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DISCLAIMER

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COVER PHOTO: Raw onions being loaded onto the conveyor belt of a new geothermal vegetable dehydration plant in the San Emedio Desert of Nevada. Owned by Integrated Ingredients, the plant produces 14 million pounds annually of dry products from fresh onions and garlic.

INTRODUCTION

This issue of the Geothermal Progress Monitor, the 16th since its inception in 1980, illustrates the potential of the liquid-dominated geothermal resource as a big money-maker in terms of company revenues and profits. The achievement of this potential by publicly-held companies, who are required to publish financial statements, has involved the use of high-quality resources and the best available technologies or, in some instances, their own innovative modifications of existing technologies as well as a high degree of technical and management expertise.

This issue also documents some of the effects of the new climate of utility deregulation and competition among independent power producers (IPPs) on the geothermal industry. In addition, the continuing importance attached to geothermal heat pumps as a preferred space conditioning technology by a number of disparate interests is illustrated by a number of articles. The success of another type of direct use application in industrial processing -- the vegetable dehydration plant shown on the front cover -- is described in INDUSTRY SCENE.

The "big business" aspect of geothermal power production by geothermal IPPs is readily apparent in reports on the Magma Power Co. and California Energy Inc. Magma reported record gains in both 1993 revenues and earnings over its 1992 performance -- $167.1 million and $74.9 million respectively. Less than a year after this announcement, California Energy acquired Magma for $950 million. This merger creates "the largest geothermal energy producer in the world," according to the Wall Street Journal, "with more than $400 million in annual revenue, 545 MWe in operation, and 530 MWe under construction."

Predictions in April 1994 that the "stagnation" of 1993 in terms of new U.S. IPP power on line will continue for two or three years prompted David W. Cox of California Energy to recommend that U.S. geothermal developers focus on international markets. Both his company and Magma Power, as well as Ormat Inc. of Sparks, Nevada, are doing just that. Either separately or jointly these companies are participating in major developments in the Philippines and Indonesia. In addition, several companies may seek to take advantage of development opportunities being offered in Nicaragua, Peru, Costa Rica, and Mexico. Mexico only recently opened its doors to U.S. geothermal investors under the North American Free Trade Agreement. More details on these developments are found in FINANCING and INTERNATIONAL.

Cox, however, also predicted that "the gridlock and uncertainty should diminish... and demand should pick up around 1996." He joined Thomas R. Sparks of Unocal's Geothermal Division, speaking to the Geothermal Program Review XII audience, in urging the industry to "redouble our efforts to sell our industry and our product in the utility, regulatory, and political arenas" in order to take advantage of an improved market and the industry's status "as an environmentally preferred technology."

Due to its environmental advantage over fossil fuels, as well as the added advantage of fixed costs, the increased use of geothermal energy can significantly advance the goal of the President's Climate Change Action Plan -- i.e., to reduce emissions of greenhouse gases to their 1990 levels by

2000. Thus, in response to the Plan, announced late in 1993, two industry/DOE collaboratives have been formed to promote the use of geothermal energy as a greenhouse gas reduction strategy. One of the collaboratives is directed toward accelerated development for electric power, and the other is aimed toward expanded use of geothermal heat pumps (GHPs). Industry and DOE are contributing to the costs of both efforts. In addition, significant funding may be available from the Environmental Protection Agency to support the GHP program due to the Agency's high ranking of the environmental benefits and low operating costs of this space conditioning technology. (See FEDERAL BEAT.)

The importance attached to GHPs by the Federal Government and the utility sector is reflected not only in the efforts of the collaborative, but in other related initiatives which are either underway or have recently been completed. Sandia National Laboratories is conducting a program aimed at reducing both residential and commercial GHP drilling costs, an essential factor in reducing upfront GHP installation costs which currently range from $2,000-$5,000 more per unit than conventional systems. Meanwhile, the Geo-Heat Center at the Oregon Institute of Technology has found, based on information supplied by utilities, that residential GHP energy savings over air source heat pumps range from 13 percent to 60 percent; the range relative to electrical resistance systems with air conditioning units is from 25 to 70 percent; and for commercial building installations, 22 to 44 percent. In addition, the Center's investigations concluded that well over one-half of the country, particularly the central and southeast, possess the hydrogeologic characteristics necessary to make groundwater heat pumps a very viable option.

The Department of Defense is seeking to exploit the cost savings achievable with GHPs in greatly reduced operating and maintenance costs. Building on its earlier program that focused on installing GHPs in base housing and other smaller buildings, DoD has initiated a geothermal space heating program for large DoD buildings. It is estimated that large reductions in emissions of several regulated gases will accrue, along with major reductions in overall electricity use and peak demand and an annual energy and maintenance savings of $100 to $200 million.

A new section of the GPM -- TECHNOLOGY DEVELOPMENT -- was added to chronicle the progress of a number of R&D projects, all of which seek to reduce the costs of geothermal development.

Although geothermal energy is a proven, reliable resource, and U.S. industry has "the best, most sophisticated technical and business skills of any nation in the world" for using it, Unocal's Sparks warned the Program Review XII audience that "we must become more cost effective."

TWO GEOTHERMAL INDUSTRY/ GOVERNMENT COLLABORATIVES FORMED IN RESPONSE TO PRESIDENT'S CCAP

In response to the President's Climate Change Action Plan (CCAP) announced in late 1993, two industry/government collaboratives have been formed to promote the use of geothermal energy as a greenhouse gas reduction strategy. The objective of the plan is to reduce emissions of greenhouse gases "to their 1990 levels by 2000 in a manner that increases economic competitiveness and creates jobs." Since geothermal energy has the important advantages over fossil fuels of negligible atmospheric emissions of these gases and of fixed fuel costs, its increased use can significantly advance the CCAP goals.

One of the collaboratives is directed toward accelerated development of geothermal resources for electric power generation. The other is aimed toward accelerated use of geothermal heat pumps.

Collaborative Effort to Stimulate Growth in Geothermal Power

The goal of the DOE geothermal power CCAP program is "to enlist the active cooperation of the geothermal industry and the organizations and companies that influence geothermal purchasing decisions to exploit more of the available, competitive geothermal resource in the United States" through cost-shared geothermal projects and an outreach effort designed to help meet the goal. Specific components of the program include:

- Stimulating the installation of new geothermal electric generating power capacity in the U.S., with the expectation that follow-on plants can be installed at a lower cost without new incentives.
- Cost-sharing the construction of The Geysers pipeline projectspearheaded by Lake County, California, to inject treated municipal wastewater into the reservoir to help maintain steam production at this geothermal power complex in which industry has invested $3.5 billion.
- Educating the geothermal user community, including utilities, utility regulators, state and federal agencies, municipalities, environmental groups, and consumer and public interest groups.

In addition to these funded components, which assume a DOE funding level of $2.8 million in fiscal year 1995, an effort will be launched to cultivate a market for geothermal power at federal facilities in response to the President's Executive Order of March 8, 1994.

These four components support the cumulative reduction of greenhouse gas emissions of a minimum of 0.8 million metric tons carbon equivalent by the year 2000. However, the ultimate success of the program will depend on the extent to which it is funded, as well as on market, regulatory, and institutional factors that may not be within the control of the program, or cannot be guaranteed.

The Geothermal Energy Association is taking the lead industry role, and is supported by the Geothermal Resources Council in addition to individual developers and equipment manufacturers. The participating utility groups include the Edison Electric Institute, Electric Power Research Institute, and the American Public Power Association. Options for increasing the assurance of a market for the geothermal power include involvement of one or more of the federal utilities such as the Western Area Power Administration and the Bonneville Power Administration. More detailed information on the programs is set forth in:

Program Plan for Climate Change Action No. 26, Form Renewable Energy Market

Mobilization Collaborative and Technology Demonstrations, Geothermal Power

This document is available from:
Geothermal Division
U.S. Department of Energy EE122
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Collaborative Effort to Stimulate Growth in Use of Geothermal Heat Pumps

The Geothermal Heat Pump Consortium is an organization of electric utilities and their institutions, equipment manufacturers and their allies, DOE, the Environmental Protection Agency, and the Consortium for Energy Efficiency. The new program developed by the Consortium, entitled the "National Earth Comfort Program," is responsive to the utility sector Climate Challenge as well as DOE's Action #26 under the President's CCAP. The cost-shared program consists of a carefully selected set of interrelated tasks and projects, the collective goal of which is to reduce greenhouse gas emissions through improved energy efficiency and to reduce the customer cost of space conditioning and water heating.

Specific goals include:

- Reduce annual greenhouse gas emissions by 1.5 million metric tons of carbon annually by the year 2000 through the use of more efficient and renewable geothermal heat pump technologies.

- Increase GHP annual unit sales from 40,000 to 400,000 by the year 2000, saving over 300 trillion Btu's annually.

- Create a sustainable market for GHPs -- a market not dependent upon utility-provided rebates or government incentives.

In order to meet these goals the program will first seek to reduce the barriers to wide-scale customer acceptance of this technology. These barriers include 1) an upfront cost of $2,000-$5,000 more per unit than conventional heating, ventilating, and air conditioning systems, and 2) lack of knowledge of the benefits and advantages of GHPs on the part of customers and opinion leaders. These problems are exacerbated by a lack of infrastructure needed to reduce costs and develop markets.

It is thus important to inform both potential GHP customers and utilities of the benefits available to them through GHP use. Customers will enjoy the lowest operating cost of any space conditioning system (as ranked by the Environmental Protection Agency), plus additional savings when the system is used to heat domestic hot water. In addition, they will experience reduced noise over air source systems as well as improved esthetics since no outdoor unit is employed; greater reliability since the system is not exposed to weathering; and increased comfort with a higher air supply temperature in colder weather.

The benefits to electric utilities include:

- Increased customer satisfaction and business stability
- Typically a lower electric cost of service than other electric options
- A flatter load profile due to the Earth's relatively constant ground temperature resulting in a lower contribution toweather related peak demand and potentially lower cost of power
- Reduced need for added utility facilities and more efficient use of existing facilities.

The collaborative program calls for a six-year, $100 million effort cost-shared by the private sector on a 2:1 basis. Funding support from EPA has not yet been determined, but may be significant. Proposed DOE funding for FY 1995 is $6.5 million. The annual membership assessment for an electric utility member is 10 cents per residential customer or $50,000, whichever is less.

For more information, call Mike McGrath, Edison Electric Institute, (202) 508-5552, or Lew Pratsch, DOE, (202) 586-1512.

TRANSFER OF TECHNOLOGY AS A MEANS TO MEET THE NATION'S ENVIRONMENTAL GOALS

"The Federal geothermal research and development program, in partnership with industry, has developed a number of technologies that are reported to be in use by industry or are manufactured and available for use," John E. Mock reminded the Geothermal Program Review XII audience. The annual review was held in San Francisco, April 26-28, 1994, and emphasized Geothermal's Role in Global Climate Change as its theme.

"In use," Mock said, "these technologies improve geothermal performance in the marketplace through direct cost reductions or indirect cost reductions through increased efficiency and/or reliability. They therefore increase the economic feasibility of greater geothermal use and, in turn, enhance the nation's ability to meet its environmental goals through substitution of this clean source of energy for less environmentally acceptable fuels."

However, Mock noted, that while many different methods are employed to transfer new or improved technologies to industry, questions arise from time-to-time that indicate that the awareness of available technologies has not permeated throughout industry. Thus, he undertook to catalogue some of the research products that are known to have been adopted by industry for applications specific to the operations of individual companies. The list presented, based primarily on reports from participating national laboratories, he noted, is preliminary and open to addition, deletion, or correction from those with more current information. The technologies are identified in the table below.

He pointed out that the transfer of technologies sponsored by DOE's geothermal R&D program has resulted both in geothermal industry commercialization and spin-offs to other industries. This type of information is included in data sheets in preparation on the various technology developments, an example of which is shown below.

Mock said that analysis of the data sheets shows that environmental benefits are not only provided by the benign nature of the resource itself, but are inherent in new or improved technologies. For example, he pointed out that those that permit more cost-effective evaluation of the likely behavior of a reservoir under production conditions not only improve the economics of the operation but contribute to the planning and execution of safe geothermal performance, reducing the opportunity for accidents with the potential to pollute the surface or subsurface environment. Similarly, he said, improvements in material performance enhance accident-free performance.

"Thus," he concluded, "collectively the economic and environmental benefits of new or improved technologies may enhance geothermal's posture in the marketplace, both in direct and indirect competition among fuels. Therefore, to the extent that more widespread industry knowledge of the availability and benefits of these technologies translates into greater growth in geothermal use, technology transfer offers the nation an important tool in meeting its environmental goals."

EXAMPLES OF GEOTHERMAL R&D PRODUCTS BELIEVED TO BE IN COMMERCIAL USE OR COMMERCIALLY AVAILABLE

- Crystallizer-clarifier
- Reservoir simulation codes
- Automated seismic processor
- GEOTHERM (brine chemistry models)
- Stable tracer compounds
- Procedure for optimizing allocations of injectate among wells
- Dispersion coefficient for species transport in fractures
- Fluid inclusion studies
- Borehole breakout studies
- High-temperature elastomers
- PCD drill bits
- Borehole acoustic televiewer
- Pneumatic turbine
- GEOTEMP 2
- GEODYNE2
- Rolling float meter
- Polymer cement composites for lining steel pipes
- Electronic logging tool
- High-temperature drilling muds
- Other lost circulation control materials and techniques

SAMPLE FACT SHEET ON COMMERCIAL PRODUCTS OF DOE GEOTHERMAL R&D

- **TECHNOLOGY:** GEOTHERM (brine chemistry models)
- **R&D PARTICIPANTS:** Researchers at the University of California, San Diego, Chemistry Department
- **METHOD OF TECHNOLOGY TRANSFER:** Annual workshop on specific applications, workbook to facilitate use, technical papers; presentations at national and international level
- **USE OF TECHNOLOGY:** To predict scale formation and other brine behavior characeristics in exploration, plant design and operation, and injection of waste brine
- **BENEFITS OF TECHNOLOGY:** Replace and extend costly laboratory simulation and provide a cost-effecti e design tool to enhance efficiency of geothermal operations; protection of underground drinking water
- **GEOTHERMAL INDUSTRY USERS:** Caithness Power, The Ben Holt Co., Unocal, others
- **USERS IN OTHER INDUSTRIES:** Potash Corp. of Saskatchewan, Unocal (Oil & Gas), Exxon Production Research Co.

SAN MARTIN SAYS GEOTHERMAL TECHNOLOGIES WELL SUITED FOR "DISTRIBUTED APPLICATIONS;" OUTLINES DIRECTION OF DOE GEOTHERMAL PROGRAM

Speaking to the Program Review XII audience, Robert L. San Martin, DOE Deputy Assistant Secretary for Utility Technologies, noted that the operating environment of electric utilities has been evolving from generation-driven planning to an end-use focus. In this evolution, he said, the new "distributed utility concept," along with demand-side management (DSM) measures and consumer needs and wants are playing increasingly important roles.

San Martin pointed out that "the concept of the distributed utility system has evolved in turn from the growing perception among electric and natural gas utilities that 'smaller might be better.' The idea is that applications of energy production, primarily electricity, which are closer to the end-use application might be more efficient from an overall energy and environmental perspective than central station plants with long-distance transmission and distribution requirements."

"Most geothermal power plants," he said, "especially those installed during the last 10 years, fit well within the definition of a distributed utility application. As the trend continues toward smaller generating units, geothermal technologies will already have the systems designed, tested, and ready for installation in areas of the country where geothermal resources are adequate for electricity generation. Newer generation binary power systems are modular and come in increments as small as 0.5 MW. They can use geothermal fluids with temperatures as low as 100°C (212°F) to generate electricity, creating the possibility of accessing lower temperature resources in areas of the country outside traditional geothermal areas on the U.S. west coast."

In addition, he said, "the distributed utility concept would also include many direct-use applications whose resources are also much more geographically dispersed than those of currently used resource areas. Geothermal direct use has many diverse applications, from industrial heat processing, to agriculture and aquaculture, to space-heating. These applications are often economical and can result in noticeable energy savings. Two such examples are the San Bernardino district heating system in California, which saves the municipality over $200,000 per year while creating 50 jobs, and the Susanville, California, district heating system which results in $90,000 savings per year. From an end-use perspective, geothermal heat pumps as a demand-side management option could result in residential energy savings of 35,000 MWe annually and even greater commercial savings."

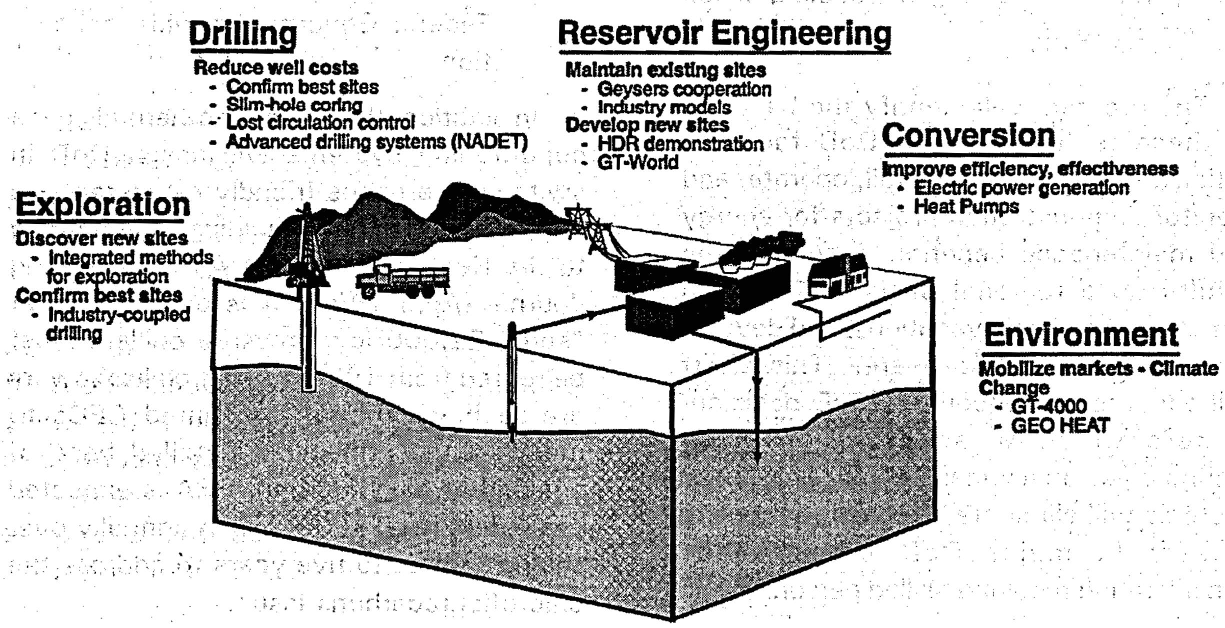
Thus, "as opportunities for dispersed generation and end use applications of geothermal energy increase in the utility market, near-term commercial opportunities for modular binary power systems, geothermal heat pumps and direct-use applications such as combination generation/process heat systems will increase."

San Martin also pointed out that as the utility sector has evolved, the programs of DOE's Office of Utility Technologies, including the geothermal program, have also evolved. The Geothermal Division's program is being built and accentuated by the various initiatives contained in EPAct and the CCAP (see above article). Its proposed FY 95 programmatic activities can be divided into "Base Program" and "FY 95 Budget Initiatives." These activities span the range of stages related to advanced technology development and can be divided into the five technology areas as follows:

The 2005 objectives of the separate technology areas are:

- Exploration - discover 25 new resource areas, focusing especially in the Pacific Northwest
- Drilling - reduce geothermal well drilling costs by 50 percent
- Reservoir Engineering - develop eight new reservoirs
- Conversion - 5,000 MWe online
- Environment - reduce CO_2 emissions by 35 million tons.

OUT's Geothermal Program Areas



More detailed information on the elements of the Geothermal Division's program are presented in several related articles in this issue of GPM and other DOE publications such as the Multiyear Program Plan.

DoD EXPANDED USE OF GHPs TO REDUCE EMISSIONS AND COSTS

Building upon a program that focused on installing geothermal heat pumps in base housing and other smaller buildings, the Department of Defense has initiated a geothermal space conditioning initiative for large DoD buildings. The major objective of the FY 94-98 program will be to establish a permanent DoD capability to specify, design, procure, operate and maintain GHP systems and groundwater cooled chillers at buildings with heating and cooling needs of over 50 tons.

The program will identify the best use of these technologies at DoD facilities nationwide. It will also install, operate, and monitor demonstration projects for energy and maintenance benefits, document the results on a regional basis to factor in climate and geologic variations, and develop design criteria and software. This effort will educate and encourage DoD decision-makers to allow adoption of these technologies on a widespread scale. These systems will eliminate the need for cooling towers (a major DoD maintenance consideration requiring skilled personnel and use of chemicals), eliminate the need to shift to more energy intensive air-cooled cooling towers, and reduce the use of ozone-damaging chloroflourocarbons (CFCs).

The expected pay-offs include:

- emissions reductions of about 3.6 million tons of carbon dioxide, 14 tons of sulfur oxides, and six tons of nitrogen oxides
- reduced refrigerant use
- a 20 percent reduction in electricity use for space conditioning and water heating
- a 20-30 percent reduction in peak electric demand
- an annual energy and maintenance savings of $100 to $200 million
- the opportunity to "fast track" a renewable energy technology for Federal Government-wide application

In addition, the use of geothermal space conditioning systems will assist DoD in switching to ozone-friendly refrigerants, a key challenge at large buildings. According to the Heating, Piping, & Air-Conditioning Journal (April 1993), it is estimated that "some 22,000 low-pressure chillers must be retired from 1996-1998 if chiller towers are to have enough reclaimed CFCs to maintain the remaining installed base of equipment." In addition, GSA is expected to spend about $100 million annually over the next three to five years to address the chloroflourocarbons issue.

The successful implementation of this program will assist DoD in achieving a 20 percent reduction in energy consumption by the year 2000 as required in Executive Order 12759, and in meeting the goal of the national Defense Authorization Act for FY 91 which calls for DoD to install 100 MWe of renewable technologies.

Several DoD research agencies participating in the program include U.S. Army Construction Engineering Research Laboratory in association with Army Cold Region Research & Engineering Laboratory and Naval Facilities Engineering Command/ Naval Facilities Engineering Services Center.

The Strategic and Environmental Resource and Development Program (SERDP) for large DoD buildings is being implemented in concert with the ongoing DOE Geothermal Heat Pump Program. While the objectives and tasks of the two will be implemented separately, the DOE program will support and enhance the SERDP effort. The point of contact for both is Lew Pratsch of DOEs Geothermal Division, (202) 586-1512

CORPS OF ENGINEERS SHARED ENERGY SAVINGS PROJECTS BENEFICIAL TO TAXPAYERS

As part of an earlier SERDP program for smaller DoD buildings the Huntsville Division of the Corps of Engineers awarded a shared energy savings contract at the Family Housing Area, Fort Polk, Louisiana, in January 1994. This contract was awarded to Co-Energy Group (CEG), Santa Monica, CA. CEG will replace the heating and air-conditioning units in 4,003 family housing units with new closed-loop geothermal heat pumps. CEG will also insulate attics, add weather stripping and caulking, install low-flow shower heads, recover heat from the heat pumps to heat residential hot water, insulate water heaters, and retrofit interior and exterior lighting throughout the housing area.

This project has some significant and important advantages for taxpayers. First, the contractor will furnish all equipment, materials, and labor necessary to perform this work and maintain the equipment throughout the life of the contract at no cost to the government. In addition to furnishing everything required with no capital outlay from the installation, the contractor will split the energy savings produced by installing more energy efficient equipment with Uncle Sam. The contractor is paid 78 percent of the dollars for energy savings for his efforts, and the government will receive 22 percent of the energy savings dollars for signing the contract.

Over the 20-year life of the contract, the government will save an estimated $44 million (in today's dollars) in lower utility bills. That amounts to total energy savings in nominal worth (including interest) of over $102.5 million.

The initial 12 test residences at Fort Polk are saving nearly 60 percent of the prior load, and it is estimated that over 70 percent of the 33 million kWh saved annually will come as a result of using GHPs. DOE plans to obtain electric load and maintenance data at this site. This will benefit utilities by providing them with statistically-valid performance data for their demand-side management programs.

The program manager at Huntsville is Bob Starling, (205) 955-4414, and at Fort Polk, Greg Prudhomme, (318) 531-6029.

"TED MOCK RETIRES"

Dr. John E. Mock, known to his many friends and colleagues as "Ted," will retire as Director of DOEs Geothermal Division January 3, 1995. Prior to joining the Division in 1981, he had many years experience in the Federal Government as scientist, research manager, patent attorney, and technology transfer advocate. When the Energy Research and Development Administration, DOEs predecessor, was established in 1975, he was named Senior Technical Adviser to the Assistant Administrator for Solar, Geothermal, and Advanced Energy Systems which led in turn to his assignment to head the Geothermal Division.

The geothermal industry has honored Ted for his services in that capacity with several awards. First, in 1991, he received the Geothermal Resources Council special Achievement Award for transferring technology from the National Laboratories to industry. In 1993, he received the national Geothermal Association special award and the Stanford University Annual Recognition Award, and, in 1994, the Aidlin Award of the Geothermal Resources Council for his technical leadership of the United States and worldwide geothermal community.

Ted's door has always been open to members of the community, and he was a willing participant in both national and international forums on geothermal energy. He and Mrs. Mock will remain in the Northern Virginia suburbs of Washington, D.C. so he will not be far from the scene of future geothermal activities.

MAGMA POWER AGREES TO BE ACQUIRED BY CALIFORNIA ENERGY FOR $950 MILLION

After a two and a half month effort to acquire Magma Power Co. in a hostile takeover bid, California Energy Co. (CEC) increased its per-share offer, and the two companies reached a friendly agreement. The turnabout, described by the Wall Street Journal as "surprising," occurred just one day after CEC terminated its earlier $924 million bid on December 3. Executives of the two companies met in New York and hammered out a $950 million takeover.

The combined company "will be the largest geothermal-energy producer in the world," according to the Journal, with more than $400 million in annual revenue, 545 MWe in operation, and 530 MWe under construction. The Investor's Business Daily noted that the combination of Magma and CEC is "the latest in a decade of consolidation in the geothermal industry, in which both companies rose to prominence as they gobbled up assets from less profitable rivals."

Under the agreement, CEC began a tender offer for 51 percent of Magma's common stock for $39 a share in cash. In the second step, CEC will choose whether to pay about $38.50 a share in cash for the remaining Magma common outstanding or to pay a combination of cash and CEC common valued at $39. If a combination were paid, Magma holders would receive about $17.50 in cash and $21.50 in stock.

Magma was founded by B. C. McCabe, whose early exploration at The Geysers led to the development of the largest geothermal power complex in the world at that site in northern California. The B. C. McCabe Foundation and Dow Chemical Co. were the largest Magma shareholders at the time of the takeover.

CEC began its geothermal operation in Nicaragua in the 1970's. Subsequently, the company was the only bidder on a contract to produce geothermal power for the Navy at the Coso field in California. This operation quickly became a highly profitable 240 MWe installation.

Both companies operate geothermal power plants in the Philippines, and CEC recently announced a joint venture in Indonesia (see related article in FINANCING) where Magma has also been seeking contracts.

INDUSTRY SPOKESMEN ASSESS GEOTHERMAL'S ROLE IN A COMPETITIVE POWER MARKET

Speaking to the audience at Geothermal Program Review XII in April 1994, two major geothermal industry spokesmen assessed the strengths and weaknesses of the industry in confronting the threshold of the new competitive power market. David W. Cox, Vice President of the California Energy Co., and Thomas R. Sparks, manager of government relations and utility affairs of Unocal's Geothermal Division, both concluded that despite demonstrated strengths, the industry must shore up some of its weaknesses in order to survive and prosper as baseload independent power producers in a drastically changing market structure.

Cox noted that 1993 "was not a banner year for IPPs" in terms of new power online, and predicted that "unfortunately this trend gets worse for the next few years, not better." "Equally as disturbing," he added, "was the reversal in the IPP percentage of market share." Other "disheartening" aspects of 1993 were the fact that natural gas continued as the predominant fuel choice, and projections that it will account for over 70 percent of new capacity through the end of the decade. In addition, he added, that "as expected, even the most optimistic energy pundits have scaled back their forecast of potential new demand through the end of the decade," and that less than 25 percent of new generation needs for the next 10 years are forecasted to be baseload -- the utilities will focus on peak and intermediate capacity.

Cox predicted continuation of the "stagnation" of 1993 for the next two or three years during which the utilities will "prepare for and leverage the deregulatory processes." A number of issues, such as the transmission provisions of EPAct, need to be resolved between FERC and the state public utility commissions.

He suggested that the U.S. geothermal industry should focus on the international markets during this period to take advantage of the phenomenal growth abroad. "The firms with the resources and foresight to work oversees the next several years will certainly be positioned to return to the domestic market in the late 1990s." He also predicted that "domestic consolidations will continue over the next couple of years," and may "accelerate given the weak market." However, he said "the gridlock and uncertainty should diminish... and demand should pick up around 1996."

Both Sparks and Cox emphasized the need to quantify "environmental externalities" so that the industry can take better advantage of its status as an environmentally preferred technology. Sparks also pointed out that this advantage will "grow in importance as our planet's population grows and resources shrink."

Sparks strongly urged the industry to "redouble our efforts to sell our industry and our product in the utility, regulatory, and political arenas," and added:

> "History is replete with stories of institutions who waited for the market to come to them... and waited, and waited, and waited. Let me assure you that lesser technologies with more aggressive marketing techniques can and will pass us by if we don't get out there and sell geothermal at all levels of government and power industry."

Although geothermal energy is a proven, reliable resource, and U.S. industry has the "best, most sophisticated technical and business skills of any nation in the world" for using it, Sparks said, "we must become more cost effective."

MAGMA POWER MAKES STRONG BUSINESS ADVANCES

Just a year prior to its acquisition by California Energy, the Magma Power Co. won contracts in December of 1993 and January 1994 to produce and sell 94 MWe of power to San Diego Gas and Electric and 69 MWe to Southern California Edison, respectively. The bids for this capacity were made pursuant to the California Public Utility Commission's Biennial Resource Plan Update under which 275 MWe in Southern California were set aside for companies utilizing renewable energy resources. Of the total amount, SCE solicited bids for 175 MWe and SDG&E sought bids for 100 MWe, all to be developed by the year 2000.

Under the terms of Magma's bids, all 69 MWe to be delivered to SCE are scheduled for start-up in 1997; 55 MWe to be delivered to SDG&E are scheduled for start-up in 1997, and 39 MWe for 1998.

Paul Pankratz, Magma chairman and chief executive officer, commented, "Magma Power is extremely pleased that we... have succeeded in winning a total of 163 MWe of the 250 MWe set aside for renewable technologies. The acquisition of Unocal's geothermal assets at the Salton Sea in early 1993, combined with our proven technology and strategic resource base, enabled us to submit highly competitive bids."

Both SCE and SDG&E filed protests with the CPUC on the manner in which certain bids were 'structured. However, after further reviews of the utilities' filings and comments of all interested parties, the bids as proposed were accepted as final. However, as of the end of December, the utilities were considering appealing the PUC decision in court.

Magma has not yet announced the location of its new plants.

The company reported record gains in revenue and earnings for both the calendar year 1993 and the first quarter of 1994. Its net income for 1993 increased 43 percent to a record $52.1 million, or $2.17 per share, from 1992 net income of $36.4 million or $1.59 per share, before the cumulative effect of an accounting change. On a pretax basis, 1993 net income rose 51 percent to $74.9 million from $49.7 million in 1992. Revenues for 1993 were up 53 percent for the year to $167.1 million from $109.0 for the prior year. These strong operating results were attributed to the three geothermal power plants acquired from Unocal, as well as the company's successful efforts to control operating costs.

For the first quarter of 1994, net income increased 71 percent to $9.4 million or $.39 per share from first quarter 1993 net income of $5.5 million, or $.23 per share. Revenues for the first quarter 1994 also increased 80 percent to $4.4 million from $22.5 for the first quarter of 1993.

Electricity revenues for both timeframes showed large increases reflecting, in addition to the acquired plants, an increase in the megawatt hours delivered from Magma's four original Salton Sea plants and an increase in the average price per kilowatt paid for the output of those plants.

Source: Magma Power Co. Press Releases 12/10/93, 1/6/94, 1/26/94, and 4/21/94

MAJOR FOOD PROCESSOR OPENS STATE-OF-THE-ART GEOTHERMAL DEHYDRATION PLANT

Integrated Ingredients' new state-of-the-art geothermal vegetable dehydration plant just south of Empire and Gerlach, Nevada, was dedicated on May 25, 1994. Integrated Ingredients (of Alameda, California) is a division of Burns Philip Food, Inc., which owns brands such as Spice Islands, Durkee-French, and Fleischmann's. The plant gives the company the ability to produce its own products for industrial and consumer markets instead of purchasing them.

The plant was located in the San Emidio Desert at the edge of the vast Black Rock Desert and the Great Basin to take advantage of the high temperature geothermal resource -- approximately 132°C (270°F), the heat of which is transferred to process air by means of a heat exchanger. The resource is also used by the OESI/AMOR II 3.6 MWe binary plant about a mile south of the dehydration plant and a gold heap leaching operation just to the north of the plant (Wind Mt. mine operated by AMAX). In addition to the availability of geothermal energy, the high desert is an ideal location for onion and garlic processing because the cold winters kill damaging microbes. Dry winters and summers also help.

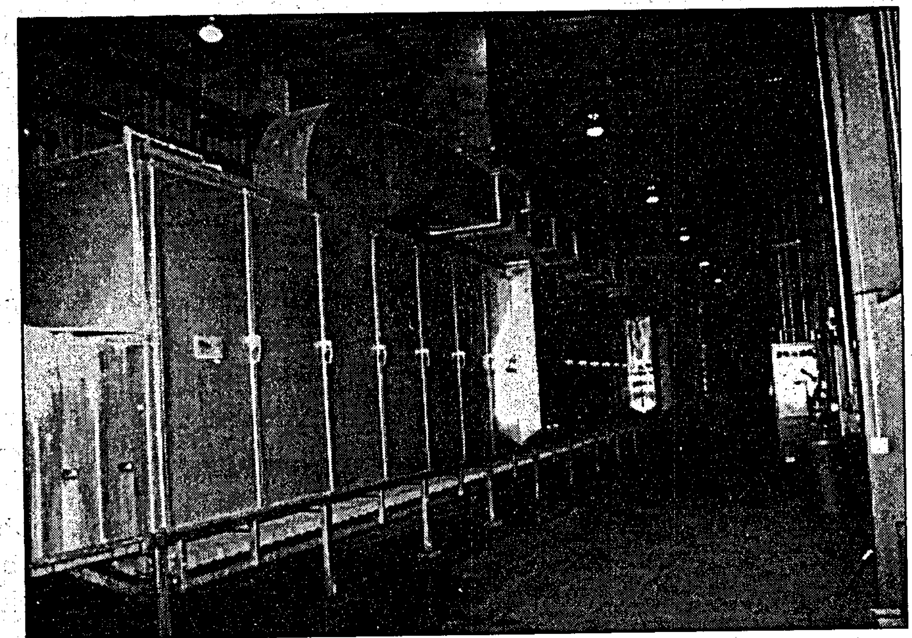
The vegetable crop is grown throughout California and northern Nevada, with the local Empire Farms providing 24 million pounds of onions per year. The processing plant operates 24-hours a day, seven days a week. When onions are hauled long distances, six double-trailer trucks per day provide 300,000 pounds of hydrated product for processing. A cold storage warehouse, kept at -0.6°C (31°F), can store as much as 24,000 tons of product, which provides for the year around operation.

The 300,000 pounds of wet onions will produce 50,000 pounds of dry product at about 5 percent retained moisture. A total of 14 million pounds of dry product are produced annually; 60 percent onion and 40 percent garlic. Product size can be powdered, ground, minced, chopped, or sliced. The final product is sold for seasoning in soups, cheeses, crackers, sauces, salad dressing, and snack food.

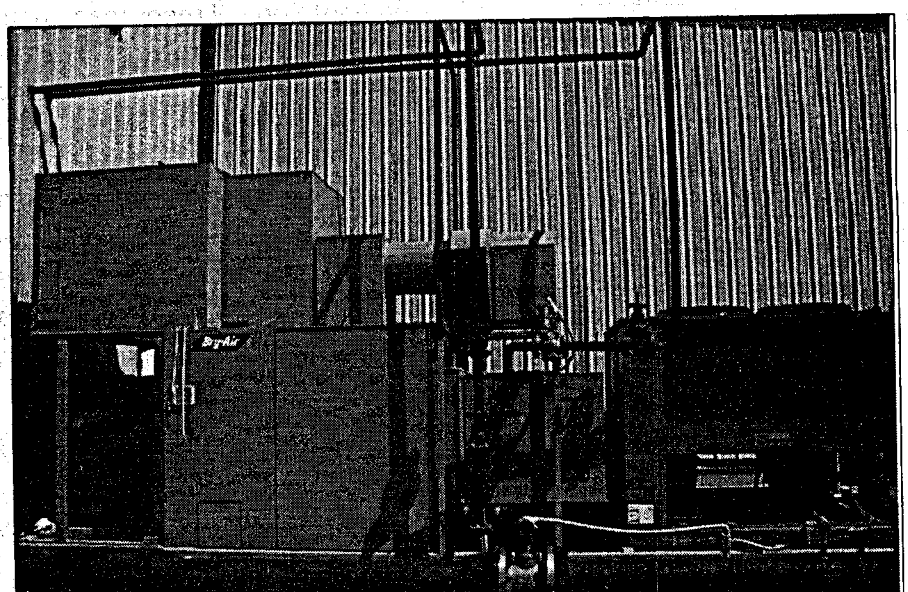
The geothermal resource used originates about 2,200 feet below the plant and is sealed by a silica cap. A 350-foot deep well just south of the plant produces 130°C(266°F) water. Up to 900 gallons per minute are supplied to the plant with a 75 horsepower pump through a 10-inch insulated steel pipeline. The discharge temperature varies depending upon the outside weather and plant operation, but can be as low as 71°C(160°F). Thus, theSource: Geo-Heat Center Bulletin 7/94 maximum energy use is around 45 million Btu per hour. A second well will supply fluid for the second drier line.

Other details on plant operation and the economic of geothermal use, as opposed to natural gas, are considered proprietary.

Source: Geo-Heat Center Bulletin 7/94



The Integrated Ingredients vegetable dehydration plant covers approximately 100,000 square feet with one drier line currently in operation. Construction of a second line is planned. The stainless steel drier line, manufactured by The National Drying Machinery Co. of Philadelphia, is approximately 12 feet wide and 200 feet long. It consists of three stages (A, B, and C shown above) and a Bry-Air drier (shown below) to remove the final moisture from the product.



The Bry-Air drier is used mainly in the winter months when the humidity is higher and can be boosted in temperature with electric energy.

FISH LAKE VALLEY GEOTHERMAL UNIT HAS BEEN PROPOSED

The Bureau of Land Management, Battle Mountain District Office and Tonopah Resource Area Office, in cooperation with Fish Lake Power Company, a subsidiary of Magma Power Co., will prepare an Environmental Assessment for a Plan of Utilization on a proposed geothermal power plant. The EA will be prepared with the assistance of a contractor and funded by Fish Lake.

The proposed project would be located in Esmeralda County, Nevada, approximately 20 miles to the north of the community of Dyer on federal leases. The specific location of the proposed power plant site would be township one south, range 35 east, section 13.

Total surface disturbance for the proposed power plant and associated transmission line would be 170 acres. The estimated duration of the proposed action would be for the life of the power plant -- estimated to be 30 years. The proposed project consists of the following components:

- Fifteen geothermal production sites.
- Eight injection well sites.
- Necessary pipelines and monitoring/power lines to connect the wells to the power plant.
- Construction and operation of a 16 MW (net) flash power plant.
- Approximately 11.6 miles of new roads, including pipeline and monitoring/power line access.
- Subtransmission line approximately 29 miles long.

The production wells will supply geothermal fluids to a centrally located power plant. Spent production will be injected back into the periphery of the reservoir. The electricity will be routed by a single pole design to the Oasis substation at the Nevada/California state line.

The EA will address the following potentially affected resources: air quality, geology, soils, wildlife/fisheries, threatened and endangered species, land use and access, vegetation, cultural resources, paleontological resources, visual resources, social and economic values, noise, hazardous materials, recreation, and hydrology (water quality and quantity).

Magma submitted an application for a construction permit to the Nevada Public Service Commission, and if the project gets the go ahead, commercial operation could begin in 1996.

Source: Geothermal Resources Council Bulletin 3/94 and 5/94

WAY CLEARED FOR FIRST GEOTHERMAL POWER PLANT IN THE PACIFIC NORTHWEST

In June 1994, an Environmental Impact Statement was issued on the Newberry Geothermal Pilot Project to be located on federal leases in the Deschutes National Forest, west of the Newberry National Volcanic Monument in Oregon. The 33 MWe power project is the first of three approved by the Bonneville Power Administration to test the feasibility of generating electricity from geothermal energy. With the EIS approval and subsequent BPA record of decision, exploratory drilling was authorized and commercial power production is expected to be online by November 1997.

The development is a joint venture of the California Energy Co. and Eugene Water and Electric Board. BPA will purchase 20 MWe of plant output, and EWEB will purchase the remaining 10 MWe under a billing credit agreement with BPA which will wheel the power over its transmission lines to EWEB's system.

The U.S. Forest Service, the Bureau of Land Management, and BPA cooperated in the EIS in accord with their separate responsibilities -- jurisdiction over surface management, administration of geothermal lease and subsurface management, and purchase and transmission of power, respectively. The EIS required some modification to the Plans of Operation submitted to BLM and the Forest Service in July 1992.

Alternative B, as the modification is called, is similar to the original proposal (alternative A) in plant design and size, size of the well field and pads, and design of the facilities except for the transmission line. It differs most in respect to location of facilities and mitigation and monitoring measures to be included. Alternative B, it was noted, provides flexibility for the agencies as well as the operator for on-the-ground siting of well pads, power plant, pipelines, and access roads.

The mitigation and monitoring requirements are described as "among the most stringent imposed by federal agencies on a geothermal operation." "The analysis shows," it is concluded, "that the emissions will not endanger the public health or otherwise have any significant adverse impacts on humans, wildlife, vegetation, or water bodies."

The final EIS is available from the U.S. Forest Service in Bend, OR on (503) 383-4703. The full set of documentation includes the final EIS, appendices, comment report, executive summary, and record of decision. The summary is likely to satisfy most needs for information on the analysis and attendant decisions.

A Glass Mountain site in northern California has also been selected by BPA for a geothermal pilot project. Exploration at Vale, Oregon, was unsuccessful, and the pilot project for that area was canceled.

TRUE/MID-PACIFIC GEOTHERMAL CLOSES OPERATION ON BIG ISLAND

True/Mid-Pacific Geothermal Venture, a company that began developing geothermal energy in Hawaii 13 years ago, is closing down its operation on the Big Island. Marketing problems were cited as the reason for True/Mid-Pacific Geothermal Venture's decision to close.

The departure does not affect rival Puna Geothermal Venture, which began supplying 25 MW of electricity to the island's power grid last year. True/Mid-Pacific, a joint venture of True Geothermal Energy Co. and Mid-Pacific Geothermal Inc., both based in Casper, Wyoming, began geothermal operations in Hawaii in 1981.

Governor John Waihee said he regretted True/Mid-pacific's decision, but understood the business considerations. Waihee said that despite True/Mid-Pacific's departure, he still believes geothermal energy is an important source of energy.

"The experience we have had with Puna Geothermal Venture, which has been supplying 25 megawatts of power to the people of the Big Island for the better part of a year now, demonstrates the enormous

The key to the abbreviations used in the following power plant tables is as follows:

DDS	-	Dry Steam
DF	-	Dual Flash
SF	-	Single Flash
B	-	Binary

Utilities

NCPA	-	Northern California Power Agency
PG&E	-	Pacific Gas and Electric Co.
PP&L	-	Pacific Power and Light Co.
PSP&L	-	Puget Sound Power & Light Co.
SCE	-	Southern California Edison
SDG&E	-	San Diego Gas and Electric Co.
SPP	-	Sierra Pacific Power Co.
SMUD	-	Sacramento Municipal Utility District
UPD	-	Utah Power Division of Pacific Corp.

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Dry Steam Plants at The Geysers)

PLANT NAME	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
PG&E Unit 1[a]	UNOCAL/Magma/Thermal	PG&E	PG&E	11	1960
PG&E Unit 2[a]	"	"	"	13	1963
PG&E Unit 3[a]	"	"	"	27	1967
PG&E Unit 4[a]	"	"	"	27	1968
PG&E Unit 5	"	"	"	53	1971
PG&E Unit 6	"	"	"	53	1971
PG&E Unit 7	"	"	"	53	1972
PG&E Unit 8	"	"	"	53	1972
PG&E Unit 9	"	"	"	53	1973
PG&E Unit 10	"	"	"	53	1973
PG&E Unit 11	"	"	"	106	1975
PG&E Unit 12	"	"	"	106	1979
PG&E Unit 15[a]	Geothermal Resources International	"	"	59	1979
PG&E Unit 13	Santa Rosa Geothermal Co.[b]	"	"	133	1980
PG&E Unit 14	UNOCAL/Magma/Thermal (Natomas)	"	"	109	1980

a Retired
b Formed by Calpine Corp. and Freeport-McMoran as new owner of leases and steam supply operations; originally Aminoil properties

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(*Dry Steam Plants at The Geysers*)

PLANT NAME	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
PG&E Unit 17	UNOCAL/Magma/Thermal (Natomas)	PG&E	PG&E	110	1982
PG&E Unit 18	UNOCAL/Magma/Thermal (Natomas)	PG&E	PG&E	110	1983
SMUDGEO No. 1	Santa Rosa Geothermal Co.[b]	Sacramento Municipal Utility District	SMUD	72	1983
NCPA No. 1[c]	Northern Calif. Power Agency (originally Grace Geothermal)	NCPA	NCPA	110	1983
Santa Fe Geothermal 1	Santa Fe Geothermal (originally Occidental)	Santa Fe Geothermal	PG&E	80	1984
Bottle Rock[d]	NCPA	Calif. Dept of Water Resources	Calif. Dept of Water Resources	55	1984
NCPA No. 2[c]	NCPA	NCPA	NCPA	110	1985
PG&E Unit 16	Santa Rosa Geothermal Co.[b]	PG&E	PG&E	110	1985
PG&E Unit 20	UNOCAL/Thermal (Diamond Shamrock)	PG&E	PG&E	110	1985
Cold Water Creek	Cold Water Creek Operating Co.	CCPA[e]	CCPA[e]	124	1988

c Originally NCPA Nos. 2 and 3
d Closed
e Plant ownership divided among Sacramento Municipal Utility District (SMUD), Modesto Irrigation District (MID), and the City of Santa Clara

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Dry Steam Plants at The Geysers)

PLANT NAME	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
Bear Canyon Creek	Santa Rosa Geothermal Co.[f]	Santa Rosa[f]	PG&E	22	1988
West Ford Flat	Santa Rosa Geothermal Co.[f]	Santa Rosa[f]	PG&E	29	1988
Joseph W. Aldlin Power Plant	Geothermal Energy Partners[g]	Geothermal Energy Partners/Cloverdale Geothermal Partners[h]	PG&E	20	1989

f The new partnership of Calpine Corp. and Freeport-McMoRan owns both field and power plant operations; originally Geysers Geothermal properties
g A subsidiary of Mission Power is general partner
h Calpine Corp. and Metlife Capital Corp. (affiliate of Metropolitan Life Ins. Co.)

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Hot Water Plants)

LOCATION (State and Site)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
ALASKA							
	Unalaska	TBD	OESI	Alaska Energy Authority	TBD	12	1996
CALIFORNIA							
Coso Hot Springs	Navy Plant No. 1, Units No. 1, 2, & 3	DF	California Energy[a]	California Energy[a]	SCE	80	1987-1988
	BLM East (Units 1&2)	DF	California Energy[a]	California Energy[a]	SCE	48	1988
	BLM West	DF	California Energy[a]	California Energy[a]	SCE	28	1989
	Navy Plant No. 2, Units No. 4, 5, & 6	DF	California Energy[a]	California Energy[a]	SCE	80	1989
East Mesa	GEM 1 (formerly B.C. McCabe)	B	GEO Operator/Mission[b,c]	GEO/Mission[c]	SCE	12.5[d]	1980
	Ormesa I	B	OESI	OESI	SCE	24	1986
	Ormesa II	B	OESI/Harbert International	OESI/Harbert	SCE	17	1988
	Ormesa IE	B	OESI	OESI	SCE	8	1988
	Ormesa IH	B	OESI	OESI/Harbert	SCE	6	1989
	GEM 2	DF	GEO/Mission[c]	GEO/Mission[c]	SCE	37	1989

a Various venture partners are involved in all California Energy Coso plants
b Magma Power original owner
c Mission Energy, a subsidiary of SCE
d Enlarged from 10 MWe

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Hot Water Plants)

LOCATION (State and Site)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
<u>CALIFORNIA</u> (Cont'd)							
Glass Mountain	BPA Pilot II[e]	DF	Calpine	Trans-Pacific	BPA	30	1996
Heber	Heber Dual Flash Power Plant	DF	Chevron Resources Co.	Calpine Corp./ERC International[f]	SCE	47	1985
	Heber Binary Project[g]	B	Chevron	To be sold by SDG&E	SDG&E	45	1985
	Second Imperial	B	Second Imperial Geothermal Co.	GE Capital	SCE	37	1993
Mono-Long Valley	Mammoth Pacific (MP) Unit 1	B	Pacific Energy[h]	Pacific Energy[h]/Constellation	SCE	7	1984
	MP Unit II	B	Pacific Energy[h]	Pacific Energy[h]/Constellation	SCE	10	1990
	MP Unit III	B	Pacific Energy[h]	Pacific Energy[h]/Constellation	SCE	10	1996 (est.)
	Pacific Lighting Energy Systems (PLES) Unit I	B	Pacific Energy[h]	Pacific Energy[h]/Constellation	SCE	10	1990
	Long Valley I	TBD	Pacific Energy	Pacific Energy	SCE	24	1998
Salton Sea	Magma Set-Aside I[i]	DF	Magma	Magma	SCE	69	1997

e Bonneville Power Administration Geothermal Pilot Project
f Partnership of Dravo Corp. and Centennial Energy original owner
g Demonstration plant supported by the U.S. Department of Energy; currently not in operation
h Subsidiary of Pacific Enterprises
i Apparent winner of BRPU set-aside solicitation

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Hot Water Plants)

LOCATION (State and Site)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
CALIFORNIA (Cont'd)							
	Magma Set-Aside II[i]	DF	Magma	Magma	SDGE	94	1998
	Salton Sea Unit 1[j]	SF	Magma	Magma	SCE	10	1982
	Salton Sea Unit 2[j]	SF	Magma	Magma	SCE	18[k]	1990
	Vulcan	DF	Magma/Mission[c]	Magma/Mission[c]	SCE	30	1985
	Del Ranch	DF	Magma/Mission[c]	Magma/Mission[c]	SCE	34	1988
	Elmore I	DF	Magma/Mission[c]	Magma/Mission[c]	SCE	34	1988
	Leathers I	DF	Magma/Mission[c]	Magma/Mission[c]	SCE	34	1989
	Salton Sea Unit 3[j]	DF	Magma	Magma	SCE	48	1989
	Salton Sea 4[k]	DF	Magma	Magma	SCE	20	1996
Wendel-Amedee	Wineagle Project	B	Wineagle Developers	Wineagle Developers	PG&E	.7	1985
	Amedee Geothermal	B	Trans-Pacific Geothermal Inc. (TPG)/U.S. Energy Corp.	TPG/U.S.	PG&E	2[l]	1988
	Honey Lake Power Facility	B[m]	GeoProducts Corp.	HL Power Co.	PG&E	30	1988
HAWAII							
	Puna Geothermal Venture I	SF/B	OESI	OESI	HELCO	25	1993

j Formerly developed by Unocal
k 20 MW negotiated power purchase contract acquired from Unocal
l Phase II will add 3 MWe
m A hybrid plant using wood waste and geothermal heat; geothermal fluid used only to preheat boiler feedwater

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES
(Hot Water Plants)

LOCATION (State and Site)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
NEVADA							
Beowawe	Beowawe	DF	California Energy (originally Chevron)	California Energy/Crescent Valley Geothermal[n]	SCE	15	1985
Brady-Hazen	Desert Peak	DF	California Energy (originally Phillips; more recently Chevron)	California Energy (originally Chevron)	SPP	9	1985
	Brady Hot Springs I	DF	Brady Power Partners	Brady Power Partners	SPP	20	1992
Fish Lake Valley	Fishlake I	TBD	Magma	Magma	SCE	14	1996
(not on KGRA)	Fallon Navy Facility	TBD	TBD	TBD	TBD	160	1998 (est.)
Dixie Valley	Oxbow	DF	Oxbow Geothermal (originally Sunedco; then Trans-Pacific)	Oxbow	SCE	50	1988
	Caithness I	DF	Caithness	Caithness	SCE	19	1996
San Emidio Desert	Empire Geothermal Project	B	OESI	Empire Geothermal	SPP	3	1987
	San Emidio I	B	San Emidio Resources	San Emidio Resources	SPP	30	1995
Steamboat Springs	Steamboat Geothermal I	B	Geothermal Development Associates (GDA/OESI)	Far West Electric Energy Fund, Ltd.	SPP	6.8	1986

n SCE Subsidiary

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES (Hot Water Plants)

LOCATION (State and Site)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
NEVADA (Cont'd)	Steamboat Geothermal IA	B	OESI/GDA	Far West	SPP	1.2	1989
	Yankee/Caithness	SF	Caithness/Sequa	Caithness/Sequa	SPP	12	1988
	Steamboat 2	B	Steamboat Development	Steamboat Development	SPP	12	1992
	Steamboat 3	B	Steamboat Development	Steamboat Development	SPP	12	1993
	Steamboat 4/5	B	Far West	Far West	SPP	24	1996
Stillwater/Soda Lake	Soda Lake Geothermal Project	B	Chevron	Institutional Investors (OESI Operator)	SPP	2.7	1987
	Stillwater Geothermal I Project	B	OESI	OESI/Constellation Development/Chrysler Capital	SPP	13	1989
	Soda Lake II	B	Amor	OESI	SPP	13	1990
Wabuska[o]	Wabuska	B	Tad's Enterprises	Tad's Enterprises	SPP	1.5	1984
OREGON							
Newberry Crater	BPA Pilot I[e]	DF	California Energy	California Energy	Eugene Water & Electric; BPA	30	1996
UTAH							
Roosevelt Hot Springs	Blundell I	SF	California Energy Co. (originally Phillips; subsequently Chevron)	Utah Power Div. (UPD) of PacificCorp	UPD	20	1984

o Declassified KGRA

GEOTHERMAL ELECTRIC POWER PLANTS OPERATIONAL, UNDER CONSTRUCTION, AND PLANNED IN THE UNITED STATES (Hot Water Plants)

LOCATION (State and Site)	PLANT NAME	TYPE	FIELD DEVELOPER	PLANT OWNER	UTILITY	RATED CAPACITY (MW)	YEAR ON LINE
UTAH (Cont'd)							
Cove Fort-Sulphurdale	Cove Fort Geothermal No. 1	B	Mother Earth	City of Provo	Utah Municipal Power Agency	2	1985
	Cove Fort Steam Plant	DS	Mother Earth	City of Provo	Provo Power Co.	2	1988
	Cove Fort Steam No. 2	DS	Mother Earth	City of Provo	Provo Power Co.	7	1989

MAGMA POWER ACQUIRES $130 MILLION PROJECT FINANCING ON THREE SALTON SEA PLANTS

Magma Power Co. announced in February 1994 that it had successfully financed a $130 million project financing, with a $5 million working capital line of credit, on the three Salton Sea geothermal power plants it acquired from Unocal Corp. in March 1993. Credit Suisse is lead agent bank, with The Fuji Bank Limited, Los Angeles Agency, serving as co-agent and The Sumitomo Bank, Limited, Los Angeles Branch, The Bank of Nova Scotia, and Bank of America NT & SA serving as lead managers. The working capital was arranged with Credit Suisse and The Fuji Bank Limited.

The financing, which consists of a six-year term loan, replaces the one-year bridge loan previously arranged by Magma in connection with its acquisition last year of Unocal's geothermal assets in Southern and Central California and Nevada. The Unocal acquisition increased Magma Power's electric generating capacity from approximately 160 MWe to 240 MWe. The three power plants acquired include a 10 MWe unit, a 20 MWe unit, and a 50 MWe unit. A 20 MWe plant expansion option with Southern California Edison, as well as 40,000 acres of strategically located geothermal leaseholds in California's Imperial Valley and 70,000 acres of geothermal leaseholds in Central California and Nevada were also included. The acquired Imperial Valley leaseholds, plus the 45,000 acres of leaseholds already owned there by Magma, are believed capable of supporting as much as 1,000 MWe of new geothermal development.

Source: Magma Power Co. Press Release 2/28/94

CALPINE TO ISSUE $100 MILLION IN SENIOR SUBORDINATED DEBT NOTES

Calpine Corp. (San Jose, California), an independent power generation company, raised $105 million by selling senior notes to enhance the firm's financial position and to fund future projects. The senior notes carry a 9.25 percent interest rate. The debt will mature in 2003, according to a company prospectus filed with the Securities and Exchange Commission in late December 1993. The firm's debt stood at $275.9 million at the close of September 1993.

In the last three years, Calpine has increased its power generation assets from $26.8 million to $271.7 million. By the end of September, the firm's consolidated assets stood at $310.7 million, with $12.6 million in shareholder equity.

A "substantial portion" of the proceeds of the senior notes is being used to pay $53 million in debt held by an affiliate of Calpine's sole shareholder, Electrowatt Ltd., based in Zurich, Switzerland. Another $36.7 million is expected to be applied to the $40.5 million debt used to buy five power plants in the last year.

For the nine months ended September 30, 1993, Calpine reported profits of $2.1 million on revenues of $49 million, compared with profits of $3.8 million on revenues of $29 million a year ago. The drop in profits is primarily due to increased operating expenses.

Source: Geothermal Resources Council Bulletin 3/94

CALIFORNIA ENERGY CLOSES FINANCING FOR 120 MW PHILIPPINE GEOTHERMAL UNIT

California Energy Company closed financing for its $218 million, 120 MW Upper Mahlao geothermal power project in the Philippines, under development as a 10-year, build-operate-transfer project. Power from Upper Mahlao will be sold to the Philippine National Oil Company, which earlier agreed to provide the project with the needed geothermal resource.

California Energy vice president David Cox said the company will put up $56 million of equity, insured by the U.S. Overseas Private Investment Corp. (OPIC) in the form of political risk insurance. The Export-Import Bank of the U.S. is providing approximately $162 million of permanent financing and political risk insurance during construction. (See related article on participation of Ormat Inc. in INTERNATIONAL.)

The company is working to secure construction financing. Upper Mahlao is expected to be operational in July 1996. The Upper Mahlao financing follows the company's March 24 close of a $400 million senior discount note for three build-own-operate geothermal projects totaling 500 MW in Indonesia and other areas.

Source: Geothermal Resources Council Bulletin 5/94

CALIFORNIA COMPANY SUPPORTS REVERSAL OF BANK POLICY

In a policy reversal that could significantly enhance the export of U.S. clean energy technologies, the Export-Import Bank (EXIM) agreed in mid-March

1994 to reverse its policy of financing only those overseas development projects that involve more that $50 million in U.S. export value. EXIM chairman Kenneth Brody committed the bank to these policy changes after the issue was raised by Magma Power Co. in a hearing before the U.S. House Banking Subcommittee on International Development, Finance, Trade, and Monetary Policy.

Magma urged EXIM to consider lowering or eliminating its $50 million "floor," set as the minimum U.S. export value necessary for financing considerations. The company argued that renewable energy development often involves smaller scale projects, particularly in developing nations just beginning to utilize their renewable resources. Assuming the U.S. is interested in encouraging renewable energy development worldwide as a means of at least partially eliminating pollution, Magma asked for changes in the bank's policies so that projects involving less than $50 million in U.S. exports could get financing. After the subcommittee agreed with the company's requests, EXIM's chairman announced that the bank will drop its financing limitation in the future.

Magma vice president Thomas C. Hinrichs praised the bank and the House Subcommittee for supporting renewable energy development worldwide. He emphasized that EXIM's policy reversal will boost geothermal energy development in both the U.S. and overseas.

Source: IGA News 1-3/94

STUDIES OF INJECTION EFFECTS AT THE GEYSERS CONTINUE -- INTRODUCTION OF TREATED WASTEWATER PLANNED

Numerical modeling, microearthquake monitoring, and seismic imaging tools are all being employed at The Geysers to increase the understanding of the effects of injection on reservoir behavior. In addition to the importance of this knowledge to geothermal development generally, it will play a critical role at The Geysers. Steam shortfalls and reduced pressure at the field have curtailed power production and emphasized the need to view injection of spent fluids not just as a means for condensate disposal, but as a reservoir management tool for replenishing dwindling fluid reserves and enhancing energy recovery.

The Earth Sciences Division of the Lawrence Berkeley Laboratory has used mathematical modeling techniques for engineering design and optimization of water injection in vapor-dominated systems. This is an extremely challenging undertaking due to the complex interplay between fluid and heat flow and the presence of gravitational instabilities and reservoir heterogeneities. The general purpose geothermal reservoir simulation tool previously developed by LBL -- TOUGH2 -- was capable of modeling most of the reservoir processes during injection, and a dispersive flex term for the liquid phase was placed into the model in order to explore phase dispersion efforts.

In tracer tests at The Geysers, long return times have been observed, indicating some delay mechanism which significantly spreads the tracer concentration in the reservoir. In order to identify the possible tracer delay mechanisms and to determine the size of delay of each of them, researchers from Stanford University compared the magnitude of delay caused by adsorption, diffusion partitioning, preferential partitioning, and permeability variation, with specific emphasis in determining the influence of adsorption on injection programs at The Geysers. They concluded that adsorption alone has very little effect, indicating that little recharge of the adsorbed mass occurs for a typical injection program at this low-porosity, vapor dominated geothermal reservoir. Diffusion was shown to have a larger effect than adsorption while preferential partitioning was shown to have no effect. Permeability was shown to have the largest effect. Tracer delay was shown to be approximated closely by known permeability variations even when adsorption and diffusion effects are ignored.

A team of researchers from Lawrence Livermore National Laboratory and LBL are monitoring two high-frequency, high-resolution microearthquake networks at The Geysers and using the data to compute seismic velocity and attenuation images and earthquake parameters such as location and rate and manner of energy release. This effort is supported with laboratory measurements of velocity and attenuation on Geysers core samples under varying degrees of saturation to enhance interpretation of the seismic images. These techniques are being used in an attempt to improve resolution enough to be able to monitor the effects of steam production and the migration of injected fluids at The Geysers on a local scale. To date, it has been found that microearthquake activity follows injection activity, and the dry, low-pressure portions of the reservoir are characterized by low velocity and high attenuation.

In addition, DOE cost-shared a major water injection test in the southeast area of The Geysers. The operating companies, Unocal Geothermal, Calpine, and Northern California Power Agency, together with Pacific Gas & Electric, began test injection of water at the beginning of the year and have monitored pressure, temperature, and flow rate on 50 surrounding wells. In mid-April, chemical tracers were injected to follow the flow of steam and water through the reservoir. Preliminary interpretation suggested that the steam went northeast and the water went southeast. A thorough interpretation is now underway to quantify the tracer test results. All of this information will provide support for a project to bring treated wastewater through a 26-mile pipeline for injection at The Geysers in an effort to increase reservoir pressure, replace produced liquid mass, and ultimately increase production rate and the productive life of the reservoir. Funding for the $40 million project is being provided by federal, state, and local agencies, with industry providing the major contribution. (See GPM No. 15). If the project is a success, a net gain of 20 to 50 MWe in plant capacity can be expected, equating to as much as 280,000 MWh.

PROGRESS CONTINUES IN DEVELOPMENT OF EXPLORATION TOOLS

The costs incurred in exploration, the first and crucial step in any geothermal development, are of special importance because the longest delay occurs between exploration and an income stream from the sale of energy. Thus, cost savings that can be realized in exploration will have more impact on the economics of a project than will equal savings later in the development.

The goal of the DOE Geothermal Exploration Research Program is the development and testing of more reliable and more economical methods to locate and characterize geothermal reservoirs. The prime focus of the research is the development of better computer codes to interpret well logging surveys, and the verification of these codes in producing fields. Two promising methods of approach were discussed at Geothermal Program Review XII in April.

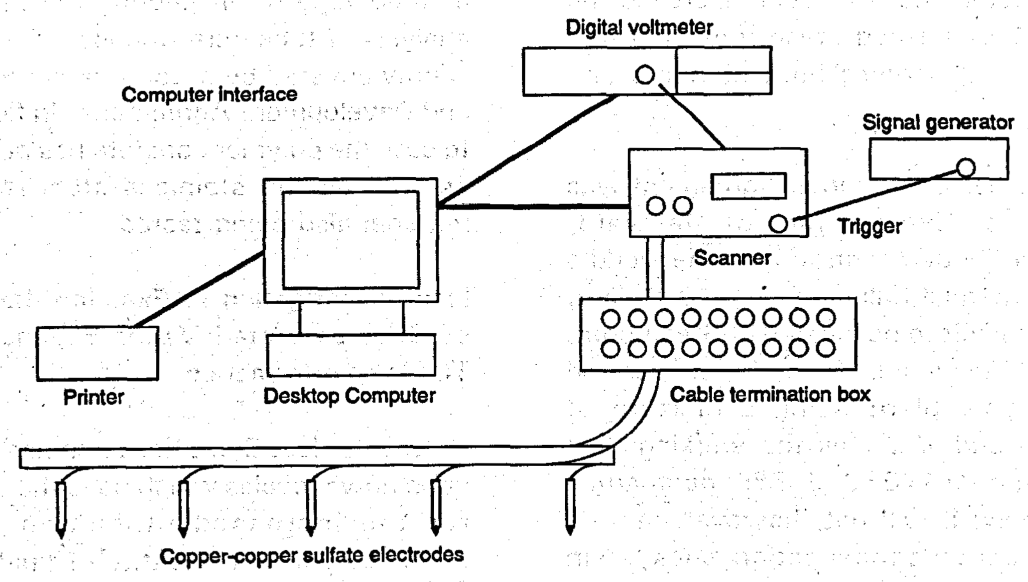
The object of the work conducted by LLNL is to develop new techniques to overcome persistent problems in data collection and interpretation when using the self-potential (SP) method in geothermal exploration. Self-potential is the only known geophysical technique in which the anomalies are a direct result of subsurface heat- and fluid-flow processes. Potentially a powerful tool in geothermal exploration, SP can also be useful in developing heat- and fluid-flow models of a field and for monitoring a field during exploitation.

Collecting SP data for geothermal exploration, however, has typically been a frustrating exercise. Although some field data shows an encouraging and almost unmistakable correlation with deep-seated geothermal activity, other data sets show poor correlation and a great deal of noise and scatter. Interpretation of data has had a similarly limited success, due in part to the lack of tools in interpreting SP and the uncertainty about the underlying causes of the observed anomalies.

The early results of the LLNL efforts to make improvements appear promising, although it will take some time to develop an effective modeling capability so that SP data can be more routinely used in geothermal exploration and fluid- and heat-flow modeling.

The correlation between reservoir temperature and reservoir volume was the focus of a University of Utah Research Institute study. If this correlation can provide a preliminary assessment of the magnitude (or volume) of a reservoir, it will be of economic value to the geothermal industry since an estimate of reservoir size will determine the scope and expenditure of subsequent exploration.

The UURI study concluded that there is a direct relationship between the volume of a hydrothermal system and its temperature. Although not precise and perhaps related to rock type, there is a general decrease in the depth limits of circulation as the system temperature increases. The volume increase, therefore, is largely a function of the area of the system, suggesting it is related to the area of the underlying heat source. Natural evolution will result in descent of the brittle-ductile transition, which can be regarded as an approximate 400°C (752°F) isotherm.



Schematic Diagram of the SP Data Collection System

TECHNOLOGY FOR IMPROVING ECONOMICS ON GEOTHERMAL ENERGY CONVERSION TO BE DEMONSTRATED

Demonstration Projects

DOE's Golden Field Office has selected two proposals for award of three-year Cooperative Agreements to demonstrate the economic benefits of improved electric generation systems in geothermal applications. One of these was signed with Douglas Energy Co. of Placentia, California, to install a 1-MWe Biphase rotary separator turbine (RST) at the California Energy Company's Coso Geothermal Project. Douglas is currently testing a 12-inch prototype device and expects to replace it with a 30-inch RST. This device will be tested at Coso for two years to demonstrate the feasibility of retrofitting existing flashed-steam power plants with Biphase turbines. It is expected that this could increase the efficiency of flashed steam power plants by up to 30 percent both at home and abroad.

The other Cooperative Agreement was awarded to Exergy, Inc. of Hayward, California, for demonstration of the world's first commercial Kalina cycle power plant, a 12-MWe unit to be located at Steamboat, Nevada. This will be a highly recuperated binary cycle plant using a mixture of ammonia and water as the working fluid operating on a 170°C (335°F) geothermal fluid supply; it will not, however, feature the distillation/condensation subsystem that is typically included in Kalina cycle designs for higher temperature heat sources. Commercial operation is expected in early 1997. Exergy projects up to a 40 percent improvement in efficiency over more conventional binary cycle designs by using this technology.

Corrosion-Resistant Linings for Heat Exchanger Tubes

This project began with the identification by Brookhaven National Laboratory of a formulation for a corrosion-resistant, thermally-conductive polymer concrete that showed promise for reducing the costs of corrosion-resistant heat exchanger tubes and piping. Idaho National Engineering Laboratory constructed a heat exchanger test skid employing tubes lined with this material, operating it first at the DOE Geothermal Test Facility and subsequently at Magma Power Co.'s Red Hill plant at the Salton Sea. The National Renewable Energy Laboratory currently oversees the project and has contributed a methodology for inspecting the tubes and analysis of tube performance. The project is now covered by a Cooperative Research and Development Agreement. In field tests to date the polymer concrete has performed as well as the stainless steel reference material also being tested.

Field Investigation to Examine the Impact of Supersaturated Vapor Expansions on Turbine Performance

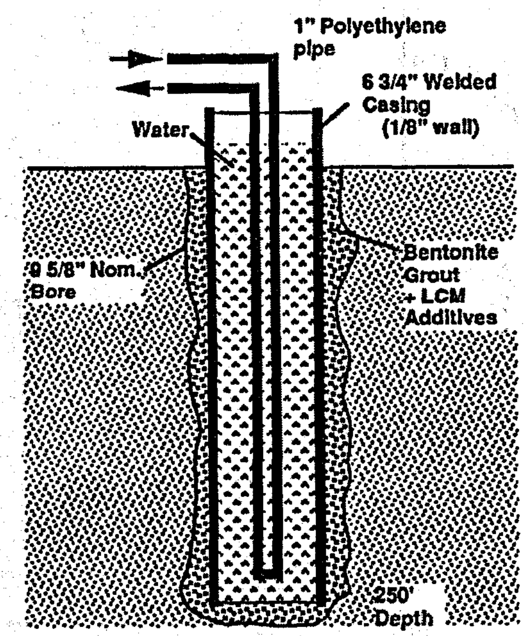
DOE's Heat Cycle Research has focused upon power cycles which have the potential for the increased utilization (power produced per unit quantity of fluid) of the hydrothermal resource. Studies to date have confirmed the viability of technical concepts that could enable binary power cycles to achieve a performance approaching practical thermodynamic maximums. Investigations in progress are examining the potential improvements that result from allowing super-saturated turbine expansions. During these metastable expansions, the working fluid is maintained as a supersaturated vapor during the turbine expansion process; if at equilibrium conditions, liquid condensate would be present. If researchers can show these expansions proceed without a degradation in turbine performance or damage to the turbine internals by any condensate which forms, a projected eight percent improvement in the performance of the advanced cycle could be realized. Investigators are presently examining the condensation behavior of these expansions, as well as determining the impact of these expansions on turbine performance.

SANDIA SEEKING LOW-COST VERTICAL GHP INSTALLATION

Sandia National Laboratories is conducting a program aimed at reducing both residential and commercial GHP drilling costs, assisting the Department of Defense in expanding use of GHPs, and assisting the Geothermal Heat Pump Consortium in expanding GHP market share.

Sandia is currently focusing its R&D efforts on the vertical installations of heat pumps. This is because of its experience with geothermal drilling technology and the belief that low-cost, vertical techniques are necessary to increase the market penetration of GHPs. This belief stems from the fact that while horizontal exchangers are more popular in residential applications and usually cost less than vertical installations, there are many cases where vertical loops are the best option due to space limitations and customer need to maximize disruption to landscaping on retrofits.

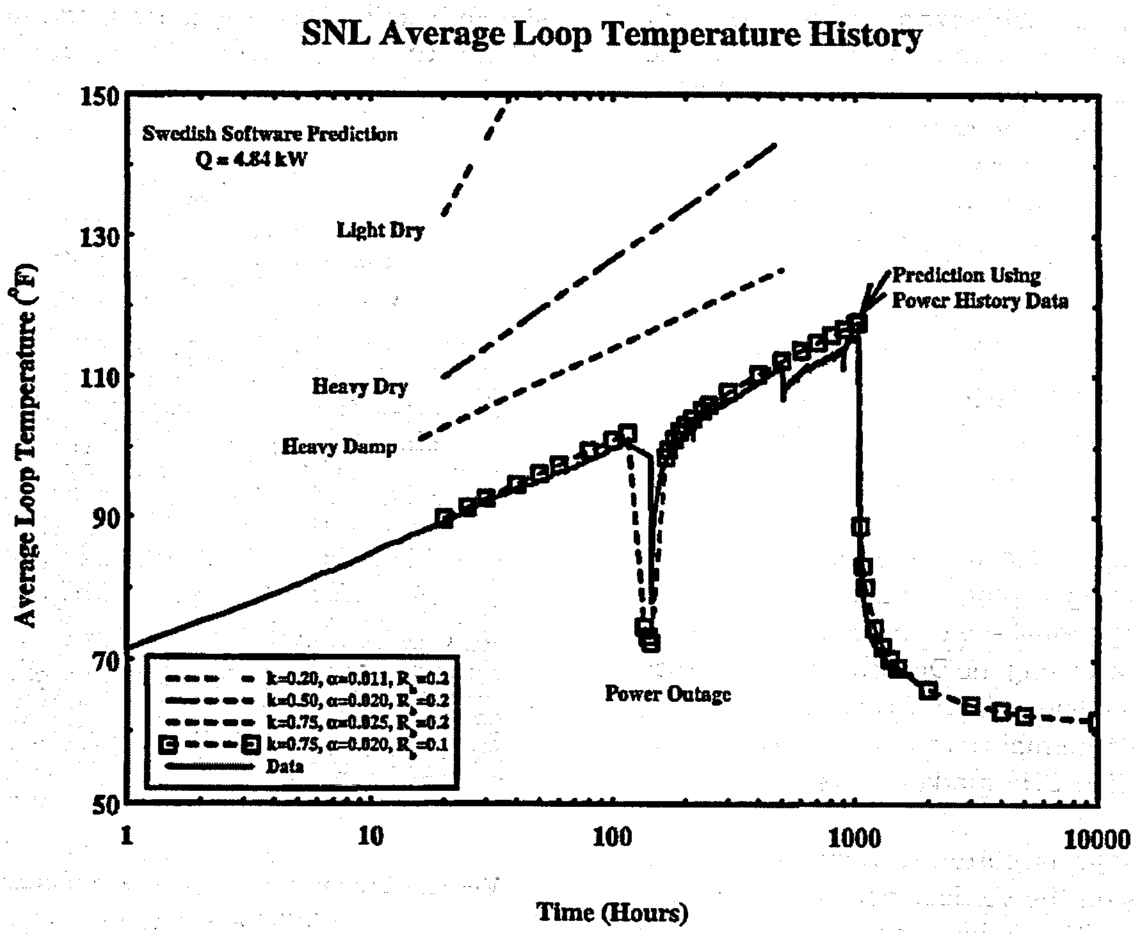
To gain experience with vertical loop installations, Sandia installed an experimental closed loop heat exchanger in Albuquerque, the details of which are shown below. This loop performed much better than expected since the soil



Vertical Ground Source Heat Exchanger at SNL Test Site

properties at the site were thought to be more like the "light dry" soil prediction shown in the graph below, as opposed to the properties for "heavy dry" and "heavy damp," terms defined by Oklahoma State university. This needs more investigation as the ability to estimate local soil properties has a profound influence on loop performance.

Plans for the test program are to continue work with vertical polyethylene loops to investigate ways to improve predicted analysis of their performance, attempt to install some test loops at lower costs, and identify other means of completion which are more stable for the Albuquerque area and arid areas of the U.S. southwest. Comparative testing of alternative geometries and/or materials for ground loops which may offer improved heat transfer is planned.



Thermal Response of Vertical Heat Exchanger at SNL

PROTOTYPE PRESSURE/ TEMPERATURE LOGGING SYSTEM FOR GEOTHERMAL WELLS AVAILABLE TO INDUSTRY

A prototype pressure/temperature logging system for geothermal wells developed by Sandia National Laboratories is available for evaluation by industry. This is the first of a suite of memory logging tools designed to overcome deficiencies in existing tools and forms the basis for future instruments.

The new technology incorporates the ability to make downhole "decisions" based on preprogrammed scenarios. In addition, the tool possesses a number of other attributes:

- minimized cost within the constraint of satisfactory performance
- transportability by ordinary passenger air service (with the exception of the cable assembly)
- measurements traceable to national standards
- compatibility with diamond-core hole dimensions
- operability to borehole temperatures of 425°C (800°F)
- minimized personnel training
- basis for more advanced instruments.

The total component cost of the pressure/temperature logging system (excluding the computer support system) is estimated to be $16,000; a system that measures only temperature is estimated to cost $10,500. These costs do not take into account engineering overhead, and any profit that a service company would require if it is to undertake support of the tool. Furthermore, they do not reflect the cost of calibration, since it is the intent of the Sandia program to identify components that are sufficiently pedigreed by their manufacture so as to minimize or eliminate the need for a calibration laboratory.

THREE RESEARCH PROJECTS UNDERWAY TO REDUCE COSTS OF GEOTHERMAL DRILLING

The Sandia Geothermal Research Department has undertaken an advanced synthetic diamond drill bit project to develop new commercial products with longer bit life and higher penetration rates in hard formations and is continuing its investigation of slimhole drilling as a valid exploration method. In addition, Brookhaven National Laboratory is investigating lightweight, CO_2-resistant cements for geothermal well completions.

Advanced Synthetic-Diamond Drill Bit Program

Over the years Sandia has contributed significantly to the development of polycrystalline diamond compact (PDC) bits which have helped to reduce the cost of drilling in soft- to medium-hard formations. For instance, drilling costs in the Gulf of Mexico have been cut in half using PDC bits, and cost savings of $100,000 per bit run have been reported in the literature. However, the hard, abrasive, and fractured rock formations drilled to access geothermal reservoirs are generally considered beyond the capabilities of current synthetic-diamond bit technology. Roller bits, which are generally used, suffer from inherently low penetration rates, accelerated bit wear, and often severe loss of hole gauge and roller bearing failures. If synthetic-diamond bit technology can be extended into harder rocks, it will have a significant cost-saving impact in the geothermal industry. Drilling experts estimate, for example, that if both bit life and penetration rate could be doubled, an average 20 percent reduction in drilling costs would occur. Since well costs represent 35-50 percent of the total costs of a geothermal project, the importance of this research to the future of geothermal industry is apparent.

Eight drill bit companies have teamed with Sandia to work on five projects to build on the potential demonstrated by new types of PDC cutters developed in recent years by industry and will pursue improvements in each branch of synthetic-diamond bit technology. The five projects include:

- Advanced PDC cutter development and bit design with Smith International and Megadiamond
- Optimization of track-set cutting structure with Security Diamond Products
- Claw cutter optimization with Dennis Tool Co. and DBS, a Baroid Company
- Optimization of impregnated diamond drill bits with Hughes Christensen Co.
- Advanced thermally stable polycrystalline (TSP) drill bit development with Maurer Engineering and Slimdril International.

The program is funded equally by industry and DOE's Office of Fossil Energy and Geothermal Division and includes joint and cost-shared work over a two-year period.

Slimhole Drilling for Geothermal Exploration

Drilling costs associated with exploration and reservoir assessment are a major factor affecting future geothermal development. Virtually all of the reservoirs discovered and found to be economically feasible for development by early industry and industry/government exploration are already in commercial production, and new, as yet undiscovered resources are essential to growth in the use of geothermal energy. Yet, the geothermal industry (utilities and operators) needs to reduce the costs of exploration to be competitive in meeting the expanding requirements in the western U.S. for environmentally benign, alternative energy sources.

Slimhole wells in lieu of production size wells have been shown to reduce oil and gas exploration costs by 25 to 75 percent, but the more hostile conditions of the geothermal environment present technology challenges that must be solved before the cost impact can be thoroughly evaluated. Thus, a government/industry group is proceeding with a project to determine whether a geothermal reservoir can be sufficiently evaluated with data collected in slimholes to satisfy the requirements of the investment community. (See GPM Nos. 14 and 15).

In-house analysis has been conducted at Sandia along with field experiments on existing geothermal coreholes and collection of an extensive data set from comparable drilling in Japan. In addition, an industry cost-shared slimhole was drilled on a producing property, the Far West Capital site at the Steamboat Hills geothermal field in Nevada.

The field test results were encouraging, showing, among other findings, that slimholes can be flow-tested with successful surface and downhole measurements and that relatively cheap and simple surface measurements (e.g., James tube and Weir box) can give flow rate and downhole enthalpy. In addition, numerical simulation of flow in the wellbore can yield a predictive curve of flow rate versus wellhead pressure, as shown by the slimhole data. Applied to a larger diameter well, this same simulation will give the same kind of production curve, giving a measure of the reservoir's commercial potential. Extrapolation from the slimhole data to the wellbore diameter of a nearby production well at Steamboat Hills gave a reasonable estimate of the larger well's actual flow rate for a given wellhead pressure.

As a comparison the slimhole, including all testing and overhead, cost approximately $150 per foot while the neighboring production well (12.25" production diameter) cost $377 per foot. Although the slimhole's greater total depth reduced its overall cost per foot, the intermediate cost of drilling the slimhole to the same depth as the large well was less than 60 percent of the latter's total cost.

However, the highly fractured, highly permeable Steamboat Hills reservoir may not be generally representative of other geothermal reservoirs. Thus, a need is indicated for further exploratory drilling and testing in reservoirs with different flow characteristics and comparison of these results with production wells in new reservoirs.

Development of Lightweight, CO2-Resistant Cements

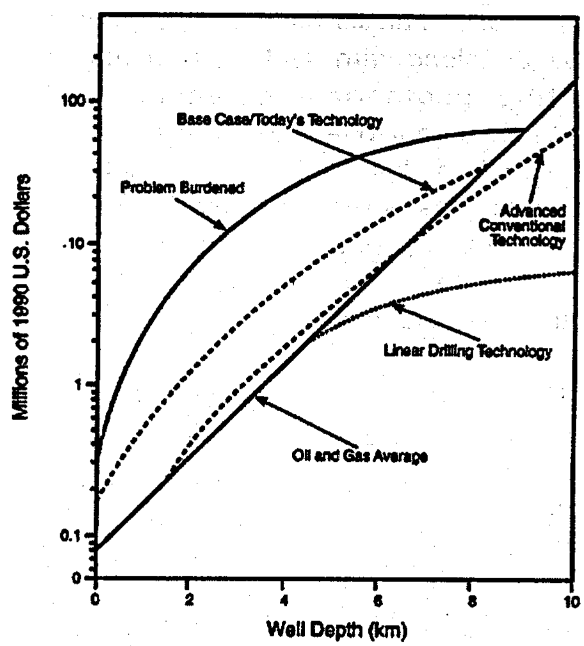
The life expectancy of geothermal wells is often limited by the durability of the cement used in completing the well. In order to preserve its durability, low permeability is a major cement characteristic needed to avoid degradation by water intrusion. In addition, formulations that will resist deterioration by carbon dioxide that may be present in the geothermal fluid are needed along with lightweight, yet strong, durable cements since conventional weight products can contribute to lost circulation zones.

A major step in developing these characteristics is the Brookhaven National Laboratory (BNL) finding that materials formed by acid-base reactions between calcium aluminate compounds and phosphate-containing solutions yield high strength, low permeability, and CO2-resistant cements when cured in hydrothermal environments. The cementing formulations developed as a result of this finding are pumpable for several hours at temperatures up to 150°C (302°F), thereby making their use for well completions technically feasible. When this cementing matrix was exposed in an autoclave containing NA_2CO_3-saturated brine for 120 days, <0.4 wt% $CaCO_3$ was produced. A conventional portland cement-based well completion material will form ~10 wt% Ca CO_3 after only seven days exposure. The addition of hollow aluminosilicate microspheres to the uncured matrix constituents yields slurries with densities as low as ~1.2 g/cc which cure to produce materials with properties meeting the criteria for well cementing.

Laboratory characterization is nearing completion, engineering scale-up is underway, and plans for field testing in a variety of geothermal fluids are being made.

A NEW DRILLING RESEARCH INITIATIVE

The National Advanced Drilling and Excavation Technologies Program (NADET) offers the potential for technology development that could dramatically improve the economics of geothermal drilling, ultimately producing a linear cost variation with depth. (See curves below.) The idea for NADET, as reported in GPM No. 15, was born of the commonality of tasks or needs in making usable underground space regardless of whether the space is large or small, deep or shallow, vertical or horizontal among geothermal, oil and gas, mining, waste disposal, tunneling, groundwater interests, as well as the drilling industry itself.



Drilling costs for completed geothermal wells (adapted from Tester and Herzog, ***Economic Predictions of Heat Mining: A Review and Analysis of Hot Dry Rock (HDR) Geothermal Energy Technology,*** MIT-EL 90-001).

In the first stage of NADET implementation, at the behest of DOE's Geothermal Division, the Massachusetts Institute of Technology established an organizing committee in May 1992 that included representatives from various industries. In April of 1994 the committee issued a report that contains a justification and rationale for the NADET program and a proposed organizational structure. The Geothermal Division contacted over 400 companies with strong underground business interests; 80 firms, including 23 geothermal companies, indicated an interest in participating. They offered their own resources ranging from funding to research experience. However, due to the scope of the program and the current financial stresses on drilling and related industries, the government will bear the majority of the developmental costs with industry assuming greater financial responsibility during commercialization.

Activities during the first implementation stage of NADET include an exhaustive search of the Russian literature on advanced drilling; a characterization of advanced drilling systems; and, perhaps most importantly, a feasibility study by the National Research Council that examined the viability of different advanced drilling techniques and made recommendations on improvements likely to have the greatest impacts on drilling economics.

During the second stage of NADET implementation, the most promising rock penetration techniques will be investigated. Novel drilling systems will be designed and analyzed; components will be fabricated and tested. Eventually, one or more prototype systems will be built and tested in the field. During the final stage, industry stakeholders will market commercialized systems based on the prototype(s). These systems will undergo extensive testing for different applications in a variety of environments. By the end of the third stage, one or more new systems will have emerged and achieved full commercialization.

"We are confident that NADET will usher in a new era of expansion and prosperity for those whose business depends on access to the subterranean world," Allan Jelacic of the Geothermal Division told the Geothermal Program Review XII audience in April. "Perhaps someday, thanks to the efforts begun with NADET, the conventional drilling rig we know so well will become just another museum curiosity."

INNOVATIVE WASTE TREATMENT TECHNOLOGY TO BE TESTED AT THE GEYSERS

CET Environmental Services, Inc. of Emeryville, California, and Brookhaven National Laboratory (BNL) have entered into a Cooperative Research and Development Agreement (CRADA) to field test the biochemical waste treatment technology developed by BNL for specific application to geothermal wastes. The test will be conducted at a Pacific Gas and Electric Co. power plant at The Geysers field in Northern Sonoma County in California.

The new technology will be applied as a waste reduction strategy for the metal-containing wastes generated. In laboratory tests, better than 80 percent removal of toxic metals is achieved in very short periods. This performance provides both economic and environmental advantages over conventional methods for treating large bulk wastes containing only trace amounts of toxic metals. The parts-per-million levels render the entire waste stream "toxic" as defined in state and federal statutes, thus requiring much more costly disposal as "hazardous" wastes. The disposal costs are increasing with increasingly stringent mandates, and space for disposal is decreasing.

The laboratory/industry partnership is expected to result in the design, construction, and operation of a pilot plant at The Geysers to demonstrate the technology. This effort is intended to bridge the gap (i.e., field testing and demonstration) between the laboratory based efforts and commercialization.

SECOND EPRI WORKSHOP ON HDR UPDATES UTILITIES ON PROSPECTS FOR HEAT MINING

The second Electric Power Research Institute (EPRI) workshop on hot dry rock, held in May 1994, focused on the status of worldwide HDR research and development, providing utilities with an update on the prospects for power generation via heat mining. The status review provided the starting point for discussions on what could and should be done next by the U.S. government, by U.S. industry, by U.S. state governments, and by international organizations or through international agreements. For the most part, the discussion centered on projects jointly sponsored by the U.S. Government and U.S. industry, with states supplying coordination and initial help in evaluation, planning, and site selection.

It was concluded that the emerging rules for electric utilities competing in power generation make it very unlikely that the rate-payers of any one utility (or small group of utilities) can pay the differential to support this new heat mining research and development effort. However, the community of interests represented at the workshop may be able to make the case for national or international support, based on the potential size and economics of this resource as a benefit for the nation as a whole and as a contribution to reduced carbon dioxide emissions worldwide.

(See following article on DOE HDR solicitation.)

DOE SEEKS COMMERCIAL-SCALE TESTING OF HDR TECHNOLOGY

The Department of Energy Albuquerque Operations Office has solicited proposals from industry to participate in a 50-50 cost-shared, industry-led project to install and operate a commercial-scale hot dry rock heat extraction and energy conversion system. It is desired that the prototype system produce and market electric power or heat generated in order to quantify the capital costs of installation and to assess the performance of the engineered HDR reservoir under conditions of practical operation over a period of at least three years.

The Cooperative Agreement sought is authorized by the Energy Policy Act of 1992 which established a cooperative Government-private sector program with respect to HDR energy resources on public lands or National Forest lands. Its goal is to provide an incentive for U.S. industry to test the commercial prospects of this technology, thereby stimulating U.S. industry to begin commercial applications. It is expected that the operator will benefit by:

- gaining experience in the utilization of a resource with the potential to become a major clean-energy source around the world

- generating income from the sale of energy produced by the prototype plant

- gaining possession of the assets of the project after the initial three years of plant operation.

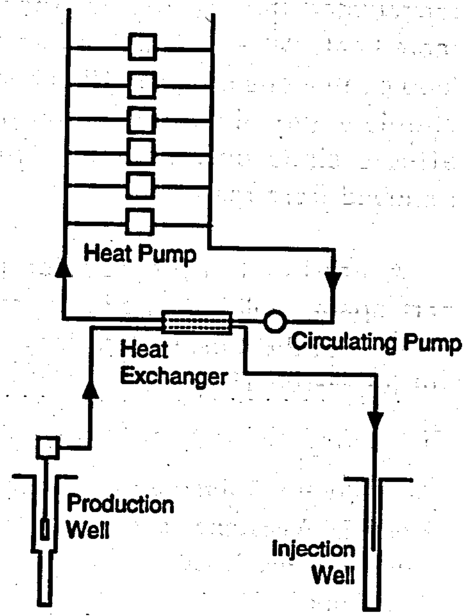
The HDR process is extremely simple both in concept and execution. It involves drilling a well deep enough to reach hot rock and pumping water down the well under high enough pressure to open natural joints in the rock. The pressurized water flows into these opened joints and is rapidly heated to the rock temperature. In this manner, an artificial geothermal reservoir is created consisting of a relatively small amount of water dispersed in a large volume of hot rock.

One or more additional wells can then be drilled into the reservoir at some distance from the first, to tap this pressurized hot water and bring it to the surface for practical use. After its thermal energy has been extracted, the same water can be recirculated through the hot rock to mine more heat. When carried out as a closed-loop continuous process, HDR heat mining should have almost no environmental effects since only heat is permanently removed from the earth.

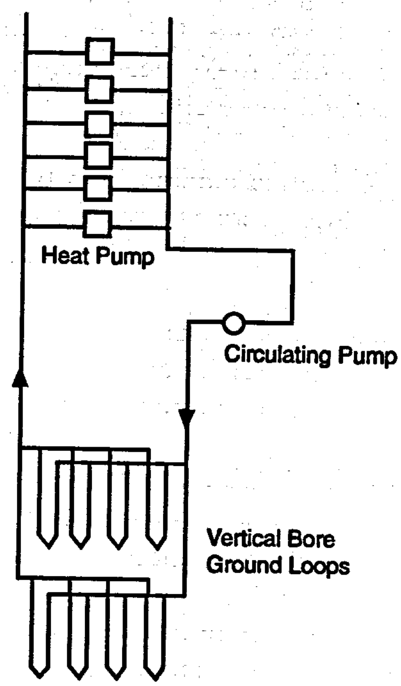
A Pre-Bid Conference for potential participants will be scheduled for January 1995, and the closing date for bids will be set for March 1995. The Point of contact is:

Ms. Laurene Dubuque,Contracting Officer
Financial Assistance and Purchasing Branch
Contracts and Procurement Division
Telephone: (505) 845-4301
Fax: (505) 845-4004

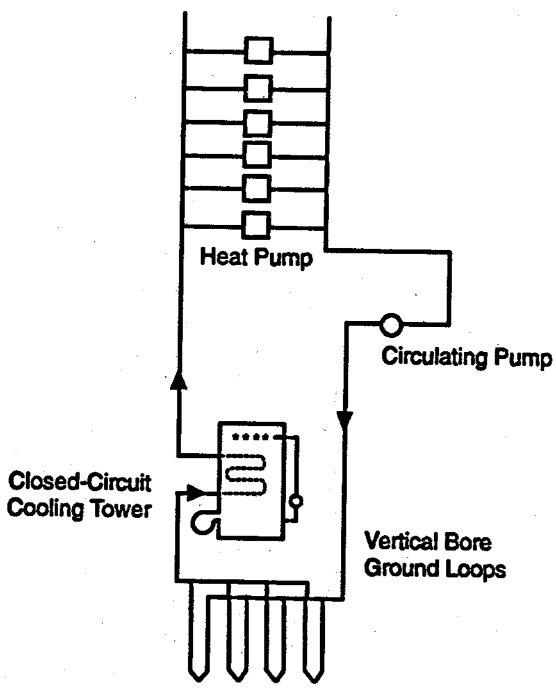
Groundwater
Heat Pump System



Ground-Coupled
Heat Pump System



Hybrid Ground-Coupled
Heat Pump System



CAPITAL COSTS OF GEOTHERMAL HEAT PUMP SYSTEMS FAVOR GROUNDWATER SYSTEMS

The capital costs associated with installation of three different geothermal heat pump systems for commercial buildings have been compared by the Geo-Heat Center at the Oregon Institute of Technology (OIT). The systems included groundwater, ground-coupled, and hybrid (ground-coupled with cooling tower) over a size range of 50 to 500 tons. The tonnage range refers to building block load rather than installed capacity. The basis for all calculations was a building loop temperature during the peak cooling load of 29°C (85°F) supply water (to the heat pumps) and 35°C (95°F) return water (from the heat pumps). Costs were developed for three groundwater/soil temperatures -- 10°C (50°F), 16°C (60°F), and 21°C (70°F) representing northern, central, and southern climates.

Based on the most favorable conditions calculated, groundwater systems -- those in which heat exchangers are used to accomplish heat rejection and supply -- enjoy substantial capital cost advantage over the other two systems over the entire range of capacity covered. Based on least favorable conditions, the groundwater system has the capital cost advantage at system capacities of 100-175 tons and above. Below this range, the hybrid system is the most attractive. Only under conditions of less than 100 tons with well depths of 800 feet do groundwater systems become more costly than ground-coupled systems.

Costs associated with groundwater wells are, to some extent, similar to those for vertical bore ground-coupled systems, as they are frequently characterized by a cost per foot of depth. However, the flow rate produced by the well rather than its depth determines the well's capacity to meet heating and cooling loads. The unit cost for small systems (50-100 tons) is often higher by a factor of 3 compared to costs for larger systems (300-500 tons).

Costs from actual ground-coupled systems rather than calculations were used in the comparisons. Costs for these systems are a function of two values -- the number of feet of borehole necessary per ton of heat rejection and cost per foot for completing the vertical bore and installing the piping. For purposes of the comparisons, the values of 150 feet per ton for 10°C (50°F) soil, 200 feet per ton for 16°C (60°F) soil, and 250 feet per ton for 21°C (70°F) soil were used. Cost per ton was estimated at $5 per foot of bore.

Hybrid systems include both a ground loop and a cooling tower. The ground loop is sized to meet the heating load and it, along with the tower, is used to meet the cooling heat rejection load. As a result, hybrid system costs are a combination of ground loop costs and cooling tower costs. Hybrid systems enjoy more favorable economics as the heating ground loop length decreases as a percentage of the cooling ground loop length requirement. This is because the cost per ton of the cooling tower is less than the cost per ton of the ground loop. Generally, the hybrid system is attractive in situations where ground loop costs per ton are high, and where the heating loop length requirement is low relative to the cooling loop length requirement.

The report on the study addresses only capital costs. Other issues -- e.g., operating costs such as electricity for pumps and fans, water treatment costs (tower), and regulatory issues with respect to groundwater -- should be considered in selecting a system to be used.

The report is available from the Geo-Heat Center, Oregon Institute of Technology, Klamath Falls, OR 97601.

PRELIMINARY RESULTS OF TWO-PRONGED LOW-TEMPERATURE GEOTHERMAL STUDY ENCOURAGING FOR INCREASED DIRECT USE

Preliminary estimates of an updated inventory of geothermal resources useful for direct heat applications indicate that 254 cities in 10 western states could potentially displace 64 trillion Btu per year with geothermal district heating. Data concurrently collected on use of geothermal heat pumps in the U.S. show that well over one-half of the country, particularly the central and southeast, possess the hydrogeologic characteristics necessary to make the groundwater heat pump a very viable option.

These findings are the result of a two-pronged program funded by Congress in FY 1991 to 1) update the inventory of low- and moderate-temperature geothermal resources, and 2) develop data which would accelerate the use of geothermal heat pumps in the U.S. The program was conducted by the Geo-Heat Center at the Oregon Institute of Technology (OIT), the Idaho Water Resources Research Institute, the Earth Science Laboratory at the University of Utah Research Institute, and teams representing the cognizant agencies of 10 western states.

The state teams have catalogued more than 11,000 thermal wells and springs, more than twice the number of the previous assessment in 1983. More than 900 low- to moderate-temperature resource areas are indicated, and perhaps a greater number of isolated (singular) thermal wells or springs.

Direct use of geothermal fluids is documented at more than 250 sites, including commercial and municipal buildings, rapidly expanding greenhouse and aquaculture industries, and major space-heating districts in California, Oregon, Nevada, Idaho, and Colorado. More than 40 high priority resource study areas have been identified, along with high potential for near-term direct heat utilization at 150 new sites.

Each state team is producing a new geothermal resource map showing thermal wells and springs for their state, and the Geo-Heat Center and UURI are working with the state teams to evaluate the collocation of resources with communities and potential users and to establish priorities for more detailed resource studies.

As part of the DOE effort to increase the use of GHPs throughout the country, OIT has collected and interpreted engineering data on the performance of existing residential and commercial (see above article) installations. In addition, OIT has investigated utility demand-side management (DSM) programs to determine: 1) the most effective and successful utility marketing and incentive programs to expand GHP markets; 2) barriers to market entry; 3) the benefits to utilities from reduced peak demand and higher annual load factors; 4) the number of GHP units installed in utility areas; and 5) suitability of GHPs for northern climates. IWRRI has focused on identifying those portions of the country with particularly favorable conditions for installations of earth-coupled and groundwater heat pumps, reaching the above conclusion on the potential for the central and southeast areas of the country. Based on information supplied by electric utilities, the other findings include:

- The percent of residential GHP energy savings over air source heat pumps range from 13 percent to 60 percent with a mean of 33 percent; savings relative to electrical resistance systems with air conditioning units range from 25 to 70 percent with a mean of 52 percent. Comparable figures for commercial building installations are 22 to 44 percent and 40 to 68 percent respectively.

- Residential system simple payback ranges from two to 6.8 years with a mean of 4.3 years; the largest barrier to faster payback is the cost of the ground loop.

- Other deterrents to installation of GHP systems include: low cost of natural gas; lack of a product service infrastructure: GHP manufacturers, suppliers, dealers, and loop installers; and lack of customer knowledge on heat pump technology.

- Incentives provided by utilities include cash rebates (average of about $200/ton), low- cost financing, discounted energy rates, and, in a few cases, ground loop installations.

UURI has completed fact sheets documenting residential and commercial GHP performance, economic analysis, and benefits. These sheets and detailed reports are available from the Geo-Heat Center.

Source: Geo-Heat Quarterly Bulletin 3/94 and Quarterly Project Programs Report 1-3/94.

GHPs RECEIVE CEC COMMERCIALIZATION AWARD

Another effort to stimulate GHP use resulted from the questions asked by DOE's Geothermal Division: Why is GHP activity lowest on the West Coast and how can a GHP market be stimulated in California? The voluntary California Geothermal Heat Pump Committee was formed to identify GHP issues and solutions. Local interests formed into self-assigned groups to: (1) site, facilitate and collect performance data from two dozen pilot GHP installations; (2) conduct a two-phase paper study of GHP economics and performance results at several California locations; (3) modify State energy efficiency codes for buildings and appliances to recognize GHPs; and (4) create a regional GHP Training Center in Davis, California, to serve utilities, builders, researchers, and GHP marketers.

In 1994, the California Energy Commission selected GHPs for its Opportunity Technology Commercialization program (OTCOM). A Commercialization Collaborative was formed to produce and implement a Sustained Orderly Development plan in the state. At the same time, the California Geothermal Heat Pump Committee has been renamed the Western Geothermal Heat Pump Committee to promote GHP market development elsewhere, concurrent with California events.

CALIFORNIA

CEC BEGINS NEW GEOTHERMAL FUNDING CYCLE; APPLICATION MANUAL REVISED

The California Energy Commission has initiated a new funding cycle of its Geothermal Program. This program enables the Commission to provide funding to public and private entities for geothermal environmental impact mitigation, as well as research, development, demonstration, and commercialization. However, the current Program Opportunity Notice states that recent recommendations of the Commission's Research, Development, and Demonstration Committee have been to fund R, D, & D projects rather than planning or mitigation projects. No program funding is available for mitigation measures required by a permit or for advertising, marketing, business plans, or drilling bonds.

To qualify, a project must directly relate to geothermal energy and be located in California or sponsored by a California company. Contingent awards are being offered for which repayment is required if the project is successful. At project completion, a contingent award is converted to either a loan or grant. If the Commission finds that the project is producing savings or revenues such that the award can be repaid in full, or in part, the award is converted to a loan with interest rates as follows:

Repayment Term (Years)	Public Entity	Private Entity
2-4 Years	ML 500 minus .1375*	Prime plus 125**
5-7 Years	ML 500 minus .125	Prime plus .625
8-12 Years	ML 500 plus .375	Prime plus 1.125
13+ Years	ML 500 plus .625	Prime plus 1.625

* Merrill Lynch 500
** Prime Rate

A matching contribution is required for all projects funded by the Commission. The minimum match requirement is 20 percent of the overall project cost. Private entities and public entities that receive significant geothermal royalty revenues from the Federal Government must provide a minimum of 50 percent of the overall project cost.

The Commission's announcement emphasizes that the Application Manual was revised in July 1994, the requirements of which are significantly different from previous versions. Non- conforming applications will be returned.

Three million dollars are available for project funding for Fiscal year 1994-95. The solicitation for applications is open and continuous.

To obtain a copy of the revised manual, application form, or more information regarding program procedures, the Commission may be reached on: (916) 654-4185.

CEC FUNDING FOR INTERNATIONAL ENERGY PROJECTS

While the deadline for filing proposals for funding pursuant to the sixth California Energy Commission's International Energy Fund Solicitation passed on November 17, 1994, this notice is included here as a reminder of the availability of these funds. A request to be put on the mailing list for future funding cycles may be made by telephoning the Grants and Loan Offices of the International Energy fund at (916) 654-4455.

The Commission awards funds to assist California-based firms in conducting energy-related export business and identifying opportunities for international energy development. Each year, $250,000 has been allocated for funding, with awards up to $25,000 per project. The International Energy Fund was created to assist firms in performing preconstruction activities leading to exports of technologies and services for power plant and energy-related installations in foreign nations. Preconstruction activities include, but are not limited to: market analyses, feasibility studies, resource assessments, site analysis, bid and/or proposal development, and establishment of technology transfer agreements. Activities may also include efforts to encourage private financing and foreign ownership of projects in these countries.

HIGH QUALITY SAN BERNARDINO GEOTHERMAL FLUID MEETS REQUIREMENTS FOR SURFACE DISCHARGE

The city of San Bernardino is blessed with high quality geothermal fluid which can be disposed of on the surface without costly treatment or injection into the geothermal aquifer. Since the fluid contains only one grain in hardness (17 parts per million as calcium carbonate) and meets nearly all the potable maximum contaminant levels for domestic drinking water, it is attractive to potential customers with problems meeting local discharge and sewer pretreatment guidelines.

For example, the fluid is used in laundry processes without the need for softening or heating. One industrial laundry, AHSL, reported total savings of $354,000 for the first year of operation on the geothermal system. It uses approximately nine million gallons per month of the fluid, and since the brine from the softening process no longer needs to be hauled away, a $50,000 savings is realized from that modification alone. In addition, the laundry meets air quality guidelines since a second boiler is no longer required.

Source: District Heating and Cooling, 1st Quarter 1994

IDAHO

GEOTHERMAL ALLIGATOR FARM

An alligator and catfish farm using geothermal waters is being developed in the Raft River area of Cassia County, Idaho. Garland Larson plans to raise thousands of alligators and to eventually produce nearly 6 million pounds of processed catfish per year. He will start this fall with 5,000 alligators -- half of the hatchlings will be about nine inches long and the other about 20 inches long.

The alligators will be raised for meat and skins. The remains of farm animals and high-protein fodder will be used to feed the alligators. A hatchling alligator will take about two years to reach a six foot length. Larson will ship most of the meat to southern states, but he hopes that people in Idaho will also take a liking to it.

Source: IGA News 1-3/94

NEVADA

FARMERS SEEK PERMISSION TO USE GEOTHERMAL RESOURCES IN CRUSTACEAN CULTIVATION

While cow, alfalfa, and sheep production may be on the decline in Douglas County, Nevada, the number of lobsters on the range could reach thousands in the next couple of years. A California company wants to open an experimental lobster farm on four acres near Minden, making use of geothermal spring waters.

Richard Leudemann of Lobster's West of Bay Port is proposing to raise about 64,000 lobsters a year in a metal building equipped with two tanks filled with 17 million gallons of water. The four-year experiment would hatch lobsters until they are ready to grow to size in larger tanks. The growout tanks would be heated by geothermal water that would be injected back into the aquifer. Live lobsters would be shipped twice a month to local markets.

Leudemann and his contractor, Scott Construction Co., will ask the County Commission for a special-use permit to run the lobster farm on agricultural property. While other kinds of farming are allowed in agricultural zones, aquaculture or lobster farming is not listed. The use permit is presently being reviewed by the county planning department.

Source: IGA News 1-3/94

OREGON

KLAMATH FALLS GEOTHERMAL DISTRICT HEATING SYSTEM RECOVERS

The downtown geothermal heating system in the city of Klamath Falls, Oregon, once plagued by leaking pipes and a cash-flow crisis, has proved to be both reliable and economical, a city official said recently. Kent Colahan, geothermal supervisor for Klamath Falls, told members of the Geothermal Advisory Committee that the system has operated flawlessly, and that revenue collected from users is increasing.

"We're to a point now that we have some unallocated funds sitting in reserve," Colahan said. The city should enter the next fiscal year with a $19,000 geothermal contingency fund, he said.

The downtown geothermal loop, originally built in 1982-84, had to be completely overhauled in 1990 to replace faulty pipe fittings throughout the system. Most government buildings in the downtown area were connected to the system, but fees collected from the government agencies failed to cover expenses. The city announced in February 1992 that it would have to find additional customers in the private sector, or shut the geothermal system down. Since then four private concerns have begun using the system, boosting revenues for the city, and three others are planning to join.

Even with all the new customers, the system is far from reaching its maximum load, Colahan said. "We are utilizing less than 10 percent of the system's capacity," said Colahan, who believes the system could heat the entire downtown district. "I am sitting down there operating at minimum, and having no trouble at all maintaining 180 degrees in the system."

Geothermal heat is already less expensive than any other form of heat, Colahan said. As more businesses and other private concerns join the system, the cost could be reduced further, he added. "If we're very successful in our marketing and getting new customers, renegotiation of contracts with our current customers could conceivably result in rates going down," he said.

Source: Geothermal Resources Council

CANADA'S FIRST GEOTHERMAL POWER PROJECT SPURRED BY FAVORABLE GOVERNMENT DECISIONS

Canada's first geothermal power project, to utilize the Meager Creek resource in the Pemburton area of British Columbia, was spurred by two supportive actions of the B. C. Ministry of Energy, Mines and Petroleum Resources. A larger lease was issued to Meager Creek Development Corp., a wholly-owned subsidiary of Canadian Crew Energy Corp., and Pacific GeoPower (PGP), a joint venture between Crew and Gary F. Atkinson Holdings Ltd. was authorized to drill an initial geothermal well on the South Meager lease.

The new lease increases the leasehold area from just over a thousand acres to nearly 5,000 acres. The authorized well is designed to provide further evaluation of the capacity and characteristics of the high-grade geothermal resource identified by B. C. Hydro's earlier exploration programs and provide technical data for the design and construction of a proposed initial 60 MWe power plant.

PGP is continuing its public consultation program with area residents and stakeholders to identify specific project issues as they arise. A Community Advisory Committee has been formed to facilitate the exchange of information between PGP and the area's residents.

The South Meager resource is estimated to have a developable capacity in excess of 250 MWe.

Source: Canadian Crew Energy Corp., 7/26/94

BOREHOLE HEAT EXCHANGERS POPULAR SPACE HEATING OPTION IN SWITZERLAND

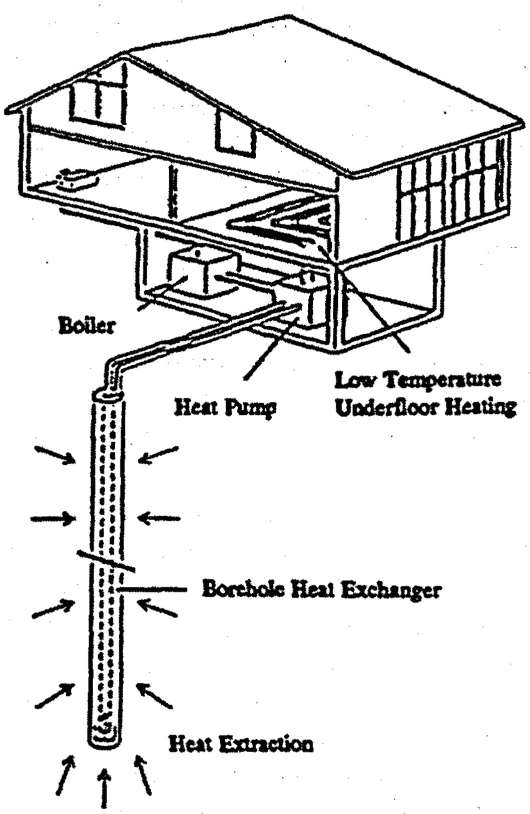
With over 5,000 operating installations, Switzerland has the highest areal borehole heat exchanger (BHE) density worldwide. The use of this technology enhances the country's efforts to reduce its dependence on foreign oil, use indigenous sources of energy, and reduce carbon dioxide emissions.

Shallow, coaxial or U-shaped BHEs are installed in 990-1650 foot deep, backfilled boreholes to extract, by closed-fluid circulation, heat from the ground. They feed the cold (evaporator) system (e.g., floor panel) to heat usually a single dwelling house. The energy supply for the heat exchanger comes from several sources: the vertical geothermal flux itself, the conduction of energy horizontally, advective transport with groundwater, if present, and the compensating effect of heat transfer between the ground surface and the atmosphere. Multiple BHEs are installed for larger units like community buildings, etc. The 5,000 such systems installed since 1980 use about 10,000 BHEs with a total length of over two million feet.

The BHE can be upscaled in order to be installed in otherwise abandoned deep boreholes (e.g., in "dry" geothermal or hydrocarbon exploratory holes). Experimental as well as theoretical studies have been pursued in Switzerland in the last 10 years to establish a sound technical and energy economics base for shallow and deep BHE systems.

Field measurements of ground and system performance parameters at instrumented test facilities over five consecutive heating seasons as well as validated numerical simulations have proven the reliable operation of the BHE systems. In addition to their reliability, projected to last for decades, there are other reasons for the BHE boom:

- Despite higher installation costs than those for conventional oil-based systems, annual "fuel" costs are considerably less. Increases in oil prices anticipated by many also make an oil-independent system even more attractive.



Principle of a BHE heating system with a borehole heat exchanger (plastic tube, installed in a back-filled drillhole, typical length about 100 m), heat pump and low temperature underfloor heating.

- Homeowners prefer an environmentally benign system with no risk of local groundwater contamination that could occur with leaking oil heaters and no emission of combustion products such as CO_2. The introduction of a CO_2 emission tax, under discussion in Europe, provides a further argument for a CO_2-free heating system.

- The Swiss Federal Office of Energy provides a subsidy when oil heaters are replaced by heat pump systems.

Encouraging new developments are on the horizon: efficient, combined heat extraction/storage can be achieved by multiple BHEs carefully managed and operated to yield optimal heat delivery. Foundation piles can be equipped with heat exchangers, although some questions remain to be solved. Finally, deep BHE's can be installed in dry (failure) holes to heat larger objects.

The reliability investigations were carried out jointly by the Institute of Geophysics at the ETH Zurich and the research and consulting company POLYDYNAMICS Ltd. Several commercial companies market the installation and maintenance of BHE systems.

Source: Geo-Heat Center Quarterly Bulletin 3/94

MAGMA POWER PHILIPPINE PLANT UNDERWAY

Magma Power Co. announced in March 1994 that its wholly-owned Philippine subsidiary, Visayas Geothermal Power Company (VGPC), had signed an EPC (engineering, purchasing, and construction) contract with Sumitomo Corp. for the company's three-unit, 216 MWe (net) Malitbog geothermal power plant to be built on the Philippine island of Leyte. The total capital cost of the plant will be approximately $280 million.

Under the EPC contract, Sumitomo Corp. will design, procure, build, and start-up the plant for VGPC on a turnkey basis. The Malitbog plant will be built in two phases, with the first phase consisting of 72 MWe (net) scheduled for start-up in July 1996 and the second phase adding an additional 144 MWe (net) for start-up in July 1997.

The power plant will be developed by VGPC under a "build, own, operate, and transfer" (BOOT) contract with Philippine National Oil Company (PNOC); ownership of the plant transfers to PNOC ten years after the commencement of commercial operation of the second phase. VGPC will generate electricity utilizing geothermal steam supplied by PNOC, and will deliver the electricity to the Philippine National Power Corporation (NAPOCOR) on behalf of PNOC.

Magma formed its Visayas subsidiary in the first quarter of 1994 for the specific purpose of owning, constructing, and operating the three-unit plant. The company opened its first overseas office in Manila which will be responsible for the Leyte project as well as supporting Magma's ongoing project development efforts in the Philippines and Indonesia.

Source: Magma Power Co. Press Release 3/10/94

ORMAT AND THE PHILIPPINES REACH AGREEMENT

Ormat Inc., of Sparks, Nevada, one of the largest manufacturers of binary and combined cycle geothermal power plants, signed an agreement in November 1993 with Philippine President Fidel V. Ramos to design, manufacture, and build a 125 MW power plant in that country.

Making the announcement, Ormat president Dita Bronicki said, "Ormat is pleased to reach this agreement with the Philippine National Oil Company (PNOC) for a Build-Operate-Transfer (BOOT) plant at the Upper Mahiao geothermal field as part of the Leyte-Cebu Power Project."

The power plant will be developed with U.S. private sector investment, and is scheduled to begin to supply electricity in mid-1996 at an estimated project cost of $200 million dollars. The project will be implemented in collaboration with California Energy Company of Omaha, Nebraska, with Ormat manufacturing and building the power plant, utilizing its original technology, and California Energy managing the financing and operating the plant. (See related article in FINANCING.) Under the BOOT arrangement the power plant will be transferred to PNOC after 10 years, at no cost.

During the operation period PNOC, which developed and owns the geothermal field, will supply the geothermal fluid. The Ormat power plant will convert this renewable energy into electricity, with a pollution-free, non-combustion technology.

PNOC will sell the electricity to the Philippines National Power Corporation (NAPOCOR) under a long-term Power Purchase Agreement.

The Upper Mahiao Plant symbolizes the government's dynamic plan to overcome power shortages by basing large portions of its power supply on indigenous energy resources. In fact, the Philippines, which derives 25 percent of its national power supply from geothermal resources, is the world's leading user of geothermal power in percentage generation and is second only to the United States in total installed capacity.

GEOTHERMAL RESOURCES OF KAMCHATKA -- UTILIZATION AND FUTURE DEVELOPMENT

The geothermal resources of Russia's Kamchatka Peninsula have been assessed based on surface manifestations (hydrothermal convection systems and hot springs), heat discharge data, and results of geothermal prospecting. About 2,314 thermal megawatts -- including 1,780 MWt from eleven high-temperature systems -- is the output of these Kamchatkan resources.

The geothermal resource potential of high-temperature systems, calculated by the volumetric method (Muffler and Cataldi) is about 1,130 MWt for a hundred-year period. These figures exclude the hydrothermal systems in the Kronotsky Preserve, like those of Geysers Valley, the Uzon Caldera, and the Big Semyachik Volcanic Massif. The potential of fields with reservoir temperatures below 150°C (302°F) is about 1,345 MWt for a hundred-year duration.

Presently only small parts of Kamchatka's geothermal resources are being utilized. Four high-temperature geothermal fields -- namely, Pauzhetka, Severo-Mutnovskoe, Bolshe-Bannoe, and Nizhne-Koshelevskoe -- have been evaluated. The Pauzhetka field is the only one under exploitation for electrical generation. An 11 MWe power plant has been installed.

The construction of the first phase (about 70 MWe) of the Mutnovskaya power plant -- as well as that of the approximately 48 mile long hot-water pipeline from the Severo-Mutnovskoe field to the town of Elizovo -- are underway.

The Nizhne-Koshelevskoe and Bolshe-Bannoe geothermal fields are not presently under production, although a power plant is planned for the former. Among the eight prospected Kamchatkan geothermal areas with temperatures below 150°C (302°), the Paratunskoe, Nachikinskoe, Esso, and

Anavgaiskoe fields are presently under exploitation. The Paratunskoe field provides thermal fluids to heat 7.5 acres of greenhouses,a health resort, and some dwellings. Thermal fluids from the Nachikinskoe field heat a health resort, while also providing water for balneological treatment. The output from the Esso field heats the village and greenhouses at Esso.

Source: IGA News 10-12/93

FIRST SLOVENE HIGH-TEMPERATURE PILOT PROJECT

Thermal II, a geothermal aquifer, is located about 1,320 feet below the town of Ljutomer, Slovenia. The reservoir temperatures reach above 175°C (347°F).

The local government, encouraged by these temperature readings, decided to build a pilot project in the form of a doublet (a production and injection well). Planned geothermal energy exploitation will resort to the use of three cascades. The first one is designed to produce electric power in a system with 1-3 MWe installed capacity. The second cascade will be used to distribute 55-80°C (131-176°F) water for district heating of dwellings and cooling/heating of industrial buildings. The third cascade will be for heating greenhouses, thermal water balneology, and aquaculture. Finally, the cooled geothermal water will be injected into Thermal II.

The cost of this pilot project is estimated at US$8.54 million.

Source: IGA News 10-12/93

COSTA RICA AND GUATEMALA BECOME GEOTHERMAL POWER PRODUCERS

The first geothermal power plant in Costa Rica has been completed, and the first in Guatemala is commissioned for August 1995. The 55 MWe single flash plant in Costa Rica is located in the Miravalles Geothermal Field in the Guanacoste region in the northwestern part of the country. A second unit of the same size is expected to be ready in the next two years. The project is being carried out by the Instituto Coslarricense de Electricidad (ICE), the national agency responsible for the electrical development of the country, assisted by three different contractors.

In keeping with its policy of encouraging investment of private capital in electric power generation based on indigenous natural resources, the National Electrification Institute of Guatemala (INDE) has entered into an energy and capacity purchase-sale contract with ORMAT as a means of exploiting the geothermal potential of the Zunil I field. This company will be in charge of building, operating, and maintaining the plant, whereas INDE will be responsible for operating and maintaining the geothermal field. The plant, commissioned for August 1995, will have a net capacity of 24 MWe. Reservoir engineering studies show that the field can supply sufficient steam to operate this capacity for a period of twenty-five years.

Source: Geothermal Resources Council Bulletin 7/94; IGA News 3/94

A NEW GEOTHERMAL FIELD BEING OPENED IN NEW ZEALAND

An 18 MWe geothermal facility at Rotokawa will be the first new geothermal development in New Zealand in over a decade. The new field lies just a few miles north of the Wairakei resource, first developed by the then New Zealand Electricity Department and is today heavily exploited by the state-owned Electricity Corporation of New Zealand.

The Italian company, Ansaldo, won the contract for development and construction of the power station at Rotokawa. The Italian concern has developed a significant number of similar plants in its home country and supplied major components for the Ohaaki geothermal plant, also to the north of Wairakei, ten years ago.

The plant is expected to be commissioned by the end of 1995.

Source: IGA News 1-3/94

OVERSEAS OPPORTUNITIES FOR U.S. GEOTHERMAL INVESTMENT

Nicaragua

The Inter-American Development Bank (IDB) recently approved financing for feasibility studies for geothermal power in Nicaragua which, if successful, will likely lead to a solicitation for private sector bids. This represents a potential market entry for the U.S. geothermal industry in Nicaragua. Geothermal energy now accounts for 35 percent of Nicaragua's electric generation. The total geothermal potential in Nicaragua is estimated to be over 1200MW.

Mexico

Mexico recently opened its doors to U.S. investors who wish to finance geothermal power plants there. Under the North American Free Trade Agreement, U.S. interests may own and operate electric generating facilities in Mexico. All such power must be sold to the Mexican Commission Federal de Electricidad (CFE), Mexico's government-owned electric power utility. An exception is made for producers who generate less than one megawatt and supply small rural communities or isolated areas lacking electric services.

Peru

Since only 43 percent of Peruvians have access to electric power, "Peru wants to attract private capital to develop geothermal projects, including power plants." This message was delivered by Dr. Juan Olazobal Reyes, the Peruvian chief of renewable resources, to attendees at a course on financing geothermal and wind projects held recently in Morelia, Mexico. The course, sponsored jointly by U.S. geothermal and wind interests, and by the Mexican government's electric power utility, attracted over 100 "students." Olazobal noted that Peru wishes to reduce its dependence on fossil fuels and hydroelectric power.

Costa Rica

Four representatives from U.S. companies in the Geothermal Energy Association met in June 1994 with Costa Rican government officials to discuss private geothermal power development. Meetings were scheduled by the U.S. Embassy, and delegates from DOE and the Embassy supported the industry in these meetings. The U.S. companies proposed a joint venture with the government utility of Costa Rica to build and operate a geothermal field and 100 MWe power plant with U.S. private financing in return for a power purchase agreement. After the investment has been repaid from electricity sales, the plant would be turned over to the government for continuing operation .

The rapidly growing demand for electricity in Costa Rica (nine percent per year) has been used to try to justify the construction of large hydroelectric plants that threaten to flood up to 20 percent of the environmentally-sensitive rain forest. Geothermal energy offers a more compatible alternative, and U.S. geothermal companies can develop this resource without increasing the country's national debt. The four U.S. geothermal companies who participated in these meetings specialize in environmental impact assessment and remediation, geothermal project financing, geothermal exploration, and field and power plant development. Costs Rican officials were very interested and requested a preliminary proposal for their consideration.

PRESENT STATE OF GEOTHERMAL ENERGY DEVELOPMENT IN JAPAN

In Japan the greater part of geothermal energy is used in direct applications. As part of its ambitious "Sunshine Project" (1974), however, the Japanese government has put in serious efforts to increase geothermal power generation. The goal is set to 600 MWe and 2,800 MWe by the years 2000 and 2010 respectively.

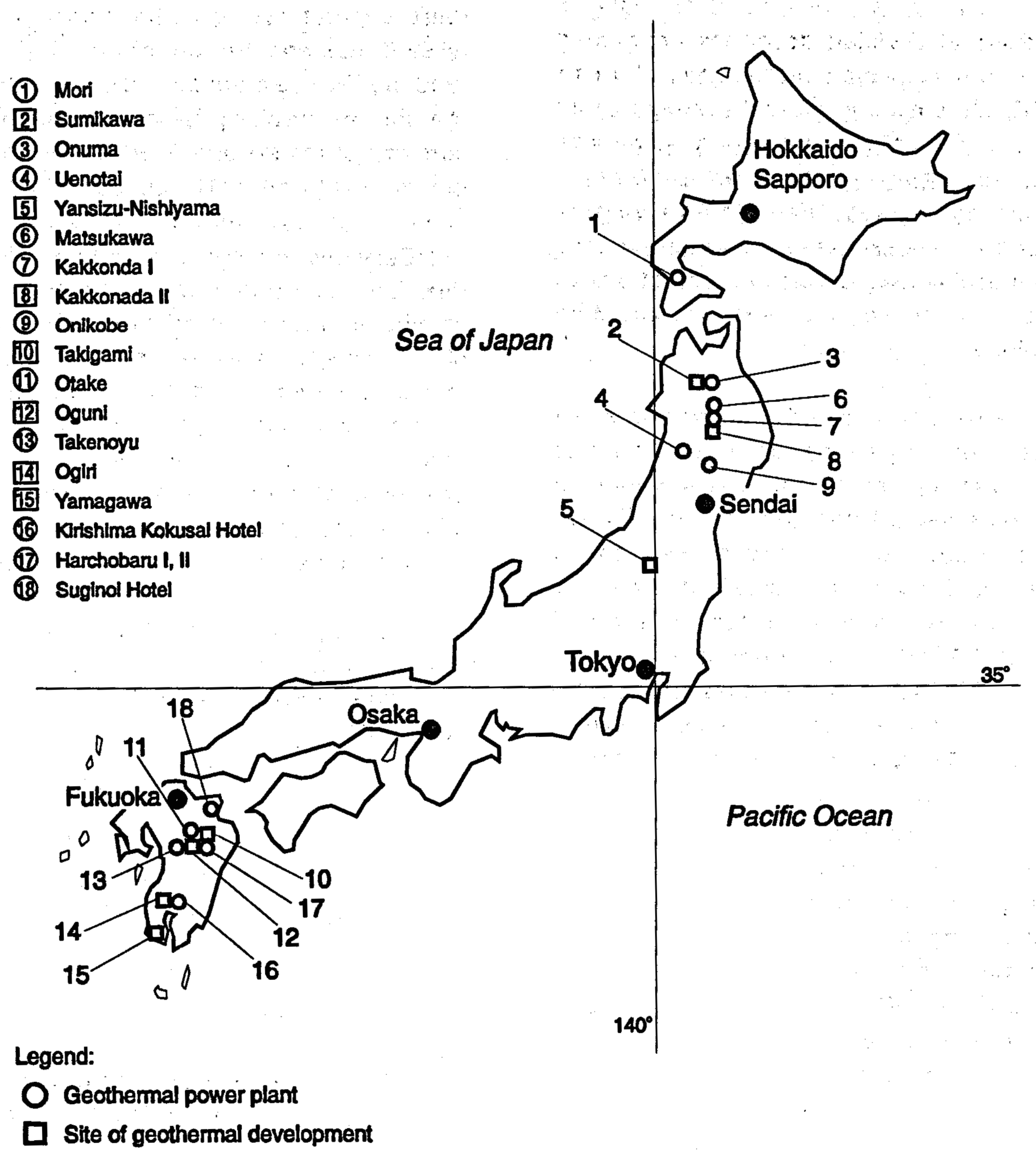
Currently three geothermal power plants are under construction in the Tohoku District and three in the Kyushu District. In these plants, steam for power generation is supplied to electric power companies by private enterprises.

In the Tohoku District, a new plant with a capacity of 27.5 MWe, the Uenotai Geothermal Power Plant, started operation in March 1994. Power plants at Sumikawa and Yanaizu-Nishiyama are scheduled to be operational in March and May, respectively, of 1995. Kakkonda No. 2 Unit, currently under construction, has a projected capacity of 30 MWe.

In the Kyushu District, Hatchobaru Geothermal Power Plant No. 2 Unit, currently under construction, has a projected capacity of 30 MWe.

In the Kyushu District, Hatchobaru Geothermal Power Plant No. 2 unit was completed in June 1990, and power plants at Yamagawa and Ogiri, both with a capacity of 30 MWe, will go into operation in 1995 and 1996 respectively. Another plant, at Takigami, is scheduled to begin operations in 1996 with a capacity of 25 MW. Construction plans for a geothermal electric station at Oguni are now taking form.

As for the direct use of geothermal energy, hotspring bathing exceeds by far all other uses, such as space heating, agriculture, aquaculture, snowmelting, tourism, stock breeding and industry. These alternate uses excluding bathing totaled 318.80 MW in 1994.



Geothermal Power Plants and Development Sites

INFORMATION AVAILABLE FOR ESTIMATING POTENTIAL FOR SMALL, OFF-GRID GEOTHERMAL POWER UNITS

A new report prepared for DOE's Geothermal Division describes conditions and costs at which quite small (100 to 1,000 kilowatt) geothermal systems could be used for off-grid powering at remote locations. The report, *Small Geothermal Electric Systems for Remote Powering*, is described as a first step in a larger process of determining locations and conditions at which markets for such systems could be developed.

The results reported suggest that small geothermal systems offer substantial economic and environmental advantages for powering off-grid towns and villages. Geothermal power is most likely to be economic if the system size is 300 kWe or greater, down to reservoir temperatures of 100°C (212°F). For system sizes smaller than 300 kWe, the economics can be favorable if the reservoir temperature is about 120°C (248°F) or above. Important markets include sites remote from grids in many developing and developed countries.

The report concentrated on the capabilities and costs of geothermal binary power conversion systems because they are the most likely to be economical at geothermal reservoirs with relatively low fluid temperatures. In addition, since in this technology the fluids (geothermal and working fluid) are always contained within the pipes, turbine, heat exchanger, or condenser, the system releases essentially no gases to the atmosphere. Costs for disposal of the geothermal fluid can be relatively low since injection back into the deep reservoir may not be needed for the small quantities involved and, if the fluid is clean enough, low- cost surface disposal may be allowed. In addition, cascade uses may become possible to utilize the waste fluid. The report provides performance and cost estimates for a modal system of 300 kilowatt capacity working from a resource temperature of 120°C (248°F).

The report is available from the Geothermal Division, EE-122, 1000 Independence Avenue, S.W., Washington, D.C. 20585.

Effects on Cost of Off-Grid Geothermal Power of Varying Project Parameter Values
(Ratio to cost of power from modal system. Values for the modal system are shaded.)

1. Power Plant Net Output, kW:	Value:	100	200	300	500	1000
	Multiplier:	2.16	1.30	1.00	0.76	0.56
2. Geothermal Reservoir Temperature, °C:	Value:	100	110	120	130	140
	Multiplier:	1.53	1.17	1.00	0.90	0.83
3. Production Well Depth, meters:	Value:		200	300	500	1000
	Multiplier:		0.95	1.00	1.10	1.44
4. Injection Well Depth, meters:	Value:	[a] 0		200	300	500
	Multiplier:	0.86		1.00	1.04	1.12

Note: [a] The O meter injection well depth assumes disposal of the geothermal fluid is to the surface.

Potential for Geothermal Electric Power in Developing Countries
(Capacity, Megawatts for 30 years)

Africa, Rift Valley		**Asia**		**Central America**		**Pacific Islands**	
Burundi	50	China	2,000	Costa Rica	3,500	Fiji	50
Djibouti	500	India	200	El Salvador	2,000	Papua N G	300
Ethiopia	5,000	Indonesia	16,400	Guatemala	4,000	Solomon Is.	50
Kenya	3,000	Philippines	8,000	Honduras	500	Tonga	50
Malawi	50	Taiwan	200	Mexico	8,000	Vanuatu	40
Mozambique	50	Thailand	100	Nicaragua	4,000		
Rwanda	200	Vietnam	100	Panama	200		
Somalia	50						
Tanzania	600						
Uganda	500						
Zambia	50	**Caribbean Islands**		**Europe**		**South America**	
						Argentina	1,000
Africa, Other		Dominica	500	Azores	100	Bolivia	1,000
		Grenada	100	Former USSR	4,000	Chile	1,500
Comoro Is.	50	Monteserrat	100	Greece	500	Colombia	1,500
Malagasy	300	Nevis-St. Kitts	50	Hungary	300	Ecuador	1,000
Sudan	300	St. Lucia	100	Poland	50	Peru	1,000
Zaire	500	St. Vincent	50	Turkey	500	Venezuela	500
Total							77,500

SPREADSHEET AVAILABLE FOR DETERMINING GROUNDWATER WELL PUMP REQUIREMENTS

A spreadsheet has been developed by the Geo-Heat Center to evaluate the peak and annual well pump electrical energy requirements for a groundwater heat pump system. Using input data such as flow requirement, static water level, well specific capacity and system capacity, the spreadsheet calculates a number of values useful in identifying the efficiency of a groundwater system. These include: peak pump power (kW), unit pump power (kW/ton), pump brake horsepower, pump head, and injection well pressure. In addition, annual pump energy and average kW can be calculated if operating hours and a load duration curve are available.

The spreadsheet is valuable in comparing the pump energy requirements of a groundwater system to those of a ground-coupled or hybrid system in commercial applications. The following is an example of a pumped well illustrating the input and output of the program:

FOURTH NATIONAL TELECONFERENCE ON GEOTHERMAL HEAT PUMPS FOCUSES ON APPLICATION IN SCHOOLS

DOE Assistant Secretary Christine Ervin welcomed over 5,000 participants to the fourth national teleconference on geothermal heat pumps on April 28, 1994. Over 200 sites were registered for the two-hour teleconference designed for school administrators and heating and cooling managers. Downsite participants were given the opportunity to telephone questions to GHP authorities, experienced school administrators, designers, and installers who were in the teleconference studio. Geothermal heat pumps are considered ideal for schools as they eliminate the need for boilers, cooling towers, highly qualified maintenance personnel, and provide individual room control.

Former teleconferences targeted utilities, contractors, and architects and engineers. Quotes of attendees from earlier teleconferences included: "The teleconference gave the industry exposure and credibility that would have taken years to obtain." "We have never had a better winter quarter." "We are not sure what impact the teleconferences had but we are sure it is positive."

Water Furnace, International, Inc., one of the nation's leading geothermal heat pump manufacturers, doubled its nine-month sales from the prior year to $21 million in 1993. Company president Daniel L. Ellis believes that the national teleconferences probably helped, but noted that "it is very difficult to determine which marketing thrust is responsible for the major sales increase." However, he said, that typical sales increases in the past have been around 30 percent annually.

COMPUTER PROGRAMS AVAILABLE FOR GEOTHERMAL DEVELOPERS

The April issue of the Geothermal Resources Council Bulletin focused on computer programs available to geothermal developers. The following is a list of the programs, their sources, a brief description of their uses, and a source for more information.

GDManager, Geothermal Energy New Zealand Ltd. (GENZL); an integrated geothermal data base management system; Calum Gunn, GENZL, P.O. Box 9717, 47 George Street, Newmarket, Auckland 1, New Zealand; telephone: 64/9/309-0469, facsimile: 64/9/309-3938.

WELLSIM, GENZL in association with Auckland University; an integrated geothermal wellbore simulation and analysis package; contact same as above.

GEMS, New Energy and Industrial Technology Organization (NEDO) under the programs of the Sunshine Project promoted by the Japanese Ministry of International Trade and Industry; a software tool that assists geothermal experts in constructing geothermal models from the results of surveys such as thermal structures, reservoir fractures, and fluid circulation; Dr. Hirofumi Muraoka and Mr. Nobuya Narita, Geothermal Energy Development Department, NEDO, Sunshine Bldg., 29th Floor, 1-1, Higashi-Ikebukuro 3-chrome, Toshima-ku, Tokyo 170, JAPAN; telephone: 81/33/987-9452; facsimile: 81/33/986-8197.

AUTOMATE, Stanford University; software package that allows engineers to perform pressure-transient well-test analyses quickly, effectively, and with greater certainty; Munro Garrett International, 2828 Routh Street, Dallas, TX 75201; telephone (800) 825-8001.

HEATTOOLS, Geo-Heat Center; spreadsheet which provides calculations of heat transfer from bare pipe to air, Reynolds numbers, etc.; Kevin Rafferty, Geo-Heat Center, Oregon Institute of Technology, Klamath Falls, Oregon 97601, U.S.A.; telephone: (503) 885-1750; facsimile: (503) 885-1754.

BAREPIPE, Geo-Heat Center; spreadsheet to evaluate the feasibility of using uninsulated buried piping in geothermal systems; contact same as above.

GHS, Geo-Heat Center; a tool for evaluating the economics of various types of systems for greenhouses; contact same as above.

TRNSLINE, Geo-Heat Center; allows the user to determine the preliminary economics for transporting geothermal fluids over moderate distances (thousands of feet); contact same as above.

HEETX, Geo-Heat Center; permits the user to determine the performance of a particular heat exchanger under conditions other than those for which it was designed; contact same as above.

CITYSS, Geo-heat Center; provides three primary calculations for geothermal district heating system: customer life cycle economics for connecting to the system, weather normalization of past customer heating fuel use data, and residential domestic hot water energy use calculations; contact same as above.

QPIPE, Geo-Heat Center; calculates the heat loss from buried pipe; contact same as above.

DHE, Geo-Heat Center; calculates the heat output (kWt) from a downhole heat exchanger in a well where convective steady-state heat transfer is predominant; contact same as above.

HEATMAP, Washington State Energy Office; provides a fast and reliable means of planning, designing, describing, and analyzing proposed and existing geothermal heating and cooling systems; Robert G. O'Brien, Washington State Energy Office, P.O. Box 43165, Olympia, WA 98504-3165; telephone: (206) 956-2014.

STAR, S-CUBED; reservoir simulation system consisting of a geothermal reservoir computer model and various supporting utility programs and program libraries; John W. Pritchett, S-CUBED, P.O. Box 1620, La Jolla, CA 92038-1620; telephone: (619) 587-8440; facsimile (619)755-0474. (Information on other geothermal software packages available.)

TOUGH2, Lawrence Berkeley Laboratory; numerical code for nonisothermal flows of multicompound, multiphase fluids in porous and fractured media; Energy Science and Technology Software Center, P.O. Box 1020, Oak Ridge, TN 37831-1020; telephone: (615) 576-2606; facsimile (615) 576-2865.

The April 1994 issue of the GRC Bulletin also contains a definitive article on "Modeling of Geothermal Systems" prepared by the LBL geothermal staff and accompanied by several pages of related references.

MAJOR SOURCES OF GEOTHERMAL INFORMATION

This section of the GPM presents a representative sample of geothermal literature that has been reported since the last issue. Wider coverage of the literature may be found in a bimonthly publication of current abstracts, titled "Geothermal Energy," published by DOE's Office of Scientific and Technical Information. The publication may be obtained from the National Technical Information Service, Springfield, VA 22161 as PB 88-914700. The annual subscription price for six issues is $90.00 (domestic) and $180.00 (outside the North American continent). The publication typically lists each paper, article, or report derived from another publication, such as conference proceedings, as a separate entry. Space does not permit separate listings in the GPM; thus, the following are recommended:

Geothermal Resources Council Bulletin, Monthly Publication of GRC, P.O. Box 1350, Davis, California 95617-1350

Geothermal Resources Council Transactions, Proceedings, GRC Annual Meetings

Stanford University Annual Workshop on Geothermal Reservoir Engineering, Stanford Geothermal Program, Dept. of Petroleum Engineering, Stanford, California 94305

Proceedings of the Annual Geothermal Program Review, Geothermal Division, U.S. Department of Energy. Available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161 (No. XI April 27-28, 1993, No. XII April-to-, 1994)

Annual Geothermal Energy Program Summary, Volumes 1 and 2, U.S. Department of Energy

Geo-Heat Center Quarterly Bulletin, Oregon Institute of Technology, Klamath, Falls, Oregon.

NOTE: Copies of the publications listed below should be obtained from NTIS at the address provided at the beginning of this article, or from one of the other sources listed. Those marked "GPO Dep." are available for inspection or interlibrary loan at Government Printing Office regional depository libraries. DOE and DOE contractors may order from the DOE Office of Scientific and Technical Information (OSTI), P. O. Box 62, Oak Ridge, TN 37831. Where given, the "GPO Dep. Order No." is the accession number for all locations; an NTIS number only is given when the document is not available at GPO. ITIS is the Integrated Technical Information System maintained by OSTI for contractor accession to DOE online databases.

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1995 World Geothermal Congress

18 - 31 May 1995
Florence, Italy

The 1995 World Geothermal Congress will be sponsored by ENEL, Italian Electric Power Company, and convened by the International Geothermal Association (IGA) and co-convened by the Geothermal Resources Council (GRC) on 18-31 May 1995 at the Centro Congressi in Florence, Italy.

The primary purpose of the World Geothermal Congress 1995 is to provide a forum for international exchange of scientific and technical information on geothermal development during the period 1990-1995.

The Congress will consist of two days of plenary sessions of invited presentations from various countries that have significant geothermal development, a day of optional excursions, and a final two days of triple-session technical presentations. In addition, there will be a poster session, exhibits of products and services, and short courses. European field trips will be available prior to and following the plenary and technical sessions.

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