Geothermal technologies
U.S. Department of Energy

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DOE Selects Awardees for Direct Use Projects

Six cost-shared grant awardees for direct use projects have been selected by the U.S. Department of Energy's National Renewable Energy Laboratory. Selections were made pursuant to a solicitation issued December 2000 for "Development and Field Verification of Innovative Geothermal Direct Use System Concepts" proposals. Available funds total $5 million for the projects.

The goal of the solicitation is to facilitate development of low-to-medium-temperature geothermal direct use technology as a technically feasible, cost-effective, and practical energy option for various applications in the United States. To be eligible for consideration, projects must use a known geothermal resource between 80 °F and 350 °F and involve the following types of applications:

- space heating (and possibly cooling), excluding single family homes;
- district space heating (and possibly cooling);
- domestic hot water for multi-family, commercial, or public/institutional buildings;
- greenhouse heating;
- aquaculture pond and raceway heating;
- industrial process heating; and
- agricultural process heating.

Proposals could involve enhancement or expansion of an existing geothermal direct use project; a completely new project for the proposer; or a direct use project involving use of spent fluid from a geothermal electric power plant. Specifically excluded from eligibility were projects designed for electric generation, single-family home heating, heat pumps, and spa heating (unless done in conjunction with another application.)

The following six proposals were selected for further technical discussions and contractual negotiations:

1. AmeriCulture, Inc., Animas, NM
   - expansion of existing business of supplying juvenile tilapia fish to other producers, and start of a new business growing tilapia to maturity for the retail market.
   - use of spent geothermal fluid from a small geothermal electric power plant or from another well on the proposer's property.

(continued on page 2)

2. City of Klamath Falls, Klamath Falls, OR

- expansion of existing district heating system into a developing area
- use of fluid from two existing geothermal wells.

3. Idaho Water Resources Research Institute and University of Idaho, Boise, ID

- construction of space heating and cooling system for the Institute's building
- use of fluid from existing geothermal wells that supply Boise's district heating system.

4. I'SOT (In Search Of Truth), Canby, CA

- design of geothermal district heating system for the proposer's complex of 32 buildings
- use of fluid from a recently drilled geothermal well funded by DOE and I'SOT.

5. Mammoth Community Water District, Mammoth Lakes, CA

- construction of a geothermal direct use system for district heating, snow melt, and wastewater treatment plant operation
- use of fluid from three standby geothermal wells owned by the Casa Diablo geothermal power plant.

6. Takeshi Toshida, Home Valley, WA

- construction of a geothermal direct use system for a hot springs resort and spa that will include space heating, water heating, and cascaded spa water
- use of fluid from an existing geothermal well.

For further information, please call Russ Hewett at the National Renewable Energy Laboratory at 303.384.7463 or email at russell_hewett@nrel.gov.

Secretary of Energy Spencer Abraham recently announced cost-shared awards totaling $234,686 to Nevada, Utah, and Idaho for geothermal resource investigations under the Department of Energy's State Energy Program. The state energy offices will use the funds to identify potential areas for geothermal power development and direct use projects.

These competitive awards provide specialized funding in addition to annual "formula" grants to each state energy office. They are part of a large grant program covering renewable energy and energy efficiency projects in 48 states, three territories, and the District of Columbia. "These projects will help to conserve energy, provide jobs, increase our national energy security, and reduce the need for new electricity generating plants," said Secretary Abraham. "These projects emphasize the Administration's reliance on the important role states play in promoting energy efficiency and renewable energy strategies, and many of these projects help support the National Energy Policy."

Project included in the three awards are as follows:

The Nevada State Energy Office, in partnership with the Nevada Bureau of Mines and Geology and the Nevada Division of Minerals, will receive a $99,686 grant to produce a fully relational, on-line database of Nevada geothermal resource information. The state's cost-share will be $92,671. The proposed database will provide detailed, state-wide information to prospective project developers to facilitate decision-making. Areas will be analyzed according to water chemistry and temperature, gradient drill hole data, production well data, cuttings and log availability, leasing and permitting information, geographic data, and geologic data. Areas will be ranked for possible development, and will be divided into two categories: high-temperature resources (primarily for power generation), and low- to moderate-temperature resources for direct use applications. Contact Dave McNeil at the Nevada State Energy Office at 775.687.4909.

The Utah Geological Survey (UGS) will receive $60,000 to enhance its current effort to summarize geothermal information using geographic information system technology to replace the outdated map published in 1980. The state's cost-share will be $15,000, to be contributed by the Utah Geological Survey, the Office of Energy and Resource Planning, and the Division of Forestry, Fire, and State Lands. The effort will promote development of Utah's significant geothermal resources by including in its database a detailed resource review and economic analysis for specific geothermal areas. Enhancements will include reviews of existing published information plus unpublished data for the state's high- and moderate-temperature geothermal areas in the Sevier, Black Rock, and Escalante Deserts of southwestern Utah, in addition to other promising areas. The UGS will then build an economic evaluation model to assess the development potential of the higher-quality sites, modeling them with respect to capital and operating costs for various types of geothermal power plants, and then will rank them based on the quality of the resource and the economic likelihood of future development. Contact Robert Blackett at the Utah Geological Survey at 435.865.8139.

The Idaho Department of Water Resources and the Idaho Water Resources Research Institute will receive a $75,000 grant, to be matched by $20,720 of state funds. The two agencies will collaborate to update Idaho's geothermal water resources inventory, evaluate areas in Idaho that have potential for geothermal power generation, and assess prospective direct use developments.

Tasks to be performed under the grant include migrating the current geothermal water resources database into Microsoft Access and updating the database, generating electronic plot files to be used for producing maps on demand, providing Internet access to Idaho's geothermal water resources, assessing the potential for power generation using geothermal resources, evaluating the potential for new district heating and other direct use projects, and ranking potential power generation and district heating projects. Contact Gerry D. Galinato at the Idaho Department of Water Resources at 208.327.7963.

orkshop

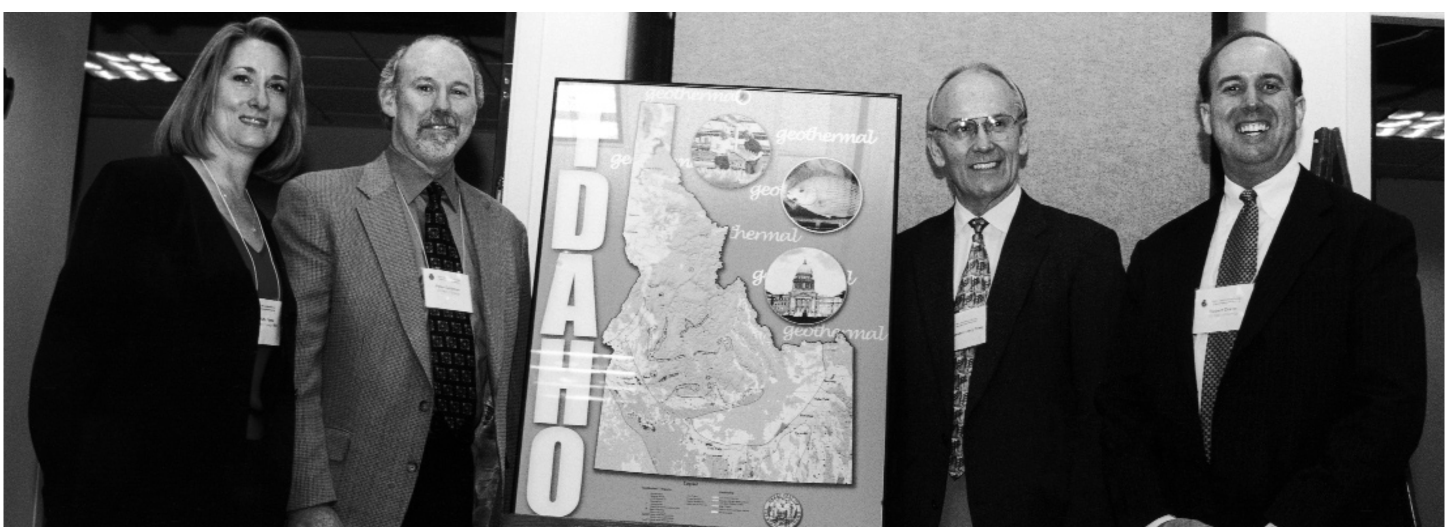
The Idaho Geothermal Energy Stakeholders Workshop, organized by the Idaho National Engineering and Environmental Laboratory (INEEL) and hosted by U.S. Senator Larry Craig, was held in Boise, Idaho, on May 31, 2001. The meeting was well attended and extensively covered by the media. Senator Craig's keynote address, which strongly supported geothermal energy as part of the overall energy solution, was particularly well received. GEA/GRC's 2001 Award for Outstanding Geothermal Contribution was presented to the City of Boise for its efforts associated with district heating. Informative case studies included descriptions by Idaho business owners of how clean, inexpensive geothermal energy provides significant

(Left to right) ***Ted Clutter****, Executive Director, Geothermal Resources Council;* ***Bill Ancell****, Boise Director of Public Works;* ***Karl Gawell****, Executive Director, Geothermal Energy Association.*

marketplace advantages. The Idaho Geothermal Working Group, currently consisting of 30 stakeholders, then met on June 1 to discuss strategies and actions to address issues associated with continued development of Idaho's geothermal resources. Minutes of the meeting are being compiled, and can be obtained from Bob Neilson, INEEL, rmn@inel.gov, 208.526.8274.

racture-Resistant

A hard-rock drill bit using thermally stable polycrystalline (TSP) diamond cutters has been developed that can reduce geothermal well costs by about 15%. The project has been conducted by Technology International, Inc., with funding from DOE and the Gas Technology Institute. Laboratory experimentation has been performed at DOE's Sandia



(Left to right) ***Kathy Pierce****, Director, DOE Seattle Regional Office;* ***Peter Goldman****, Director, DOE Office of Wind and Geothermal Technologies; U.S. Senator* ***Larry Craig****;* ***Robert Dixon****, DOE Deputy Assistant Secretary, Office of Power Technologies.*

National Laboratories (SNL), NASA's Jet Propulsion Laboratory, and the Colorado School of Mines.

With more than 5,000 kilometers (16,400,000 feet) of hard rock drilled per year worldwide, a cutter that lasts longer and cuts more effectively is of prime interest to industry. Diamonds in metal have been used for drilling since about 1700 BC when the Chinese used diamond stone pounded into a stabilizing brass alloy to dig as deep as 200 feet to fresh water. A recent advance in metallurgy developed by this project has significantly increased the impact resistance of the TSP diamond cutter. When employed in a high speed rotary TSP diamond drill bit, higher rates of penetration can be gained.

Conventional polycrystalline diamond compact (PDC) cutters drill soft to medium rock efficiently. However, in hard rock drilling applications, where extreme friction produces high temperatures, the PDC cutter wear rate increases significantly, especially above 300 °C. Furthermore, the PDC cutter loses all structural integrity above 700 °C. The improved TSP diamond cutters experience less wear than the PDC cutter when tip temperatures exceed 300 °C, and can operate at temperatures up to 1200 °C.

In the past, TSP diamond cutters were not practical because of insufficient strength of attachment to tungsten carbide substrates, and insufficient impact strength. When TSP diamond discs are brazed to tungsten carbide substrates, high residual thermal stress is developed during cool-down. The cause of the stress is the mismatch between the coefficient of thermal expansion, Young's modulus, and Poisson's ratio of the two components. Depending on the magnitude and sign of this stress, delamination (debonding) of the braze filler metal joint may occur, or the diamond may fracture. Two novel methods of controlling residual thermal stress have been developed: microwave heating, and combustion synthesis using the self-propagating, high-temperature synthesis reaction of nickel (Ni) and titanium (Ti) (or combinations of these two methods). Both processes result in desirable preferential heating of the lower-thermal-expansion TSP diamond.

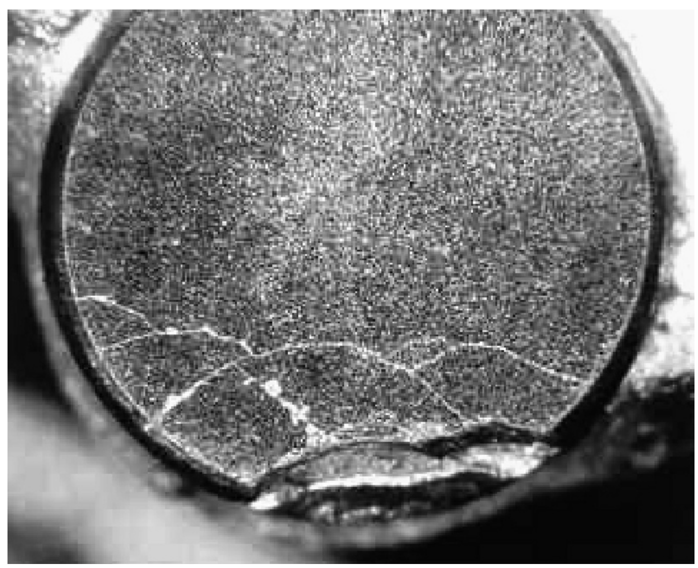
Microwave brazing was performed in a specially designed, single-mode microwave reactor. Researchers discovered that the TSP diamond absorbs microwave energy more efficiently than does the tungsten carbide substrate. Combustion synthesis brazing is achieved by applying a multilayer deposit of titanium and nickel between the TSP diamond and the tungsten carbide. A conventional braze filler metal is placed over the Ti/Ni layer in some cases. When the assembly is heated, a combustion (exothermic) reaction occurs between Ti and Ni. The generated heat is sufficient to preferentially heat the TSP diamond. Thus, both methods allow the dissimilar materials to shrink together when cooling. Microwave and combustion synthesis brazing methods have been employed to join other dissimilar material pairs, such as silicon carbide and molybdenum.

Finite Element Modeling (FEM) analysis was performed to determine the magnitude of the critical thermal residual stress that would occur during conventional brazing. The stress was found to be sufficient to cause the diamond to crack. Initial conclusions of the FEM study were as follows:

1. Critical stresses in the TSP diamond increase with increasing braze temperature. Braze temperatures in excess of 700 °C can cause the TSP diamond to crack.

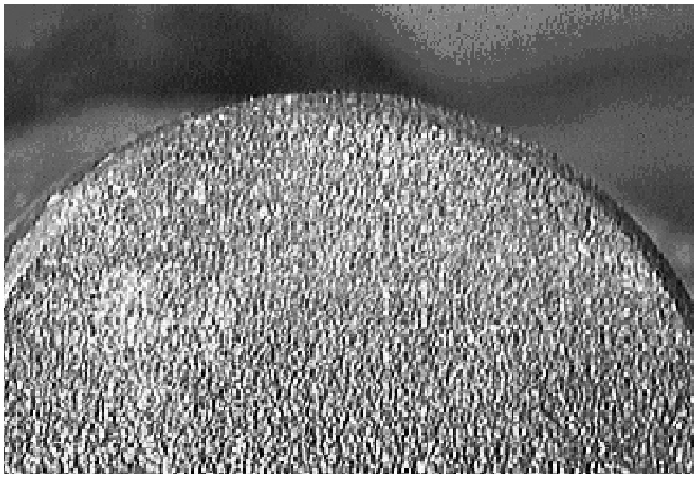
2. Critical residual thermal stress occurs in the TSP diamond with braze filler metal thickness of less than 50 microns (0.002 inch). The thicker the braze layer, the greater is the stress relaxation, with a maximum occurring when the braze layer deforms plastically.

A fracture pattern called "halo fracture" or "edge chipping" can occur when the drill bit rotates unsymmetrically, causing high dynamic forces against the TSP diamond cutter. Typical damage to the conventional TSP diamond cutter is illustrated below.



Damage known as "halo fracture" is shown on a conventional thermally stable diamond (TSP) cutter above.

Recent drill bit tests at SNL's Geothermal Hard Rock Test Facility have shown that "halo fracture" can be prevented, as shown below, with a combination of metallurgical and design enhancements. These specially treated and brazed TSP diamond cutters have superior impact resistance in laboratory hard-rock cutting tests. Further laboratory and initial field-testing will be performed to verify these conclusions.



Metallurgical and design enhancements have reduced "halo fractures" or "edge chipping" from TSP diamond cutters.

For more information, please contact Keith Bennett, DOE Golden Field Office, 303.275.4905, keith_bennett @nrel.gov; William Gwilliam, National Energy Technology Laboratory, 304.285.4401, wgwill@netl.doe.gov; Brian Gahan, Gas Technology Institute 847.768.0931, bgahan@gti.org; or Bob Radtke, Technology International, Inc., 281.359.8520, radtke@kingwoodcable.com.

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Verification Projects

OVERVIEW

The National Renewable Energy Laboratory (NREL) issued a Request for Proposals in the spring of 2000 for construction of small-scale (300 kWe to 1 MWe) geothermal power plants in the western United States. Funding contracts have been signed for three projects, and preliminary design work has begun.

The three power projects, each of which also includes a direct-use function, represent a variety of concepts and locations:

1. A 1-MWe evaporatively enhanced, air-cooled binary-cycle plant in Nevada including an upstream onion and garlic dehydration operation;

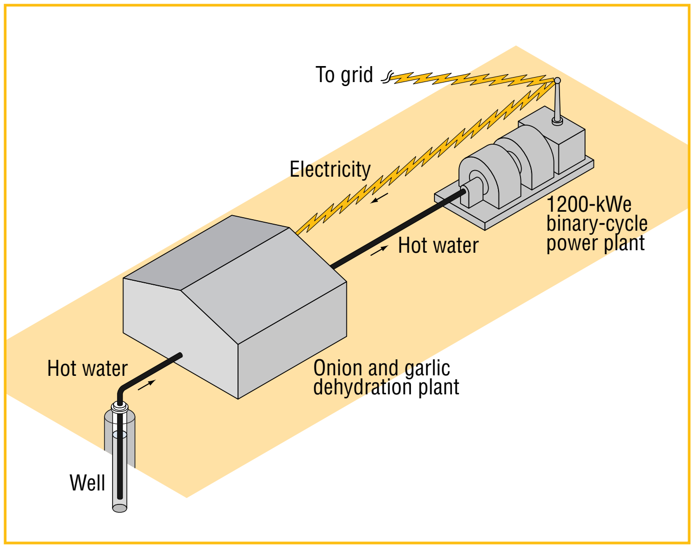
2. A 1-MWe water-cooled Kalina cycle plant in New Mexico, including downstream heating for a fish hatchery; and

3. A 750-kWe low-temperature flash plant in Utah, including downstream heating for a greenhouse.

PROJECT SPECIFICS

1. Empire Energy

Located in Empire, Nevada, about 90 miles north of Reno, this project involves the design, installation, and operation of a 1200-kWe (gross) air-cooled, binary geothermal power plant that will be placed downstream of a geothermally heated dehydration plant that produces 26 million pounds of dried onion and garlic annually. The power plant, which will be located within a few hundred feet of the dehydration plant, will use 1200 gallons per minute (gpm) of 245 °F geothermal fluid from an existing 1800-foot production well in the San Emidio geothermal system. The power plant will deliver 1000 kWe of net power for sale to Empire Foods, LLC, the company that operates the dehydration plant.

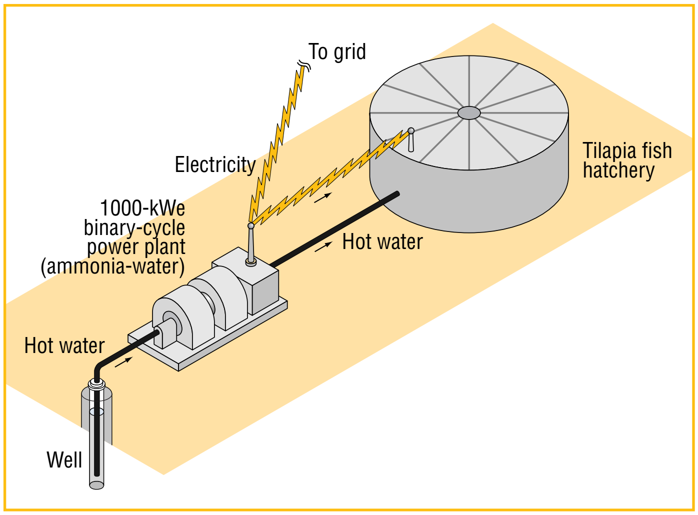


This project will employ evaporative cooling enhancement of the air-cooled condensers to improve summer performance. Also, the direct use will occur upstream of the power plant rather than downstream, because of the temperature requirements of the dehydration process.

The estimated total cost of the project is $2,585,000, 80% of which will be provided by DOE through NREL.

2. Exergy/AmeriCulture

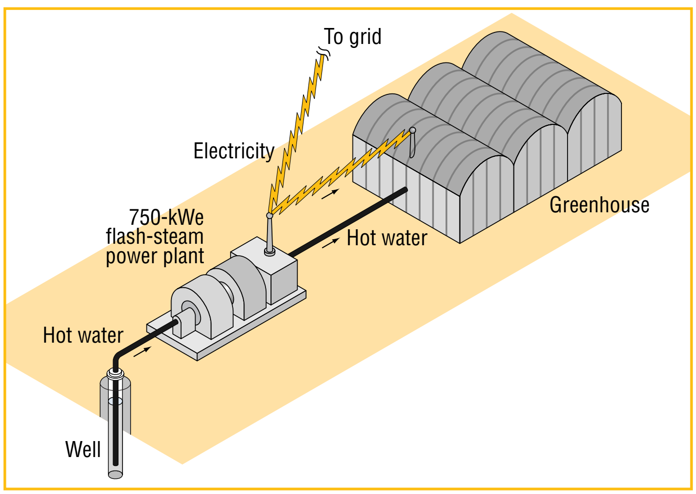
Located near Cotton City, New Mexico, this project involves the design, installation, and operation of a 1420-kWe (gross) water-cooled Kalina cycle geothermal power plant that uses ammonia-water as the working fluid. The plant will deliver approximately 1000 kWe net electric power to the nearby AmeriCulture fish hatchery. The project will use an existing 400-foot production well to provide 1000 gpm of 240-245 °F brine from the Lightning Dock geothermal resource to the power plant. The exit brine from the plant will be used to heat the hatchery's tilapia tanks.



Total estimated cost of the project is $3,370,000, 50% of which will be provided by DOE through NREL.

3. Milgro-Newcastle

This project is located about 150 miles northeast of Las Vegas, Nevada, in Newcastle, Utah. It involves the design, installation, and operation of a low-pressure flash plant that will use an estimated 260 °F resource from the Escalante Valley geothermal resource. The plant will deliver 750 kWe net electric power to the Milgro Nursery for internal consumption, and then provide downstream water at 190 °F for heating greenhouses at the nursery.



The estimated total cost of the project is $2,550,000 (including about $400,000 for well development), 44% of which will be provided by DOE through NREL.

DATA COLLECTION AND EVALUATION

All three projects are expected to begin operation between April 2002 and September 2003. Each project will be monitored over a three-year period following plant startup, and detailed data on performance and costs will be collected. The data will be analyzed to (a) identify operating characteristics, operation and maintenance requirements, and economics of the plant; (b) determine the resource supply characteristics (temperature and flow rate) as a function of time; (c) determine the applicability and effectiveness of the plant in providing distributed power generation; and (d) extrapolate the plant's expected technical and economic performance over its life cycle.

To determine subsystem performance, measurements of flow rate, temperature, pressure, and, where applicable, quality will be made at key points around the power cycle. Operators will provide performance reports to NREL on a monthly basis during the first year of operation, and quarterly thereafter. At the end of the three-year data-collection period, each operator will prepare a final report describing all performance and cost results, and including suggestions for research and development efforts to improve cost-effectiveness of small-scale geothermal power plants. At the conclusion of the project data collection periods, NREL will publish a final report assessing the performance and costs of all projects.

For further information, please contact Chuck Kutscher at NREL at 303.384.7521 (email at Chuck_Kutscher@nrel.gov); or Brandon Owens at NREL at 303.384.7490 (email at Brandon_Owens@ nrel.gov).

Term Test of
Temperature Submersible
ells

A greatly improved submersible pump developed by Baker Hughes Centrilift Corporation for hot geothermal wells has passed preliminary tests in a well at Steamboat Development Corporation's 30-MW power plant near Reno, Nevada. Three of the pumps are now undergoing long-term testing in separate wells, and performance to date is excellent, according to Steamboat.

DOE awarded a $229,000 grant to the two companies to develop a down-hole pump that could withstand the high temperatures found in geothermal wells at electricity generating plants. Baker adapted its Centrilift pumps, long used in oils wells, for the hot, harsh regime of geothermal wells.

The project had three objectives:

1. Increase the horsepower in a high-temperature application to provide increased flow and greater head, and accommodate higher bottom-hole temperatures;

2. Decrease the time and cost of installation; and

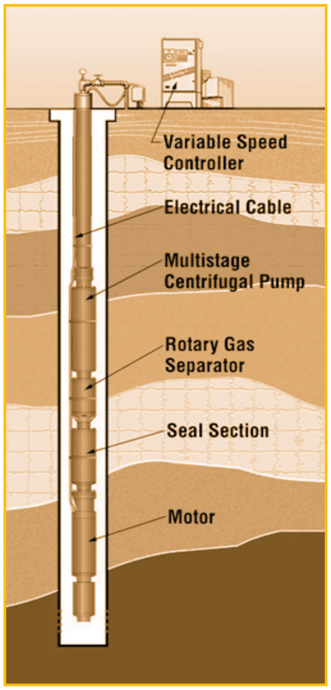


Diagram of main components of the submersible pump.

3. Promote wider use of submersible electric pumps in geothermal applications.

These objectives led to three steps in the development process:

1. Installing a larger-diameter submersible electric motor in the original pump to provide greater horsepower;
2. Using a plug-in electrical connection to reduce installation time; and
3. After preliminary tests, making further improve ments and re-installing the pump for a long-term test.

The new pump has five primary components: surface controls, cable, motor, seal section, and pump. A rotary gas separator is an optional addition when gas is present.

Steamboat's tests show that the modified Centrilift pump is well suited to geothermal applications. Initial data indicate a significant cost advantage over conventional lineshaft pumps usually used in geothermal wells.

For further information, please contact Bill Price at Steamboat Development Corporation, 775.321.4444, ext. 3019; or email at BillPrice@FarWestEnergy.com.

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T Logging System

ElectroMagnetic Instruments, Inc., (EMI) has reported successfully deploying their newly developed high-temperature 3D induction resistivity tool. Geo-BILT (Geothermal Borehole Induction Logging Tool) is an extended induction logging tool designed for 3D resistivity imaging around a single borehole. The tool was developed in a joint program funded by DOE, the California Energy Commission, and EMI. EMI was responsible for tool design and manufacture, and numerical modeling efforts were addressed by DOE's Lawrence Livermore National Laboratory (LLNL) and other contractors. EMI and LLNL conducted field deployment.

The tool features a series of three component sensors offset at 2, 5, and more than 10 meters from a three-component source. The combined package makes it possible to do 3D resistivity imaging up to 50 meters from a single well.

Manufacturing and testing were completed this spring, and initial deployment began in May at the Lost Hills oil field in southern California at leases operated by Chevron USA. This site was chosen for the initial field test because of the favorable geological conditions and the availability of a number of wells suitable for tool deployment.

The Chevron site features several fiberglass-encased observation wells close to water injection wells. Water injection is used for pressure maintenance and for secondary sweep of the heavy oil formation. The injected water typically has a much lower resistivity than the oil-bearing formation, and as the water floods the formation, resistivity in the affected layers decreases. The non-uniform flow of water creates a 3D resistivity structure that closely simulates borehole conditions adjacent to flowing fractures in geothermal boreholes. It is therefore an excellent site for testing the 3D capability of the tool in a low-risk environment.

The photo below shows deployment of the upper section of Geo-BILT. The upper section, which houses the transmitter and the upper two receivers, is more than 45 feet long and must be deployed as a single unit because of the rigid antenna. The tool is hoisted using a novel rolling sling attached to the tool at two points to maintain tool rigidity.

Deployment of upper section of Geo-BILT logging system.

Preliminary data analysis shows good correspondence between Geo-BILT results and conventional logging data, as well as clear indications at several depth intervals of a near-well 3D structure. Further analysis, including 3D imaging, will be undertaken in the coming months; results will be presented at geothermal meetings this fall and winter. The first geothermal tests are scheduled for the fall.

For further information, contact Mike Wilt at ElectroMagnetic Instruments, 510.232.7997, or email at mike@emiinc.com.

Invitation for Industry Participation in Research on Non-Destructive Testing and

Geothermal power plant operators are invited to participate in testing rapid, on-line, long-range non-destructive testing (NDT) methods to detect piping damage caused by corrosion and erosion-corrosion. Brookhaven National Laboratory (BNL) is investigating the use of these methods to detect damage and to estimate corrosion growth rates at specific locations. BNL also is examining deterministic and probabilistic methods for estimating remaining strength and life of damaged piping, and how these methods can be used to reduce plant operating and maintenance costs. Currently, theoretical and experimental aspects of long-range guided waves and dynamic NDT methods are being examined. Performance of these techniques is being compared with conventional ultrasonic wall thickness testing. The photo below shows conventional ultrasonic equipment. Researchers are initially testing corroded piping removed from geothermal power plants. Following this laboratory-scale testing, field demonstrations will be conducted at operating power plants, probably in the next two years. Geothermal industry members interested in collaborating with BNL on this project should contact Dr. Marita Berndt, 631.344.3060, allan@bnl.gov. Sections of damaged piping and potential demonstration sites are required.

Ultrasonic wall thickness testing on pipes.

GEA and World Bank Meeting: Increasing Geothermal Energy

In May, the Geothermal Energy Association convened a workshop on Capitol Hill to promote use of geothermal energy in developing countries, where reliable energy is greatly needed and where geothermal is an often-overlooked option. Twenty people attended in person or by phone from GEA member companies, the U.S. Department of Energy, the World Bank and the International Finance Corporation, the U.S. State Department, and the Office of the U.S. Trade Representative.

The purpose of the day-long meeting was to identify obstacles to geothermal development and to propose ideas for greater private-sector investment in developing countries. U.S. and international agencies can play a critical role in this effort through improving investment climates, providing funding assistance, and making advanced geothermal technologies available to U.S. industry through research and development programs.

Prior to the meeting, GEA prepared and distributed a draft white paper on the subject. Meeting discussions focused on improving and finalizing the white paper, which will form the basis of an action program involving all stakeholders. A potentially important use of the white paper is to enable U.S. companies to establish links with a proposed international geothermal program co-sponsored by the International Energy Agency and the World Bank Group (which includes the Global Environment Facility as well as the International Finance Corporation). This multi-lateral program will focus on improving the policy and regulatory framework for private-sector investment in selected developing countries, and helping private companies obtain financing for up-front exploration activities.

The program's vision is to connect private partners with existing programs and interested agencies to combine resources and coordinate efforts and capabilities. Officials anticipate that the program will be funded at a level of $50-100 million over the next three to four years and will include both contingent loans and guarantees.

How to Reach Us

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