is directed toward establishing the physical (thermal and chemical) characteristics of the geothermal resource, and the other toward determining the financial (economic and technical) viability of the proposed project.

To date, most software programs have been directed toward the former track. However, the activities involved in the process, such as exploration, confirmation drilling, and reservoir engineering, are expensive and may not be justified unless the economic and technical aspects of the proposed project are thought to be favorable. Fortunately, overall commercial feasibility of a project can now be determined quickly and inexpensively through computer simulation.

With support from DOE's geothermal technology program, the Washington State University Energy Program has developed and recently released a sophisticated computer model to be used, not only to simultaneously determine the physical characteristics of a geothermal resource and the financial viability of a proposed geothermal district energy system, but also to serve as a detailed design and operational tool for the system. HEATMAP© GEO, one of a suite of HEATMAP© models, has been under development since the late 1980s and is now recognized internationally as the standard for integrated district energy analysis, planning, design, and operation. Other entities that have supported development of the model include: U.S. Department of Defense, U.S. Navy, U.S. Army Corps of Engineers, New York State Energy Research and Development Authority, Canadian Ministry of Energy and Mines, Swedish Council for Building Research, and Swedish Trade Office.

HEATMAP© Geo provides several unique economic and technical features for geothermal analysis, including: the ability to assess thermal distribution opportunities of produced energy that will be available for sale to various space heating and cooling, greenhouse, industrial processing, and industrial distribution consumers; the design of direct use geothermal applications in conjunction with fossil fuel peaking and thermal storage; integration of geothermal energy with the production and sale of electricity (e.g., cogeneration); integration of geothermal with cooling applications; integration of various economic alternatives including well pumping and disposal with district

(continued on page 2)

energy provided from a geothermal or geothermal/fossil fuel peaking source; the capacity to quantify and provide graphical analysis of actual greenhouse gas emission reduction for specific geothermal site applications; and enhanced economic analysis capability optimized for geothermal operation and maintenance to ensure reliability of service and long-term economic system life.

The software program is easy to use and provides a simple means for planning new geothermal district energy opportunities as well as evaluating existing system performance, or to model the effects of various potential alternative system strategies. The software can be a valuable tool for community planners or other groups in defining all aspects of developing, evaluating, and justifying a potential geothermal project.

The model has four primary modules:

Load—provides peak and yearly energy demand data on a building-by-building level. It allows for input of actual loads derived from utility bills, or estimated loads based on climatological data and end-use consumption characteristics.

Production—prescribes the geographical placement of all production and injection wells, as well as central heat exchangers and integral peaking, back-up, and storage facilities.

Distribution—defines the layout of the energy distribution network, correct sizing of pipes to meet consumer loads, and hydraulic and thermal analysis of flows within the network.

Economic—analyzes both public- and private-sector financing scenarios and provides complete tax tables, debt and equity financing mechanisms, and calculations of minimum sales price based on minimum revenue requirements or a more traditional life-cycle cost analysis.

The entire model is coupled to AutoCAD, a software program that inputs a three-dimensional depiction of the geographical location of the subsurface resource, and also outlines the locations of all surface components of the project, including the piping network for energy distribution to customers. Further work is underway to make the model compatible with other CAD and GIS graphic packages. Finally, the model has a complete library of climatalogical information, production equipment, distribution system components, and fiscal tables, all of which are user-modifiable.

HEATMAP© GEO underwent extensive testing prior to release and has now been used to conduct studies in 14 communities over the past two years. The program is also receiving considerable attention in Europe, and development of customized versions of the program for use in several Eastern European countries is now under discussion.

For further information, please contact Dr. Gordon Bloomquist, 360.956.2016, or bloomquistr@energy.wsu.edu.

DOE's Idaho Operations Office is seeking applications for university research projects in earth science to expand the geothermal knowledge base. University R&D is sought to enhance exploration tools, increase reservoir productivity, and improve reservoir management. Approximately $2,000,000 is expected to be available over the next three fiscal years. A maximum of $500,000 is expected to be available in fiscal year 2002 to fund the first year of selected research efforts. DOE anticipates awarding three to five grants, each with a duration of three years or less. Proposals are due on February 28, 2002. For more information, see *www.eren.doe.gov/geothermal/geosolicitations.html#awards.*

Contracts for near-term drilling technology development were issued to **Two-Phase Engineering and Research, Inc.**, and to **APS Technology**. Two-Phase Engineering and Research will modify the LEAMS unit to achieve noise reduction and to improve its performance in the areas of condensation, corrosion, and hydrogen sulfide abatement. APS Technology will build and test a turbine alternator, which will be suitable for use in geothermal drilling. Power from the alternator will run a thermoelectric cooling system to cool critical electrical components of a geothermal measurement-while-drilling system. For more information, contact Allan Sattler, Sandia National Laboratories, 505.844.1019, arsattl@sandia.gov.

Several projects were awarded under DOE's broad-based solicitation for communications and outreach activities. The **Oregon Institute of Technology's Geo-Heat Center (GHC)** will continue to provide technical assistance and maintain its repositories of information. **Resolve, Inc.**, will establish a National Geothermal Collaborative, conducting consensus-based stakeholder outreach to address issues affecting the geothermal community. **Bob Lawrence and Associates** will develop a GeoPowering the West database, add content to the GeoPowering the West Web site, develop an electronic newsletter, and design a project financing workbook. The **National Conference of State Legislatures** will develop and distribute publications and technical assistance to state legislators and staff about the benefits of geothermal development. The **University of Nevada at Reno's Great Basin Center for Geothermal Energy** will improve geothermal stakeholder outreach in Nevada and the Great Basin, in addition to their resource assessment and R&D activities.

Curtis Framel of DOE's Seattle Regional Office was a featured speaker at a day-long seminar on "Nevada's Geothermal Resources" in Elko, held at the geothermally heated Elko Convention Center. In addition to providing attendees with a solid background in the fundamentals of geothermal energy, Framel described DOE's "GeoPowering the West" initiative. GeoPowering the West addresses the nontechnical barriers to geothermal energy development, including legislative, market, environmental, and other issues.

The Elko seminar was co-sponsored by the Nevada Water Resources Association and the Geo-Heat Center. The seminar was designed to give NWRA members an introduction to Nevada's vast geothermal resources and applications, and was one of a series of similar events presented around the state by the Association. The event was also open to the public and attracted approximately 50 attendees, including Elko County Commissioner Warren Russell and several representatives of the mining industry in the area. Mining companies hold vast areas of land with geothermal potential in the I-80 corridor of northern Nevada.

Other speakers from government and industry covered various geothermal topics. James Taranik spoke on efforts to establish a Center for Geothermal Energy at the University of Nevada at Reno. He was followed by Lisa Shevenell of the Nevada Bureau of Mines and Stuart Johnson of Caithness Energy Corporation who discussed the nature and quantification of the state's geothermal resources. Kevin Rafferty of the Geo-Heat Center covered direct use applications. Dean Alford of Converse Consultants in Elko, one of the event organizers, provided the group with a pre-tour description of the two Elko geothermal district heating systems, scheduled for an afternoon field trip. The formal presentations concluded with a regulatory panel including Richard Hoops from the U.S. Bureau of Land Management, Tom Gallagher from the Nevada Division of Water Resources, and John Snow from the Nevada Division of Minerals.

The afternoon field trip included visits to both geothermal district heating systems in Elko and to the famous Elko Hot Hole spring. The Elko Heat Company system that serves much of the downtown area is the only geothermal district heating system in the U.S. developed and operated by a private entity and serving a primarily private business customer base. The Elko County School District system, serving numerous public buildings on the east side of Elko, is designed for the highest temperature drop (most efficient fluid use) of any system in the U.S.

Two attendees traveled from Mammoth, California, where a geothermal district heating system is being considered, specifically to take advantage of the opportunity to tour the Elko systems.

The Elko seminar provided an excellent opportunity to promote awareness of geothermal's great potential to supply clean, economical heat and power.

For more information about GeoPowering the West, contact Susan Norwood at the U.S. Department of Energy, 202.586.4779, or Susan.Norwood@ee.doe.gov.

DOE's Brookhaven National Laboratory, in collaboration with the Caithness Operating Company of Reno, Nevada, won an "R&D 100 Award" for developing a technology to recover commercial-quality silica from low-salinity geothermal brine, a byproduct of geothermal energy production. Brookhaven chemist Mow Lin invented the new silica recovery process with retired Brookhaven scientist Eugene Premuzic and Caithness researchers.

Commercializing this valuable commodity from brine, which is generally disposed of as waste, results in cheaper geothermal energy production. Silica is used widely as a drying agent for products such as salt; as a polishing agent for toothpaste and other products; as a filler, extender, and reinforcer for plastics, paper, paint, and rubber; and as a

Winners of the R&D100 Award for Geothermal Silica recovery include (from left to right) Mow Lin of Brookhaven National Laboratory (BNL); Stuart Johnson, Caithness Operating Company, Reno,Nevada; and Eugene Premuzic of BNL.

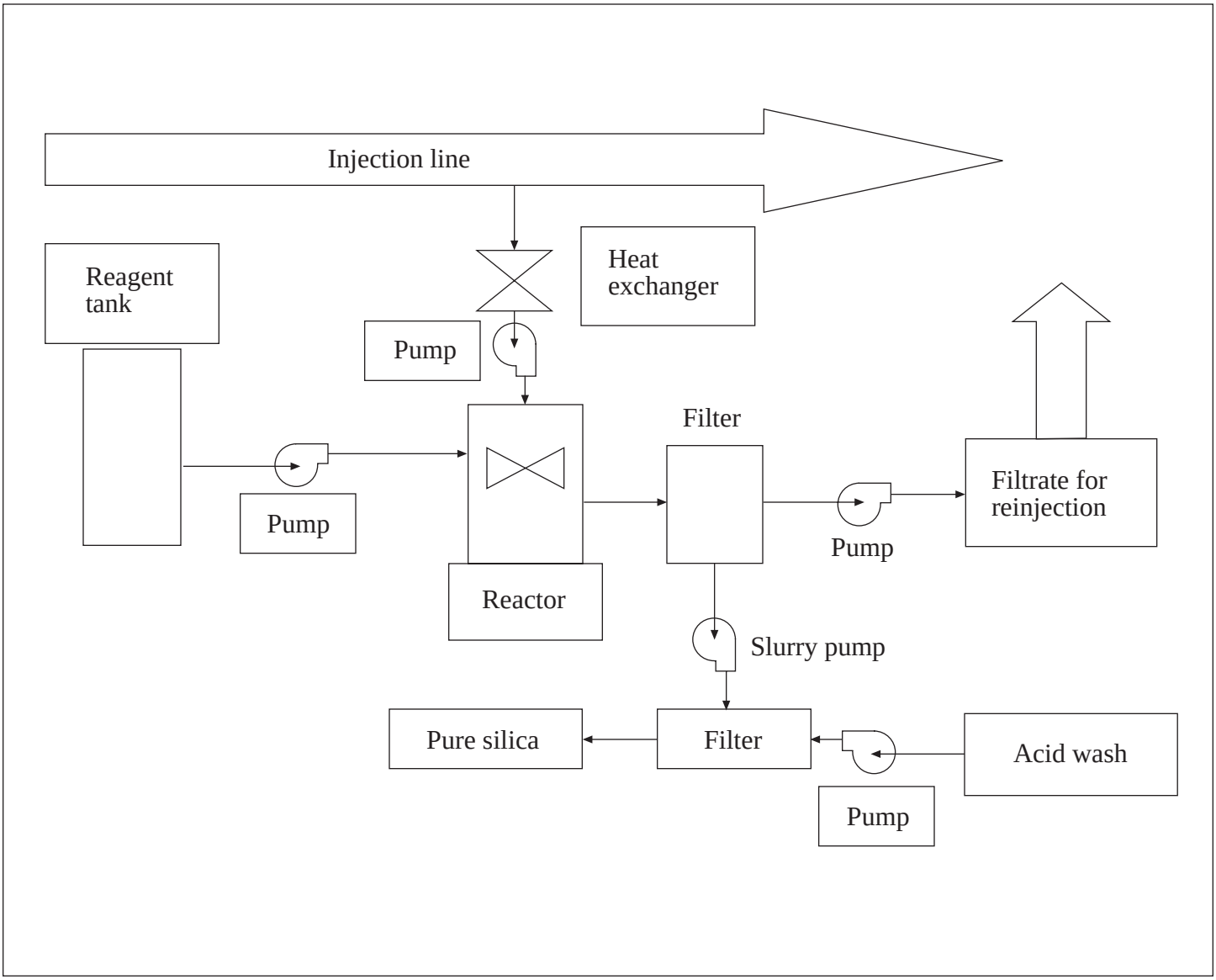
catalyst for oil refining. It also has applications in fiber optics and nanoscience. Removal of silica also reduces scale formation in the geothermal power plants and piping, thereby cutting maintenance costs and improving overall operating performance.

R&D 100 Awards are given annually by *R&D Magazine* and a panel of 70 specialists to the top 100 technological achievements of the year. Secretary of Energy Spencer Abraham said, "I'm proud of the award-winning work done at the Department's Brookhaven National Laboratory. This accomplishment demonstrates the value of government-funded research to the nation."

Previous research at Brookhaven focused on silica recovered from high-salinity geothermal brines that contain many impurities. These impurities may include iron and other metal salts such as zinc and manganese, which have to be removed at high cost in order to produce marketable silica. In contrast, the new Brookhaven/Caithness technology, based on precipitation and filtration, recovers silica from low-salinity brines that contain very few impurities. Since the recovered silica using the new process is 99.9 percent pure, much purer than most silica on the market today, many new uses may be found for it, such as chemical production and refinements of existing products, particularly in nanoscale materials such as chips for sub-micron electronic circuits.

Brookhaven and Caithness are now taking steps to commercialize the process. The laboratory has received many inquiries about the process and its products, and Caithness will finalize plans for testing the appropriate markets.

For further information, contact Mow Lin at Brookhaven National Laboratory, 631.344.3064, or mow@bnl.gov

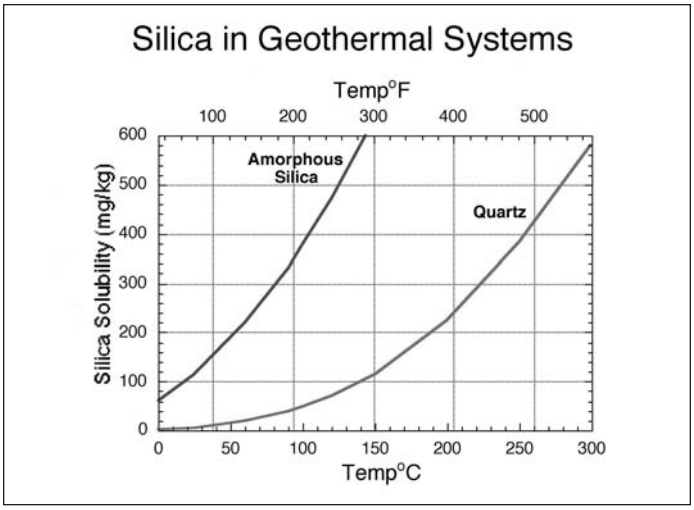


Mow Lin's flow diagram of geothermal silica production from 50MW plant.

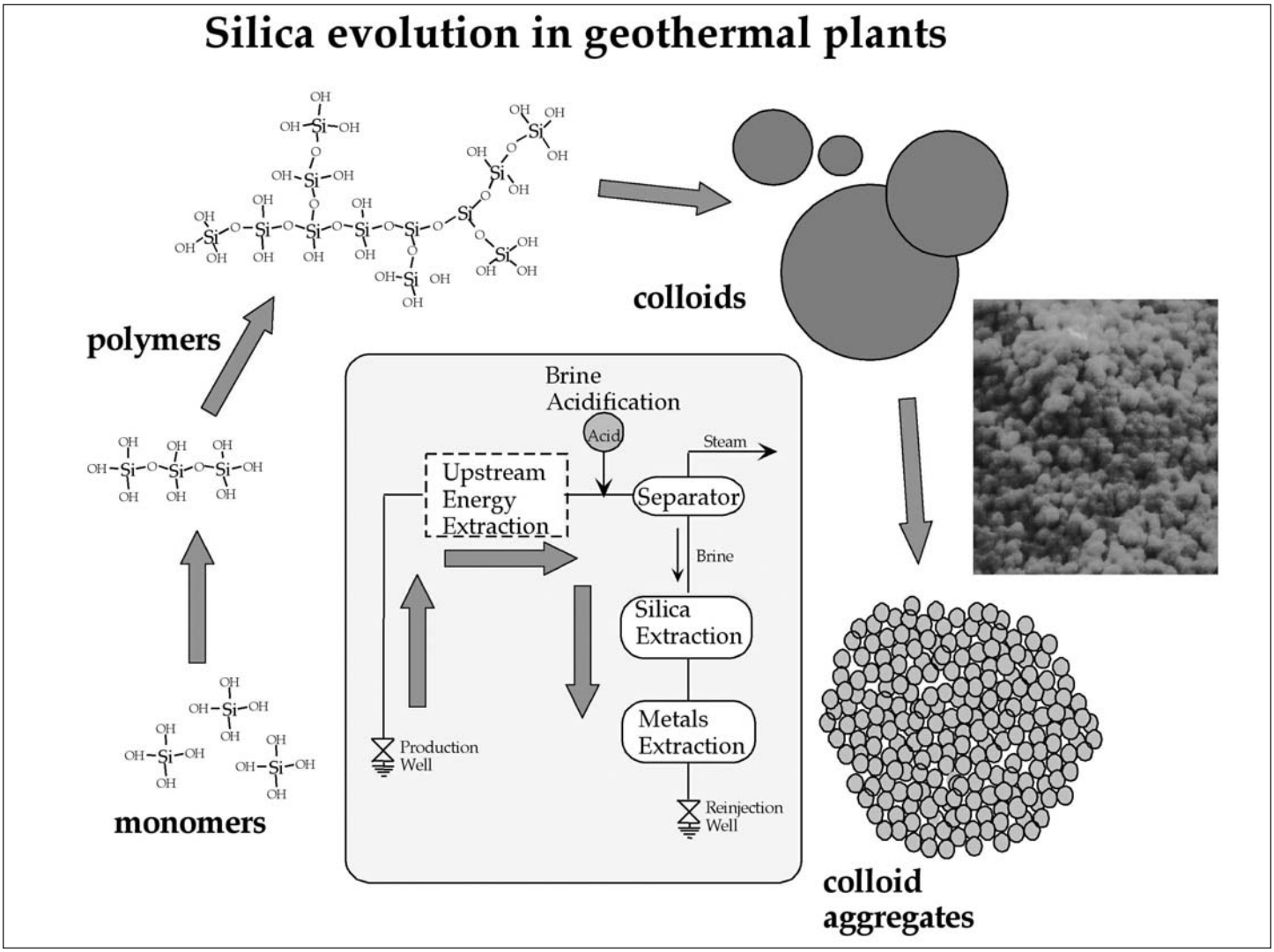
Livermore Lab Also Producing Commercial Silicas from

Silica scaling in geothermal power plants has long been seen as an operational problem. However, scaling is now being reevaluated by DOE as an opportunity to generate a useful byproduct of electric power generation—high quality silica in commercial quantities.

DOE's Lawrence Livermore National Laboratory is developing simple techniques for producing silicas for commercial use. The lab also hopes to develop a basic understanding of how the properties of a fluid affect the properties of silica precipitates. This will extend the



Silica will stay in solution (metastably) until it cools to amorphous silica saturation. Below that, silica will start to scale.



As it cools during passage through a geothermal power plant, dissolved silica polymerizes into larger molecules that eventually coalesce to form silica colloids. The colloids may then agglomerate and in the process form one type of silica scale. Silica extraction alleviates the scale problem, and also helps avoid silica precipitation problems in any potential downstream metal extraction process. SEM photograph above shows 50-nm silica colloids produced in the lab from simulated Coso geothermal fluid.

extraction technology to many different geothermal fields, and tap into a number of important silica markets.

Livermore researchers induce silica precipitation by adding salts or changing the fluid pH. Fluid pH affects the rate of silica polymerization; salts affect the surface charge and agglomeration behavior of silica polymers. The precipitate is removed by filtration or centrifugation and characterized to determine the particle size, texture, surface area, chemical composition, and molecular structure of the silica surface. This characterization work allows lab researchers to fine-tune the processing conditions to match the properties of geothermal silicas with those of commercial silicas.

For geothermal silicas to be marketable, they must not only match the properties of commercial silicas, they must also be valuable enough and in sufficient quantities to make geothermal production costs favorable. (The current price of commercial silica is around 50 cents per pound.) In addition, the market size should be large enough to absorb the potentially large volume of geothermal silicas. The flux of silica through geothermal plants worldwide is estimated at about 3 million lbs./day, compared with the worldwide use of synthetic silicas of about 5.4 million lbs./day, so geothermal-derived silica could become a major factor in the market.

Livermore researchers have currently identified four geothermal sites in California for further investigation as sources of commercial silica. They are nearing completion of laboratory testing for each site and have scheduled field-testing to begin in early 2002.

For more information, please contact William Bourcier 925.423.3745, billb@llnl.gov, or Carol Bruton 925.423.1936 bruton@llnl.gov at Lawrence Livermore National Laboratory.

The Geothermal Resource Exploration and Definition (GRED) program is a cooperative effort by DOE and the U.S. geothermal industry to evaluate additional geothermal resources throughout the western United States, and to promote their development and increase geothermal electrical power generation. Total DOE funds committed to the cost-shared program over three years equal $4,450,000. Seven awards were made in August 2000. The current status of the projects is described below.

The Rye Patch, Nevada, project focuses on development of an abandoned high-temperature geothermal site. Subsequent geophysical work has identified two target sites that could power a geothermal electric generating plant. Phase II was completed by re-entering a pre-existing shallow well that had severe lost-circulation problems, using new foam technology to seal off the zone, and continued drilling to the target depth of 2,110 feet, penetrating a limestone reservoir. An initial flow test was run with excellent results, and additional evaluation will be performed during Phase III testing in FY02.

The Blue Mountain project site in Nevada was identified during gold exploration. A 2,000-foot well will be drilled to confirm the existence of a high-temperature geothermal reservoir associated with overlapping spontaneous potential, resistivity, and shallow-temperature gradient anomalies, and to determine the reservoir's production characteristics. Drilling should start in the near future.

The Cove Fort-Sulphurdale project in Utah focuses on locating and drilling a test well to explore the western extension of the area. The exploration phase included resistivity, ground magnetic, and microgravity surveys that suggest the presence of fault structures and low resistivity zones, possibly indicating a major upflow zone for the geothermal system. A well was sited and drilled to a depth of 2,000 feet in the fall of 2001, and results are now being analyzed.

The Fourmile Hill project near Glass Mountain, California, is the focus of exploration work to characterize its resource. A Phase I temperature gradient well was drilled in September 2001 to finalize assessment of the site, reaching a total depth of 4,417 feet. Temperature logging of the well will be performed in the near future.

The Steamboat, Nevada, project investigates a shallow boiling reservoir in the northern Steamboat Hills and Steamboat Springs area. Two slim-hole wells were drilled during March and April of 2001, reaching total depths of 2,000 and 973 feet, respectively. Several fracture zones were encountered with noticeably large fracture apertures observed in recovered core. Data from these two wells indicate that a large thermal zone with high-temperature fluids exists at a relatively shallow depth. Testing of this reservoir is continuing.

The U-Boat project in Nevada involves geophysical exploration of the deep geothermal resource beneath the Steamboat Known Geothermal Resource Area (KGRA) using seismic and gravity studies. The objective is to constrain the location of the deep fault system and productive zone at this site. The geophysical exploration consisted of 3-D surface seismic, microseismic, and gravity

surveys. Results are being processed and interpreted. All data will be correlated to obtain the most probable fault-system geometry and site a test well.

Finally, the project in New Mexico's Lightning Dock KGRA is currently used only for heating applications, but investigators believe that higher temperature waters are present in deeper fault systems. The ongoing Phase I exploration work includes gravity, resistivity, and aeromagnetic surveys that will be completed shortly. Evidence indicates that major lineaments cross the geothermal region, providing pathways for movement of the hot water.

Future work includes drilling test wells in at least two more projects and continued testing of well performance in all completed wells. Also, DOE plans a second solicitation in 2002.

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

A first-time-ever summit conference on renewable energy technologies was convened by Secretary of the Interior Gale Norton and Secretary of Energy Spencer Abraham on November 28th. Senior Administration officials from Defense, Agriculture, the Council on Environmental Quality, the Environmental Protection Agency, and the Federal Energy Regulatory Commission joined Norton and Abraham to promote greater use of geothermal, wind, solar, biomass, and hydropower resources occurring on federal lands.

The full title of the conference was "National Conference on Opportunities to Expand Renewable Energy on Public Lands." Key members of Congress also participated, including Senator Byron Dorgan of North Dakota, Congressman Zach Wamp of Tennessee, and Congressman Mark Udall of Colorado, all of whom are members of the 192-member Congressional Renewable Energy Caucus.

Secretary Norton opened the conference and welcomed participants, who included many leaders from the renewable energy industries, by stating: "Our shared mission is both simple and noble. We must explore ways to better capture the sun's light, the sky's wind, the land's bounty, and the earth's heat to provide energy security for America's families." She added, "The President's National Energy Policy specifically directs me to reduce delays in geothermal lease processing. In September, BLM held a competitive sale and issued seven new leases in Nevada. Last month, BLM issued 20 leases, and plans to process many more in the coming year. We intend to eliminate the backlog on these applications in 2003."

Assistant Secretary of Energy for Energy Efficiency and Renewable Energy David Garman read a statement from Abraham which said, "Among the most popular recommendations contained in President Bush's National Energy Plan is one encouraging increased use of renewable energy production—biomass, wind, geothermal, and solar—on federal lands. Our goal is to work toward tangible solutions to eliminating access limitations to federal lands to increase the use and production" of these energy resources.

Opening statements were followed by panels of industry leaders from each renewable technology. The geothermal panel led off with panelists Jonathan Weisgall of MidAmerican Energy, John Miller of Calpine, Ross Ain of Caithness, and Jane Long of the University of Nevada School of Mines. Each speaker gave a five-minute opening statement, followed by a 10-minute question and answer period. The panelists' principal focus was on the difficulty in obtaining geothermal leases from Interior's Bureau of Land Management, and they candidly related several stories that exemplify BLM's delays in processing lease applications. Other points raised by the panelists were:

- the need for more geothermal-qualified personnel in BLM licensing offices
- the need for a better balance between oil and gas licensing and geothermal licensing
- making geothermal licensing a priority, in view of its environmental benefits
- the need to eliminate duplication in the lease application review process
- revisions in the royalty rules to treat geothermal equitably with oil and gas royalties
- the need for Interior to set a good example by buying more green power
- the fairness of extending the production tax credit to geothermal energy.

Dr. Long emphasized the need for an updated geothermal resource assessment by the U.S. Geological Survey, to replace the 30-year-old Circular 790. She said that advances in geology and related sciences, particularly new exploration and characterization technologies, would undoubtedly reveal greater resources and a much larger energy potential than currently estimated. She specifically cited advances in the ability to detect "blind" geothermal reservoirs, i.e., those with no surface expressions.

DOE Participates In IEA's Geothermal Implementing

DOE's geothermal R&D program has supported and participated in the International Energy Agency's "Implementing Agreement for a Co-Operative Program on Geothermal Energy Research and Technology" since 1997. The Geothermal Agreement also works with the International Geothermal Association, thereby providing an important framework for broad international collaboration in geothermal R&D.

The DOE's Wind and Geothermal Program participates in two of the Agreement's six annexes:

ANNEX III: HOT DRY ROCK

On a task-shared basis, participants have collaborated on the following activities: 1) developing an economic model to predict production costs and identify the most cost-sensitive parameters on which to focus future R&D; 2) identifying opportunities for technology transfer between conventional geothermal projects and enhanced geothermal systems such as hot dry rock; 3) collecting and archiving in consistent formats data from field projects; and 4) evaluating various techniques for geothermal reservoir assessment.

Future plans include completion and final publication on a Web site of the economic model, extension of collaboration to new Australian and German partners, and continued exchange of personnel, information, and experience between participants and projects.

ANNEX IV: DEEP GEOTHERMAL RESOURCES

Work under this Annex addresses the following topics: 1) research on exploration and reservoir engineering technologies for deep, hot reservoirs; 2) research on drilling and logging technologies, including review and collation of field experience from within participating countries; and 3) exchange of information and establishment of a database on fluid chemistries, materials properties, and corrosion problems, together with field-testing.

Work planned for the future includes derivation of a standard classification of job categories in drilling operations in order to rationalize the database. The outcome of this analysis will be used to develop a future program aimed at reducing overall drilling costs. While continuing with literature compilation, participants in this annex will focus on corrosion problems and materials guidelines for deep acidic wells.

Another Annex on Advanced Geothermal Drilling Techniques has been approved and a work plan is being drafted by several countries, including the United States. Plans are to focus on 1) compiling actual cost data on geothermal drilling to identify key cost components that might be reduced by new technologies or by different drilling practices, and 2) identifying and cataloguing the most successful drilling technologies for publication in a *Handbook on Geothermal Drilling: Best Practices*.

More information on this and other IEA agreements is available at *www.iea.org*.

Nevada Geothermal Issues Workshop

Great Basin Center for Geothermal Energy
University of Nevada at Reno
January 11, 2002

Focus Areas:

- **Leasing, public land policy, siting and permitting, and cultural issues**
- **Transmission and access to the grid**
- **Knowledge base, database, technology transfer, and assessment of potential resources**
- **Economic and power purchase issues, tax incentives, and benefit analysis**
- **Outreach, public relations, and training of professionals**
- **Panel discussion and focus area summary**

Registration:

http://www.nbmg.unr.edu/geothermal

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