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GEOTHERMAL PUBLIC INFORMATION ISSUE

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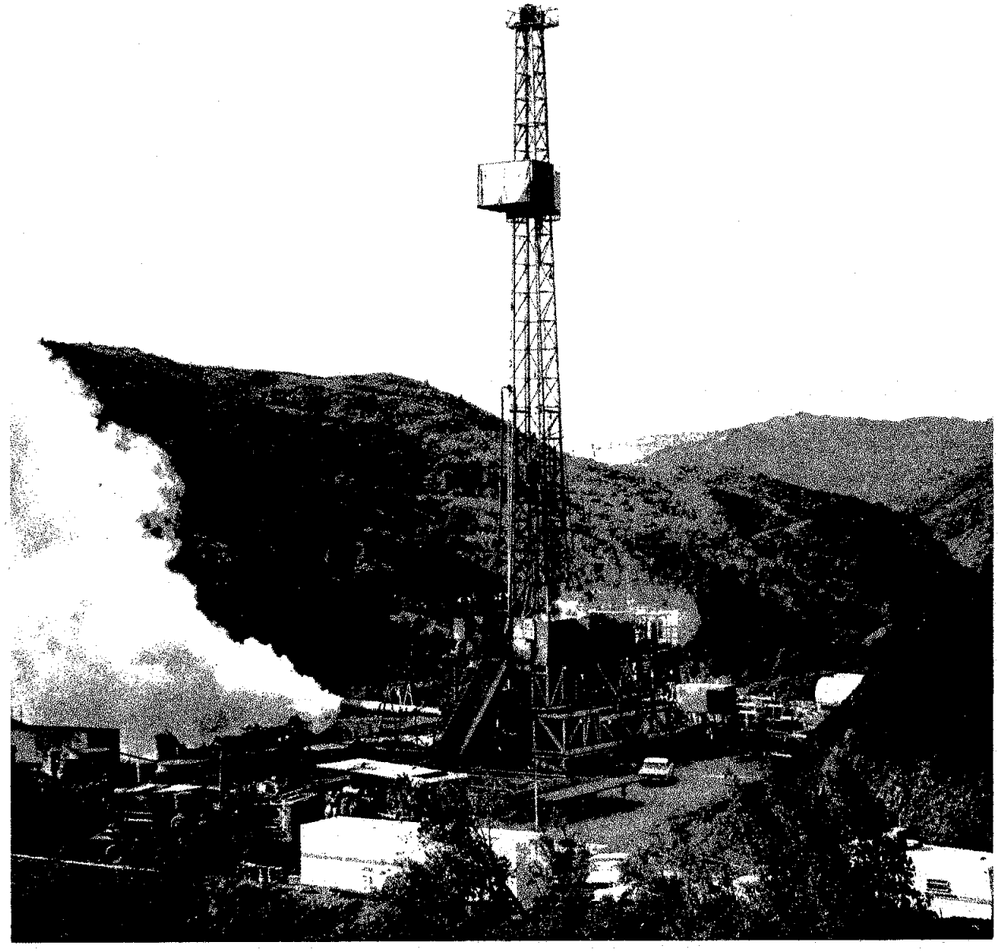
GEOTHERMAL HOT·LINE



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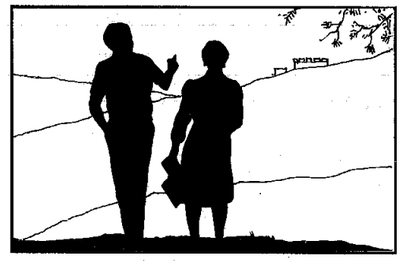
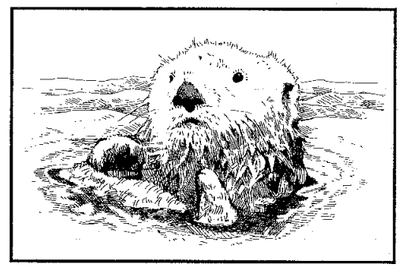
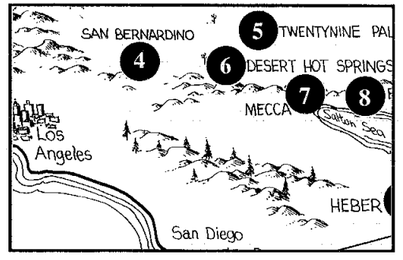


Public information issues and programs. Pages 1-19.



Sierra Club geothermal policy. Page 18.

Dr. Henry Ramey, The Geysers, 1989. Page 32.



Geothermal development, Southern California. Page 43.

GEOTHERMAL PUBLIC INFORMATION

Nontechnical Geothermal Public Information: Views

Geothermal projects can live or die by expressions of public opinion just as surely as by reservoir management techniques. Today, as the industry continues to emphasize developmental activities, public visibility continues to increase and public beliefs move to the forefront of concern.

This concern was recognized at the recent Geothermal Resources Council meeting in Santa Rosa. Almost 10 percent of the attendees came to a preliminary meeting on nontechnical geothermal public information, cochaired by Anna Carter and me. The topic was, should the 1990 Geothermal Resources Council (GRC) meeting in Hawaii include a special session on geothermal public information? The answers were uniformly positive. And, I am pleased to announce, the GRC has approved a Geothermal Public Information Special Session for the meeting, which we will again cochair.

by Susan F. Hodgson

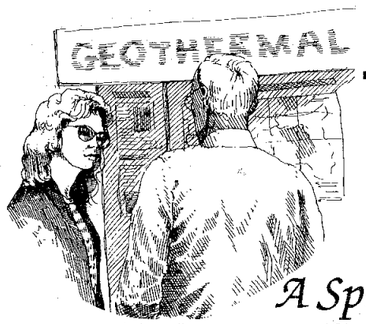
The session, titled *Geothermal Public Information: Issues and Programs,* will be on Friday, August 24. We hope you will attend.

What is nontechnical geothermal public information? It refers to materials prepared for children or adults who have little or no knowledge of geothermal energy, even though such materials vary widely in complexity and content. This definition includes what has been called "semitechnical" information, which is more fact-filled than most general descriptions. People needing semitechnical material include scientists working as project evaluation specialists for legislators or conservation groups, and members of communities near geothermal projects.

What comments were made at the preliminary meeting on geothermal nontechnical public information? Many people said it's important to identify the groups needing information about geothermal development, such as the news media,

legislators, the general public, communities near geothermal development, stockholders, school children, environmental organizations, and personnel in regulatory and utility organizations.

John Geyer pointed out that the goal of all outreach should be one of a "consistent and expected presence". Several people said that members of the geothermal community can help each other by networking and developing a central database. Everyone does not have to reinvent the wheel. Many public-information facts are helpful to everyone.



However, Janet Bowers mentioned that we must "educate ourselves first, getting these facts straight as to environmental impacts, megawatts on line, etc."

Sally Collins said that good public-information programs are tailormade to specific situations. Measurement instruments can be built into programs to gauge their effectiveness.

Many thought news-media coverage should have a higher priority. Press releases, talking with editorial boards of newspapers and magazines, and being available for interviews on local radio and television stations are inexpensive ways to get exposure, and the time to do it is before a crisis hits.

And, meeting attendees said we need to talk among ourselves about public information issues and programs. I hope the public information articles in this *Hot Line* issue are a good first step in this regard.

A Special Session on Geothermal Public Information will be held in Hawaii.

Everyone needs to know what nontechnical geothermal public information products are available and how to order them. Unfortunately, no master list exists, and many, still-useful items are forgotten every year.

For this reason, the Division of Oil and Gas has undertaken to make a worldwide survey of available nontechnical geothermal public information. A copy of the survey is in this *Hot Line* issue. If you have not yet filled one out, please do so now and return it to the division, as soon as possible, with TWO COPIES OF EACH REVIEWED ITEM. One of the copies will be given to the Geothermal Resources Council (GRC), and displayed at the 1990 GRC meeting in Hawaii. The second copy will be kept in the division's archives.

Each item will be entered on a master list of nontechnical geothermal public-information items. The list will be distributed to the geothermal community, published in the *Geothermal Hot Line*, and sent to each contributor.

Send the survey form and the copies of each item to: Susan F. Hodgson, Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, California 95814.

Thank you for your help.

SURVEY OF NONTECHNICAL* GEOTHERMAL PUBLIC INFORMATION

California Department of Conservation
Division of Oil and Gas

* **Nontechnical** refers to materials prepared for adults or children who have little or no knowledge of geothermal energy, although such materials vary widely in complexity and content.

1.	**ITEM TITLE** WRITE IN SHADED COLUMNS			
2.	**TYPE OF ITEM**	**(a)** factsheet **(b)** pamphlet **(c)** book **(d)** newsletter (may include nongeothermal data) **(e)** report to stockholders **(f)** press releases (send packet of typical releases) **(g)** poster **(h)** map **(i)** photographs **(j)** speech **(k)** exhibit (describe briefly) **(l)** slide presentation **(m)** film **(n)** videotape **(o)** other (specify)		
	ENTER APPROPRIATE LETTER (Send me two copies of each item. See below.)			
3.	**LANGUAGE(S) USED** (Please send samples for each.)			
4.	**AUDIENCE(S)**	**(a)**children **(b)**general public (adults) **(c)** communities near geothermal development **(d)**county, state, federal, or legislative officials **(e)**media **(f)** organizations, such as environmental groups **(g)**technical or scientific project evaluators **(h)** stockholders **(i)**other (specify)		
	LIST ALL THAT APPLY			
5.	**HOW DO YOU EVALUATE THIS ITEM'S EFFECTIVENESS?**	**(a)**We note negative and positive media coverage. **(b)**We note types of project support and opposition. **(c)**Other (specify). **(d)**No evaluation.		
6.	**COST PER ITEM**	(Also, if items have a limited distribution, specify the conditions under which they are available.)		
		$ MAY ITEM BE ORDERED? YES ☐ NO ☐	$ MAY ITEM BE ORDERED? YES ☐ NO ☐	$ MAY ITEM BE ORDERED? YES ☐ NO ☐
7.	**DISTRIBUTED BY**	NAME (contact for more information) ORGANIZATION ADDRESS TELEPHONE		
8.	**COMMENTS**			

To describe more than three items, attach additional sheets.

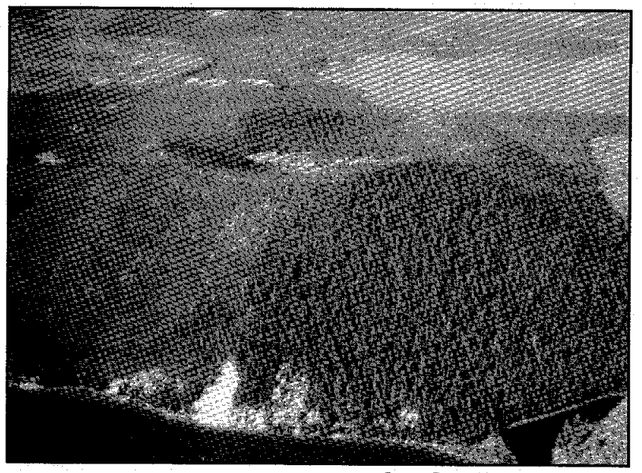
Return this survey and two copies of each reviewed item to: Susan F. Hodgson, Editor, Geothermal Hot Line, 1416 Ninth St., Room 1310, Sacramento, CA 95814, U. S. A. For more information, call (916) 323-2731; Telefax (916) 323-0424.

Each item you send will be placed on a worldwide list of available, nontechnical geothermal public information, which will be published in the *Geothermal Hot Line* and sent to each contributor.

One copy of each item you send will be given to the Geothermal Resources Council and displayed at the GRC 1990 meeting in Hawaii. The second will be kept in the Division archives.

The Newberry Volcano Geothermal Public Information Program

Background



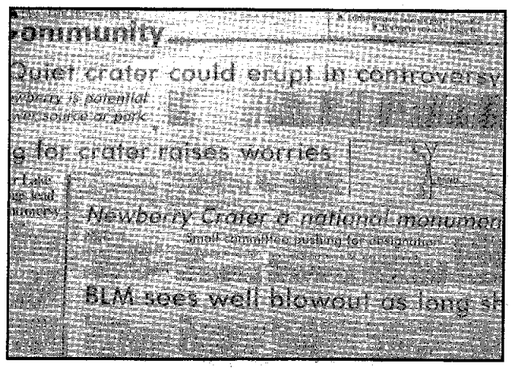
Lava Cone, Newberry Volcano.

The Deschutes National Forest is in Central Oregon, an area famous for its beauty, diversity, and recreational opportunities. Two areas in the forest have high geothermal potential: one is just west of Bend, Oregon, near the Three Sisters Wilderness Area (where land has been leased for geothermal development), and the other is the Newberry Volcano area.

About two-thirds of all federal geothermal leases in Oregon and Washington (250,000 acres) are in this forest, and half of these are on the Newberry Volcano (125,000 acres). Newberry Volcano is the site of the only Known Geothermal Resource Area (KGRA) not yet leased in the Pacific Northwest. (Note: All KGRA's are classified by the Bureau of Land Management, BLM.)

Of the 31,200 acres in the KGRA, 11,360 acres lie within the crater rim, an area closed to geothermal leasing and development by the U. S. Forest Service due to the intensive recreational use and confined nature of the caldera. The remaining 20,000 acres in the KGRA await completion of an Environmental Impact Statement to determine where and under what conditions leasing should occur. The area is one of the Forest Service's highest priorities for mineral projects in the Pacific Northwest.

Over 30 shallow, temperature-gradient wells have been drilled at Newberry since 1975; 7 of these were drilled to depths greater than 4,000 feet. The hottest temperature recorded is 509°F at a depth of just over 3,000 feet, inside the caldera. In May 1988, the BLM approved a GEO Newberry Inc. proposal for drilling the first deep production well (10,000 feet) at Newberry. While this well has not yet been drilled, exploration interest in Newberry remains high. According to 1985 Bonneville Power Administration (BPA) estimates, a potential for 1,000 to 2,000 megawatts may exist at Newberry Volcano.

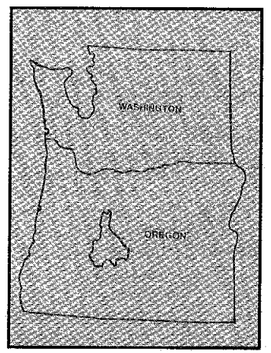


The headlines.

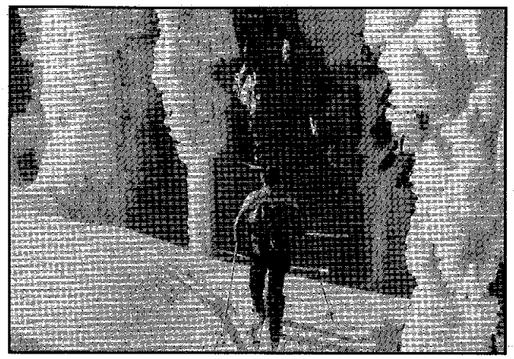
by Sally Collins, Lands and Minerals Staff Officer, U.S. Forest Service, Deschutes National Forest, Bend, Oregon

Complex Boundaries

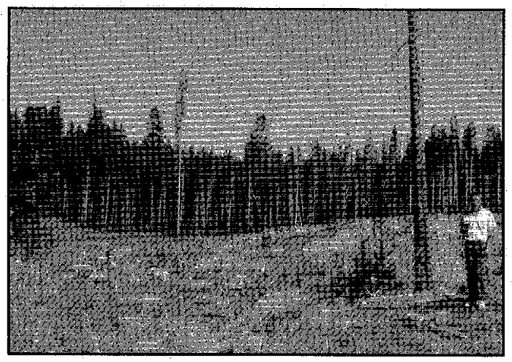
A number of superimposed boundaries from a number of different entities exist at Newberry. These boundaries cause some of the complexities found in managing and developing geothermal resources at Newberry Volcano. For these and other reasons, planning for and managing geothermal resources on Newberry is complicated, and has the potential for controversy.



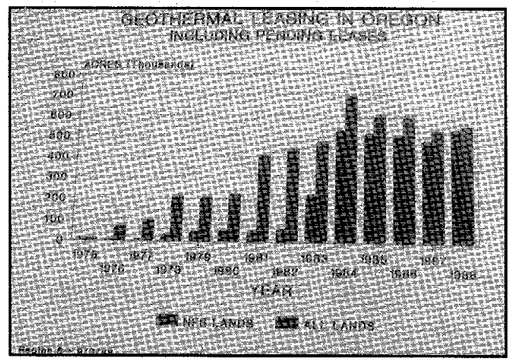
Deschutes National Forest, Central Oregon.



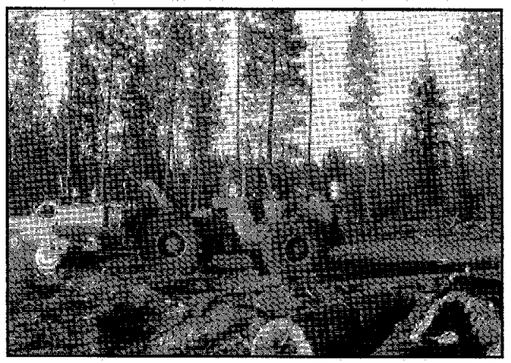
Skiing in the forest.



Proposed Newberry GEO Inc. drilling site.



Geothermal leasing in Oregon, including pending leases.

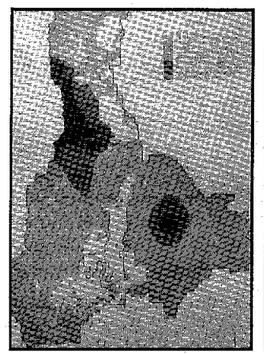


A timber harvest at Newberry.

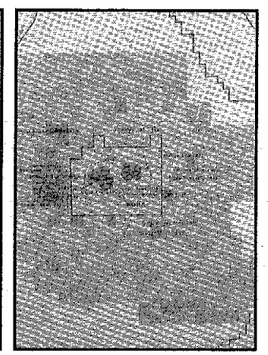
Besides the BLM-designated KGRA and the Forest Service No-Development Area, Deschutes County has identified an 18,000-acre area "unsuitable" for geothermal at Newberry. This area was also designated by the State of Oregon Energy Facilities Siting Council (EFSC) as unsuitable for siting power plants over 25 megawatts. The EFSC has also identified a slightly larger area as a "less unsuitable" area.

Within this latter boundary, the state would likely impose some surface restrictions on power-plant sitings.

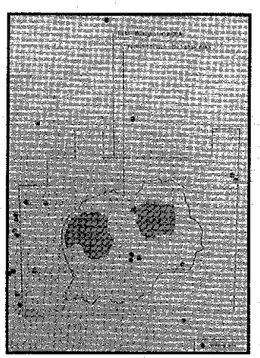
The National Natural Landmark system, designated to identify and preserve significant national features, is overseen by the National Park Service. Under this system, the Park Service encourages landowners to impose restrictions. The



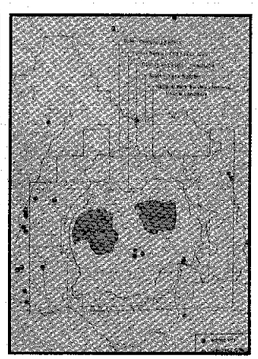
Geothermal potential, Deschutes National Forest.



Newberry Known Geothermal Resource Area.

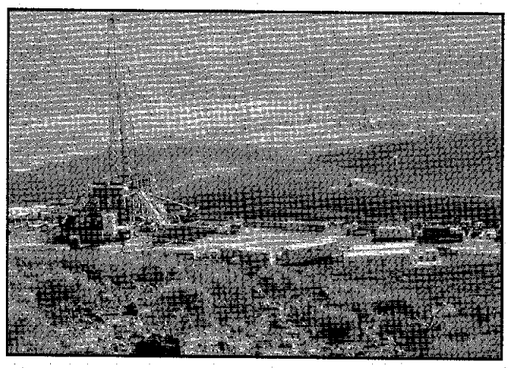


Drill site locations.



Superimposed boundaries at Newberry.

Community leaders at The Geysers Geothermal field.



The leaders visited a drill site near Reno, Nevada.

Park Service has identified a 17,400-acre area at Newberry as a National Natural Landmark. This designation--one of only six in Oregon--publicly highlights the national significance of the features at Newberry.

Over the last few years, a community group in Central Oregon has initiated an effort to have Newberry Crater and surrounding areas designated by Congress as a National Monument. This effort, fueled in part by geothermal activities at Newberry, continues to accelerate. The proposal--to establish a 62,000-acre monument administered by the Forest Service--would protect and encourage the interpretation of important geologic features in the Newberry area.

Under the proposal, geothermal leasing would be permitted (with no surface occupancy restrictions) for one-half mile into the monument boundaries. This stipulation would provide some opportunity for slant drilling, as no surface developments would be permitted inside the monument boundaries. Provisions will be included in the legislative language to ensure geothermal development outside the boundaries is not restricted. The proposal provides for compensation of existing leaseholders who have leases within the boundary, and eliminates the need for completion of the EIS in the KGRA to allow for a competitive lease sale. The proposal has broad-based support in Central Oregon, and was introduced into both houses of Congress by members of the Oregon delegation in November 1989.

Aside from the monument proposal, the Forest Service's "Forest Plan" for Deschutes National Forest identifies management requirements for Newberry. In addition to its policy of no lease boundaries on the rim of the caldera, the Forest Service has identified in this plan a number of management boundaries in the Newberry area that could affect geothermal development: timber management areas, bald eagle habitat areas, recreation and scenic areas, research natural areas, and special-interest areas. While geothermal development is compatible with most of these, some management restrictions will likely apply.

The Newberry Volcano, A Geothermal Public Information Program

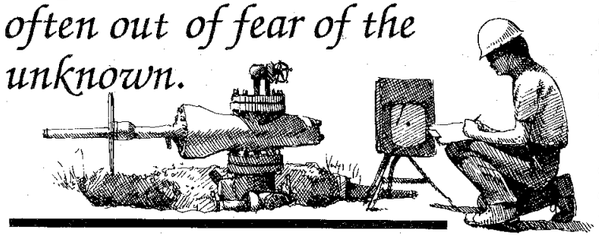
For the last few years, heated debates over the development of geothermal energy projects have occurred in the Crater Lake area, which is fewer than 100 miles south of Newberry. When the Forest Service received the deep-well proposal for Newberry and saw that KGRA leasing efforts at Newberry were off to a start, it was reasonable to assume that some heated exchanges were on their way to Central Oregon.

To deal with this potential for controversy, personnel at the Deschutes National Forest developed the strategy of distributing their own geothermal data before the issue of geothermal development received widespread visibility. The Forest Service made a conscious decision to meet with the press before articles were written, and with both the public and our own employees before they read about geothermal development in the newspapers. The reasons for this are obvious, but sometimes forgotten: when people are uninformed, they tend to react emotionally, often out of fear of the unknown.

The Forest Service wanted to be sure that the Central Oregon community really understood geothermal energy, what the resource was, how it is developed, the basic technology for electrical production, and the environmental effects. Then, with a solid factual basis, the public could form reasoned opinions about geothermal.

The Forest Service ran somewhat of a risk in doing this. As employees, we were not in a position to promote or discourage development of any of the resources we managed, and

When people are uninformed, they tend to react emotionally, often out of fear of the unknown.



it was important in this case to remain neutral as well. We went to great pains to maintain this neutrality, to present all available information, and to look at all viewpoints. Needless to say, by virtue of the attention we gave the issue, we were accused of promoting geothermal development--particularly at first. We had a fine line to walk in this regard and still do, but feel that the effort has been well worth it.

Program Activities

The Forest Service public information strategy combines tours, training, displays, and public meetings.

Community Leaders' Trip

In October 1987, the Deschutes National Forest, in conjunction with the BLM and the BPA, took 12 members of the Central Oregon community on a weekend trip to California and Nevada. The object of the trip was to look at current geothermal technology. We saw different levels of development and impacts, letting tour members understand what might come soon to Central Oregon. The members included a county commissioner, a chamber of commerce representative, a county planner, a Mt. Bachelor Ski Corporation representative, a water commissioner, environmental group members, a state representative, and a rural electric cooperative board member.

The group toured The Geysers and saw large-scale development. They visited smaller power plants in various stages of development around Reno, Nevada. They saw, first-hand, the state-of-the-art geothermal resource development technology used for exploration, production, and electrical power generation.

The trip has paid off in more ways than can be described here. A few examples will illustrate the value of this kind of effort:

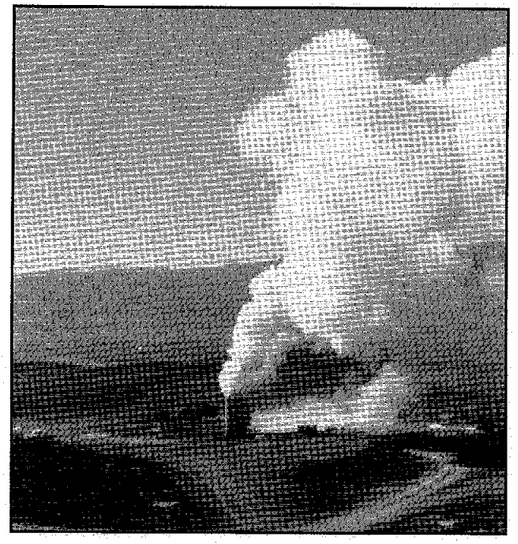
o One conservation group representative headed off a National Sierra Club appeal on GEO's drilling proposal, citing the strong, local conservation group's support for the good geothermal planning that had gone into the effort.

o An Oregon natural resources representative of a conservation group went against the group's president and stated support for GEO's drilling project, even after the organization had publicized its pledge to fight the geothermal development statewide.

o Another conservation group member discovered erroneous information being distributed about geothermal by another federal agency and contacted the Forest Service to intervene. She would not have known it was misleading had she not taken the weekend trip. This has opened an important dialogue between the Forest Service and this agency.

o Presentations on geothermal development are being made throughout the community by many trip members. And, more importantly, their informal conversations about geothermal energy are expanding the network of informed people in Central Oregon.

The Forest Service continues to meet with these people and has recently expanded the group to include people in the northern part of the forest, where geothermal exploration is just starting.



Witnessing a flow test near Reno, Nevada.

Deschutes National Forest Management Team Trip

Following the Community Leaders' Trip, the Forest Service took its management team on a similar trip. The group consisted of managers of wildlife, timber, recreation, engineering, minerals, and watersheds. The forest managers learned what is involved in geothermal development so they could respond to requests and questions with accurate information. In addition to going to The Geysers, the group traveled to two other California areas: the Imperial Valley and Mammoth Lakes. They saw a variety of technologies and projects in various stages of development.

Other Tours

A number of other tours were undertaken as part of the geothermal strategy. In September 1988, the interdisciplinary team planning the leasing of the Newberry KGRA traveled to the Fishlake National Forest in Utah to look at geothermal-development issues there. In the spring of 1989, several managers of the Regional Forest Service Office in Portland traveled to California and Utah to look at geothermal development. In addition, dozens of local tours to Newberry have been made and continue to be undertaken.

Training Sessions

In February 1988, the Forest Service, in conjunction with the BLM, Bonneville Power Authority (BPA), and the Pacific Northwestern Chapter of the Geothermal Resources Council (GRC), sponsored a 2-day introductory training session at Central Oregon Community College (COCC)in Bend. This course, modeled after the introductory course of the national GRC, attracted participants from a number of agencies throughout the northwest. The reason for holding the meeting, however, was to train Forest Service field people who manage a variety of resource programs. These are the on-the-ground people who need to know how geothermal development activities will affect the programs they manage.

In April 1989, the Deschutes National Forest sponsored a 4-week introductory geothermal class at COCC for any interested person in the Central Oregon community. Over 40 people attended the course, emphasizing the interest shown by the community.

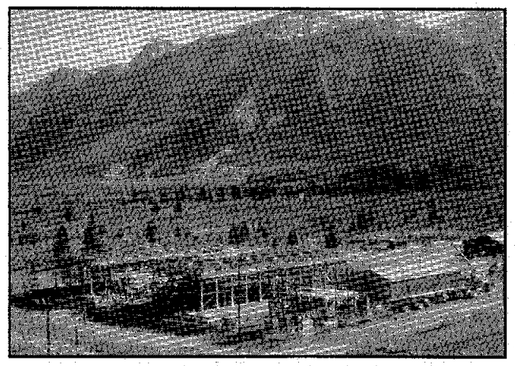
In November 1989, the Regional Office of the Forest Service sponsored a course in Geothermal Regulations for Deschutes employees. This course will be expanded this spring to a one-day community college course. In addition, the Forest Service is working with the local chapter of the GRC to coordinate two introductory geothermal courses and a geothermal Public Information Forum in 1990.

In December of 1989, the Deschutes National Forest participated in a geothermal panel discussion for the Northwest Power Planning Council. The purpose of this presentation was to look for ways to facilitate geothermal development in the Pacific Northwest, a key part of which will be working with the public. There is a strong sense that unless a proactive public-information program is instituted and the public effectively involved in the process, geothermal development will not take hold in the Pacific Northwest.

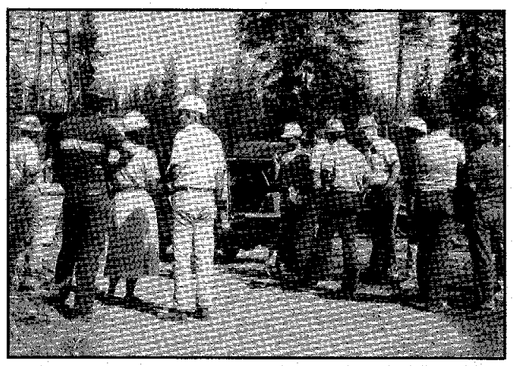
Displays

With the support of the BPA, BLM, and the Pacific Northwest Chapter of the GRC, three geothermal displays have been developed. These have been used by the Forest Service to interpret geothermal resources for the public and possible resource development in Central Oregon. The display at Lava Lands Visitor Center made its debut in the spring of 1989, and will reach thousands of visitors stopping at the center each year.

A portable display was also developed, showing the tours,



Forest managers visited the Mammoth-Pacific Power Plant.



A local geothermal tour.

Visitor center at Lava Lands National Monument.

Visitors gather by the portable exhibit.

press coverage, and public-involvement efforts to date. The display was exhibited at the national GRC meeting in San Diego in 1988, and has traveled to numerous other meetings in Oregon and Washington. The third display, two relief models of Newberry Volcano, will be used in helping the public understand drilling and leasing proposals at Newberry.

Program Evaluation

What have the Forest Service's public awarenesss efforts accomplished? They certainly have generated a lot of enthusiasm for involvement in geothermal planning efforts in the community and in the Forest Service, itself, and have also provided the basis for a factual response to geothermal proposals.

Those involved in planning and executing the strategy have learned a lot about making such a strategy successful and where the pitfalls are. We have come to a number of conclusions that we fully intend to draw upon in future efforts. Some of the conclusions are:

(l) A public-awareness strategy, like a marketing strategy, must be carefully planned (preferably written) and followed. It need not be extensive, but should include, at a minimum, a list of what is to be done, when, by whom, and how much it will cost. This puts the strategy creators in the position of managing the program, rather than others (the news media, special-interest groups, other public agencies, other companies) managing it for you--and not always to your liking.

(2) The strategy must be proactive, not reactive. It is critical that it be initiated before a controversy ensues, if at all possible.

(3) The selection and order of activities are very important. One activity builds on another. The timing of these activities, relative to other issues in the community, can affect the attention given to them.

(4) The strategy must focus on the right people. All too often, we talk to people who already know what we want to tell them or who we know agree with us. These are generally not the people we need to spend our valuable and limited time and energy trying to reach.

(5) Information must be presented objectively, factually, and unemotionally, and must not--at all costs--be viewed as a "sell-job." Teach, don't tell. This means dialogue, not one-way communication. People are instantly suspicious of being told how environmentally sound a project is, especially by the company proposing it, when this is done in an obvious selling manner.

(6) A public-awareness strategy works best when it includes both the company proposing a project and the agencies involved. The agencies must be neutral, as this introduces objectivity into the program.

(7) A public-awareness strategy takes a lot of time. The Forest Service planned for much more than could be accomplished. Rather than sacrifice quality, activities were postponed that were not critical to the overall plan. It is also critical to offer followup activities, (e.g., meetings, tours, informal discussions, etc.) that are also time consuming. Once people become involved, they need to be kept involved, so they are there when you need them.

(8) Local support is the key to success of any geothermal project. Facilitating the understanding of a project is the best way to gain that support. From an industry standpoint, the best way to avoid administrative log jams is to build local support with a public-involvement strategy. Working together with local conservation groups, chamber of commerce representatives, and others in the community will--in the long run--take you much further than lobbying at

departmental levels in Washington, D.C. The latter builds deep-rooted resentment in the local community, at agency field offices, and even at gubernatorial and legislative levels.

(9) You can't do it alone. To be successful, partnerships must be built with all potential players in a project. The momentum these partnerships can carry is surprising, as people make special efforts to make their time, expertise, and even funding available.

What we are witnessing in the Forest Service and the BLM as federal land managers is incredible competition for use of every acre of public land. With fewer acres available and more and more competing interests, this situation will only intensify in the future. This is why it is critical to take public involvement strategies seriously, to develop them carefully, and implement them with the best people available.

The Consensus Process: Creating a National Monument Designation for Newberry Volcano

Almost 2 years ago in the Deschutes National Forest, it seemed as though Newberry Volcano erupted. Actually, what ignited was not energy from the earth, but community interest, when geothermal drilling proposals for forest leases hit the press in the fall of 1987. The event signaled to the public the possible construction of power plants on volcano flanks. Through efforts of the U.S. Forest Service and many others, that interest has evolved into a long, sometimes frustrating (but very successful) consensus process that may result in a National Monument Designation for Newberry Volcano. The following are my reflections on our experiences with this consensus process.

The group of people involved in the consensus process came from the timber industry, geothermal companies, recreation users, wildlife interests, tourism concerns, local government, the U.S. Bureau of Land Management, and the U.S. Forest Service. Representatives of these groups were contacted and all joined the monument committee--not necessarily to see a monument created, but to see that their concerns were met. By not participating, each would run the risk of the proposal going forward without their ideas included or their interests protected.

Those of us involved in the effort to reach a consensus have marvelled at the resiliency of this process, which has repeatedly met internal and external assaults, albeit with difficulty, yet continually resurfaced, mostly intact. What factors continued to put pressure on the group? How was the group able to cope with them? What glue held the group together? What magnet retained members who were disgruntled or only marginally satisfied with the results achieved with the process? How were they able to agree on a package that satisfied everyone's interests substantially? And finally, will the agreements be sustained through the rigors of the national legislative process?

by Sally Collins
Lands and Minerals Staff Officer
U.S. Forest Service
Deschutes National Forest
Bend, Oregon

The Tensions That Pulled It Apart

The monument committee had to contend with a variety of issues that threatened to bring the group's effort to a crashing halt.

1. Initially, the group lacked good operating guidelines. Without clear rules by which agreements could be made, the agreements were not trusted. People felt left out of the process, that they were being treated unfairly, or that they were being manipulated.

2. Some individuals brought prior opinions about others to the consensus process. Previous experiences with specific individuals clouded some people's ability to trust others in the group, despite good-faith efforts.

3. Physical distance played a role in communication breakdowns. Those who had to travel great distances missed some informal, spur of the moment meetings. They had to trust others to represent their interests fairly.

4. New people continued to enter the process after sensitive agreements had been made by the group. This caused frustration and backtracking, and slowed down the process. Needless to say, some new players did not feel, at least initially, very welcome to participate.

5. Many of the consensus participants reported to other entities, such as boards of directors, state groups, or immediate supervisors. While most operated as legitimate representatives for their interests and had the authority to negotiate for these interests, external pressures clearly came into play on numerous occasions.

6. Corporate philosophy, whether from a private or public corporation, appeared to conflict with the concept of consensus. Some individuals continued to operate as if they were closing a business deal or playing a hand of poker, trying to outmaneuver an opponent. Focusing on interests, not positions; explaining why; and openly sharing information made some people uncomfortable. In the end, some individuals truly did not catch on to the idea of a consensus.

7. Unrelated political tensions facing national environmental and industry groups played a role in committee negotiations with such groups. Specifically, the old-growth/spotted-owl issue was heating up at the same time the monument issue surfaced, with some environmental groups in Oregon critized for giving up too much too soon in that process. Initially, this made it difficult for the national groups to support the monument legislation, because it appeared to them as though too much was given up in the consensus process.

8. Pressures increased when the economic status of some of the participants changed in the process, and travel was constrained.

9. The consensus process took a tremendous amount of time and, toward the end of the process, most people had little energy left for dealing with much of the controversy.

The Glue That Held It Together

At a number of points in this process, most of us in the Forest Service would have given odds that the proposal would be dropped, that it could not overcome the pressures and internal strife. And yet, the process overcame the obstacles, time and time again. We have concluded that the group held together for several important reasons.

1. As the proposal evolved, almost all participants stood to gain more by supporting the proposal than by not supporting it--to varying degrees of course. Geothermal companies, though they lose lease rights inside the monument, acquire equal-value rights, noncompetitively, closer to the heat source in the volcano. Timber interests maintain a boundary that has minimal effect on long-term timber supply. Environmentalists get a monument that protects the area, local government sees benefits to tourism, and the federal government may avoid years of appeals and litigation over where geothermal leasing can take place.

2. After 18 months of involvement, most individuals were dedicated to the process and wanted to see it completed.

3. Most of the key individuals involved in the process had consensus personalities. They were good listeners, were willing to work towards mutual goals, and had a strong sense of personal and professional integrity. They encouraged people to think in terms of what they wanted, not what they thought they should get or what they stood to lose.

4. As time wore on and people understood one another better, personal bonds, even friendships, developed. These bonds meant as much to some participants as the agreements. Most participants knew that they would be working together on future issues (e.g., geothermal development activities outside of the monument proposal). To some, it was critical that relationships remain intact to ensure more ease in reaching approval for these future projects.

Role of the U.S. Forest Service

The U.S. Forest Service played a key role in this effort and will likely be called upon to serve in similar roles elsewhere. The proponents of the monument were local professionals--doctors, attorneys, and business people who had little time and experience coordinating an effort of this magnitude. While they abounded in self-confidence and enthusiasm, they generally did not have the skills or experience to draw on. The Forest Service did, and it played an indispensable role in advising, coaching, facilitating, and supporting the group as it moved forward. Also, the Forest Service had most of the information needed to make the resource decisions called for by such an effort.

To Summarize, the Forest Service:

1. Encouraged the committee to include all parties affected by the process,
2. Organized the field trip to Mt. St. Helens National Monument/Columbia Gorge,
3. Introduced a structure and process for conducting business,
4. Provided facilitators and mediators,
5. Provided resource data and conducted analyses,
6. Provided legislative drafting services,
7. Offered the skills and knowledge of resource experts, especially in geology and landscape architecture,
8. Served as the key link between the committee, Congress, the BLM, and the U.S. Forest Service's Washington, D.C. office staff, and
9. Offered critical advice on public-involvement efforts and interpersonal-communications needs.

In addition, in the year prior to the monument proposal development, the Forest Service conducted an extensive public-outreach effort on geothermal resources. By coordinating and offering classes at the Deschutes National Forest, providing a display at Lava Lands Visitor Center, giving numerous presentations, and leading a tour of geothermal

power plants for community leaders, the Forest Service established a strong, open dialogue with the community on geothermal resource development. Individuals involved in these efforts played an effective, key role in the monument process.

Role of Others

A number of others played important roles in the monument effort, and, without their participation, significantly different outcomes might have occurred. The news media, particularly in Bend, was very supportive of the consensus effort and gave it fair and consistent coverage. The BLM was responsible for some of the more delicate negotiations on compensating geothermal leaseholders. These efforts, mostly invisible to and out of the hands of the monument committee, were some of the most difficult of the process. The office of Congressman Bob Smith (R-OR) made important contacts in Washington, D. C. and was consistently available for advice and organizational support. It was clear to everyone that this proposal was important to them, and they responded quickly to every request.

The Legislative Affairs Staff for the Forest Service in Washington, D.C., was similarly connected to the process. They provided advice on a daily basis and steered the process in a direction that would most likely result in the agency chief's support. Finally, the chair of the monument committee is due much credit for holding the committee together over the two-year period. His willingness to listen to all sides, to openly discuss the issues, and to negotiate reasonable compromises between the interests were key factors in holding the effort together.

Conclusions

If the monument proposal becomes buried in a congressional committee, never to surface again, would the Deschutes National Forest and other participants in the consensus process consider this a wasted effort? Most people would not because, with the recognition this proposal has given the Newberry area locally, all activities in the area will take place with added public interest and scrutiny. In addition, all participants learned how complicated and convoluted a seemingly simple natural-resource decision can be. The controversy and political intrigue touched everyone involved. All had to put themselves in another's shoes on more than one occasion, and all learned from it. Most participants now have a much better appreciation for what the Forest Service deals with in its attempts to make balanced resource decisions.

Finally, I think most who participated learned a lot about consensus as a decision-making process. While it is slow and often frustrating, the process can also be incredibly rewarding, with results more durable than those developed in other ways. Most participants learned that consensus is not unanimity. It is a process wherein all members have complete understanding of the reasoning leading to a decision. Each member is willing to support that decision at varying levels of commitment. Each member did not necessarily agree completely with a decision, but all generally felt that, in the end, they each had had a fair chance to influence that decision. It is hard to imagine a more valuable result.

Why Public Meetings Don't Work

A public meeting--or series of meetings--may meet the letter of the law, and even the intent of the law, but in all likelihood it won't build support for a project, it won't develop the public trust in the proponent or the agency promoting or permitting the project, and may very well ring the death knell for a project.

How can this be? We're required by a plethora of laws to hold public meetings on projects. We do it all the time and, often, no one even comes to the meetings.

I maintain that if there is even a hint of controversy, a public meeting may be the worst way to initiate a public-involvement program. Why?

1. A public meeting doesn't allow for effective education. By the time a meeting is called, people are often already mad and are not ready to listen, they are only willing to voice their opinions, often without all of the facts. Clearly, the meetings often come too late in the public-involvement process.

2. Many public meetings are poorly managed and facilitated. An agency who calls a meeting is often doing it to satisfy an obligation. It tends to convey the sense that the decision is already made anyway, and that input isn't really going to make that much difference. The words may not say this, but the public's perception is that this is the case. This impression results from unclear objectives, unfocused discussion, and poor direction and leadership.

3. Public meetings are overused. People have been to hundreds of these meetings, many of them unproductive. It shouldn't be too surprising that people don't come to lots of meetings, unless they are angry and want to vent their anger. However, just because they don't come doesn't mean there is no opposition to (or support for) a project. Often, individuals have elected to give their input in the form of protests, appeals, and marches on the governor's office.

4. Public meetings are impersonal. Information is passed in one direction only, and no effective dialogue is developed. No personal relationships form, and no trust is encouraged. Differences are made more dramatic, as opposed to lessened in a search for common ground. Barriers are enlarged, not diminished.

5. Public meetings often set a convenient stage for opponents of a project to rally the support to kill it, right then and there. Armed with inaccurate information and intense emotions, one project opponent can do more to stop a project in a single emotional speech (especially with a ready audience and the press on hand) than a proponent can possibly hope to combat, armed with the best data and rationale. Is it fair to do this to a legitimate project? I maintain we do it all the time.

Public meetings are not inherently bad, they simply need to be carefully orchestrated as part of a more complete and effective plan for public outreach that develops trust through dialogue, and understanding through proactive, participatory education programs.

by Sally Collins
Lands and Minerals Staff Officer
U.S. Forest Service
Deschutes National Forest

Combating NIMBY: How To Build Public Support

Conventional marketing approaches can work when you are selling a project to an engineer or industrial plant operator. But the same strategy will fail, possibly endangering your chances to permit a project, when you attempt to sell your alternative energy project to the public.

A public relations problem, labeled with the trendy acronym NIMBY "not in my backyard", has become an increasingly popular response to new development. Indeed, the NIMBY phenomenon is part of our inheritance as power-plant builders.

NIMBY describes an understandable, thoroughly American trait. Everyone will defend their property if they believe it is threatened.

But NIMBY has become more than a matter of dollars and cents. NIMBY opposition often takes a nastier turn, where project opponents enlist environmentalists to join them. By the time this opposition reaches outside the neighborhood it may be too late to contain it through mitigation. When things escalate, the opponents often take an "all or nothing" position.

In California, one alternative energy developer proposed a large gas-fired cogeneration project at an existing industrial plant. The plant, which had stood for decades, was in a sleepy, run-down village. The plant manager assured the developer that residents wouldn't object to the project, and the developer, being new to the area, believed him.

Over 300 angry townspeople attended the first public meeting on the project. Many in attendance were new residents who were "gentrifying" the town. These people became the core organizers against the project. They intervened against it and delayed the project's approval for years. The project developer spent thousands of staff hours and millions of dollars trying to counter the sustained, sophisticated local attack that had come out of "nowhere."

How can you avoid this nightmare? What are the essential "how to's" in marketing a project to the host community?

Research the Community

Base your site selection on plenty of information about the community. Give yourself plenty of time to research the community. Reach your own conclusions about the place through contact with several insiders; don't take any single person's opinion as gospel. When you need professional help, sign on local professionals who are well respected in the community to represent you. Your civil engineer, attorney, and real estate broker should all be local. These professionals will be indispensable to you later on.

by Robert Kahn
President of Robert D. Kahn & Co. Inc., a public relations firm in Sacramento, California.

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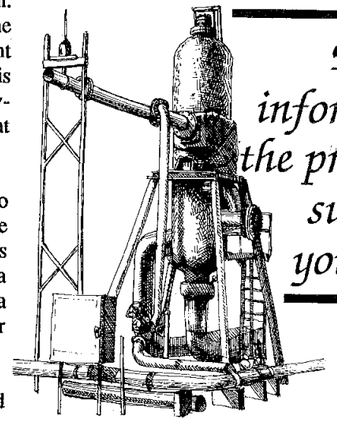
Study how decisions are made in the community. Observe several city council meetings; watch the dynamics of the city's leadership. Find out who the town's opinion makers are and the role the media plays in town. Determine what is the town's most important new economic trend: is the community growing or in decline? What are its aspirations?



Provide ample information about the project--to your supporters and your opponents.

It is also important to identify competitive forces in the area. Is anyone planning a similar project? Has a previous developer soured people on it?

Your research will lead to a comprehensive assessment of the community. The report will help you determine whether or not to build there. If environmentalists defeated a solid waste plant the year before, what chances do you think you'll have to site a waste-to-energy project? Perhaps another community will be more hospitable.

Announcing the Project

Once you've determined to move ahead, carefully plan the official announcement of the project. Clue in the town's leadership well before you make your formal announcement. Also be sure to inform your future neighbors at this stage. If possible, secure appearances by leading citizens to attend the press conference. It helps to be welcomed to town by the head of the Chamber of Commerce, local construction trade union, or good-government group. These groups' support will be vital if the project becomes controversial later on.

Selling Your Project to the Public

Emphasize the project's benefits to whomever you're speaking with in the community. Show how the project will improve air quality by displacing existing polluters. Emphasize the employment potential of the project and show its value to the total tax base.

Provide ample information about the project--to your supporters and your opponents. Be as generous distributing information about the project to the community as you have been thorough in collecting information about it.

Since you'll probably be preparing an EIR, be forthcoming on every aspect of your project in advance--all of it will come out eventually anyway, and you'll look better if you volunteer detailed information of your project before you're required to do so. A key advantage of full disclosure is that you enhance the credibility of the project's positive aspects when you "tell all."

Countering Opposition

An attack on the project can come from disgruntled neighbors, from unions (if you're nonunion), or from self-proclaimed environmentalists, or from a combination of the above. You may also see behind-the-scenes opposition developing from the local utility, powerful real estate interests, or competitors.

Don't panic. If you've laid the groundwork properly for the project, your supporters will be willing to stand by you. Their support is necessary because politicians typically watch carefully to see who fields the largest crowd. A project developer needn't show that he or she has stronger support than the opposition, but he or she must demonstrate credible support--enough to show the politicians that they won't lose office for supporting the project.

Building public support in the middle of a controversy is nearly impossible. It's always hard to get people to help you, particularly if you are desperate when you ask. You need people to send in letters to the newspaper; contact local decision makers; attend public meetings; speak out in support of the project; and host coffees where neighbors can learn about the project. The best policy for successful development is to inform yourself about your host community and inform the community openly about your plans well before the project starts. You can build trust by being open and proactive; disclosure won't help you if it comes about as a result of pressure.

The National Energy Strategy, January 1990 Update

The new National Energy Strategy will play an important role in determining the mix of energy technologies the Bush Administration and Congress will support during the coming years. Admiral Watkins, Secretary of Energy, has formed a task force to write the strategy. This task force is seeking input from the public. Admiral Watkins stated recently that public input will form the most important data base for development of the strategy.

Energy technologies that are not mentioned in the National Energy Strategy are not likely to receive support from the top management of the U.S. Department of Energy (DOE) or from the Congress. The impact of this strategy on the entire geothermal industry could be significant, for better or for worse. A negative evaluation would make it more difficult to obtain tax, royalty, and lease treatment favorable to continued geothermal development. Geothermal energy might not receive favorable treatment from regulating bodies and environmental groups. And federal and state geothermal programs could suffer. In short, geothermal energy could become a nonissue.

Five public hearings were held by the DOE in August and September 1989 in separate U. S. cities, and a further series was held in December 1989 and January 1990 to collect public input. In the first series, there was no clear advocacy for geothermal energy at all. In the second series, Unocal presented positive testimony at a hearing in Houston. However, the number of times that a specific energy type, such as geothermal, is brought up in hearings or in written testimony or letters, will be important. If there is no good evidence that a significant portion of the industry and the public at large is thinking about geothermal energy as a viable alternative, we will be relegated to the basement.

by Phillip M. Wright
Technical Vice President
University of Utah Research Institute

Obviously, we need to work to ensure that the spotlight is on geothermal energy among the alternative technologies in the National Energy Strategy.

You can take an important step to help. The National Energy Strategy Committee is accepting written testimony and letters of support. Written testimony should present your thoughts and positions on any of the important issues in geothermal development. You may wish to address R and D needs, the large resource base, the positive environmental aspects of geothermal development, the need for better tax treatment, or other issues. If you do not wish to provide testimony, a simple, one-page letter supporting geothermal development would be of great help. Such a letter could be written as a private citizen, not necessarily tied to company or agency affiliation. PLEASE HELP WITH EITHER TESTIMONY OR A LETTER. This should be done as soon as possible.

Letters and written testimony should be submitted to:

Linda G. Stuntz
Deputy Under Secretary
Office of Policy, Planning, and Analysis
PE-1
U.S. Department of Energy
1000 Independence Avenue
Washington, D.C. 20585
Attn.: National Energy Strategy Committee

with a copy to:

Admiral James D. Watkins
Secretary of Energy
U.S. Department of Energy
1000 Independence Avenue
Washington, D.C. 20585

Geothermal Outreach in Utah

On October 1989, about 40 people attended an all-day seminar for Utah geothermal developers and regulators. The seminar, first of an annual series, was held to bring Utah's geothermal community together for education and informational exchanges. The seminar was organized by the University of Utah Research Institute (UURI), and sponsored by UURI and the Utah Department of Natural Resources.

by Phillip M. Wright
Technical Vice President
University of Utah Research Institute

The seminar was divided into three sessions. The first covered the nature of geothermal energy and how to develop it. The second dealt with state and federal regulations for geothermal development in Utah. In the third, case studies were presented for successful projects.

Highlights of the first session included a discussion of future electrical demand by consultant John Geyer. John concluded that the utilities will soon be faced with a deficit of generating capacity, with aging plants, and with increased pressure to limit carbon-dioxide emissions because of concerns about the greenhouse effect.

In the regulatory session, it was brought out that almost all of the geothermal regulations are in a state of revision. Bob Hendricks said the Bureau of Land Management will produce an updated set of federal regulations over the next year. Utah's regulations are being updated by the Division of Water Rights in the Department of Natural Resources and the Division of Environmental Health in the Department of Health.

The case studies session presented an opportunity for Utah developers to boast a bit. Win Tatham, of Utah Correctional Industries, described a farm for tropical fish that is operating at the Utah State Correctional Facility. The project uses cascaded waste heat from the geothermal heating system at the prison.

At the end of the day, the participants concluded that the meeting was a success and that there was something of interest for all.

We need education and communication about the potential of geothermal energy to provide a clean, reliable source of electricity, as well as home and industrial heat. Whereas the general public knows about traditional energy sources such as natural gas and coal, few people even know that the earth is hot inside and that this heat can supply a significant portion of our energy requirements without releasing gases that contribute to the greenhouse effect.

The geothermal community has not done its job in getting the word out. Lack of credible information hurts developers when they interact with regulators, causes environmental groups to campaign against geothermal energy when they should be supportive, makes it difficult for companies to obtain proper tax, royalty, and leasing treatments from state and federal governments, and for federal and state agencies to maintain their geothermal budgets.

Few of these items are problems for solar developers because the solar community spends a considerable amount of effort on education and communication as well as on lobbying at the federal and state levels. If our industry is to thrive, we must begin immediately to make up our deficit in public education. The UURI seminar was conducted as a first step in this direction.

New Geothermal Group Formed

A new group has been formed, the Geothermal Association of Imperial County. Currently, membership is open to power producers and steam developers. The membership may be expanded in the future.

Geothermal Visitor's Center Planned

Pacific Energy plans to build an unattended kiosk with geothermal energy displays near Mammoth Lakes, California, close to the intersection of Highways 395 and 203. These displays will explain the area's geology, geothermal resources, and how a geothermal power plant works.

Geothermal Energy Education Office

A Geothermal Education Office has been established in Tiburon, California, by Mary Condy and Marilyn Nemzer. Ms's. Condy and Nemzer created the office to help teachers find current, accurate information on geothermal energy.

They would like everyone with printed materials, slides, or videos that teachers might wish to use, to send samples to their office. If you are a teacher, or just interested in energy education, ask to be on their mailing list. The office is at 664 Hilary Drive, Tiburon, California 94920. Phone 1-800-866-4GEO.

Geysers Technology Center on Hold

In February 1989, the Board of Supervisors for the County of Lake decided against committing funds to construct and operate a Geysers Area Geothermal Technology Center. Although public support and interest in the project was strong, the negative decision was made due to financial problems in the county, where a great deal of money is needed for infrastructural development.

At the meeting, the Board of Supervisors did choose a site for such a center. The selected location is on the eastern side of The Geysers Geothermal field, quite close to Route 175 and just north of the Socrates Mine Road turnoff.

A feasibility study for a Geysers Area Geothermal Technology Center was prepared for Lake and Sonoma Counties in January 1987 by Blayney-Dyett, Urban and Regional Planners, MBT Associates, Architects. Plans for the complex include a vista point overlooking the field, an exhibit room, a picnic area, an office, a laboratory for geothermal studies, a small conference room, and parking facilities.

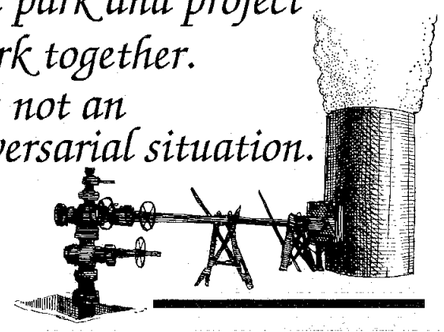
Geothermal operators at The Geysers were asked to rank the relative importance of the function of such a center. More than half indicated that visitor information was very important, and two thought this function would be somewhat important. No other function was ranked as highly, as the following summary of responses shows:

	Number Ranking Activity as:	
	Very Important	Somewhat Important
Visitor Information	5	2
Research Library	2	2
Short Courses	3	2
Clearinghouse	2	1
Environmental Quality	1	2

Geothermal Development in Costa Rican National Parks: An Interview with Dr. Daniel Janzen

On July 25, 1989, 210,000 acres of Costa Rican tropical dry forest, cloud forest, and rain forest became Guanacaste National Park. The park is not comprised totally of pristine, natural areas. Old farms, pastures, and other long-cleared sites are included, as well. Dr. Daniel Janzen, a professor of biology at the University of Pennsylvania and a major force in the park's formation, believes enough undisturbed land is in the park to provide the seeds needed to restore all park areas. He coordinates these restoration activities, and says that parts of the park already recovering are used for education, ecotourism, and research programs. He believes that "...the natural world is by far the most diverse and evocative stimulation known to humans. The technical part of making a forest regrow is easy. It's the social decision to do it that's difficult."

The park and project work together. It's not an adversarial situation.



by Susan F. Hodgson

Dr. Janzen feels that "social decisions" are pivotal reasons for the success of his 25 years of work in Costa Rica. In early 1989, he spoke at the University of California, Davis, about social influences in natural restoration work. I asked him, then, his opinion on the development of geothermal power projects within the boundaries of Costa Rican National Parks. This is what he said.

D. J.: They're thinking about opening another geothermal project inside our park.

S. H.: And what do you think of that?

D. J.: I don't know, I have no problem with any of that.

S. H.: You have no quarrel?

D. J.: No. The way I see it is I don't mind at all paying 5 percent of the surface area of a big national park if you can keep society feeling like you and society are working together. That implies that the park and the project work together. It's not an adversarial situation. Rather, it is one where they work to minimize the damage from whatever the project is.

S. H.: In general, what do you think geothermal companies can do to help preserve tropical areas or other natural areas as geothermal projects are undertaken?

D. J.: Oh, it varies from country to country. I won't try a generalization for all companies in all countries. What I would say is that the concept I just mentioned is terribly important for any area. This is that the interaction between the environment and the park

system on the one hand, and the geothermal company on the other hand, should be a true collaborative interaction with both of them working to make it not be a problem. If it's an adversarial situation, somebody's going to lose.

The second thing is, if the geothermal company, itself, is a profit-making organization, which it normally is, then I think it's entirely fair for some portion of that profit to go to the actual maintenance of the park or other reserve that contains this unit.

S. H.: How would you suggest companies get information on tropical areas? Often, in the United States, students are not taught tropical biology.

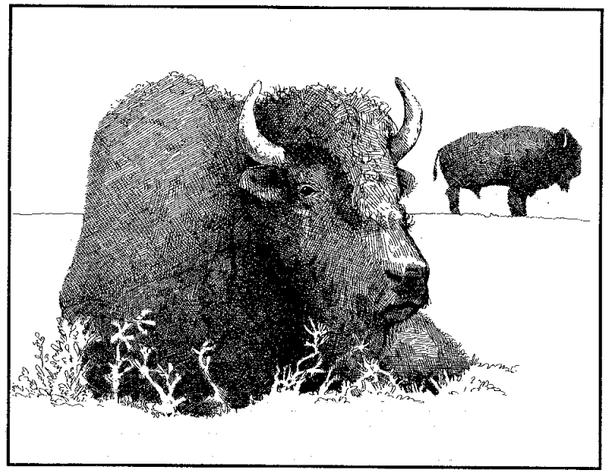
D. J. I can't speak for the old-world countries, but for any new-world country where a geothermal company is going into production or beginning to do exploratory work or anything like that, there are plenty of biologists locally in the conservation community, in the university community, who can be involved with them. If they say they can't find people, it's because they don't want to find people. They're there.

For further information, contact Dr. Janzen at the Department of Biology, University of Pennsylvania, Philadelphia, Pennsylvania 19104. Telephone (215) 898-5636.

Sierra Club Policy: Geothermal Energy

Adopted November 15, 1980
Policy Code 3.1.1

The following policy on geothermal energy has been adopted by the Sierra Club Board of Directors, and reprinted with permission.



The Sierra Club recognizes that geothermal energy is a potentially plentiful and favorable energy source. The heat energy stored beneath the surface of the Earth is vast, and could itself, if available, supply all of the energy needs of humankind. Its availability for direct use and for conversion to other forms of energy is, however, presently restricted to the utilization of naturally occurring underground reservoirs of hot water or steam. These are limited in number and capacity, generally depletable, and in many cases geographically situated far from sites of energy demand. Also, the exploitation of these reservoirs is frequently accompanied by detrimental impacts on the environment. Among these are the emission of toxic gases and chemical substances which result in the degradation of air quality, the threat of water pollution, damage to living organisms, and hazards to public health. Additional problems arise from the heavily industrial character of geothermal operations for electrical generation; the frequent occurrence of exceptional natural, scenic, and archaeological values in geothermal resource areas; and the adverse effects that geothermal fluid removal may have on nearby hot springs and other natural thermal features.

This factual situation leads the Sierra Club to adopt a position of caution with regard to present geothermal technologies, to recognize that they cannot contribute more than a small percentage to the national energy supply, and to favor the advance of other methods of Earth heat utilization which can, for the most part, be developed independently of naturally occurring hydrothermal reservoirs.

Specifically, we favor and encourage:

1. Non-electrical, direct heat uses of Earth heat and geothermal fluids for space, agricultural, and industrial heating in situations and localities where naturally occurring hydrothermal features will not be degraded; and

2. The development of techniques for the extraction of heat contained at depth in dry hot rock, in sedimentary basins, in geopressured systems, and in the Earth's normal temperature gradients. Such developments would assist in avoiding some of the impacts and hazards of geothermal operations under present technology, would provide greater flexibility in project and facility siting, and would vastly extend the available Earth heat resources.

With regard to the use of present technologies for the extraction and conversion of energy from geothermal fluid and steam reservoirs, we urge the following:

1. The basing of all federal and state geothermal leasing decisions and all geothermal project permitting decisions at all government levels on appropriate data relating to anticipated environmental and social impacts;

2. The resolution of land-use conflicts in geothermal resource areas by planning and zoning appropriate to the protection of natural, archaeological, and social values;

3. The protection of hot springs, geysers, thermal pools, and other thermal features and their ecological, educational, aesthetic, and recreational values;

4. The gathering of predevelopment base-line data, the monitoring of environmental impacts and cumulative effects, and the adoption of appropriate environmental and social safeguards in relation to existing and proposed development projects;

5. The development of improved directional drilling technologies for minimizing surface disturbance in resource production areas;

6. The development of methods for the containment of geothermal steam and brines and accompanying gases and chemical components within enclosed production systems; and

7. Geothermal reservoir management procedures that will allow a balance to be maintained, where possible, between field recharge and heat and fluid withdrawal.

Except where direct heat utilization for space heating in buildings and lodges is compatible with primary preservation purposes, the Sierra Club opposes geothermal leasing or development in the following areas:

1. Lands included in or adjacent to federal, state, or local park systems or in wildlife refuges and management areas;

2. Areas known to provide habitat for rare or endangered species;

3. Areas designated as valuable for archaeological remains;

4. Units of the National Wilderness Preservation System;

5. Units of the Wild and Scenic Rivers System;

6. Units of the National Trails System;

7. Areas reserved by the Secretary of the Interior or the Secretary of Agriculture for ecological, scenic, natural, wildlife, geological, educational, historical, or scientific value, including Primitive Areas, Roadless Areas, Natural Areas, and Pioneer Areas;

8. Areas of de facto wilderness under study by the Secretary of the Interior or the Secretary of Agriculture for reservation as part of one of the preservation systems listed above; and

9. Areas of de facto wilderness which are the subject of intensive study by recognized citizen groups or coalitions, resulting in formal proposals to the agencies and/or Congress for reservation as a part of one of the preservation systems listed above.

For further information, contact the Sierra Club, Public Affairs, 730 Polk Street, San Francisco, California 94109. Phone (415) 776-2211. A copy of the above policy on geothermal energy is available for twenty-five cents.

NOTE: Doug Scott, Sierra Club conservation director, has distributed a letter dated November 1989, describing a Sierra Club "Clean Air Campaign." The club will be addressing proposals in the Bush Administration's Clean Air Act (*see* Legislation in this issue).

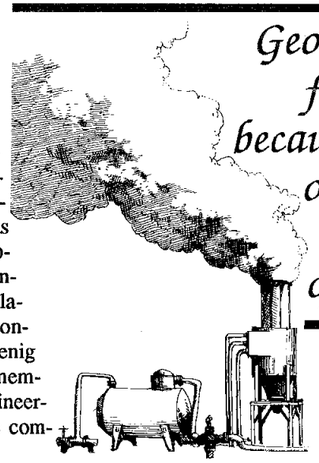
CALIFORNIA

NORTHERN CALIFORNIA

Santa Rosa, 1989: The State of Geothermal

"Over 700 people attended. It was our most successful meeting since 1985, in Hawaii," said Dave Anderson, Executive Director of the Geothermal Resources Council (GRC). "The exhibits were sold out. The poster sessions worked well, and the program was excellent!"

During the meeting, in his address to the membership, GRC president James Koenig stated that the GRC membership mirrors the geothermal industry, reflecting its new stability. "The theme of geothermal exploration has been replaced by development, with focuses on concern for commerce, regulations, finance, and environmental impacts," Mr. Koenig said. "Most new GRC members come from the engineering, supply, and finance communities."



Geothermal will fit the future because it's based on the values and needs of the future.

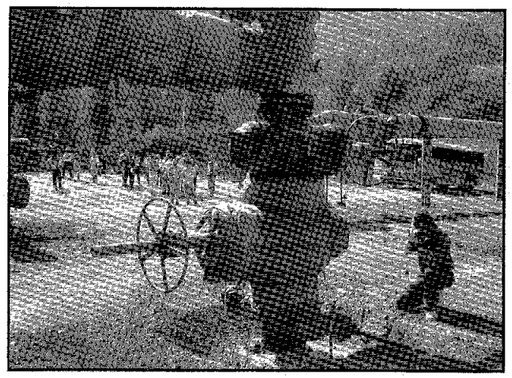
Dr. Carel Otte, former president of Unocal Geothermal Division and now senior advisor for the company, spoke about the meeting's theme: three decades of development at The Geysers Geothermal field. "Anyone interested in energy has to come to The Geysers," Dr. Otte said. "Development at The Geysers launched the U.S. geothermal industry. Today, development at The Geysers has reached its maturity. We at Unocal feel its steam is a depletable resource. Early power plants have had a 30-year run. Unocal hopes the earlier plants will be retired. The key to the future is developing new exploratory techniques. Are there other resources completely hidden? To find them means diligence and hard work. We know how to drill for and produce a resource. The real challenge is in finding them. Geothermal is an important part of our energy mix.

"Geothermal can't be part of the energy scheme unless risk capital is provided. The government must take the lead and establish long-term political and energy policies," Dr. Otte concluded.

Ronald L. Loose, Director, Office of Renewable Energy Technologies, U.S. Department of Energy (DOE), also spoke. He said that by conservative estimates, the United States' geothermal resource accounts for nearly 40 percent of the nation's total renewable energy resource base.

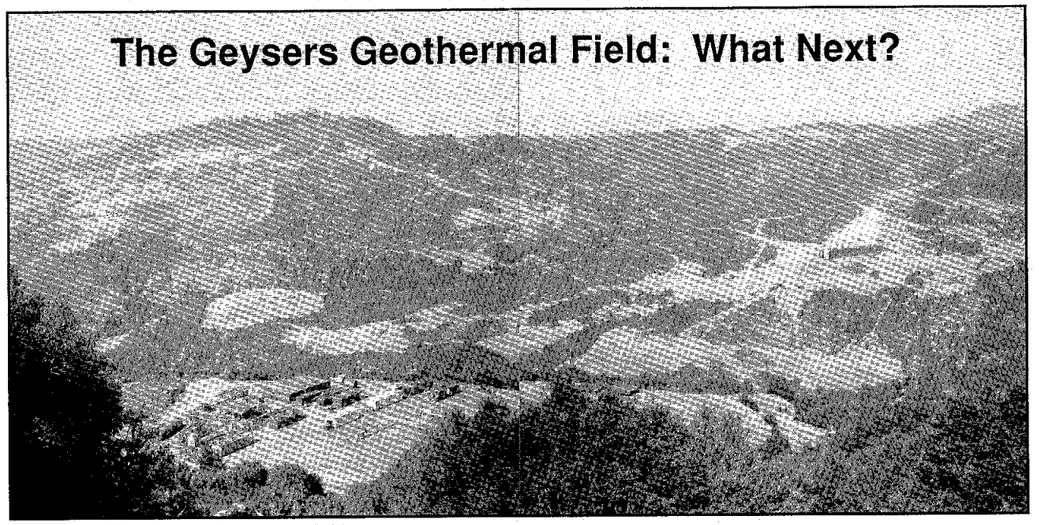
"As the DOE geothermal program shifts focus to assist industry in resolving the issues that constrain hydrothermal resource development, we must carefully evaluate and make hard decisions with respect to the allocation of our limited financial resources," Mr. Loose said. "The DOE feels that the R & D support of the Geothermal Technology Division should be focused sharply and effectively on the major technical and financial hurdles identified by industry as the greatest inhibitors to increased hydrothermal development. Throughout the development of the National Energy Strategy, we intend to make renewable energy, including the geothermal options, the "good news story" at the department," he concluded.

Joseph W. Aidlin, long-time developer and supporter of geothermal energy, summed up the sentiments of many in a luncheon address when he said, "Geothermal will fit the future because it's based on the values and needs of the future. Today, we have a greater concern to use the resources of our society in ways that best complement our way of living. Geothermal energy fits that mold."



On a field trip to The Geysers Geothermal field. Photo by Susan F. Hodgson.

The Geysers Geothermal Field: What Next?



Panorama of The Geysers Geothermal field.

California Energy Commission

On September 21, 1989, the California Energy Commission (CEC) held an Informational Hearing in Sacramento on the decline of electrical power generation from The Geysers Known Geothermal Resource Area (KGRA).

The CEC hearing notice stated that "This information (the decline), if correct, has important implications for the CEC's electrical supply forecast, related transmission and power plant and siting cases, geothermal research and development, and general state energy policy."

Representatives from private geothermal steam-producers and power-plant operators, state agencies, public utilities, and the U.S. Department of Energy were among those asked to present testimony at the hearing.

Questions to which they were asked to reply included:

> What is the extent of generation decline in the KGRA?
>
> What are the causes for this decline?
>
> What is the predicted extent of future decline?
>
> What measures could be taken to ameliorate the decline?
>
> Are there measures which should be taken to preserve other KGRA's?

CEC Chairman Charles R. Imbrecht opened the hearing to say that the CEC wants "...to fully and completely understand the implications of the decline as they affect adequate generation capacity and power plant siting."

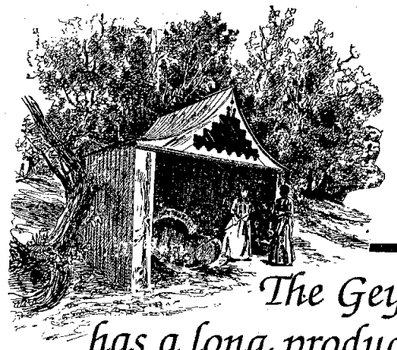
In testimony submitted by Unocal Geothermal Division, Unocal Corporation, four causes of steam-supply decline were identified: accelerated pressure decline of existing wells and new make-up wells; increasing interference of wells (the diversion of steam that could have been produced from an existing well into a new well); the discovery of corrosive steam in the northern portion of the field, thus reducing the potential steam supply; and higher levels of noncondensible gases in the steam, found as drilling moves north and west. Unocal feels these factors have severely reduced production from the developed Unocal leases and have made the undeveloped areas of the leasehold much less conducive to development.

To ameliorate these factors, Unocal proposed four general approaches: use the existing steam more effectively in power plants, in pipelines, and by operating power plants at lower pressures; increase the value of generation by cycling plants and wells to maximize generation during peak-demand periods; drill the remaining steam reserves; and create new reserves; and, hopefully, improve the deliverability through water injection. "Unocal has had both positive and negative experiences with water injection, and it is our recommendation that injection receive more study," a

by Susan F. Hodgson

Unocal representative stated. "Unocal feels that measures already in place or identified at The Geysers can be effectively expanded to improve declining performances there."

Pacific Gas and Electric Company (PG&E) testimony included the following statements: "As a power-plant operator, PG&E is trying to extract the most value for its rate payers from the steam supply. For some time, PG&E has been implementing a program of modifying equipment at The Geysers to improve unit steam-utilization rates. Several units have had turbine-tip seals, turbine water-wash systems, and/or condenser modifications installed. Changes to turbine casing drains and air ejectors have been made at some units to reduce steam consumption. PG&E will continue to evaluate these and other modifications for our units and implement them where it is economically justifiable to do so."



The Geysers still has a long, productive life.

Geysers Geothermal Company Division, Freeport-McMoRan Resource Partners, concluded its statement as follows:

"The Geysers still has a long productive life. Measures to be taken in The Geysers and other fields, if necessary, are clearly going to be directed toward preservation of the resource for its best use now, and more particularly for the energy and environmentally sensitive years ahead. The Geysers, therefore, should properly become a model for future preservation of California's geothermal provinces through implementation of new cooperative efforts. The industry has already assumed this leadership role and will require the joint efforts of the California Energy Commission and the California Public Utilities Commission to implement new operating modes that recognize not only value added to the California ratepayer but the need to employ the highest use standard for California's invaluable geothermal resources."

After all the testimony had been presented, Chairman Imbrecht stated that the CEC's best option was to coordinate and reconcile the available models of the geothermal reservoir at The Geysers. As a result, CEC Commissioner Robert Mussetter, the presiding member of the Siting and Regulatory Procedures Committee, wrote in a letter dated November 3, 1989, that the CEC "...staff was instructed to prepare a work plan to develop projections of generation capacity and energy that will be available from The Geysers in the future. These projections will be discussed in the Energy Commission's 1990 Electricity Report.

"Energy Commission staff members Darrel Woo from our Energy Facilities Siting Division and Michael Smith from our Energy Technology Development Division have been assigned to coordinate this effort. They have prepared a plan that involves the formation of a technical advisory committee. The advisory committee will be chaired by Messrs. Woo and Smith and comprised of experts representing the developers and operators at The Geysers. In addition, the California Division of Oil and Gas and the California State Lands Commission will be represented.

"The advisory committee's function will be threefold. First, the advisory committee will prepare the generation and energy projections for The Geysers and submit them to the Energy Commission in January 1990 for use in the upcoming Electricity Report. Second, the advisory committee will initiate a thorough review of the existing reservoir models and numerical codes with the long-term objective of improving their accuracy. Third, the advisory committee may make recommendations to the Energy Commission, the Department of Energy, and other appropriate parties regarding the efficient management of the steam resource."

U.S. Department of Energy

In addition to the activities of the CEC, the Geothermal Technology Division of the U.S. Department of Energy (DOE) announced that, because of the situation at The Geysers, it will participate in what Director John E. Mock called "...a broadly supported, highly focused research effort." The Geothermal Technology Division has "...earmarked about half of its reservoir technology R & D budget for cooperative studies with industry at The Geysers in federal FY 1990," Dr. Mock said.

At the Geothermal Resources Council meeting in Santa Rosa in October 1989, Dr. Mock said he does not recommend a lengthy project. "Near-term R & D is needed because of the urgency of the problem. Possible approaches include:

- Developing and field testing new geophysical equipment designed for surface and downhole measurement of electromagnetics and seismic attenuation to map fracture location and orientation;

- An analysis of production and interference test data to refine computer models of The Geysers. The models are needed to confirm methods that predict reservoir processes and evaluate the response of the system to development;

- The development of equipment and methodology to identify fractures carrying injected fluids and to determine whether or not fluid injection and projection produce strong, recognizable signals; and

- The development of potential tracers and of field techniques for tracer injection, sampling, and interpretation.

"The potential for extending the life of The Geysers through improved power-plant turbine efficiency is another research area at The Geysers that the DOE will consider as a possible basis for cost sharing with industry", Dr. Mock said. "Both power-plant operators and DOE heat-cycle researchers have suggested investigating several means for reducing the amount of steam required per unit output of power."

"Industry must take the lead in defining the problem and prioritizing a research agenda. The national laboratories under contract to the Department of Energy will help," Dr. Mock concluded.

After the Santa Rosa meeting, Dr. Mock and Marshall Reed, a Geothermal Technology Division program manager, met with representatives of companies operating at The Geysers, representatives from federal and state agencies regulating the KGRA's development, and scientists from research organizations investigating The Geysers reservoir. At the meeting, the attendees were asked for research proposals for The Geysers.

From the proposals suggested, two studies have been chosen for immediate DOE funding:

"A Thermodynamic Study of Hydrogen Chloride Vapor" - a study that is underway at Oakridge National Laboratory,

and

"The Development and Testing of Vapor-Phase Tracers" - a study that is underway at the University of Utah Research Institute.

The remaining proposals will be considered by the DOE and industry representatives for possible joint funding, or for funding by the DOE.

Q. *California Energy Commission:* What is the extent of generation decline in The Geysers KGRA?*

A. *Pacific Gas and Electric Co.*: PG&E Geysers Power Plant is currently experiencing a steam shortfall of more than 300 MW, or about 22% of its installed megawatts.

A. *California Department of Water Resources*: The (Bottle Rock) Power Plant attained 55 MW gross generation sporadically in 1985 and since has declined. At the present time, the plant is generating between 13 and 15 MW.

A. *Sacramento Municipal Utility District*: The decline in generation at (Power Plant) SMUD GEO #1 is directly proportional to the number of new wells being drilled in the resource field.

A. *Central California Power Agency No. 1's* Coldwater Creek Geothermal Power Plant has not yet reached full power runs using both units. Problems in the steam field, primarily well bridging (blockages) and corrosion, do not allow us to recognize or quantify a declining steam resource if a decline problem is actually occurring within the steam supply area.

A. *Northern California Power Agency*: NCPA reduced the output of its geothermal power plants from 246 megawatts on a gross basis (MWG) in April of 1988 and reduced the output even further to 150 MWG in November of 1988. The purpose of the load reductions was to attempt to reduce the rate of NCPA's geothermal reservoir productivity decline. Reducing the output of NCPA's geothermal power plants had the effect of reducing the reservoir productivity decline rate from approximately 4 percent per month to 2 percent per month.

A. *California Public Utilities Commission*: CPUC Staff first learned about the generation decline from PG&E in April 1988 when PG&E filed its application for Energy Cost Adjustment Clause.

* All responses are quoted from testimony presented at the 9/21/89 California Energy Commission Informational Hearing on the decline of electrical power generation at The Geysers KGRA.

Dam Planned for The Geysers

The Northern California Power Agency (NCPA), a consortium of 12 California cities, and Geysers Geothermal Company are jointly proposing the construction of a dam on Big Sulphur Creek at The Geysers Geothermal field. The dam will be operated by NCPA, who will manage it in accordance with a proposed, joint, groundwater injection program. The injection program is designed to reduce steam-pressure declines and improve steam production on leases operated by these two companies. The proposed dam site is near the northern boundary of NCPA's Geysers' leasehold in Sonoma County.

Water yields from the proposed project are constrained by the amount of rainfall on the NCPA leasehold, the dam's height, the installed pumping capacity, and the nature and extent of downstream-water use and associated water rights.

During an average water year, the proposed project is expected to capture and deliver about 2,400 acre-feet of water (about 8 percent of the total annual Big Sulphur Creek stream flow measured at the USGS's, Geysers Resort stream gauge). Water yields for dry (90 percent exceedence probability) and wet (10 percent exceedence probability) years are 400 and 4,200 acre-feet, respectively.

These water yields are based on estimated and observed streamflow conditions on the NCPA leasehold, tentative instream flow requirements for the proposed project, and the assumption that all existing and proposed downstream, water-diversion projects are operated at their maximum diversion capacities, as stipulated in the water-rights applications.

GEO Explains Corporate Situation

On May 1, 1989, Geothermal Resources International, Inc. (GEO) issued a statement regarding its geothermal projects and corporate affairs.

GEO, commenting on its Coldwater Creek Geothermal Project in The Geysers Geothermal field of Northern California, said the company continues to work towards establishing a cooperative funding plan, but little progress has been made during the past month. The objectives of such a plan, if agreed upon, would be to:

1) Provide for payment of nearly $6 million to project vendors, many of whom hold liens on the Coldwater Creek Geothermal Project and have the power to commence enforcement proceedings soon, and

2) Provide funds for two additional geothermal wells, installation of a corrosion-mitigation system, and improvements of certain existing wells.

According to GEO's chief executive officer Ronald P. Baldwin, the 130-megawatt Coldwater Creek power plant, owned and operated by the Central California Power Agency No. 1, was shut down on April 11, 1989, because of mechanical problems within the plant, which may be related to corrosion.

GEO is pursuing the sale of its Unit 15 steam field in The Geysers to a purchaser that is also negotiating with Pacific Gas & Electric Company to purchase the 55-megawatt Unit 15 power plant. GEO shut in the Unit 15 steam field in April 1989 because of nonpayment of steam sale revenues from Pacific Gas and Electric Company (PG&E). "The company continues to negotiate with PG&E for payment of these revenues," Mr. Baldwin said.

Freeport-McMoran Resource Partners Announces Agreement To Sell Geothermal Energy Assets

(Reprinted from press releases issued by Freeport-McMoran Resource Partners.)

Freeport-McMoran Resource Partners, Limited Partnership (NYSE: FRP), announced on November 21, 1989, that it has signed a letter of understanding with a group of investors led by Calpine Corporation regarding the sale of FRP's geothermal energy business. As proposed, FRP would sell its *producing* geothermal energy properties in The Geysers area of Northern California, including geothermal properties to be transferred to FRP by Freeport-McMoran Inc. (NYSE: FTX), to a joint venture involving the Calpine group for a cash consideration of $254 million and a 55 percent interest in the joint venture after a defined payout of the Calpine group's investment. FRP will recognize about $60 million in its financial statements as its investment of the 55 percent residual interest in the producing geothermal energy properties.

Additionally, FRP will retain its *undeveloped* geothermal energy assets, located in the Salton Sea area of the Imperial Valley in Southern California and in the Medicine Lake area of Northern California, which (collectively) have a book value of approximately $22 million. The Calpine group will have a preferential right to fund future capital costs and to earn as much as a 50 percent interest in these undeveloped properties.

Rene L. Latiolais, president and chief executive officer of FRP, said: "This transaction will allow FRP to obtain a significant amount of cash from the sale of its producing geothermal energy properties, while at the same time retaining a residual interest in these properties, thereby providing the opportunity to share in the benefit from their potentially higher future values.

"Proceeds from the sale will be used to reduce debt and, ultimately, to finance the development of our Main Pass Block 299 sulphur discovery, which is now confirmed as the largest existing Frasch sulphur reserve in North America. Main Pass Block 299 should provide a 20- to 30-year cash flow stream to FRP. The synergistic fit between this sulphur discovery and our existing agricultural minerals operations is affording FRP the opportunity to sell its producing geothermal energy properties while our assets and net income base continue to grow. We will continue to review all of our assets to ensure their long-term benefit to FRP."

The proposed transaction is subject to execution of a definitive agreement, financing, and certain other matters, including the approval of the board of directors or managements of FRP, Calpine, and its investors. The definitive agreement is scheduled to be executed on December 20, 1989, and will close as soon as possible thereafter.

FRP is engaged in the production of phosphate and nitrogen fertilizer products; the exploration, mining, and transportation of sulphur; the mining of phosphate rock; and the exploration, development, and production of geothermal energy. FRP also receives royalties from a proprietary process used by FTX for the recovery of uranium oxide from phosphoric acid.

Calpine Corporation is a developer, owner, and operator of geothermal, cogeneration, and hydropower projects, based in San Jose, California.

On December 31, 1988, FRP's geothermal assets consisted of 57,686,000 megawatt-hours of proved and probable steam reserves (equivalent to 519 billion cubic feet of natural gas), production facilities, and the 27-megawatt West Ford Flat electric generating power plant located in The Geysers Geothermal field of Northern California. The assets to be sold also include the 20-megawatt Bear Canyon electric generating power plant and the related 3,761,000 megawatt-hours of proved and probable steam reserves that, together with associated project financing, will be contributed in the near future to FRP by Freeport-McMoran Inc. Such assets also include undeveloped steam reserves in both the Salton Sea area of the Imperial Valley in Southern California and the Medicine Lake prospect in Northern California.

In 1988, FRP's geothermal steam production was 1,819,900 megawatt-hours, and geothermal revenues were $29,013,000. The West Ford Flat electric generating plant was placed in service by FRP in December 1988 and earned reported revenues of $4,192,000 in the first quarter of 1989. The Bear Canyon electric generating plant was placed in service by Freeport-McMoran Inc. in late 1988 and reported revenues to Freeport-McMoran Inc. of $2,896,000 in the first quarter of 1989.

One-Half of Aidlin Plant Purchased

Fifty percent interest in the 20-megawatt Joseph W. Aidlin Geothermal Power Plant at The Geysers Geothermal field was purchased by Calpine Corporation and Metlife Capital Corporation. Calpine develops, owns, and operates power facilities throughout the United States. The company, established in 1984, is based in San Jose, California. Metlife is an affiliate of Metropolitan Life Insurance Company, based in Bellevue, Washington.

The two firms formed a partnership, Cloverdale Geothermal Partners, which purchased one-half of the plant from Geothermal Energy Partners Ltd., a partnership of two subsidiaries of Mission Power Engineering Company, of Irvine, California, itself an indirect subsidiary of SCECorp.

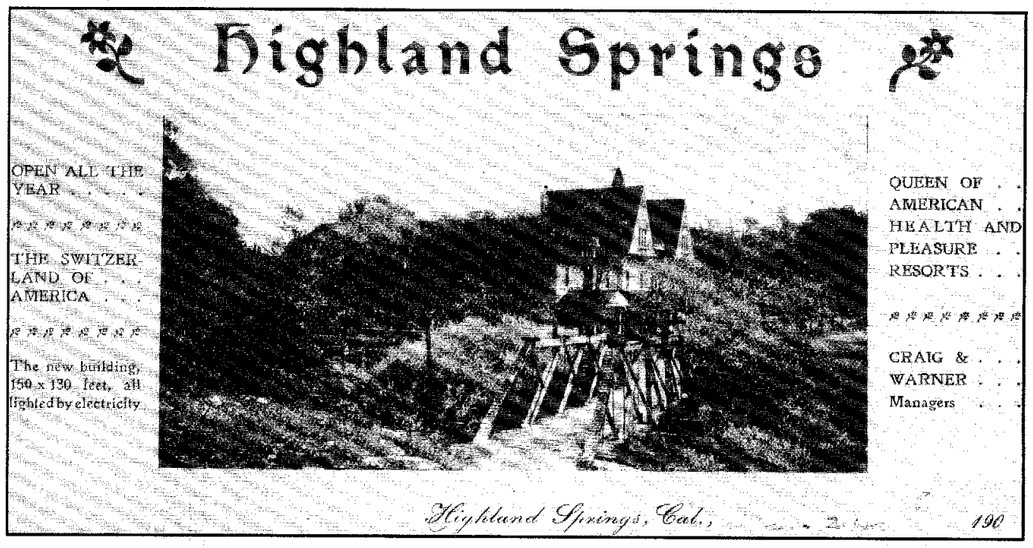
The Aidlin Power Plant is being operated by Calpine under a 5-year contract. The new plant began operating in May 1989.

Unit 15 Sale Discussed

Pacific Gas and Electric Company (PG&E) is investigating the possible sale of its Unit 15 Geothermal Power Plant at The Geysers Geothermal field. The reason given by a PG&E spokesperson for the possible sale is "lack of steam available to operate the plant."

Unit 15 began operating in 1979. It was built for about $37 million. Discussions on the possible sale are underway with Oxbow Geothermal Corporation of Reno, Nevada, and other companies.

Old Letter Found



Highland Springs

OPEN ALL THE YEAR

THE SWITZER LAND OF AMERICA

The new building, 150 x 130 feet, all lighted by electricity

QUEEN OF AMERICAN HEALTH AND PLEASURE RESORTS

CRAIG & WARNER Managers

Highland Springs, Cal., 190

On January 26, 1908, the following letter was sent to the California State Mining Bureau, under the above letterhead.

Gents:
I enclose pieces of ore which please identify.
I have found a large ledge of it.
Is there any use for it or value.
Yours respectfully,
F. W. Gilham

As a reply from the Mining Bureau, "manganese ore" was penciled in at the bottom of the page.

Highland Springs is at the southwestern corner of Big Valley, in Lake County, California. The drawings and captions that follow are reproduced from the back of this sheet of stationery. The resort's claim to "no steep, narrow, or dusty roads in going to Highland Springs," may be a reference to the stagecoach roads used by visitors traveling to The Geysers Resort, today The Geysers Geothermal field.

Dutch or Emms Spring.

Lovers' Retreat.

The Seltzer Springs.

Lawn Tennis Grounds.

Thousands Cured by the Waters at Highland Springs.

DR. J. S. ADAMS, of Oakland, California, says: "The climate, scenery and location of Highland Springs are unsurpassed. For Rheumatism, Neuralgia, Gout and kindred diseases these waters are excellent. For Torpid Liver, Dyspepsia and Kidney Complaints, these Springs are not excelled in America, and probably not in the world."

Among the many great advantages of this place is the number of springs and the fact that no one of them has to be depended upon for the cure of all diseases.

The eminent physician, DR. A. P. HAYNE, of San Francisco, says: "I know of no resort for health in this State where the number and variety of waters are so marked and beneficial as Highland Springs."

Thirty natural springs, from which can be had every known mineral water.

Being absolutely free from fogs and winds, the climate is all that can be asked for, and only six hours travel from San Francisco, a journey to it is a pleasure instead of a hardship.

Nature's Kidney, Stomach and Bladder Restorer. Beats the world on these troubles. A sure cure for dyspepsia in its most aggravated form.

No steep, narrow or dusty roads in going to the Highland Springs. Only 12 miles of comparatively level road in easy coaches take you there.

Tickets for Calistoga Route on sale at Southern Pacific Depots. For Donahue-Hopland Route, at 650 Market Street (Chronicle Bldg.), and at Tiburon Ferry. For Special Stage, at Fashion Stable, Woodland.

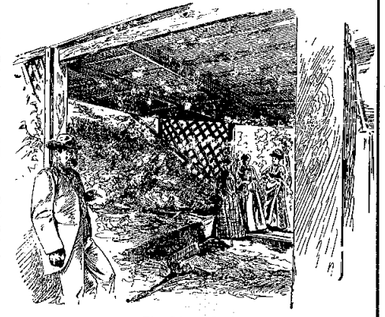
FROM	FARE
Woodland via Calistoga	$7.10
Sacramento via Calistoga	7.20
San Francisco via Calistoga	5.00
San Francisco via Donahue-Hopland Route	4.50
Round-Trip Tickets via Donahue-Hopland Route	8.00
Woodland, Special Stage, four or more	6.50

Parties can send their families here and feel and know that they are safe, and that every attention will be shown them.

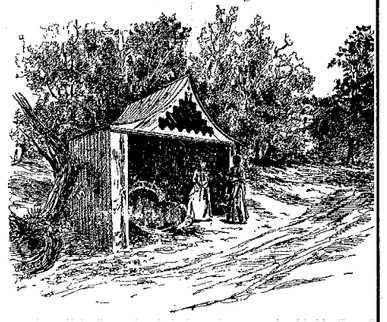
RATES REASONABLE. For full particulars, address CRAIG & WARNER, Managers, HIGHLAND SPRINGS, LAKE COUNTY, CALIFORNIA.

(OVER)

Drive around Highland Springs.



The Diana Spring.



The Neptune.

Croquet Ground.

San Francisco Office, No. 316 Montgomery Street.

A Visit to the California Geysers - 1888

by Dr. Winslow Anderson

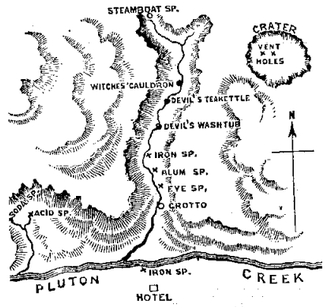
This excerpt by Dr. Anderson is reprinted, with permission, from the August 1969 issue of the *Mineral Information Service* (now, *California Geology*). It is included for its details about The Geysers area, and for Dr. Anderson's prose.

From 1847, when they were discovered, until the 1920's, when the spa went out of style, a great variety of descriptions of the wonders of The Geysers were written, ranging from pale to deep purple in style.

The one quoted here is one of the less exaggerated, but more interesting accounts. Its author was Winslow Anderson, M.D., who was awarded the annual prize of the Medical Society of the State of California for the year 1889 for the book in which it appeared. The book, entitled Mineral springs and health resorts of California, with a complete chemical analysis of every important mineral water in the world, *was published in 1892 by the Bancroft Company. It has served as a basic source for information on California springs since that time. The account reprinted here has been abridged by the omission of chemical analyses and medical recommendations. Spelling and capitalization have been altered to modern forms as in "The Geysers" and "sulfur".*

The reader should be warned that Dr. Anderson was a physician, not a geologist; although his account was no doubt useful medically, and is one of the most interesting of the "travelogs" of the day, his geology is not as good. In addition, some place names have changed since 1880, and may be confusing to the modern day explorer.

. . . Edit.



This marvelous region—this branch of Hades, nestling among the umbrageous oaks and firs in the pine-clad mountains, rich in manzanita groves, sweet-scented shrubbery and wild flowers, and surrounded on all sides by his Satanic Majesty's prodigious laboratory—is located in the northeastern part of Sonoma County, about 100 miles north of San Francisco, 16 miles from Cloverdale, and 26 miles from Calistoga. This Plutonian realm was discovered in 1847 by Mr. William B. Elliot. One day while out hunting in that section of the country he scaled the northern mountain overlooking this partially extinct volcanic region, and came suddenly upon this wonderful scene. Imagine his fear and astonishment at beholding for the first time The Geysers! He remained awestruck for a few moments, and then hastened away to inform his companions that he had discovered the very mouth of the infernal regions!

Since that time to the present these famous springs have been the objects of wonder and admiration to all the many thousands who visit them yearly.

Formerly tourists rode on horseback for many miles up the narrow mountain trails to visit this natural wonderland, which is situated about 1,700 feet above the sea level, but, thanks to the push and enterprise of western civilization, we now travel in comfortable six-horse stages from the termini of the Cloverdale and Calistoga railroads over excellent mountain roads to the geysers. It is a good plan to go by way of Cloverdale and return by way of Calistoga, as you then see all the grandeur and beauty of the surrounding country.

Leaving Cloverdale after luncheon, comfortably seated in your stage, with an experienced and accommodatingly communicative driver, who takes pleasure in pointing out the many objects of interest, you soon cross the Russian River and commence the ascent. The hills and mountains are robed in evergreen verdure of indigenous flora, gigantic oaks and towering pines. Here and there the huge boulders and rocky cliffs stand out in bold relief, and as you wind up and around the mountain sides, with the Pluton River many hundred feet below, basking and smiling in the afternoon sun and rippling along its moss-covered banks and bright-pebbled bottom, with here and there a miniature cascade and waterfall, you feel that words cannot describe the grandeur of the scenery. The elevated roads on the mountain slopes frequently bring you to a sharp curve, where the view is unobstructed, and where the stagedriver is afforded an excellent opportunity of showing his skill in handling the six-in-hand. Now and again the road turns so sharply that the "leaders" are out of sight before the curve is rounded.

As you gain in altitude the view becomes more and more extended until your eyes leap like live thunder from peak to peak and valley to valley for miles around, feasting upon the beauties of nature.

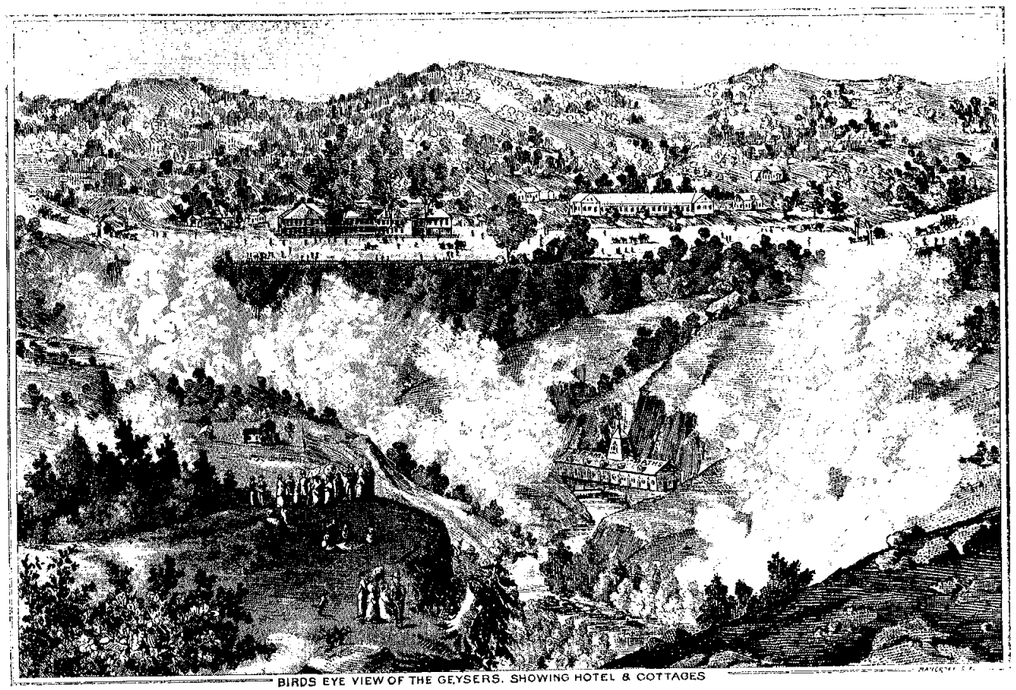
Some two or three miles down the cañon, before you reach The Geysers, your attention is called to the large white, or yellowish-white, banks across the cañon. They are known as "sulfur" banks and consist of deposits of sulfur and cinnabar with incrustations of salts of sodium, potassium, magnesium, sulfur, etc. They are extinct craters, or the deposits of geysers and fumaroles which have died out, leaving evidences of volcanic action behind.

In the immediate vicinity of The Geysers several large deposits of sulfur and quicksilver have been mined and ores shipped to San Francisco.

Near these sulfur banks we found the famous "Indian Springs," at which the great Edwin Forest camped for one season and was completely restored to health. Tradition informs us that our aborigines traveled to these springs from far and near, and bathed in the extensive mud or moor springs close by and drank the water, which they found possessed miraculous curative powers.

As we drew nearer and nearer the sylvan resort our ears were greeted with sounds like those of a steamboat or locomotive—puff—puff—at regular intervals. These, we were told, and as we ascertained afterwards, came from the "steamboat" springs.

After a few more horseshoe curves have been passed, and several more of those magnificent landscapes have been mentally photographed on your brain, you reach The Geysers resort.



BIRDS EYE VIEW OF THE GEYSERS. SHOWING HOTEL & COTTAGES

The many cozy cottages, the hotel and grounds, are situated in a leafy dell on the side of the mountain opposite Geyser Cañon. The huge oaks and pines afford pleasant shade to the commodious verandas as you sit and enjoy the pure, dry, invigorating and exhilarating mountain atmosphere and picturesque scenery which surrounds you on every side.

Having indulged in one of those spendid sulfur Hammam baths, where the skin is rendered soft, white and pliable owing to the medicinal effects of the mineral ingredients, you are ready for dinner, and a good one it was during our visit to The Geysers in 1888.

The evenings are cool, clear and charming, insuring sound and refreshing sleep.

A Trip Through Geyser Cañon

Bright and early next morning we set out for our trip "over the river" to his majesty's Plutonian shores. In the summer season the best time to start out is from 4:30 to 5:00 a.m., in order that you may perceive the full volume of the steam and sulfurous vapors as they rise several hundred feet into the air. Later in the morning the sun's rays condense the vapors so that they are not visible as far above the ground.

You are now armed with a long staff, like the pilgrims of old, and with your guide you set out to cross the Pluton River—this time on a bridge. Before doing so, however, your attention is called to a cool, clear spring, known as the "iron" spring. It is located near the edge of the Pluton River, on the same side as the hotel. This iron spring, on analysis, is found to contain valuable salino-chalybeate (iron) mineral ingredients.

Immediately after crossing the Pluton River, a change in the atmosphere becomes noticeable. On the side where the hotel and resort with the many picturesque and cozy cottages are built, the air is pure, dry and invigorating, on the side where Geyser Cañon is located, the atmosphere is mixed with the perfumes from the interior realm.

Near the path on the bank of the river, as you proceed up the cañon is situated quite a remarkable spring, containing large quantities of aluminum, sulfate magnesia and silicic acid. It is known as the "Alum Spring."

Following your guide, you soon realize that you are nearing the brink of eternity. You now cross "Devil's," or Geyser, Cañon and come to the "alum and sulfur" spring, having a temperature of 160° F. Proceeding farther on you next see the "black sulfur" springs, in which we find sulfide of iron. The ground is now getting warm under your feet, and the fumes from the "lower regions" make you think of the hereafter, and as you push on, a deep and steep ravine is entered, from which boiling hot steam and gases escape in every direction until you feel awestruck in this strange place! Passing along through the ravine, with the boiling water running at your feet, you enter "Proserpine's Grotto," in which is placed the "devil's armchair." This latter is a huge boulder which nature has hollowed out in the shape and form of a large parlor chair. In this you sit with great solemnity, to make sure of the benevolent friendship of his Satanic majesty.

The next point of interest is the "Devil's Kitchen," with warning signs of "danger" stuck up in every direction. The country rock is serpentine, sandstone and limestone, with igneous deposits and incrustations of sulfur, soda, cinnabar, etc., and as the fumaroles, cracks and fissures emit their boiling waters and vapors saturated with free sulfurous, sulfuric, hydrocholric acids and carbonic anhydride, all having strong

Along the hogback.

disintegrating action on the formation, everything is, in consequence, soft and yielding. The banks and rocks are like clay and sand, easily dislodged upon the slightest touch—hence the signs of danger.

You are now fairly in the mouth of a boiling, seething, trembling and smoking Plutonian realm. The ground under your feet is becoming hotter and hotter, and the sulfurous fumes and vaporous steam are nearly suffocating. Early in the morning these vapors rise to a height of 300 to 500 feet. It is also observed that these wonderful subterranean forces exhibit more activity at or near the full moon.

In this *olla podrida* of Hadean liquids are several interesting points and springs to be observed. Near at hand is a hot "Epsom salt" spring, having a temperature of 150° F., and over 140 grains of magnesium sulfate to the gallon of water. Another boiling spring of "iron and sulfur" has a temperature of 208° F. On the right side of the path is a large, black, sulfurous spring continually boiling and rumbling as the black, inky fluid reaches the bright dawn of day at a temperature of 162° F. It is the "Devil's Inkstand," a hot sulfurous iron and alum sulfide and sulfate water which makes very fair writing fluid. For this purpose it is used at the Geyser hotel, where the visitor inscribes his name on the register with his majesty's ink.

You next come to the "hot alum" spring, containing, as will be seen from the following analysis, over 60 grains of aluminum sulphate to the gallon. It is an alumino-ferruginous sulfurous water.

As you proceed along the not over "straight and narrow path," it is literally and practically important that you follow your guide and the "narrow path" here, lest one misstep hurl you into that "undiscovered country, from whose bourn no traveler returns." Innumerable springs and vents and subterranean outlets spurt and spout in every direction. "Pluto's Punch Bowl" is a large spring of hot lemonade, containing sulfuric acid and sulfates. The "Geyser Smokestack" is a large opening, from which issue volumes of sulfur-laden fumes, which rise into the air for several hundred feet, where it condenses and deposits again on the ground as water and sulfur, etc.

One of the most interesting springs in Geyser Cañon is the "Witch's Cauldron," a large, boiling, circular spring of over seven feet in diameter and of unfathomable depth. The water has a temperature of 212° F., and is unceasingly boiling and bubbling. The spring is a black, sulfurous fluid as black as the inky cloak of Hamlet. As the awestruck tourists "round about the cauldron go" they see, in their imagination, the solemn ghost of Banquo rising and materializing in the fumes of the "charmed pot," and with a small stretch of the imagination you once more see the three witches and hear their husky voices chanting a solemn incantation.

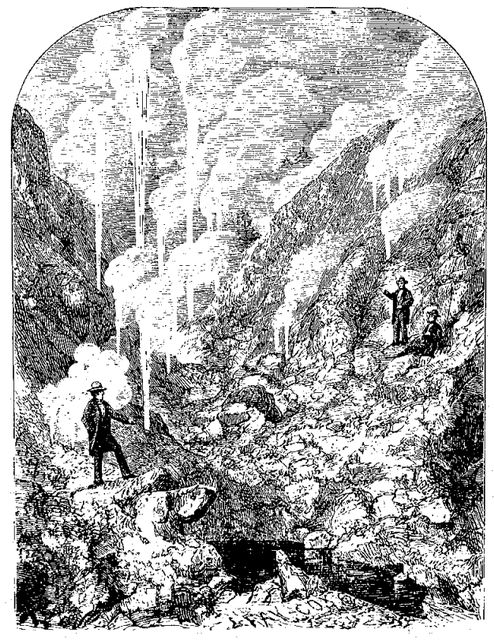
On analysis this remarkable fumarole, having its source probably hundreds of feet below the surface, yields water rich in sodium, calcium and magnesium sulfates.

Next comes the "Devil's Canopy" and the "Geyser Safety-valve," an intermitting, scalding spring, which ejects streams of boiling water to the height of 15 feet; then the "Devil's Pulpit," a little elevation where his Satanic Majesty (presumably) goes to direct the workings of his laboratory.

A little farther up and to the left are the wonderful "Steamboat Geysers," which can be heard a mile or more away, blowing and snorting intermittently at high pressure. This is seemingly a true geyser. The steam is so hot that it does not begin to condense until it is ten or fifteen feet from the surface. Tourists are very apt to burn their fingers trying to find out what makes the noise, as the steam is not visible. The temperature here is 214° F.

Around these hundreds of springs are incrusted deposits of crystallized sulfur, magnesium, alum, etc., etc. In many places one can stick his alpenstock into the sides of the banks, and immediately hot steam and vapors will issue.

You then pass on to the "Devil's Gristmill," where a large column of steam escapes from a hole in a rock with so much



The witches' cauldron.

force that stones and sticks placed at the orifice are blown away like bits of paper. Loud subterranean noises are heard within resembling those of a gristmill, hence its name.

Going still farther up, the ravine is found to bifurcate. The left fork is still active, having dozens of springs, with temperatures ranging from 100° F. to 210° F. The right fork is cool and pleasant, with several pure water springs. Ascending at the bifurcation some 160 feet you come to an elevation—a plateau of smooth, plastic clay stained with iron and sulfur. This clay has a temperature of 170° F. A long pole is introduced into the yielding clay and forthwith issue hot, smoking vapors. The edge of this plateau is called "Lover's Leap." Here the view of the boiling, seething, roaring, steaming, groaning and bubbling springs below is one of unrivaled grandeur. 160 feet below you and all along the "Devil's" Cañon is one mass of smoking fury, shrill whistles, regularly intermitting puffs and groans, issuing from the interior of the earth. This sight alone is worth the whole trip.

To the eastward is "Lover's Retreat," a pleasant oasis in this wilderness of sulfurous clouds. Here also is the "Temperance Spring,"—of clear cold water. Near it is a large fallen oak, which serves at once for a seat, and a knot hole in one of its huge branches is known as the "Post-office." Here we leave our cards in case civilization is never reached again.

Going along the usual route, we pass over the "Fire Mountain" with its hundreds of small orifices through which miniature geysers issue. The temperature of this ocherous clay is 175° F. A little east of this is located "Alkali Lake" and the "Lava Beds." Here the crust is so thin that stamping hard on it produces a hollow sound. This is evidently an extinct volcanic crater on a small scale. We now pass the "Indian sweat bath" and come to another remarkable spring known as the "Devil's Tea Kettle." This is one of the strongest vapor springs on the coast. The orifice is three feet in diameter, opening out of the side of the mountain with a huge boulder overhanging it. The "Tea Kettle" spring is about half a mile from the active springs in Geyser Cañon. The vapor is emitted with such force that a large bunch of brush placed in front of it is instantly swept away for many feet. This steam is above the boiling point and is sulfurous in character, and contains a large quantity of free sulfuric acid. Formerly a huge cone with a steam whistle attached to it was constructed over the orifice, but it made such a noise as to keep the guests awake at night, and was therefore taken down.

Your route now lies along the side of a mountain where a narrow path has been cut out of solid igneous rock. Below you is the Pluton River, and above you the snorting geysers. Issuing from the side of the solid glass mountain are two remarkable springs—the "Hot Acid" and the "Lemonade," whose waters are rich in the potassium salts so valuable in many conditions and diseases. The acid spring is remarkable for the fact of its having 154 grains of free sulfuric acid to the gallon, and the lemonade spring from the fact that it is one of the few springs in California which has free muriatic acid.

The water is pleasantly sour, and with sugar or syrup, makes one of the nicest of lemonades.

The next place of interest is the "Devil's Oven," a large excavation in this silicon oxide mountain where in years gone by this igneous rock was at a white heat. All over this realm of subterranean outlets the crust of the earth is covered with the products of the Plutonean shores—sulfur, iron, magnesia, nitre, alum, etc., etc. On again reaching Pluton River, several more cold and hot springs are seen. Some are sulfureted and others are ferruginous, magnesic and aluminic.

Several hundred feet up the Pluton River has been constructed a large and commodious bathing establishment, which spans the river. Every facility for bathing has been arranged. The hot sulfurous vapor issues directly through the side of the mountain, and gains admission into suitable apartments where the bather can enjoy the medicinal effects of the sul-

Geyser canyon.

furous fumes and steam vapors at any desired temperature. Then there is the plunge and individual tubs and sweating chambers, and comfortable dressing-rooms. One half of the bathing facilities are for ladies and the other half for gentlemen.

This bathing fluid is remarkable on account of the large amount of borates it holds in solution.

This is one of the best bathing waters on the coast. The borates and sulfates render the skin soft, white and pliable, cleansing the 7,000,000 little pores on the cutaneous surface of an average-sized man.

A large swimming pond has been constructed by damming the Pluton River. The water has a temperature of 75° F., and is a combination of all the mineral spring waters.

The Geyser Springs, hot and cold, flow daily about 100,000 gallons. The area covered is about 400 acres. Most of the activity, however, is confined to the "Devil's" or Geyser Cañon, and comprises about 60 acres.

Many of the springs resemble *true* geysers, such as we have in the "wonderland of America"—Yellowstone Park—and in Iceland; but scientific authorities classify our California geysers as fumaroles or openings and outlets in a volcanic district.

As the first visitors at this California Hecla were at a loss for motive power to produce all these boiling, steaming and spouting Stygian sluices, they naturally turned to their early teachings for a solution of the phenomena. As they were all good people and had early been taught the power of his Satanic Majesty located—well he used to reside in the infernal regions, presumably in the center of the earth—why they most naturally gave him the credit and named the springs with their present euphonious names of "Devil's" this and "Devil's" that, a process of reasoning that has been applied to names given at a more recent date. In order to be true to nature we have described the springs with their names as we found them.

The Geysers are wonderful and picturesque exhibitions of the nearly extinct volcanic forces slumbering beneath the romantic "Devil's Cañon," and the resort is one of the pleasantest and most salubrious watering places we find on the coast, and destined to become one of the world's greatest sanitariums.

Remarks on Three Reservoirs: Wairakei, Larderello, and The Geysers - 1989

The following essay is based on a presentation by Dr. Ramey on September 13, 1989, to the Society of Petroleum Engineers and The Geysers Geothermal Association.

Larderello and Wairakei: Here are two totally mature systems that have gone through stages seen at The Geysers in recent years -- rapid declines in rate, rapid declines in pressure, but then changes. Here are two systems that you would think were exhausted, and, instead, there's a fresh wind blowing, and brand new plans to continue to extend the development of both reservoirs. Will this occur at The Geysers?

In the early 1960's, the problem at Wairakei was that the pressure appeared to be dropping rapidly. I was asked to do the reservoir engineering and the thermal calculations for the field. It was plain that we were going to need heat balances like those used in steam-injection oil recovery. I began to search the literature on geothermal systems. Many conclusions were logical. One idea was that systems like Wairakei were big, active hydrothermal systems. There was natural recharge of surface waters at depth into them. If you could discover the recharge rate and produce at that rate, you'd have an inexhaustible energy source that would last forever. This seemed reasonable.

The only thing that I saw in the literature that didn't make good sense was a comment that because all oil and gas reservoirs are closed systems, separate from any source of recharge, and because all hydrothermal geothermal systems are recharge systems subject to water influx, there's nothing in oil and gas reservoir engineering that applies to geothermal systems. I knew this to be wrong, because I'd been doing water drive gas-and oil-reservoir performance matching and design for a long time.

The Wairakei steam field was originally a compressed, hot liquid field, unlike The Geysers in that it was mainly filled with liquid on discovery and development. My students and I were given the production history and asked to calculate what would happen in the future. We had already developed models for water-drive petroleum reservoirs. All we did was add energy balances and other features specific to a hot-water geothermal system. We correlated pressures with

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by Dr. Henry J. Ramey, Jr.

Henry J. Ramey, Jr., is the Keleen and Carlton Beal Professor of Petroleum Engineering at Stanford University. In the early 1960's, he performed the first reservoir engineering study of a geothermal system at Wairakei, New Zealand, and has studied The Geysers Geothermal field since the fall of 1966. Dr. Ramey is interested in heat and mass transport in porous media, well behavior, and enhanced recovery of fluids and energy from subterranean reservoirs.

With his associates Frank G. Miller and William E. Brigham, Dr. Ramey has advised Pacific Gas & Electric Company on development at The Geysers since the fall of 1966.

depth, time, and areal location, finding a good correlation all over the field. We did a performance match with several kinds of aquifers recharging the reservoir. The computer program was designed to select the aquifer by minimizing the difference between the measured and computed pressures.

On the first pass through the program, the program printed out "no recharge," rejecting recharge on the basis of significant numbers. My reaction was surprise because I was convinced that Wairakei was a recharge system. Having reviewed field data, I was sure that there were leaks from the reservoir running to the surface. It appeared that natural recharge was small compared to production from wells. There was no reinjection.

The reservoir model used assumed there was an unknown reservoir, that it contained initially some pounds of steam and some pounds of water. It had an unknown volume and rock, and initially started at some temperature and pressure. There was natural, terrestrial heat flow through the system at the start. There could be recharge into the system of water at some enthalpy, perhaps unknown. Then, the system is produced. We measure what is produced (the mass and the enthalpy, among other things), and we measure the pressure and temperature at the wells.

The numbers that came from the performed match for the mass of water were very large. We didn't realize it at the time, but the apparent compressibility of geothermal systems could be 100- or 1,000- fold larger than the isothermal compressibility of hot water. We decided that we had measured not only the reservoir fluid, but much of the aquifer recharge fluid, as well.

In trying to do this New Zealand study, I sought data about Larderello, in Italy. Larderello was a steam system, like The Geysers. The system was drilled around the turn of the century, and I was specially interested in Larderello, expecting that there would be enough performance history that we could do performance matching. However, at the end of World War II, we bombed the Italian steam field, and the Germans blew up everything that we didn't when they left. There wasn't much old performance information.

I began to study The Geysers when I moved from Texas A & M to Stanford in 1966. We had just finished the Wairakei study. Although it looked like we had gotten a marvelous match and everything seemed to make good sense, one thing bothered me. We forecasted that in the future, liquid would begin to boil in the reservoir and form a steam cap, and that the steam cap would grow. We said it would become like a gas-cap oil reservoir, and the water that was left, the so-called irreducible water saturation, would have to vaporize. When it did, perhaps capillary pressure would begin to affect things. The temperature and pressure wouldn't be those of a flat surface of water boiling on a stove above ground.

Instead, there should be vapor pressure suppression as the liquid saturation became lower and lower. As it became more and more difficult to vaporize the liquid, a good question was, How much of the liquid could actually boil? How much would affect performance? We didn't know, and we began research to solve the problems.

In the fall of 1966, I was approached by Pacific Gas and Electric Company (PG&E) and asked if I could do the same kind of thing for The Geysers that I had done in New Zealand. Al Bruce of PG&E handed me a piece of yellow-lined paper with a list of questions. He told me there was little data. The wells hadn't been produced. He asked me how many megawatts could be installed, how long power production would last, and the other rather important questions we're still wondering about.

When I began this study, I spent about a month in the offices of the Thermal Power Company on Market Street in San Francisco, reading all of the drilling tour reports. I met many geothermal pioneers who impressed me. From the steam production side, Mr. B. C. McCabe of Magma Power and Dan MacMillan of Thermal Power Company were giants. I admired both of those men and enjoyed talking with them.

Other pioneers worked for PG & E. Dean Worthington was a vice president who had the vision to recognize the future for a new energy source during a time the price of crude oil was at an all-time low.

We began to do engineering. At the time that this study was requested by PG&E, data for The Geysers were confusing. The pressures that we measured in the first set of pressure buildups in February 1967 indicated a broad range of pressures in the field. The original attempt to assess this geothermal system was made assuming it was a recharge system, and that the steam bubble would be replaced by water coming in peripherally.

In the next year, the tax trial for the steam producers at The Geysers was held, and we were asked to prepare information for the producers. Within two weeks of the date of the trial, it still appeared that The Geysers was a recharge system. But a reservoir engineering study indicated that the rate of pressure decline had been too great to permit recharge. The original steam system appeared to be separated from the surrounding hydrosphere, and the steam was depleting.

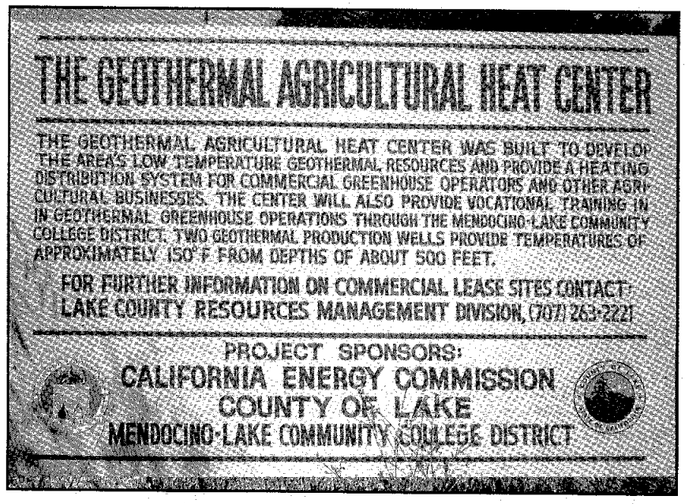
An old geologic study of The Geysers published by Allen and Day in 1927 was found to support this discovery. They

pointed out that the steam wells drilled at The Geysers in the 1920's had encountered extremely high pressures. They said this proved that the steam in The Geysers steam zone had no connection with the groundwater. How could the groundwater get down, if the steam could not get out? This important observation was overlooked for 40 years. It was a rather important finding in regards to the tax trial, and was largely responsible for establishment of the depletion allowance for geothermal steam production.

The Geothermal Agricultural Heat Center

Text and photos by Susan F. Hodgson

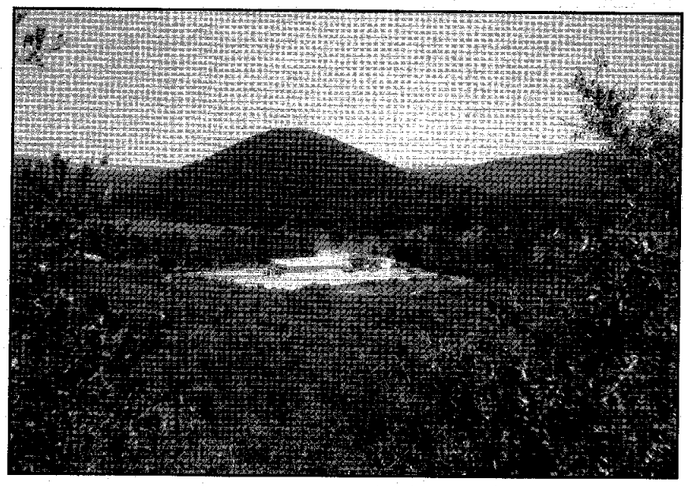
On May 19, 1989, the County of Lake Geothermal Agricultural Park and the Elaine H. Neasham Geothermal Center were dedicated at a site 7 miles south of Kelseyville, California. Construction on the $700,000 project began in January 1988. The funding was from the California Energy Commission, the County of Lake, and Mendocino-Lake Community College District.



Currently, from 4- to 10- acres of land are available for lease at the site for commercial developers wishing to construct greenhouse-agricultural businesses that will be heated by the geothermal system. The charge for the geothermal heat will be about 20 percent below that for other available fuels.

View of the Geothermal Agricultural Heat Center.

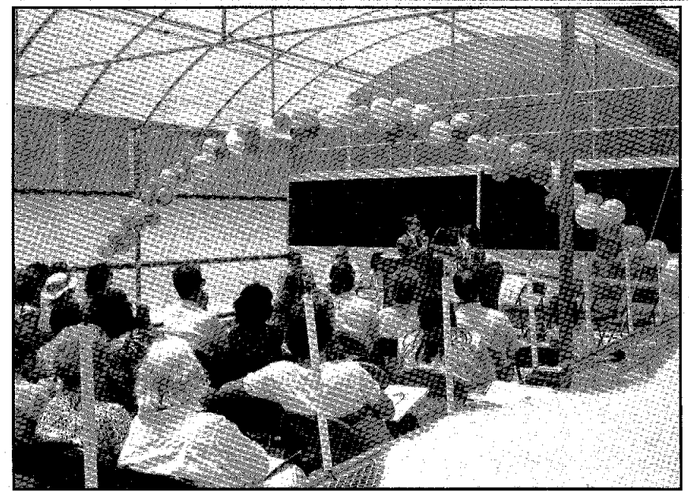
The photograph was taken from the site of 1 of 2 production wells drilled for the project. The single injection well was drilled next to the dark objects to the left of the greenhouse.

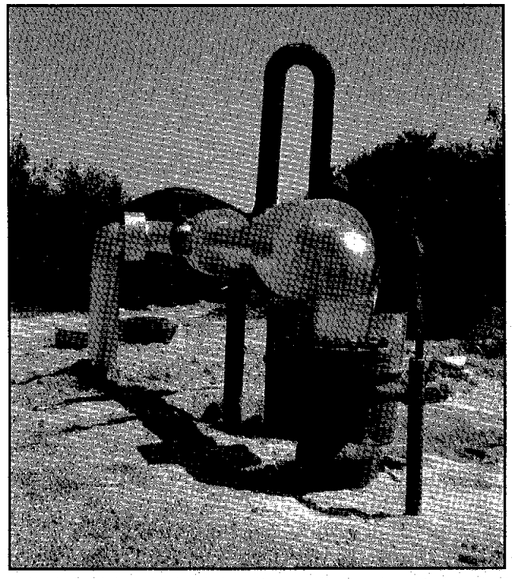


At the center's dedication ceremony, Elaine H. Neasham received a plaque from Dr. Leroy R. Lowery, President, Mendocino-Lake Community College District. In prepared remarks, Mrs. Neasham said that her family wants to bring geothermal energy to the average person.

The land for the project is leased by Lake County from the Neashams at no charge until commercial activities begin. The county is responsible for constructing and operating the geothermal system.

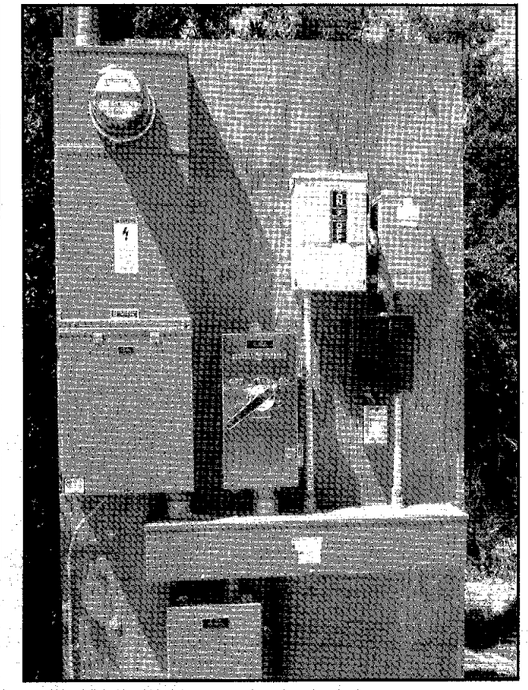
Mendocino-Lake Community College District is responsible for constructing and operating the agricultural greenhouse, and for offering vocational training courses on geothermal greenhouse operations.



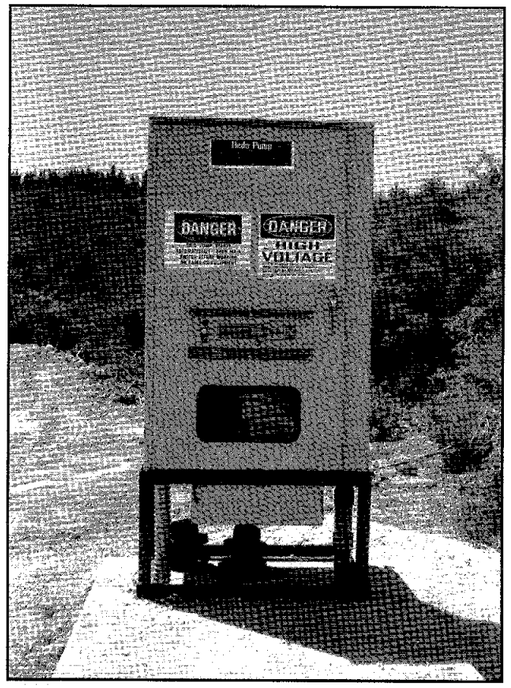


Lake County well "AG Park" 3, 1 of 2 production wells drilled for the project, was drilled to a total depth of 148.7 meters. It produces 63.9°C hot water at a total mass flow rate of 32,143.7 kilograms per hour.

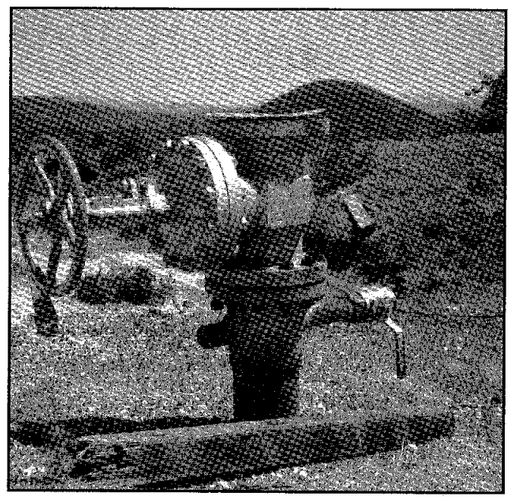
Both production wells are drilled on a bluff overlooking the 3.5 acre greenhouse site, and the geothermal water reaches the greenhouse storage tank through gravity flow. Next, the water passes to the heat exchanger in the greenhouse, and then to the injection well.



The automatic well-pump controls for "AG Park" 3 are operated at this wellside panel.

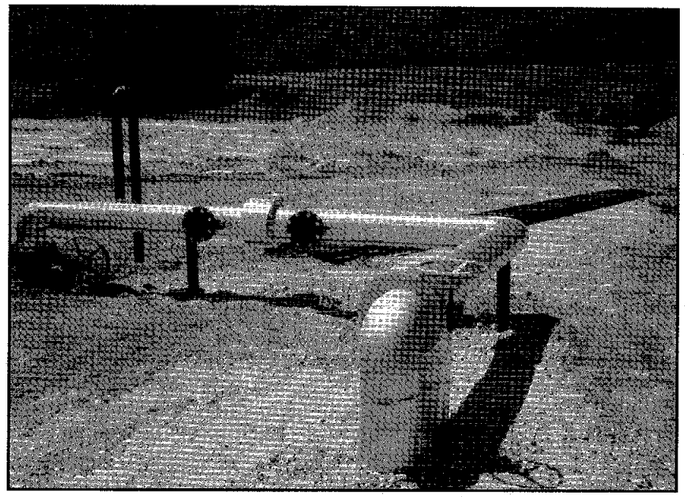


Variable-speed drive panel at the well site of "AG Park" 3.



Lake County well "AG Park" 2 is a completed production well not yet on line. The well was drilled to a total depth of 180.4 meters and can produce 57.2°C hot water. The total mass flow rate for the well is 31,238.2 kilograms per hour.

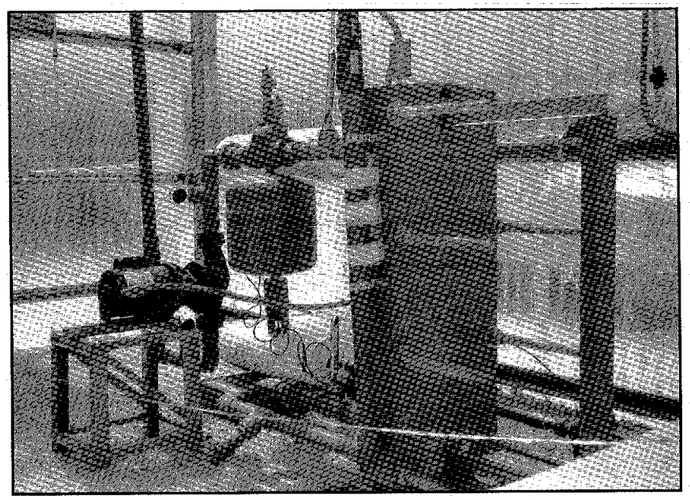
Lake County well "AG Park" 1. The 491.1 meter-deep injection well was drilled behind the greenhouse.

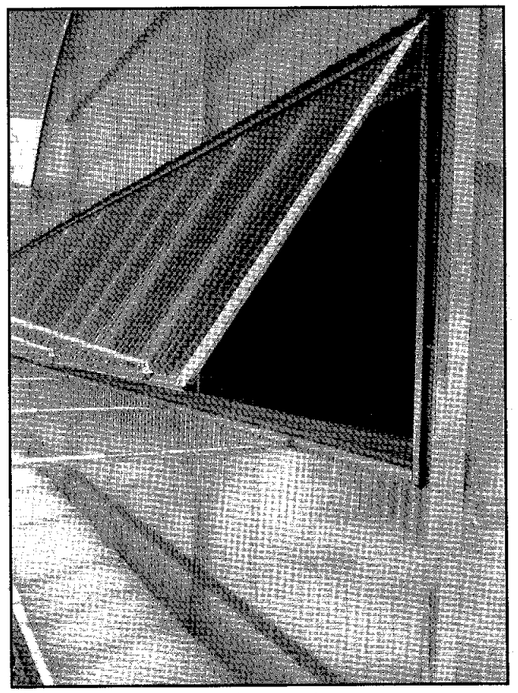


"The system is designed with low maintenance in mind," said Kevin Rafferty, Research Associate at the Oregon Institute of Technology - Geo-Heat Center, while looking at the greenhouse heat exchanger, center photo.

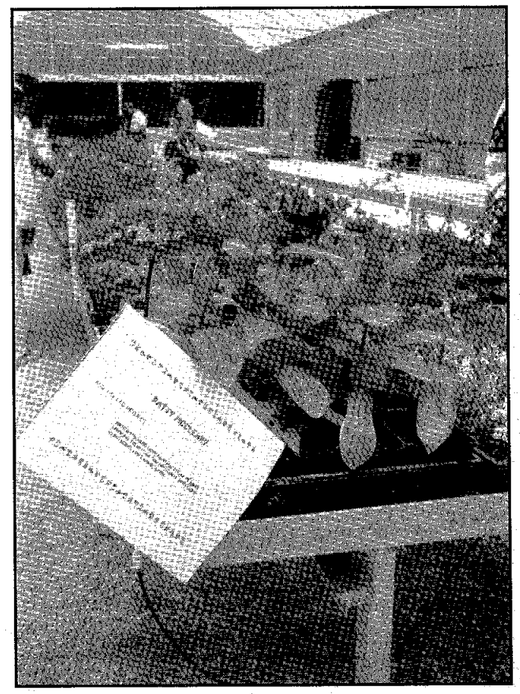
"The geothermal water never contacts the greenhouse heating equipment, which forestalls corrosion. Instead, during the October-to-April heating season, geothermal water at 60°C enters the heat exchanger and is used to heat a closed loop of water to 54°C. The 54°C water goes to the fan-coil units, which heat the greenhouse. Now cooled to 40°C, the water is returned to the heat exchanger for reheating.

"Once the geothermal water in the heat-exchanger drops to 46°C, it is passed to the injection well," Mr. Rafferety concluded.





In summer months, the greenhouse must be cooled. Fans pull air in through fibrous, swamp-cooler pads, over which water is circulated. Airflow over the pads is controlled by opening and closing the louvered panels on the outside of the greenhouse (see photo).



Geothermal greenhouse project by student Patty McCleary for Agr. 141 Lab. "Identifying and propagating local plants. Knowing their uses for medicinal purposes. Using herbs for landscaping."

Coming this fall --

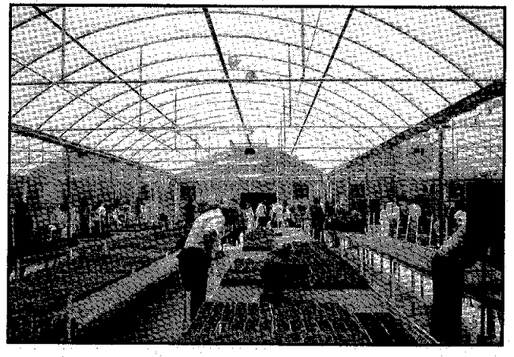
Our Geothermal Courses

and other Horticulture Classes

Many of our Horticulture Classes in Lake County (listed under the heading of Agriculture!) will be taught in the new Elaine H. Neasham Greenhouse Center.
The geothermal greenhouse is heated by natural water wells, and the courses provide a unique opportunity in the state of California for vocational training in geothermal greenhouses.

Heading on a flier distributed by Mendocino College, Lake County Center. For more information, call (707) 263-4944.

"Each small community has high expectations and specialized needs," said Ruth Lincoln, Director of the Mendocino College Lake County Center. "In Lake County," she continued, "this means geothermal energy. The college hopes to get even more involved in geothermal agricultural courses. Our work has attracted a high level of volunteerism. Two groups, Friends of the Greenhouse and the Horticultural Club, have been especially helpful."



The geothermal and irrigation supply systems for the greenhouse were designed by Brown & Caldwell Engineers. Technical assistance was supplied by the Oregon Institute of Technology - Geo-Heat Center.

The greenhouse construction, under the supervision of Gib Cooper, was undertaken by developmentally disabled adults through Konocti Industries. These same individuals and others are being trained in greenhouse management and in bedding plants.

For further information on the Geothermal Agricultural Heat Center, contact Mark Dellinger, Lake County Geothermal Coordinator (707) 263-2221.

Geothermal tomatoes, propagated in the greenhouse.

Mono County Update

Mammoth Chance

The proponents of Bonneville Pacific Corporation's Mammoth Chance Geothermal Project have filed an appeal with the Third District Appellate Court in which they challenge the December 1988 Writ of Mandamus decision by the Mono County Superior Court to set aside the use-permit issued for the project by the Mono County Board of Supervisors. A court date for the appeal has not been set.

Mammoth-Pacific II and III

On October 5, 1987, the Mono County Planning Commission issued a use-permit for the Mammoth-Pacific II Geothermal Power Plant and denied, without prejudice, the use-permit for the Mammoth-Pacific III Geothermal Power Plant. The Sierra Club and the California Department of Fish and Game (DFG) appealed the Mammoth-Pacific II decision to the Mono County Board of Supervisors, who rescinded the Mammoth-Pacific II use permit without prejudice on February 22, 1988.

Pacific Energy, the project proponent, then returned to the Board of Supervisors with evidence that refuted the allegations made by the Sierra Club and DFG regarding potential project impacts to local hydrologic resources and mule deer populations. On December 6, 1988, the Board of Supervisors reversed its earlier decision and reissued the use permit for the MP-II Project.

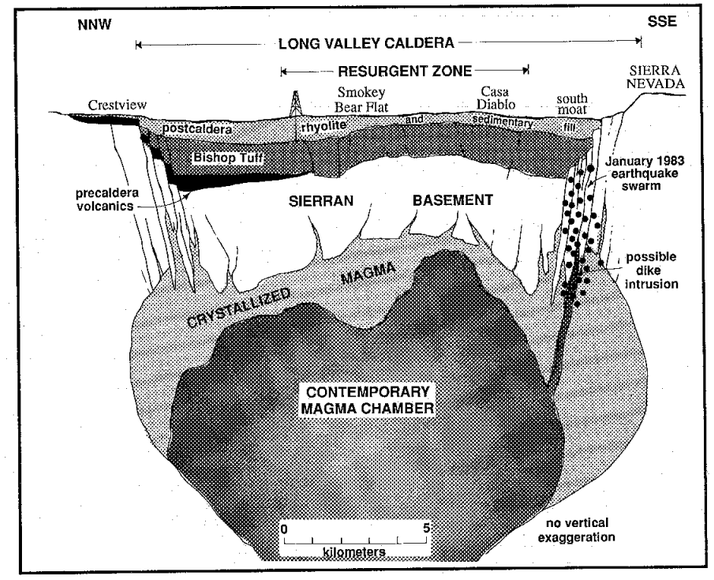
Subsequent to reissuing the use permit, DFG filed a petition for a Writ of Mandamus with Mono County Superior Court. However, the case never came to trial as extensive out-of-court meetings were conducted and a settlement was reached among DFG, Pacific Energy, and Mono County.

Today, the Mammoth-Pacific II project is permitted and well-pad construction and well-drilling operations are scheduled to begin in the late spring or early summer of 1990.

The Deep Magma Well

"I'm very pleased with the way it turned out. In Phase I, we accomplished what we set out to do," said James Dunn, project manager and supervisor of Sandia National Laboratories Geothermal Research Division. Dr. Dunn was referring to the U.S. Department of Energy (DOE), Magma Energy Program, whose 4-phase deep well is near Mammoth Lakes, California, in the Long Valley caldera. "We began drilling August 1, 1989, and stopped at 783 meters (2,568 feet). The well is straight, the casing has been cemented, and we hope to undertake Phase II in the summer of 1990. Then, we will drill to about 2,286 meters (7,500 feet).

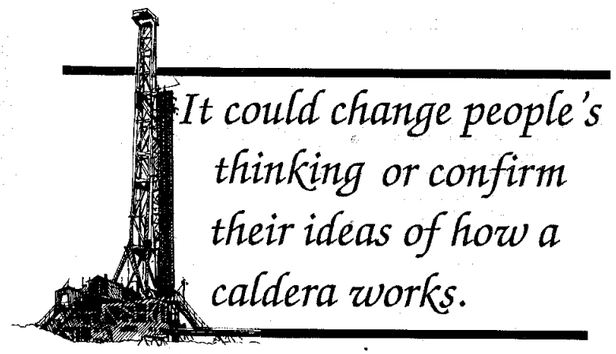
"We have just finished coring 185 feet below the bottom hole," Dr. Dunn said, at a meeting in October 1989. "The



Well site of the deep, magma well, "Long Valley Federal" 51-20, Section 20, Township 3S, Range 28E.

by Daniel Lyster, Director
Mono County Energy Management Dept.
HCR79, Box 221
Mammoth Lakes, CA 93546

core samples are being analyzed by many geologists. We will learn more about the Bishop Tuff. We will core next year, as well. Then, we hope to be coring the interface between the Bishop Tuff and the Mt. Morrison roof pendant rock (the top of an old magma chamber).



It could change people's thinking or confirm their ideas of how a caldera works.

"It would be so great to get some of the information from inside the caldera. It could change people's thinking or confirm their ideas of how a caldera works.

"This type of data doesn't exist anywhere else. Our greatest potential geothermal resource base is a silicic caldera system. No one has tested this idea by drilling," Dr. Dunn said.

The $8 million, 3.8-mile-deep magma well, funded by the DOE Geothermal Technology Division, will be the deepest well ever drilled into an active caldera system. The project was undertaken to evaluate the use of magma as a high-quality, clean-energy alternative to fossil fuels. The deep well will be used to answer fundamental questions about the existence of magma at drillable depths and the ability of geophysical techniques to accurately locate magma bodies. The project is designed and managed by Sandia.

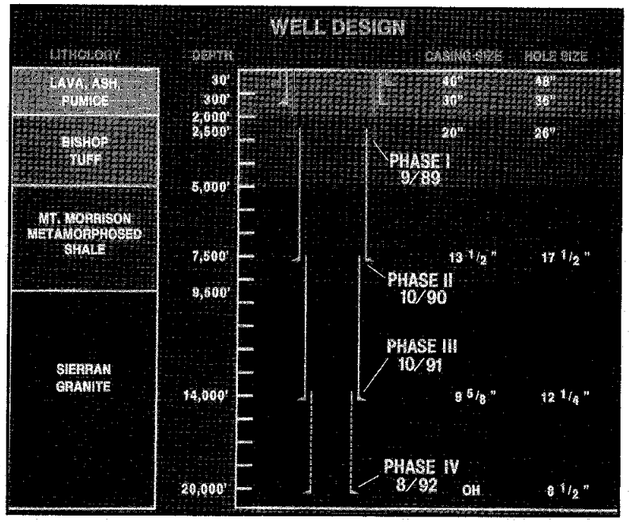
The well is also of significant interest to the Continental Scientific Drilling Program (CSDP), which is supported by the DOE's Basic Energy Sciences Division, the National Science Foundation, and the U.S. Geological Survey. As part of this program, scientific measurements will be made in the deep magma well to aid in understanding caldera-forming processes, and the conditions under which magma exists inside the earth's crust.

"While commercial power generation from magma might be 20- to 30-years away, information gained in this first-of-its-kind project will mark a major step in proving the idea can work," said Dr. Dunn.

Many believe magma to be a huge, potential energy resource. Magma bodies in the U.S., buried within 6 miles of the earth's surface and with temperatures higher than 600°C (1,112°F), are estimated to contain up to 500,000 quads of energy. (One quad -- a quadrillion British Thermal Units -- is the energy equivalent of 172 million barrels of oil,and California produces about one million barrels of oil a day.)

The Long Valley caldera is a large depression created by volcanic eruptions that occurred about 700,000 years ago. Located in the Inyo National Forest, about 3.5 miles northeast of the town of Mammoth Lakes, the well is being drilled on a feature called a resurgent dome -- a large, low, rounded hill that is the blistered-up floor of the caldera. At this site, a recent, subsurface magma flow created a measurable bulging of the earth's surface, an indication of the proximity of magma to the surface. "Our drilling site is 2 feet higher than it was 10 years ago," one scientist noted.

Over the past 15 years, hundreds of scientific investigators have used a variety of geophysical techniques in an attempt to define the caldera and the subsurface magma chamber. The chamber may contain as much as 200 cubic miles of magma, although a few tens of cubic miles is more probable,

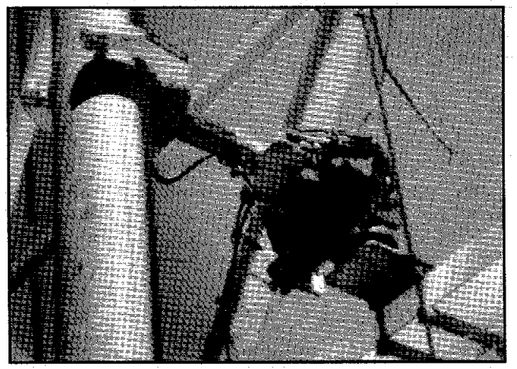


according to John B. Rundle of Sandia's Geophysics Division. The roof of the chamber seems to be about 4 miles beneath the resurgent dome.

Plans call for the well to be drilled in four stages. Each stage will be followed by an extensive period of testing and evaluation. In Phase I, the well was drilled to a depth of 783 meters (2,568 feet). The second phase calls for drilling and casing the well to a depth of 2,286 meters (7,500 feet) in the summer of 1990. In Phase III, the well will be drilled and cased to 4,267 meters (14,000 feet). Phase IV, scheduled for the summer of 1992, calls for drilling the well to 6,096 meters (20,000 feet) or until a bottom-hole temperature of 500°C (930°F) is reached. The first two phases are expected to take fewer than 60 days for drilling, while the last two may take up to 90 days each. After the final drilling phase, site restoration will be undertaken, including regrading, reseeding, and replanting.

Critical project elements are the borehole measurements and experiments conducted at each stage:

1. The temperature and heat-flow measurements will define a thermal signature and help scientists determine if molten conditions exist beneath the caldera. The physical and geochemical analyses of cuttings will reveal the history and subsurface structure of the caldera.



This hydraulic casing alignment tool holds the top of the casing straight as the couplings are screwed together. With the tool, 66 joints of 20-inch casing were run in about 6 hours, without cross-threading or coupling problems. The tool was developed with a grant from the DOE.

2. The analyses of fluids and gases encountered during and after the drilling will provide scientific data on the caldera's hydrothermal system and subsurface conditions. (Drilling equipment must be designed to withstand these conditions.)

3. The down-hole geophysical measurements will help define the extent of the magma body.

Geothermal District G2

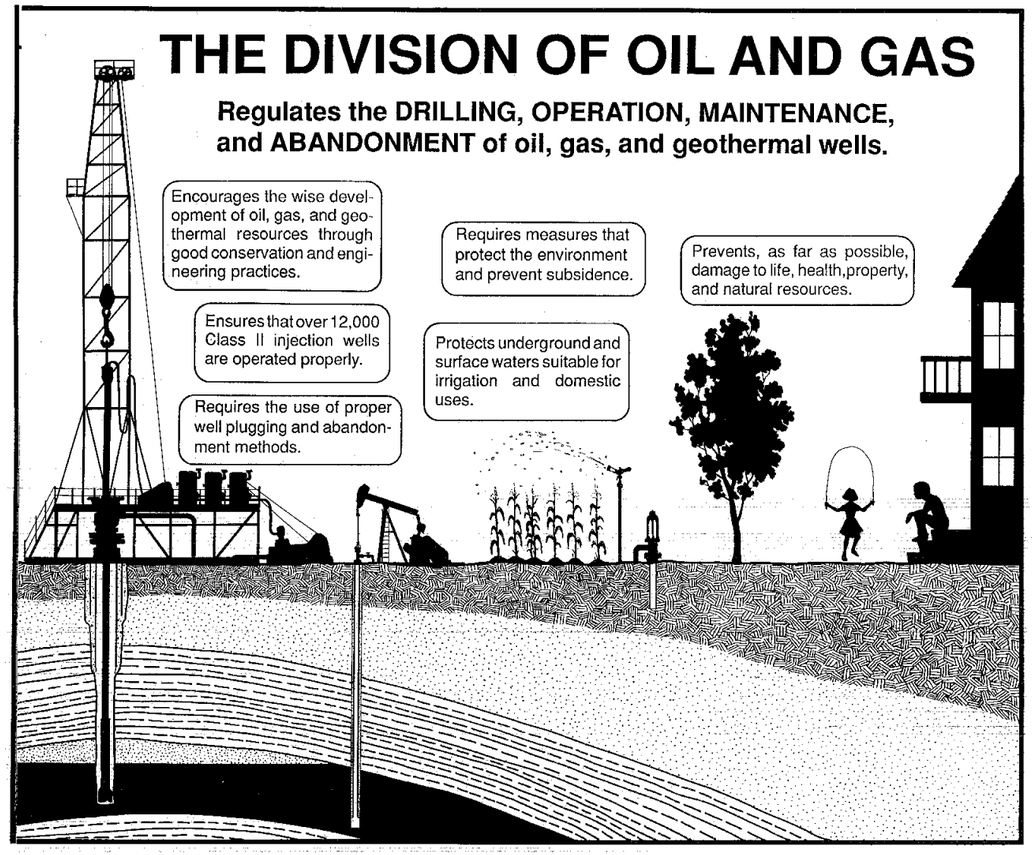
The Geothermal Section of the Department of Conservation, Division of Oil and Gas, is divided into three district offices. Differences among the geothermal projects overseen by the district offices reflect the variety of geothermal resources and resource development activities in the state. The last issue of the *Geothermal Hot Line* included a summary of geothermal activities in District G1. A summary of District G2 activities is presented here, and a summary of District G3 activities will appear in the next issue.

Geothermal District G2 encompasses 12 counties in Southern California. High-temperature electrical generation development occurs in the Imperial Valley and the Coso Geothermal Resource Area. Most of the high-temperature geothermal wells drilled in District G2 are development wells. This means they are drilled closer than 1/2 mile to a commercial geothermal well.

Low-temperature geothermal development is found throughout the district. Most low-temperature wells drilled in District G2 are exploratory wells, which means they are drilled farther than 1/2 mile from a commercial geothermal well.

The Division issues permits for well operations (e.g., drilling, plugging, etc.). To ensure compliance with permit stipulations, division engineers periodically inspect well leases, operations, and equipment.

by Timothy S. Boardman
Geothermal District Engineer



Roadlog: Geothermal District G2, September 1989

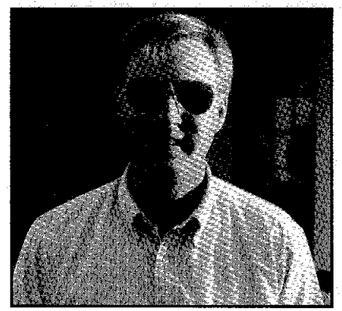
1. Paso Robles Area

The tour begins in the northern portion of District G2, at Paso Robles in San Luis Obispo County.

There are several hot springs in Paso Robles, which became a famous resort spa in the 1870's. These springs have encouraged the development of local, low-temperature geothermal projects through the years.

In the fall of 1988, the City of Paso Robles, with California Energy Commission funding, drilled a low-temperature well, "Test Hole" 3. The well was drilled as an exploration well to assess the potential of the low-temperature resources.

The well encountered 40°C (105°F) artesian water flowing at 1,890 liters/min. (500 gal./min.) at a depth of 220 meters (724 feet). When the well reached 329 meters (1,079 feet), problems occurred, and drilling was suspended.

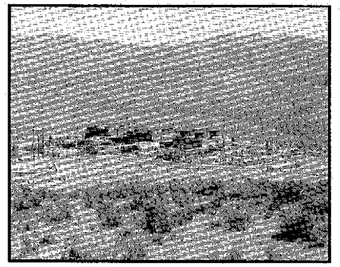


Tim Boardman.

2. Coso Geothermal Resource Area

Next, we travel east across the San Joaquin Valley, over the Tehachapi Mountains, and into the Mojave Desert. Here, a few miles east of Highway 395 in Inyo County, we come to the Coso Geothermal Resource Area.

The Coso Geothermal Resource Area is near Coso Hot Springs and inside the boundaries of the China Lake Naval Weapons Center. The geothermal reservoir at Coso is water-dominated, and well depths range from 460 to 2130 meters (1,509 to 6,990 feet). The wells have been completed with temperatures over 370°C (700°F) and operating wellhead temperatures of up to 250°C (480°F).



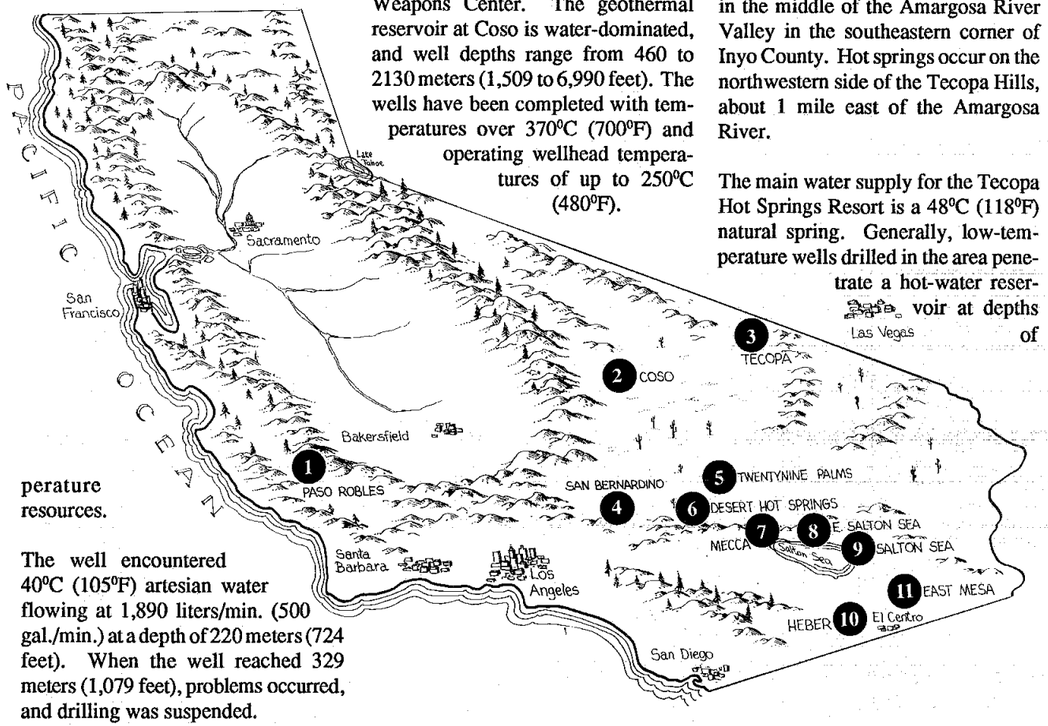
Coso Geothermal Resource Area. Navy Power Plant No. 1, Units 1, 2, and 3. Together, they generate 80 megawatts of electricity, net.

California Energy Company is developing and operating the field. By the end of 1989, power plants generating 230 megawatts of electricity are scheduled to be on line.

3. Tecopa Hot Springs Area

As we continue east on Highway 178, we come to the Tecopa area, which is in the middle of the Amargosa River Valley in the southeastern corner of Inyo County. Hot springs occur on the northwestern side of the Tecopa Hills, about 1 mile east of the Amargosa River.

The main water supply for the Tecopa Hot Springs Resort is a 48°C (118°F) natural spring. Generally, low-temperature wells drilled in the area penetrate a hot-water reservoir at depths of



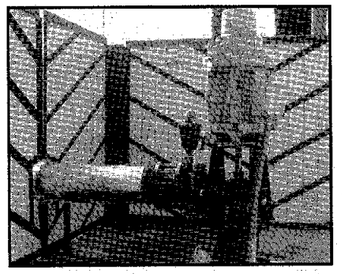
around 70 meters (230 feet). Most of these wells were drilled with cable tools and have surface pipe cemented below the near-surface sand and gravel. Many of the older wells in the hot spring area were hand dug many years ago and produce only from the upper, and cooler groundwater strata. The wells produce from 38 to 95 liters/min. (10- to 25-gallons per minute) of geothermal fluid.

In April 1980, the Inyo County Board of Supervisors issued a moratorium on drilling new geothermal wells in the Tecopa Hot Springs Area in an effort to protect the hot-water supply for Tecopa Hot Springs.

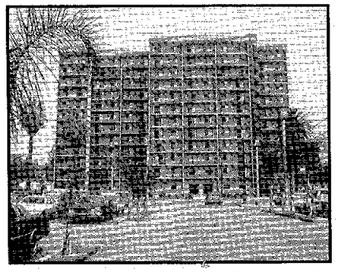
4. San Bernardino Geothermal Resource Area

From Tecopa Hot Springs, we travel southwesterly on Highway 127 to the San Bernardino Geothermal Area. This area of shallow, low-temperature geothermal resources is fault-controlled and was discovered while drilling for cold water.

The City of San Bernardino Municipal Water Department owns and operates a district-heating system in the downtown area. When pumped, each of the two production wells in the system can produce up to 18,900 liters/min. (5,000 gallons per minute) of 57°C (134°F) water. The water is used for space- and water-heating projects.



Well "Mill and D Street," one of two geothermal production wells in the San Bernardino Demonstration Geothermal District Heating System.



St. Bernardines Retirement Plaza, a 12-story structure included in the geothermal district-heating system.

Some of the facilities in this system are the Wastewater Treatment Plant (2 digesters and 3 buildings), the City Animal Control Center, San Bernardino Blood Bank, City Hall, City Convention Center, Central City Library, the 12-story Saint Bernardines Retirement Plaza, and the 13-story Ramada Inn. The district-heating system is able to heat about 4 billion cubic feet of space. Additional development is planned in the southern portion of the system.

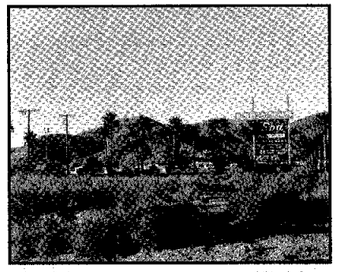
Currently, the nearby cities of Loma Linda and Colton are investigating the possibilities of developing their own geothermal district-heating systems. Loma Linda has received funding from the California Energy Commission to assess the geothermal potential in the area; if the assessment is favorable, development may be started. Colton has just started the process for receiving assessment funding.

5. Twentynine Palms

Next, we journey east on Highway 10 to Twentynine Palms in the Mojave Desert. This south-central portion of San Bernardino County has four geothermal areas that were delineated in a 1985 study by the URS Corporation for the San Bernardino County Department of Housing and Community Development. Two of the areas were considered unsuitable for development. The report states that fluids of 71°C (161°F) occur at depths less than 122 meters (400 feet), with hotter fluids at greater depths. The report concludes it is feasible to use these geothermal fluids for space heating and cooling.

6. Desert Hot Springs Geothermal Resource Area

Now, we travel to the Coachella Valley at the northern end of the Salton trough. Here, most of the City of Desert Hot Springs lies within the Desert Hot Springs Geothermal field. The city, taking its name from the local hot springs, calls itself the "Spa City of the World".



A spa in Desert Hot Springs, California.

The Desert Hot Springs Geothermal field includes several dozen low-temperature geothermal wells used commercially for spas and pools. Temperatures in some of these wells reach 90°C (194°F). (Although these hot-water wells are shallow, they produce fluid from a deep convection system.) A maximum resource temperature of 135°C (275°F) may be expected at a depth of 1,200 meters (3,940 feet).

7. The Mecca Area

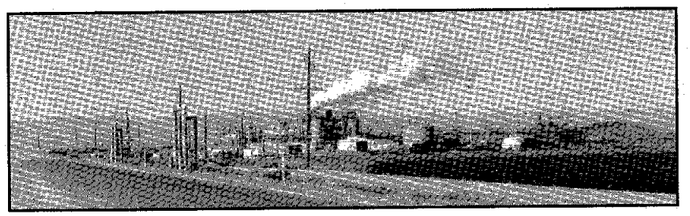
In the southern Coachella Valley, on the northwestern shore of the Salton Sea in Riverside County, several wells produce low-temperature geothermal fluids. The wells are about 213 to 274 meters (700 to 900 feet) deep, and produce geothermal fluids at 54°C (120°F). The fluids are used to heat greenhouses for the production of fresh flowers.

8. The Eastern Salton Sea Area

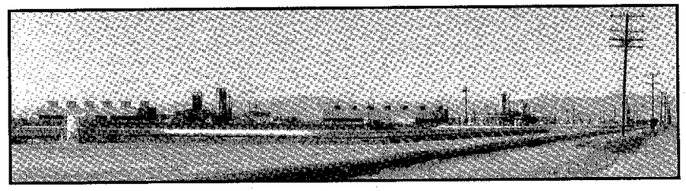
Several commercial, low-temperature geothermal spa and aquacultural developments are on the eastern shore of the Salton Sea. One, Pacific Aquafarms, raises tilapia (a fish native to Africa) in the produced water, which is relatively fresh for the Salton Sea area, with about 4,500 ppm total dissolved solids. The temperature of the reservoir is about 142°F, and the wells are about 152 meters (500 feet) deep.

A pond at Pacific Aquafarms, near Niland, California.

Salton Sea Geothermal Project, Unit 3, Unocal.



Salton Sea Geothermal Project, Unit 1, Unocal.

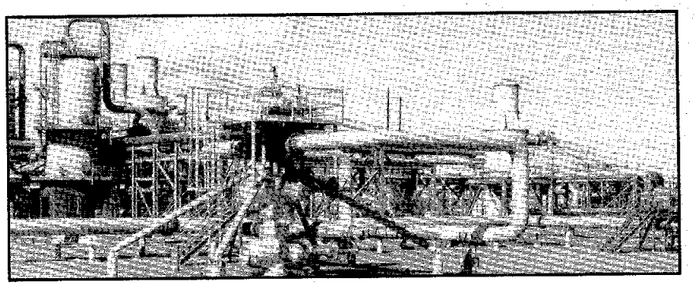


Vulcan Power Plant (left) and Del Ranch Power Plant, Magma Power Company.

9. Salton Sea Geothermal Field

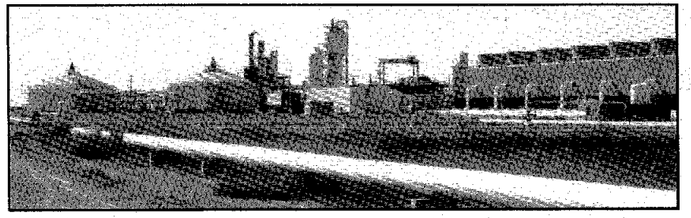
Next, we travel south to the Salton Sea Geothermal field. Located at the southern end of the Salton Sea, the Salton Sea Geothermal field is the largest in the district. By the end of 1989, six geothermal power plants were generating 193.8 megawatts, net, of electricity in the field.

The Salton Sea geothermal reservoir is water-dominated, with 260°C (500°F) water at depth. The quality of the reservoir water is poor, with total dissolved solids averaging 200,000-300,000 ppm. The technology to produce and generate electricity from such fluids had to be developed before the field's current projects could be undertaken.

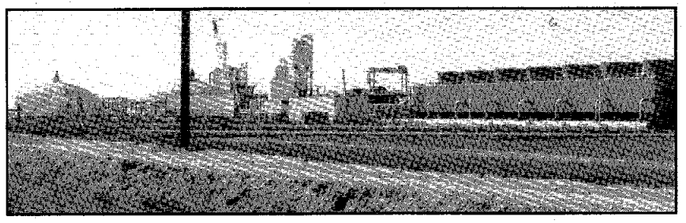


Well "Vonderahe" 1, world's largest geothermal well.

The Salton Sea Geothermal field contains the largest geothermal production well in the world, "Vonderahe" 1, which is capable of producing over 990,000 kg/hr. of fluid. The well is operated by Unocal Geothermal Division, a subsidiary of Unocal Corporation. The well supplies geothermal fluid to the Salton Sea Geothermal Project, Unit 3, a geothermal power plant that generates 47.5 megawatts, net, electricity. The plant is owned by Desert Power Company, a subsidiary of Unocal Corporation. Also, there is the Salton Sea Geothermal Project, Unit 1 -- a 10 megawatt, net, power plant owned and operated by Earth Energy, Inc., another subsidiary of Unocal



Elmore Power Plant, Magma Power Company.



Leathers Power Plant, Magma Power Company.

Corporation.

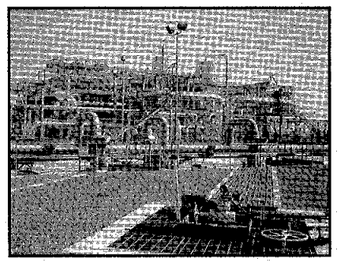
Four Magma Power Company geothermal power plants are operated in the field: Vulcan, generating 32 megawatts, net; and Del Ranch, J.J. Elmore, and Leathers, each generating 34 megawatts, net.

10. Heber Geothermal Field

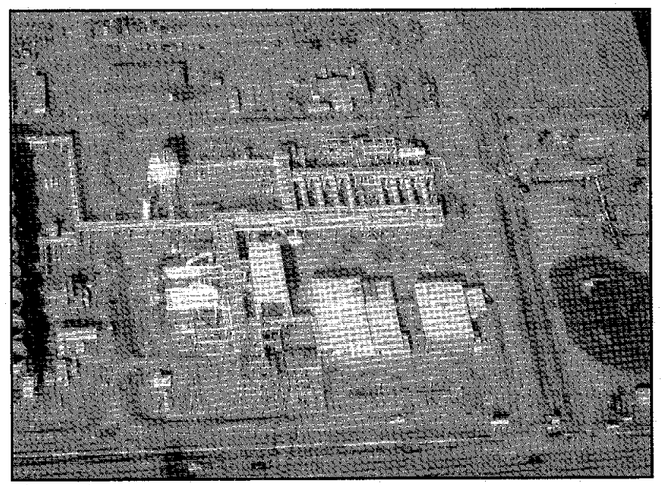
Heber Geothermal field is about 1 mile south of Heber, California, in the southern portion of the Imperial Valley. The geothermal reservoir ranges in depth from 610 to 1,830 meters (2,000 to 6,000 feet) and produces 181°C (358°F) geothermal fluid. Geothermal production wells at Heber are operated by Chevron Geothermal Company, a subsidiary of Chevron USA Inc.

Two electrical generating plants are in the field. One, a binary plant rated at 45 megawatts, net, is operated by San Diego Gas and Electric Company (SDG&E). The plant has been shut down since June 1987 due to contractual disagreements between Chevron Geothermal (unit operator) and SDG&E. The plant has 13 production wells on the site that are produced with submersible pumps. The spent fluid is pumped into injection wells northwest of the power plant.

The second geothermal power plant in Heber Geothermal field is a dual-flash plant owned by Centennial and ERC, and operated by Imperial Power Services, Inc. The plant is rated at 47 megawatts, net, and is operated from 10 production wells on the plant site. The wells produce 3.68 million kilograms per hour (8.10 million pounds per hour) of geothermal fluid.



The dual-flash geothermal power plant, Heber Geothermal field.



The Heber binary geothermal power plant, Heber Geothermal field..

11. East Mesa

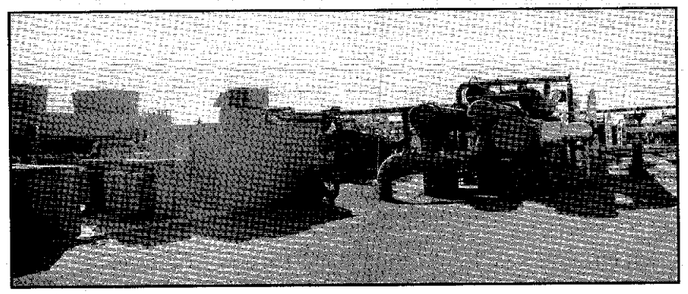
East Mesa Geothermal field is in the eastern Imperial Valley, 6 miles southeast of the Town of Holtville and just north of Highway 8. All geothermal production and injection activities for this field are on federal lands; thus, the Bureau of Land Management, rather than the Division of Oil and Gas, holds all permitting authority. However, the division does maintain contact with operators in the field.

Ormesa IE Power Plant.

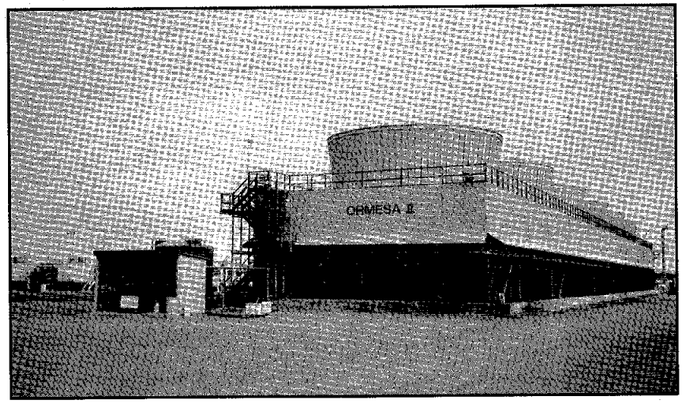
The East Mesa field reservoir is water-dominated and production wells range from 1,524 to 1,830 meters (5,000 to 6,000 feet) in depth. The produced fluid temperatures vary from 143° to 176°C (290° to 350°F).

Geothermal Resources International, Inc. (GEO) operates two geothermal power plants in the East Mesa field. One, the McCabe Power Plant, is a 13.4-megawatt, gross, binary plant. The second, the GEM 1 Power Plant, is less than one-half mile northwest. This is a 43 megawatt, gross, 40 megawatt, net, dual-flash plant. Fifty percent of the GEM 1 plant is owned by GEO East Mesa Limited Partnership, and 50 percent by a wholly-owned subsidiary of Mission Energy Company.

Ormesa Geothermal operates three binary electrical generating plants in the East Mesa field: the Ormesa I Power Plant, a 30-megawatt, gross, plant; the Ormesa IE Power Plant (an extension of Ormesa I), a 10-megawatt, gross, plant; and the Ormesa II Power Plant, a 20-megawatt, gross, plant.



Ormesa I Power Plant.

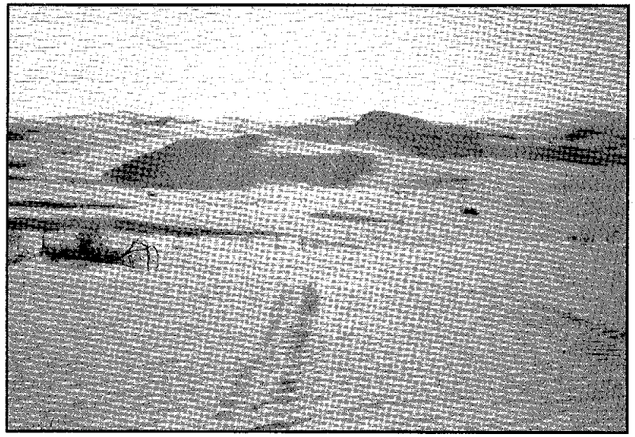


Ormesa II Power Plant.

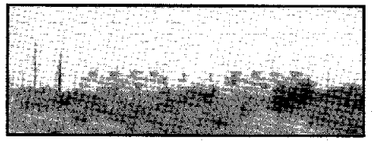
Tests for Power Plant Ormesa 1H began on December 3, 1989. The acceptance test for the 12-megawatt, gross, power plant is scheduled for March 1990. Three production wells and 4 injection wells will be used to operate the 12 Ormat units at the power plant.

The Algodones Dune Field, East of East Mesa

Text and photos by Susan F. Hodgson

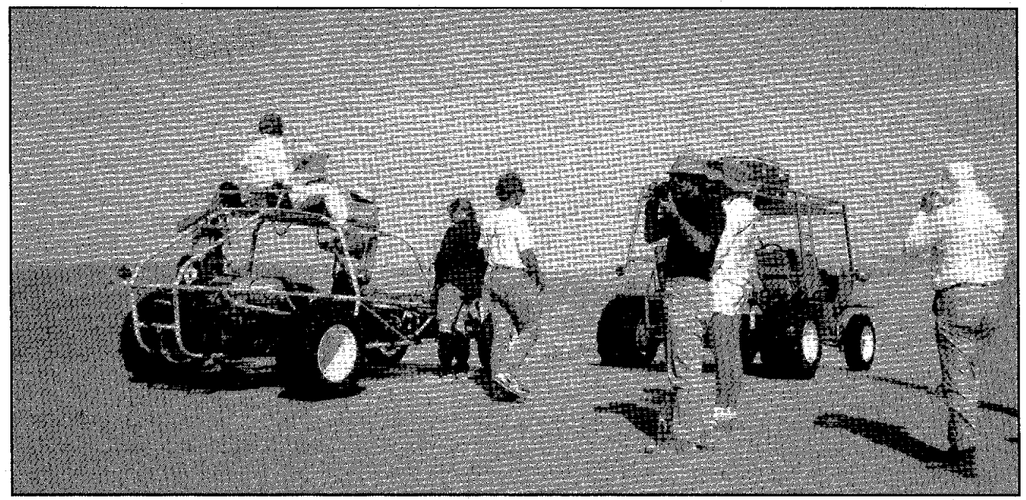


Mounded on the eastern flank of the Imperial Valley, labeled as "Sand Hills" on road maps, the beautiful Algodones Dune field stretches across Interstate 8 near the California-Arizona border.



West of the immense dunes stands the new GEM 1, a 43-megawatt, gross, geothermal power plant in East Mesa Geothermal field.

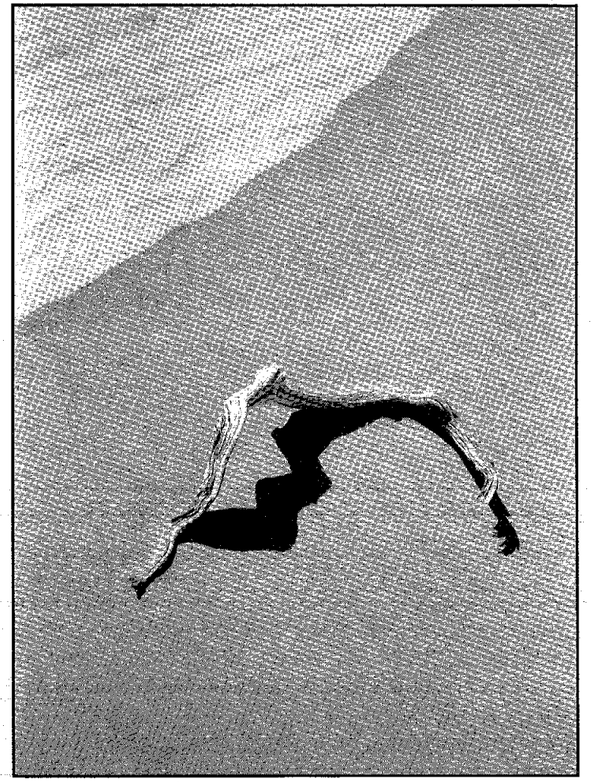
View toward the northeast from the Salton Sink showing the Algodones Dunes in the middle ground and the Cargo Muchacho Mountains in the background. The San Andreas fault possibly parallels the sand ridges in the foreground, although evidence is inconclusive. The All American Canal and U. S. Highway 8, photo right, transect the dunes in one of the remarkable flat-floored, relatively sand-free depressions within the dune area. Photo by John S. Shelton. Caption and photo from the Geologic Atlas of California, *prepared by the California Department of Conservation, Division of Mines and Geology. Reprinted with permission.*



The Algodones Dunes are". . .one of the most morphologically diverse and largest dune fields in North America. They trend NW-SE for 75 kilometers along the eastern side of the subsiding Salton Trough," according to a guidebook of the American Association of Petroleum Geologists, Pacific Section. In May 1989, members of the organization visited the Algodones Dune Field on a field trip.

"Although the net direction of superimposed dune migration is to the NE, the seasonal wind directional changes cause the bedforms to reverse their migration direction." From the guidebook, prepared by Sweet, Havholm, and Kocurek, Dept. of Geological Sciences, University of Texas-Austin, and Clark, Unocal, Brea, Ca.

After visiting the Algodones Dune field, I searched for information on geothermal exploration in the area. I learned of six temperature-gradient wells that were drilled at the western edge of the dune field in Sec. 33, T.15S., R.19E., in the early 1970's. Two of the TG wells showed temperature reversals. Because of this feature, the wells, "USBR-UCR" 115 and DWR "Dunes" 1, are discussed in an interesting paper, "Critique of Geothermal Exploration Techniques," published by Tsvi Meidav and Franco Tonani in the Proceedings, Second United Nations Symposium on the Development and Use of Geothermal Resources, May 20-29, 1975.



Before reprinting portions of this paper, background information on well DWR "Dunes" 1 may be of interest. It is reprinted, with permission, from the *Munger Oilogram*, January 30, 1973.

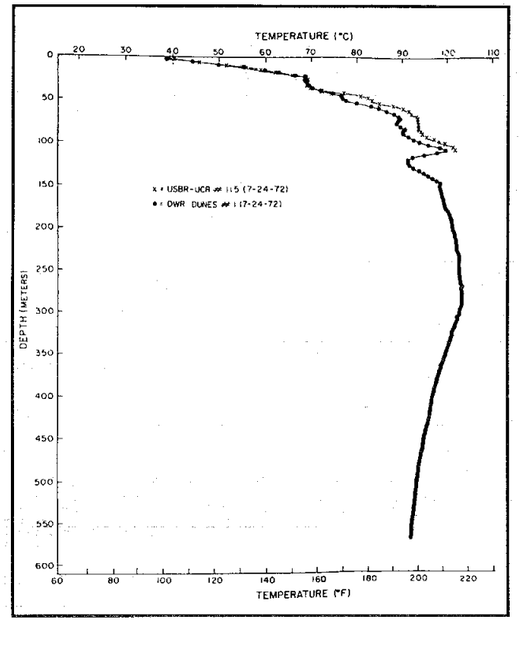
DUNES ANOMOLY IMPERIAL COUNTY
Dept. of Water Resources "Dunes" 1 16c.40 2016'T.D. Pg 1946'.
33-15S-19E, Fr. SE cor. 2640'N 2640'W R/A 4c.2016 Drid. 18" hole, hard form.
Spud 6/2/72 El. 184'KB 281'. Lost, rec. core bbl.
(Company Rig) 629'. Ran Welex Log at T.D.
(±2000' - Exploratory) Reamed, C.O. to 2016'. To perf. & test at 300'
(1½ miles W of So. Pac. R.R. Town of Ogilby) 800' & 1800' in collaboration w/U.C. at Riverside. Expects to produce from ±800' zone. Well plugged to 1927'. Fluid tests by U.C., Riverside, for mineral, chemical content, and temperature. Tem. slightly over boiling. Ran Temp. surveys. Max. temp. 220° at ±900'. Temp. at ±600' 210° and at 2000' 195°-200°. Contract awarded Go-Int'l. to perf. zone ±850-900'. Perf'g. lower Int. ±1910-1970'. Test fluid before perf'g. 40' Int. within 850-900' & 300-350'. Perf'd. 910-970', flow tested. ±Int. 340-80', 850-890', & 879-919' perf'd.; wtr. samples being analyzed at U.C. Riverside (Int. were perf'd.) Wtr. samples from 3 Int. 340-80', 850-890' & 1879-1919' being tested for chemical characteristics. Solids 2-4000 ppm. 8 samples wtr. taken from Int: 340-80', 850-890' & 1879-1919'. Highest temp. 218° from 850-90' zone; temp. at btm. dropped to ±200°. Solids at 1325', 2500 ppm; & +3000 ppm at btm. Cores & wtr. samples of 3 Int. being analyzed by U.C. Riverside. 12/15/72 - will drop until preliminary rpt. on cores & wtr. samples of Ints: 340-80', 850-90' & 1879-1919' are released from U.C., Riverside.

Here is the excerpt from the paper by Meidav and Tonani, reprinted with permission.

"Temperature-gradient measurements and their dependent parameter, conductive heat flow, have often been employed as a primary criterion for selection of a drilling target. The implicit assumption is that temperature gradients measured in shallow holes may be linearly extrapolated to a great depth. However, such an assumption would hold true only in a perfectly impermeable medium, where no water flows.

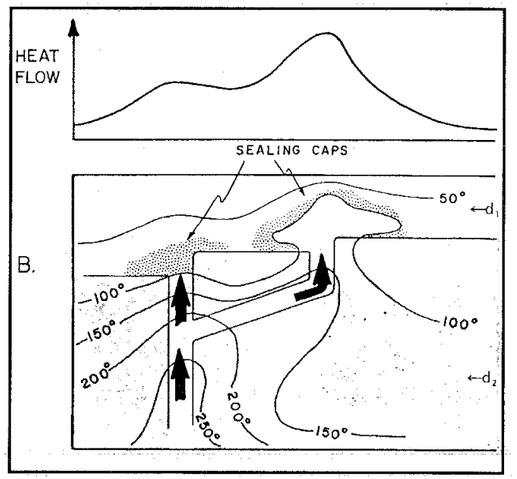
"A most dramatic example of the potential pitfall that could result from extrapolating either temperature gradient or conductive heat flow may be shown by recourse to the Dunes anomaly, Imperial Valley, case history (Combs, 1973). Here, a shallow temperature gradient and conductive heat-flow measurements (shown by x marks in Fig. 1) suggested a most positive geothermal potential for the area, if the steep temperature gradient extended to any great depth. Subsequent drilling and temperature-gradient measurements to a depth of 600 meters showed that the bottom of the previously drilled temperature-gradient hole was also the top of a quartzitic cap layer. Below that depth, the temperature gradient reversed itself (solid line in Fig. 1). The negative gradient is caused by the presence of a hot-water cap layer that flows laterally across the borehole.

Figure 1. Temperature-gradient profiles, Dunes anomaly, California. The "x"-marks designate data gathered in a shallow temperature-gradient survey of the area. The solid line represents subsequent temperature gradients measured in the exploration hole that was drilled subsequently (data by Combs, 1973).



"Figure 2 is a schematic representation of a conceivable thermal water flow regime in a complexly faulted area, which could explain the negative temperature gradient in the Dunes anomaly. It further demonstrates the dangers associated with neglecting the vagaries of vertical and lateral thermal-water flow. A steep, shallow-temperature gradient is a condition that could manifest the existence of an economic geothermal reservoir in the area, but could also indicate rapid upward flow due to the buoyancy of water in a normal-gradient area. Conversely, in an area of high infiltration rates of rainwater or strong lateral ground-water flow, the absence of a significant temperature gradient does not necessarily rule out the existence of a geothermal reservoir below. This is of special importance in grabens, where strong lateral flows could take place, but where geothermal reservoirs may occur. Finally, heat-flow measurements in a mountainous terrain must be compensated for terrain effects. Otherwise, genuine temperature anomalies may be masked by terrain effects, and false anomalies created in places."

Figure 2. A model of hot-water flow in a faulted geothermal system that could result in the highest heat flows and steepest temperature gradients in shallow holes (drilled to a depth d_1) being associated with the coldest reservoir temperature (drilled to a depth d_2).



Thus, near to so much geothermal development, the Algodones Dune field remains apart. It holds a different resource in reserve, that of repose and of rare, compelling beauty.

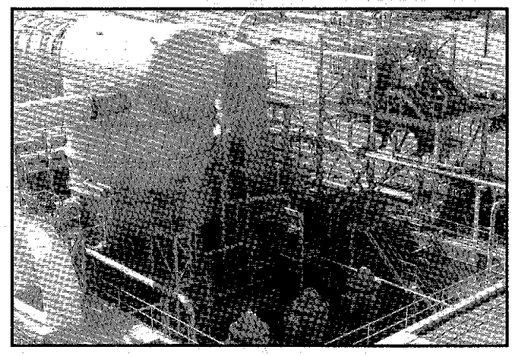
Power Plant GEM 1 on Line

On April 28, 1989, Geothermal Resources International, Inc. (GEO) announced the completion of a successful synchronization for one of the two 21.5-megawatt generating units at its GEM 1, East Mesa Geothermal Project in the Imperial Valley of Southern California.

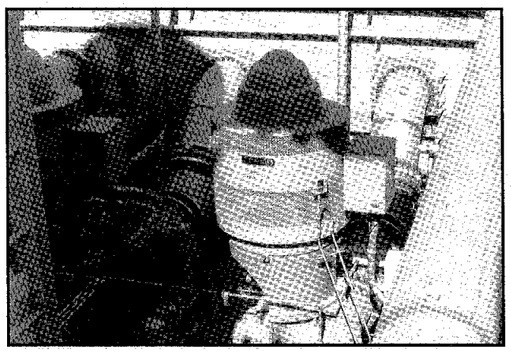
According to GEO's chief executive officer Ronald P. Baldwin, the synchronization represents the first time the East Mesa Geothermal Project, begun in May 1988, has produced electricity that has been sold to Southern California Edison Company.

GEO owns a 50 percent partnership interest in the GEO East Mesa Limited Partnership, which in turn owns the 43-megawatt, gross, (40-megawatt, net) GEM 1 plant and the 13.4-megawatt, gross, B.C. McCabe Geothermal Power Plant, also in East Mesa.

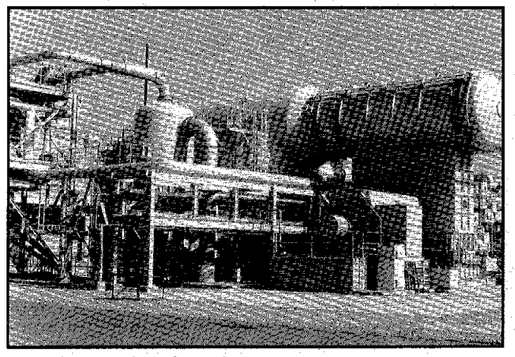
Mr. Baldwin said that as a result of favorable treatment provided under existing tax law, certain geothermal expenditures produce significant tax benefits. GEO is actively pursuing a possible sale of its portion of the tax benefits inherent in the East Mesa geothermal project. GEO anticipates that this sale, if accomplished, might result in proceeds to the company of up to $12 million, after payment of related expenses.



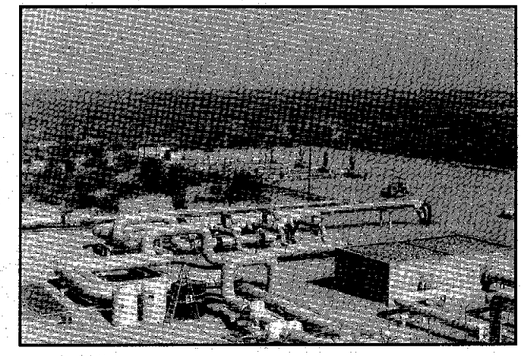
Turbine and generator, GEM 1 Power Plant. Injection pumps are in the pit. Photos by Timothy Boardman.



Close-up of an injection pump, GEM 1 Power Plant.



Turbine and generator, GEM 1 Power Plant.



Well pad, GEM 1 Power Plant, 3 production wells and 1 injection well. Rock mufflers are at photo lower-right.

Ormesa IE Update

On March 17, 1989, Ormat Energy Systems, Inc. announced the financial closing and full funding of the Ormesa IE Geothermal Project at East Mesa Geothermal field. The annoucement follows the power plant's successful completion of the 25-day acceptance test.

The project was structured financially as a 20-year leveraged lease, with Constellation Investments, Inc. and Chrysler Capital Corporation providing the equity funds. Prudential Capital Corporation provided the long-term debt, the proceeds of which were used to pay off Bankers Trust Company and the Bank of Nova Scotia, who acted as the construction lenders.

Ormesa IE was completed in 6 months and is expected to sell about 8 megawatts, net, of electricity to Southern California Edison Company.

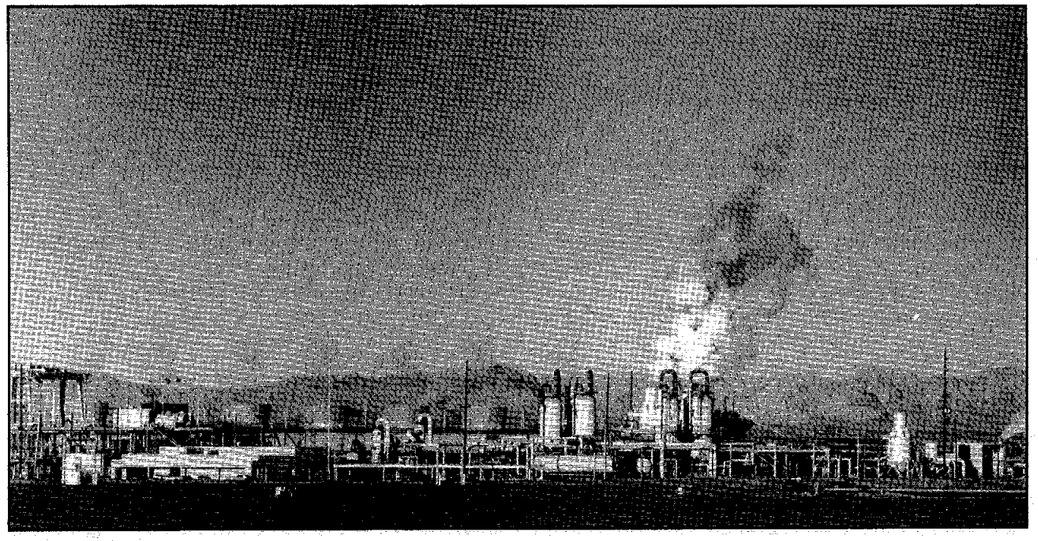
The project consists of 10 water-cooled Ormat energy converters, cooling towers, and related equipment. Geothermal water at a temperature below 300°F is pumped to the power plant units from 4 production wells.

Salton Sea Unit 3 Dedicated

On April 5, 1989, Unocal Corporation and its subsidiary, Desert Power, dedicated Salton Sea Unit 3, a 47.5-megawatt, net, geothermal power plant in the Imperial Valley. The new power plant, owned by Desert Power, began commercial operation on February 14, 1989. Geothermal wells producing the hot brine used to operate the power plant were drilled and are operated by Unocal Corporation.

"Unocal has been dedicated to technological innovation since it began in 1890, nearly a century ago," said Richard J. Stegemeier, Unocal's president and chief executive officer, in his remarks at the dedication ceremony. "And here we have an outstanding example of its value. It took 10 years of research and development for Unocal to solve the problems associated with the highly saline geothermal brines of the Salton Sea reservoir."

Construction of the $110 million steam-separation and power-generation facilities for Salton Sea Unit 3 began in December 1986. Electricity generated at the power plant is transmitted by the Imperial Irrigation District to Southern California Edison Company in the Coachella Valley.



Salton Sea Unit 3. Photo courtesy of Unocal.

Salton Sea Unit 3,

Fact Sheet

Electrical power generation: 54 megawatts, gross; 47.5 megawatts, net
(purchased by Southern California Edison)

Resource Production		Power Generation	
Number of wells:	5 (2 producers and 3 injectors)	Turbine:	MHI 5-stage, dual flow/ dual entry condensing type
Deepest well drilled:	"Sinclair" 23 at 7,400 ft.	Condenser:	Ecolaire dual zone shell-and-tube
Production rates:	2,500,000 lbs./hr. for "Vonderahe" 1 1,750,000 lbs./hr. for "Sinclair" 10	Noncondensible gas removal system:	Nash-Kinema 3-stage ejector
		Cooling tower:	Marley 7 cell counterflow
Average temp. of reservoir fluids:	520° F		
		Equivalent annual savings in oil:	500,000 bbl
Total dissolved solids in reservoir fluids:	200,000 to 300,000 parts per million	Construction began:	December 1986
Steam production system:	Flashed stream, 3 stages of separation to turbine	Commercial operation:	February 14, 1989
		Quantity of concrete:	20,700 cu. yds.
Steam requirement for power plant:	617,000 lbs./hr. at 100 psig 262,000 lbs./hr. at 10 psig	Quantity of structural steel:	835 tons
		Total length of pipe:	63,000 feet
		Electrical wire and cable used:	75 miles

Coso Phase I Completed

California Energy Company's Coso Geothermal Project is in the China Lake Naval Weapons Center in Inyo County, California. The project area includes 24,000 acres of federal land, including acreage under contract with the Navy and leased from the Bureau of Land Management.

When Phase I of the Coso Project was completed at the end of 1989, the project included nine geothermal power plants, generating a total of 230 megawatts, net. The electricity is sold under long-term power-sales contracts with Southern California Edison. In late 1989, six of the units were generating electricity: Navy Power Plant No.1,Units 1, 2, and 3; BLM East, Units 1 and 2; and BLM West, a one-unit plant.

"By the end of 1989, Navy Power Plant No. 2, Units 4, 5, and 6, were synchronized," said Jim Moore, CEC senior vice president, exploration. "We will continue to explore and evaluate the resource at Coso. Over the next few years, we'll make appropriate decisions over where to expand the field," he concluded.

PUC Approves SDG&E Contract with Navy

On September 27, 1989, the California Public Utilities Commission (PUC) found reasonable a contract under which the United States Navy may purchase electricity from San Diego Gas & Electric (SDG&E) at a discount. The PUC concluded that utility customers are protected adequately under this arrangement.

The contract offers the Navy a 5 percent rate discount on base rates for 89.5 megawatts of electricity over 10 years. The Navy must pay for 89.5 megawatts even if it does not take the full amount. If the Navy purchases more than 89.5 megawatts, the excess will be billed at the regular, undiscounted rate.

For two subsequent 10-year periods, the discount will increase to 15.5 percent. The Navy has the option to cancel the contract for the next 10-year period, and either the Navy or SDG&E may cancel the contract for the third 10-year period. In return, SDG&E will be allowed to keep four existing combustion turbines rent free on Navy property.

The PUC's Division of Ratepayer Advocates (DRA), which looks out for consumer interests, recommended PUC approval for the plan. The DRA estimated that SDG&E's customers will benefit by up to $121 million under the contract, and will benefit even more if the proposed SDG&E merger with Southern California Edison occurs.

Benefits to customers are based on the fact that the Navy could by-pass SDG&E and acquire electricity from others at a lower cost. A by-pass by a major customer such as the Navy would force the rest of SDG&E's customers to pick up the by-passed customer's share of the utility's fixed costs of service. Savings to SDG&E--and hence its customers--also occur because it would cost the utility $30 million to move the four turbines now situated on Navy property to another location.

No party that regularly participates in PUC proceedings opposed the contract or requested hearings.

OTHER WESTERN STATES

Utah Power Plant to Reach 11 Megawatts

The Ben Holt Company has received a contract to provide engineering and other services to Utah Municipal Power Agency, Spanish Fork, Utah, in connection with a planned 7.4 megawatt, net, addition to this agency's 3.6 megawatt, net, geothermal power plant at Cove Fort, Utah.

The power plant addition will use a condensing steam turbine. The power plant facilities already in place include a topping turbine installed ahead of four Ormat units.

The Ben Holt Company will test new geothermal wells, develop an optimum design, prepare a bid package for construction, manage the construction, and start up the new facility. A new cooling tower will be built, and H_2S abatement equipment installed. Project completion is scheduled for September 1990.

Six new, dry-steam wells drilled by Mother Earth Industries, Inc., will be used to operate the power plant. Well "42-7", drilled by Unocal Corporation, will be used for injection.

Mother Earth Industries has drilled two additional dry-steam wells in the field for use in future expansions of the Cove Fort project.

California Energy Company Negotiating with Chevron

In January 1990, California Energy Company, Inc. announced it had entered into negotiations with Chevron Resources Company regarding the sale of certain of Chevron's geothermal operations and properties located in Nevada and Utah to California Energy for an undisclosed cash amount.

Soda Lake Geothermal II Permit Sought in Nevada

An application was filed with the Public Service Commission of Nevada by AMOR IX Corporation, a wholly owned subsidiary of Ormat Energy Systems, Inc., for a permit to construct the proposed Soda Lake Geothermal II Project under the provisions of the Utility Environmental Protection Act. The proposed Soda Lake Project is located in Churchill County, Nevada, about 7 miles northwest of Fallon. It consists of a 13 megawatt, net, modular binary geothermal power plant, with geothermal production and injection wells and associated facilities. The electricity produced at the project will be sold to Sierra Pacific Power Company under a long term agreement.

At this time, AMOR will be the developer of the Soda Lake II Project. Ormat will be the operator.

Texas is First: Geopressured Power Plant On Line

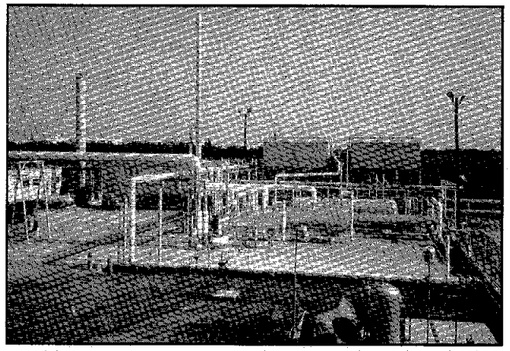
"We are completing our start-up phase and carrying out performance tests. We expect to complete testing in mid-November 1989, and embark on continuous operation," said Richard Campbell, a Project Manager with The Ben Holt Company. Mr. Campbell was referring to a 1 megawatt power plant in Brazoria County, Texas, built by The Ben Holt Company to demonstrate electrical generation from a geopressured, geothermal resource. The power plant first produced electricity for the Houston Lighting and Power Company grid on October 19, 1989. The plant uses a unique hybrid-cycle concept in which electricity is generated from two or more sources of energy. Fluid for the demonstration plant is produced from one geopressured well, "Pleasant Bayou" No. 2.

How does the hybrid cycle work? First, methane gas is

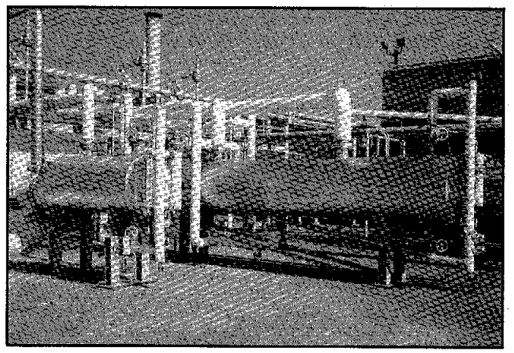
extracted from the produced fluid. Then, one-half of the methane gas is burned in a reciprocating engine generator to generate electricity directly. The remaining gas is sold.

To generate additional electricity, exhaust heat from the engine is combined with heat from one-half of the produced fluid to heat isobutane in a binary power-plant cycle. The other half of the produced fluid bypasses the power plant. It is blended with used plant fluid and injected.

Funding for the demonstration plant is provided by the U.S. Department of Energy and the Electric Power Research Institute. The Ben Holt Company designed, procured materials, constructed, and operates the hybrid power plant. Eaton Operating Company of Houston drills and maintains the high-pressure wells, and the Institute of Gas Technology of Chicago provides above-surface handling of the high-temperature, corrosive fluids.



General view of the 1-megawatt, demonstration power plant. The reciprocating engines/generators are to the left, the control trailer in the rear to the left, the binary cycle turbine in the rear-center trailer, the heat exchangers center photo, and the condensers in the rear, to the right. Photo courtesy of The Ben Holt Company.



Power plant heat exchangers, with the control trailer in the rear, left, and the condensers in the rear, right. Photo courtesy of The Ben Holt Company.

Locations of potential geopressured resources in the United States. Compiled by Dr. J. Negus-de Wys, manager, Geopressured Geothermal Program, Idaho National Engineering Laboratory.

A geopressured resource is characterized by methane dissolved in brine at high temperatures and pressures. It is hoped that energy can be recovered from the high-temperature brine, from the dissolved methane, and from the hydraulic energy of the high-pressure wellhead fluid.

Geopressured resources occur in Texas and Louisiana at depths of 10,000 to 20,000 feet, onshore and offshore, in a wide band extending from Louisiana to the Mexican border, and in many other locations, worldwide. Potential sites in the United States are outlined on the accompanying map.

Yellowstone Geyser Destroyed by Explosion

In September 1989, park officials reported a thermal explosion destroyed Pork Chop Geyser in Yellowstone National Park, according to the *San Francisco Chronicle*. The geyser was part of the park's Norris Geyser Basin, the hottest and most seismically active geyser basin in the world.

A park spokesperson said experts believe the explosion occurred after a geyserite deposit blocked one of the geyser's vents. The explosion was witnessed by a park visitor, who said the geyser erupted to about 100 feet, or about three times its normal height. Rangers who came to the site found the geyser replaced by a pool of hot water.

Pork Chop Geyser erupting in June 1988.

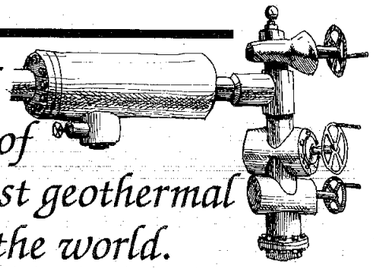
Hawaii Update

Hawaii Geothermal Plant Closed

The State of Hawaii is permanently closing the Hawaii Geothermal Plant, a 3-megawatt geothermal power plant on the Island of Hawaii. The power plant will be shut in by the end of 1989. The action has been taken because it has not been possible to keep the power plant operating in an environmentally sound manner.

Geothermal well HGP-A, used to operate the single-flash power plant, will be shut in temporarily. This well was completed in 1976, with a bottom-hole temperature of 676°F. It was one of the hottest geothermal wells in the world.

The well was one of the hottest geothermal wells in the world.



Ultimately, plans are to reactivate the well, possibly selling steam to the nearby Ormat Energy Systems project.

by Gerald Lesperance
Geothermal Program Officer
Department of Business and Economic Development
130 Merchant St., Suite 1060
Honolulu, Hawaii 96813

Scientific Observation Hole Program

The state's Scientific Observation Hole Program will start in December 1989. Four temperature-gradient wells, each about 4,000 feet deep, will be drilled in the Kilauea East Rift Zone to gather scientific data about the area.

Exploration Wells

In November 1989, True/Mid-Pacific Geothermal Venture started drilling the first exploratory well under its permit to develop up to 100 megawatts of electrical power from the Kilauea Middle-East Rift Zone. The company has been involved in permitting and legal issues concerning this activity since 1982.

Puna Geothermal Venture

The Puna Geothermal Venture is owned by Ormat Energy Systems, Inc. The company plans to develop a 30-megawatt geothermal power plant on the Island of Hawaii in the Kilauea Lower East Rift Zone, and sell the electricity to Hawaii Electric Light Company, a local utility.

Presently, the Hawaii Department of Health is reviewing the company's request for authority to construct (air permit) 13 additional wells and the power plant itself. A contested case hearing concerning these activities has been requested by various organizations on the Island of Hawaii.

500-Megawatt Project

On November 1, 1989, Hawaiian Electric Company (HECO) received five technical proposals from consortia interested in financing, developing, owning, and operating the geothermal steam fields, power plants, and inter-island underwater cable system that will provide the Island of Oahu with 500 megawatts of geothermally-produced electricity. A working committee is evaluating the proposals. The geothermal development will occur in the Kilauea East Rift Zone on the Island of Hawaii.

The lead companies in the five responding consortia are: Mission Power Engineering Company; Mission Energy Company; Pacific Gas and Electric/Bechtel Generating Company; ABB (Asea Brown Boveri) Energy Ventures; and Kealohi Partners, Ltd. (a limited partnership of Fluor-Daniel, C. Itoh, and others).

Business proposals were received from the five consortia on December 1, 1989. HECO's intent is to begin negotiating with a "short list" of the consortia early in 1990, leading to a Power Purchase Agreement with one by the end of 1990.

The State of Hawaii will participate in portions of the evaluation and negotiation process. Governor Waihee has indicated to proposers that he is willing to consider requests for indirect financial support of the project if he is convinced that the project would not be able to proceed without state support.

The first block of electricity to go on line would be about 25 megawatts, to be delivered in 1995. The 500-megawatt total would be reached about 10 years later.

The State Department of Business and Economic Development (DBED) has recently contracted with ERC Environmental and Energy Services Company (ERCE) of San Diego to prepare a Master Development Plan for the 500-megawatt geothermal/cable project; analyze overland transmission corridors for the inter-island cable system; and prepare an Environmental Impact Statement. Integral to and integrated in these three tasks is a major public-information and public-input program.

Public Information Program

The State of Hawaii has an aggressive public information/participation program. At least five public-participation meetings are scheduled to be held at four locations on the Islands of Hawaii, Maui, and Oahu. The initial round was held in October and November 1989. The next round will start in December 1989, with other rounds scheduled during 1990. All are facilitated by a professional mediator.

The DBED -contracted short video on geothermal development has been completed. The videotape includes footage on activities at The Geysers Geothermal field in Northern California. DBED has a public documents room in Honolulu, and is completing a second one in Hilo. The rooms contain every document pertinent to Hawaii's geothermal development and the underwater cable system. Anybody in Hawaii can telephone the document rooms on a toll-free line.

As the Hawaii geothermal program has taken shape, opposition has mounted. The major opponents are: The Pele Defense Fund, who oppose it on religious and Hawaiian cultural issues; the Rainforest Action Network, who are opposing it on a number of environmental and cultural issues besides rainforests; and certain community associations within the Puna District where geothermal development would occur.

The state's general position is to stress the importance of the need to reduce its 90-percent dependence on imported oil for electricity. Recently, the DBED has also stressed the global air-quality advantages offered by geothermal energy, and the disadvantages offered by fossil fuels. The general approach is to demonstrate the positive cultural, environmental, and social activities of the state. Factual information is offered to counteract inaccurate statements.

Submarine Power-Cable Tests Completed in Hawaii

In June 1989, the Hawaiian Electric Company (HECO) announced the completion of a successful, design-feasibility test for the submarine power cable to be used in the Hawaii Deep Water Cable (HDWC) research program. The $2.6 million laboratory test was funded by the U.S. Department of Energy and conducted by Pirelli Cable Corporation of Milan, Italy. The cable will be used to transmit electricity generated by geothermal energy on the Island of Hawaii to the Islands of Maui and Oahu.

"Because of the extremely difficult environmental conditions involved in this project, we had to verify all mechanical and electrical characteristics essential to ensure survival of the cable during deployment and operation over its 30-year design life," said HDWC Program Manager William Bonnet. "This allows the U.S. to be on the frontier of new submarine cable technology, a technology that is applicable to other deep-water cable projects around the world."

The cable was selected after a rigorous technical and economic analysis of 251 candidate cable designs. The selected design is for a 300 KV DC, self-contained, oil-filled cable. Six thousand feet of the cable were fabricated by Pirelli for the testing program.

The cable was subjected to standard mechanical and electrical cable-industry tests, supplemented with tests designed to simulate loads the cable will experience in the most stressful parts of the cable route. The cable met or exceeded all design specifications. HECO has received a final report and a videotape of the laboratory testing in Milan from Pirelli Cable Corporation.

In November 1989, cable installation and retrieval procedures were tested successfully in the Alenuihaha Channel between the Islands of Hawaii and Maui. This completes the HDWC research program that began in 1982. It has received both federal and state funding.

"We are extremely delighted with the results," said Hawaiian Electric Company President, Harwood D. Williamson, "for it not only proves the feasibility of laying and retrieving a deep-sea electric cable, but also moves Hawaii a step closer to the possibility of energy self-sufficiency."

Hawaiian PGV Plant Status

On September 25, 1989, Hawaiian Electric Industries, Inc. (HEI) of Honolulu, Hawaii, and Ormat Energy Systems, Inc. (OESI) of Sparks, Nevada, signed a Memorandum of Understanding (MOU) to develop jointly geothermal power plants on the Island of Hawaii.

Under the terms of the MOU, Ormat would sell 50 percent of its subsidiary, Puna Geothermal Venture (PGV) to the HEI subsidiary, Hawaiian Electric Renewable Systems (HERS). Ormat would continue to be the managing partner for geothermal projects to be developed by the partnership. However, on December 20, 1989, HERS announced that OESI had decided to terminate the negotiations.

"We understand that the decision by OESI was based on the inability of the parties to agree on certain business issues under discussion," said HERS president Alfred P. Manning.

PGV is the first company to receive the governmental approvals necessary to develop a commercial geothermal power plant in Hawaii. A 25-megawatt power plant is expected to be operational by the end of 1990. PGV has a contract to sell electricity produced by the plant to Hawaii Electric Light Company, which serves the Island of Hawaii.

Besides PGV's 500-acre power plant site, PGV has surface rights to 10,000 additional acres in the Puna District of the Island of Hawaii, with mineral-lease rights for 4,500 of these acres. A small experimental geothermal power plant owned by the State of Hawaii has operated in this area since 1982.

Hezy Ram, president of Ormat Energy Systems, said "We see a great deal of synergy in joining forces with HEI. Ormat brings 25 years of worldwide leadership in developing pollution-free power plants utilizing locally available heat sources, as well as a track record of developing and operating nine geothermal power plants, with two more under construction."

HEI president C. Dudley Pratt, Jr. said, "HEI is pleased to be an active participant in the development of geothermal energy in Hawaii. HEI is committed to being a leader in renewable energy development in the state, and our agreement with Ormat supports this goal."

Canadian Activity at Meager Creek

In April 1989, Canadian Crew Energy Corporation announced it had responded to a request from the British Columbia Power Export Corporation (Powerex) for Expressions of Interest from independent power producers to supply electrical power for the United States export market.

The company has proposed to supply initially 60 megawatts of power from the Meager Creek Geothermal Cogeneration Project, with additional, phased, 50-megawatt increments being developed until the presently estimated electrical-generation potential of 260 megawatts is reached. Subject to a favorable response from Powerex, and the demonstration by the company of the technical and economic feasibilities of the project, the company intends to be in a position to produce and deliver electrical power by September 1992, with the full development of 260 megawatts being possible by 1998.

Pennant Holdings Ltd., indirectly the largest shareholder in the company, has agreed to lead a consortium of Canadian and overseas investors to fund the design and construction of the initial power plant. A letter of undertaking has been provided by Pennant relating to the initial project equity requirements of about $30 million for the development of the initial 60 megawatts. Subject to the company successfully negotiating long-term power supply contracts with Powerex, Pennant is prepared to provide 50 percent of this requirement through an equity investment in the company and, in addition, would endeavor to underwrite the other 50 percent of required funding from Canadian institutions or private investors. The company is pleased to have the financial commitment of the Pennant Group and the technical support of its engineering subsidiary, John Holland Holdings Ltd., an Australian construction group, for this project.

The estimated cost for development and construction of the initial 60 megawatt facility is projected at about $150 million, which is proposed to be funded on an 80/20, debt/equity ratio. The total estimated cost of the project, if developed to its full potential, will be in the order of $500 million.

The Meager Creek project represents the first geothermal power project in Canada. Fully developed, the project will provide economic benefits to the Squamish-Lillooet region and the Province of British Columbia. The project area is located some 100 miles north of Vancouver, near the village of Pemberton.

The Meager Creek resource has been extensively researched and evaluated during a 10-year study carried out by B.C. Hydro and Power Authority, involving expenditures exceeding $30 million. Over 80,000 feet of diamond drilling was completed prior to the completion of three large-diameter 8,000-to 9,000-foot deep, exploration wells at the site. Extensive environmental and other related studies have been carried out in relation to the project, which, when fully developed could provide in excess of 1,800 person-years of employment in the construction phases, and up to 200 direct and 600 indirect permanent jobs for operations. Substantial steady employment levels will occur during the 8-year construction schedule.

The design of the proposed geothermal power plant and cooling tower will ensure that no toxic pollutants are released to the atmosphere. Plant layout will be such that minimum disturbance will result to the Meager Creek Valley. Essentially, the power plant project will be environmentally benign. In addition, the geothermal energy constitutes a renewable energy resource if the reservoir is managed properly.

Mexican Development: An Interview with Rafael Molinar

"Exploration's our priority. We want to find new geothermal fields in Mexico," said Rafael Molinar, Reservoir Engineer at Mexico's Comisión Federal de Electricidad. "We want to find high-temperature geothermal sites throughout our country. These need to be in places most strategic for participating in new industrial development.

by Susan F. Hodgson

"For example, geothermal fields could be developed in conjunction with the expansion of the country's agribusiness industry. The electricity for agribusiness activities, such as food processing, could come from geothermal energy. To develop these fields, we plan to use 5-megawatt wellhead generators, bringing the electricity on line in small increments.

"As for low-temperature development," Mr. Molinar continued, "we have other sources to power such projects. Low-temperature development is not needed by Mexico now as much as is electrical generation. So, for us, such projects are not the best uses of time and money.

I asked Mr. Molinar about Los Azufres Geothermal field in central Mexico. He said six, 5-megawatt wellhead generators are operating in the field, along with the 50-megawatt Baca power plant, purchased in the United States.

I asked about the ultimate electrical generation capacity of Los Azufres. Mr. Molinar said that such a prediction is difficult to make, and not really pertinent under the field's current development plan. He said the field is being developed from the particular to the general. In other words, as producing wells are drilled, 5-megawatt wellhead generators are installed. Then, when enough successful wells exist, they're connected to larger power plants. "The practice will continue until the field's capacity is reached," he said.

"At La Primavera Geothermal field in west-central Mexico, about 12 wells have been drilled," Mr. Molinar added. "About 30 wells have been drilled at Los Humeros Geothermal field, in east-central Mexico. To date, no electricity has been generated from either field.

"A new geothermal field, Las Tres Virgenes, is near Santa Rosalia in Baja California. One geothermal well has been drilled there, and the area has good potential for tourist development.

"At Cerro Prieto Geothermal field, just south of Mexicali, 3 geothermal power plants have the capacity to generate 620 megawatts of electricity.

Geothermal energy provides about 3 percent of the electricity for the country as a whole," Mr. Molinar added. (As a note of comparison, geothermal energy supplies about 3 percent of the total energy needs of California.)

I asked Mr. Molinar about environmental protection measures. He said that Mexico is very interested in protecting the environment. For example, waste water in some fields is injected into a reservoir, and power plant exhaust emissions are burned.

"If, at the moment, geothermal development is having growing pains," Mr. Molinar concluded, "remember that change will come. Every country will find a way to increase geothermal power generation. The future will be better."

Loan for Costa Rica's Electric Energy Sector

The Inter-American Development Bank announced the approval of a $182.8 million loan for a program to finance electricity generation, transmission, and distribution, as well as the reconditioning of generating units in Costa Rica.

The project, estimated to cost a total of $264.1 million, will enable Costa Rica to meet its growing demand for electricity, and to improve the economy, efficiency, and reliability of its national system.

The project, to be executed by the Instituto Costarricense de Electricidad (ICE), will have four components. One is the construction of the Miravalles II geothermal plant, with a generating capacity of 55 megawatts. The project will include 7 production wells (3 of which have been drilled), 4 injection wells, plus the necessary equipment, valves, and pipes. The plant's power house will be equipped with a turbine, a cooling tower, and a 62-MVA enhanced-capacity step-up substation.

Between 1970 and 1987, electrical energy usage in Costa Rica showed a rapid average increase of 8.9 percent annually. It decreased to 1.6 and 3.4 percent for 1982 and 1983, respectively, due to the country's economic crisis. Between 1984 and 1987, demand grew at an average annual rate of 7.8 percent. Nearly 82 percent of Costa Rican homes are connected to electric service.

About 84 percent of the country's installed generating capacity comes from hydroelectric plants, and the remaining 16 percent is of thermal origin. Between 1980 and 1986, thermal energy practically was eliminated when the Arenal, Corobici, and Ventanas-Garita hydroelectric plants, also financed by the IDB, came on line and produced a surplus of power. The surplus was exported to other countries through the interconnected Central American system. However, starting in 1986, Costa Rica was forced to import energy from Honduras. In 1987 when these imports reached 5.5 percent of total electrical consumption, it became necessary to restart thermoelectric generation using imported oil.

Since the electrical surplus of neighboring countries is diminishing, Costa Rica must expand its own generating and distribution capacity. Even when the geothermal plant of Miravalles I and Sandillal--which are also being financed by the IDB--start operations in 1992 and 1993, respectively, the increase in demand will require additional expansion.

Central America

A symposium on the Energy and Mineral Potential of the Central American-Caribbean Region was held in San Jose, Costa Rica, in March 1989. The symposium was sponsored by the Circum-Pacific Council for Energy and Mineral Resources, the Ministerio de Recursos Naturales Energía y Minas, Costa Rica, and the Refinadora Costarricense de Petróleo.

The "Potential of Geothermal Resources" was the title of a technical session included in the symposium. The session was cochaired by Alfredo Mainieri of the Instituto Costarricense de Electricidad and David Sussman of Unocal Corporation.

A copy of all the papers presented at the symposium will be published in the first quarter of 1990 by the Circum-Pacific Council for Energy and Mineral Resources. For further information about this publication, contact Ms. Mary Stewart at (713) 622-1130.

The following material is excerpted from abstracts of the papers prepared for the geothermal technical session. The information is reprinted courtesy of Mr. Sussman and Ms. Stewart.

Status and Geologic Setting of Geothermal Fields in Central America, Mexico, and the Caribbean

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The 1989 installed geothermal capacity in Central America and the Caribbean is 869 megawatts, of which 71 percent is in Cerro Prieto field, Mexico. The projected installed geothermal capacity of the region is 1,020 megawatts by 1992, reflecting power plants expected to be brought on line in Costa Rica, El Salvador, Guatemala, St. Lucia, and Mexico.

With few exceptions, high enthalpy geothermal fields in Central America and the Caribbean region are associated with active volcanic belts at plate boundaries. In Mexico, three high-enthalpy fields occur within the 1200 km-long Trans-Mexican Volcanic Belt (TMVB) along the western margin of the North American Plate. The 1100 km-long Central American volcanic belt and TMVB result from subduction of the Cocos Plate beneath the western margins of the Caribbean and North American Plates, respectively.

Several of the Central American and Mexican geothermal systems are related to young silicic volcanism (e.g., Los Humeros and La Primavera in Mexico, and Miravalles in Costa Rica). However, Momotombo (Nicaragua) and Ahuachapán (El Salvador) Geothermal fields appear to be associated with mafic- to intermediate-composition volcanic centers.

In addition to magmatic heat sources, Central America hosts an extensive system of grabens in and behind the volcanic arc. The intersection of tensional structures and young volcanic centers yields highly favorable settings for exploitable geothermal systems. Several geothermal fields are being explored in Honduras, all of which are well to the east of young arc volcanism. These fields are related to graben faults and are similar to geothermal areas under development in the Basin and Range Province of Nevada and Utah, USA.

In the eastern Caribbean, the density and volume of Quaternary volcanoes is lower than in Central America and Mexico. Relative plate velocity is low at the convergent boundary between the Caribbean and the North and South American Plates. To date, one geothermal field is operating at La Bouillante, Guadeloupe (4 megawatts) and a discovery well was drilled at Soufriere, St. Lucia.

Geophysical Exploration in Las Pailas Geothermal Field, Rincón De La Vieja, Guanacaste, Costa Rica

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Geologic mapping and geophysical prospecting using electric, magnetic, and gravity methods have been conducted in the Las Pailas Geothermal field to evaluate its geologic and geophysical characteristics and geothermal potential. Las Pailas is located at the foot of the southern flank of the Rincón de la Vieja volcanic complex, in the volcanic cordillera of Guanacaste Province, Costa Rica.

Four rock units were mapped (from the oldest to youngest) at Las Pailas: an ignimbrite sequence, andesitic lavas, lahar deposits, and Recent alluvium and colluvium.

The Bouguer gravity map (density 2.3 g/cm^3) of the region shows negative anomalies are related to thick ignimbrite sheets or to fractures, and positive anomalies are associated with hills formed by lava. Locally, an increased rise in gravity shows a positive increment to the northeast, which indicates a dip of the local basement to the southwest. In the local magnetic map, a negative anomaly stands at nearly 300 gammas, which coincides with the largest concentration of surface thermal manifestations. Negative magnetic anomalies dominate the remainder of the map, and could correspond with thick, hydrothermally altered igneous rocks in the subsurface.

Las Pailas represents a good prospect for geothermal development in Costa Rica.

The geoelectric model allows a detailed description of the strata, to a depth of 500-800m, where the resistive basement (50-500 ohm-m) is detected. In the upper 200-300m, layers of lahars, lavas, and pyroclastic flows with relatively high resistivities (10-80 ohm-m) are found, underlain by two conductive layers of cap rock (between 200-300m and 500-800m deep). The upper conductive layer (4-15 ohm-m) is associated with possible lavas and hydrothermally altered pyroclastic flows with low secondary permeability, possibly clays. The lower conductive layer (1.5-2.5 ohm-m) may be affected by temperature and vertical convective flow, in addition to meteorization. Comparing these geoelectric results with the Miravalles field 20 km to the east, a high-enthalpy geothermal field between 200° and 250°C can be inferred at Las Pailas.

Based on the favorable geologic and geophysical characteristics of the area, further studies are recommended. Las Pailas represents a good prospect for geothermal development in Costa Rica.

Seismology Studies at the Miravalles Geothermal Project

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The Miravalles Geothermal Project (MGP) is in the Guanacaste mountain range, and inside the Miravalles volcanic caldera. The Guanacaste range is a chain of andesitic Quaternary stratovolcanoes aligned NW-SE, and composed of pyroclastic rocks, lava, and fluvio-lacustrine deposits. Glowing avalanche deposits formed gently sloping ignimbritic plateaus on both sides of the mountain range. These geologic units are under constant regional stress, derived from the subduction of the Cocos Plate under the Caribbean Plate and the regional uplift of the volcanic arc, resulting in a complex system of faults.

The Costa Rican Institute of Electricity (ICE) Geology Department started seismological and volcanological studies in the northwestern part of the country in 1974. Since May 1974, a network of 10 seismic stations has operated in the Guanacaste region. A local network was also set up at Miravalles to study in detail the microseismicity in this area. Microseismic observation at Miravalles has been very successful in determining background seismicity, stress field, seismic alignments, and active or potentially-active faults within the project area. Other specific techniques such as seismic noise and wave attenuation have been valuable tools for localizing the best geothermal resource areas.

Geothermal Development in Nicaragua

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With the beginning of operations of a 35-megawatt unit in Momotombo Geothermal field in August 1983, Nicaragua joined the group of countries that exploit geothermal resources to produce electricity.

Recently, a second 35-megawatt unit has been placed in service in Momotombo field, increasing installed capacity to 70-megawatts. The installed capacity from other sources

(hydroelectric, diesel, etc.) has reached 360 megawatts, and the country's demand reaches 220 megawatts, so that geothermal plants represent 20 percent of the installed capacity. This translates to slightly more than 40 percent of the total annual generation.

Current plans for Momotombo field include drilling four production wells for field development, even though there is sufficient steam for both plants. A reservoir pressure decline of 5 percent is anticipated during the next 5 years, based on our experience with the first plant.

Considering the old age of existing power plants, economic hardships resulting from military activity, and Nicaragua's dependence on electricity, geothermal energy has become a vitally important source of base-load power. The government is accelerating geothermal development rapidly.

Several other geothermal areas are in the feasibility stages in different regions of Nicaragua. However, due to lack of financing, they have not been developed. These include El Hoyo-Monte Galán, San Jacinto-Tizate, and Granada-Masaya-Nandaime prospect areas. Other projects are in the research stage, including the Cosiguina Peninsula, Volcán Casitas, Chiltepe Peninsula, and Tipitapa areas.

In addition to Ahuachapán, the Chipilapa field in the eastern part of the country and the Berlín field in the west will begin commercial production in 1989, with an initial capacity of 10 megawatts, each. The Coatepeque field is the subject of detailed investigation and exploratory drilling for additional exploitation.

The total installed electric capacity in El Salvador is 690.9 megawatts. According to the National Energy Plan, this will have to increase by about 520 megawatts by the year 2000. Geothermal resources are programmed to satisfy about 38 percent of the additional requirements during this period. The additional 200 megawatts of geothermal energy will come from four different areas.

The National Energy Plan is already in progress, and has been fortified with ample concessional funds administered by European and North American Governments.

Prefeasibility Study of Geothermal Areas in Honduras

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Between 1985 and 1987, the National Electric Company (ENEE) simultaneously conducted two geothermal resource evaluation projects. One of the projects was made in cooperation with US-AID and the other with PNUD. The first was a rapid evaluation of previously identified areas, concentrating ultimately on the Platanares prospect. The second project was an evaluation of central Honduras, involving detailed studies of the Azacualpa and San Ignacio areas, and the Comayagua and Sula Grabens.

Detailed studies at Platanares, Azacualpa, and San Ignacio included geochemistry, geology, gravity, magnetics and electric resistivity studies, and several small-diameter gradient holes up to 680m deep. All of these studies (except drilling) were also carried out in the Comayagua and Sula Grabens.

In the thermal systems studied, no evidence exists for magmatic heat sources. The thermal fluids are probably heated by deep circulation of meteoric water along faults, creating conditions giving rise to temperatures around 170°C.

These data are interpreted to indicate that Platanares is the highest priority prospect, having measured temperatures over 160°C at only 250m depth, and production data showing a significant potential for energy production.

Geothermal Resources of El Salvador

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El Salvador, a country almost entirely volcanic in origin, lies along the Pacific Ring of Fire. Volcanism has remained active here from the Tertiary until the present time. The principle Quaternary volcanic centers are on the edge of the central graben, which traverses the country in a WNW-ESE direction. The predominant geologic conditions in these volcanic areas are favorable for the existence of economically exploitable geothermal reservoirs.

Geoscientific studies have revealed the existence of a nearly continuous, shallow, thermal anomaly. These studies define areas with characteristics that justify their further evaluation for possible development.

The Ahuachapán Geothermal field, with an installed capacity of 95 megawatts, has produced a savings equivalent to $300 million through the replacement of oil imports by geothermal power generation. The acquired experience has permitted the consolidation of a national technical infrastructure responsible for geothermal development in new areas.

Current Status of Geothermal Activities in Guatemala

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Geothermal exploration and development activities in the Republic of Guatemala have been conducted by the Instituto Nacional de Electrificación (INDE), Geothermal Development Unit, with the aim of using this resource to generate base-load electricity.

Since 1972, the unit has completed reconnaissance, prefeasibility, and feasibility studies in several geothermal areas. Plans for 1992 include installation of the first geothermal electric plant of 15 megawatts in Zunil, Department of Quezaltenango, and the completion of feasibility studies for either a second Zunil power plant or for the Amatitlán geothermal area. A vegetable dehydration plant has been constructed in Zunil in cooperation with the Ministry of Energy and Mines of Guatemala and Los Alamos National Laboratory, USA. In addition, preliminary prefeasibility studies are underway in the areas of Tecuamburro and San Marcos.

Status of Low- and Medium-Enthalpy Geothermal Development in Ecuador

Excerpted from a report by Ing. Miltón Balseca G., Instituto Nacional de Energía, Unidad Geotérmia, Av. Mariana de Jesús, No. 2307 y Martín de Utreras, P. O. Box 007-C, Quito, Ecuador.

Because of the variety of energy resources in Ecuador (oil, gas, and hydroelectric), the development of geothermal energy has been planned in terms of energy diversification, with the use of high-enthalpy resources for electrical generation and with the use of low- to medium-enthalpy resources to substitute for and/or complement conventional energy resources in the industrial and agribusiness sectors of the country.

Ecuador's first geothermal studies were undertaken at the end of 1978 by the Instituto Ecuatoriano de Electrificación (INECEL). Basic information was compiled for distribution at a meeting between INECEL and the Organización Latinoamericana de Energía (OLADE). In 1979, field reconnaissance work was begun at a national level. The final report was completed in mid-1980.

At the conclusion of the report, several study areas were defined as priority locales, potentially interesting from the point of view of high, medium, and low-enthalpy resources. The reconnaissance study by OLADE-INECEL concentrated along the Andean cordillera, where the best geothermal surface manifestations are found. In this way, three areas were chosen for high-enthalpy projects (Priority A) and three for medium- and low-enthalpy projects (Priority B).

After the reconnaissance study, the Instituto Nacional de Energía, (INE) began its work in geothermal, mandated by the Law of Creation of the Institute, dedicating itself to the development and coordination of medium- and low-enthalpy geothermal projects for direct-heating use.

In its geothermal work, INE focused its interests in areas with a hydrological system that includes surface manifestations, and in areas where a possible market exists for uses of direct heat (such as an industrial park).

INE, conscious of the large geothermal potential of the country, opened its doors to the investigation of this unconventional energy source, hoping that this may someday be accessible and usable on a large scale. It plans to meet the following objectives:

- To create an experimental demonstration project to study the technical feasibility of the use of this energy source in Ecuador, carried out by the country.

- To create, among the different state institutions, a group of technical experts capable in the areas of exploration, production, and end-uses of geothermal energy.

- To test whether the technical requirements for the development of geothermal energy are completely compatible with the level of technical development of the country.

With a view towards achieving these objectives, INE began geoscientific reconnoitering and prefeasibility studies in 1982 in the areas covered by Priority B: the area around Volcan Ilaló, near Quito, which is known as the project "Valle de los Chillos."

To advance the investigation and development of geothermal energy in Ecuador, INE has planned some studies as complementary activities to the two projects. These include the elaboration of a geothermal inventory with a data bank; an evaluation of the country's geothermal potential; establishing a legal framework for developing this energy source in Ecuador; and planning other direct-use projects, both agricultural (e.g., greenhouses, dryers, etc.) and aquacultural (fish-farming).

Translated by Susan Hodgson

New Geothermal Exploration in the Philippines

"We're encouraging more private sector participation in resource development, including geothermal," said Wenceslao De La Paz, Executive Director of the Office of Energy Affairs of the Philippine Government. "Geothermal energy fills 8 percent of the total energy requirement of the Philippines. We hope to double this amount in the next 5 years. The Philippines is the second largest user of geothermal energy in the world."

Mr. De La Paz made the statement on October 2, 1989, as he and Stephen C. Lipman, president of Unocal Geothermal Division, signed an agreement by which Unocal will undertake geothermal exploratory activities in the southern portion of the Island of Luzon. The work will occur in a 699-square mile area at Mt. Isarog, a volcano in the Province of Camarines Sur.

Unocal currently produces 660 megawatts of electricity from geothermal power plants on Luzon through its subsidiary, Philippine Geothermal, Inc. Another 230 megawatts of electricity in the Philippines is generated from geothermal power plants owned by the Philippine National Oil Company.

Mr. Lipman said this is the first geothermal exploratory project since 1971 in which Unocal has been involved formally. "We were looking for ways to expand our operation," he said. "There is a large need for new electrical generation. The Philippine economy has improved under President Aquino, who has brought foreign investment back into the country to invest in new developments. We like doing business there. We want to reinvest our earnings from our past projects in a manner that expands our Philippine operations."

"We've had internal problems," said Mr. De La Paz, speaking of the Philippine Government. "Now, we have worked out changes largely to make it more economically viable to invest under the new government. We'll continue our discussions with Unocal to work out a mutual arrangement on this exploratory project."

"The potential is there to reach an agreement for the future, and we wanted to get started now on the exploratory effort," added Mr. Lipman.

The two men were asked if the Philippine people are aware of the role geothermal energy plays in their country. "We pride ourselves on using geothermal energy," Mr. De La Paz said.

"There's a public dialogue that goes on," said Mr. Lipman. "People know about geothermal. Metropolitan Manila is very much aware of the geothermal resources, as are the rural areas directly affected by them," he concluded.

by Susan F. Hodgson

Bechtel Group Part of Japanese Geothermal Development

Fujita Corporation USA, in conjunction with Waza Corporation of Japan and the Bechtel Group, will collaborate on the development of Japanese geothermal energy in the Fujita Geothermal field. Bechtel will conduct extensive feasibility studies for the development of the geothermal field. Based on the Bechtel study, Fujita and Waza propose to request that Bechtel proceed, on a phase-by-phase basis, to:

- o Design and engineer a high-technology, state-of-the-art geothermal power plant; and
- o Handle construction management and supervision for the construction of one or more geothermal power plants, including procurement of required materials and training manpower resources necessary for operations.

Fujita and Waza will assist Bechtel in the mobilization, design, and development of the proposed Bechtel work.

Fujita Corporation and Waza Corporation, headquartered in Tokyo, have been actively engaged in the development of this new geothermal energy source since May 1988. Kazuaki Fujita, president of Fujita USA as well as Fujita Japan, has expressed his strong belief that Japan's future energy demands can be achieved by utilizing Bechtel's technology in conjunction with Japan's geothermal resources.

DEVELOPMENT

TECHNOLOGY

Assessing Fluid Inclusions

"Fluid inclusion microthermometry is the most useful in terms of chemistry," said Joe Moore, Geochemistry Section Head at the University of Utah Research Institute (UURI). "It's also a fast way to learn probable quantitative well temperatures. The process takes just a few hours, compared with regular thermal logs that take a few months to produce. In most cases, the inclusion temperatures are close to the temperatures measured by the thermal logs, but this is not always the case. That's why temperature logs are run, as well.

"However, certainty increases once we find out that the measurements for the inclusion temperatures match those on the thermal logs," Dr. Moore continued. "Then, we can assume that the inclusion fluid chemistry and gas content match those in the modern geothermal system. We also know where the well has been drilled within this geothermal system.

"Fluid inclusion microthermometry is commonly used in geothermal fields all over the world and with good success," Dr. Moore concluded.

NOTE: The following paragraphs further explain fluid inclusion microthermometry. The material is excerpted, with permission, from the May-June 1989 issue of UURI Outlook.

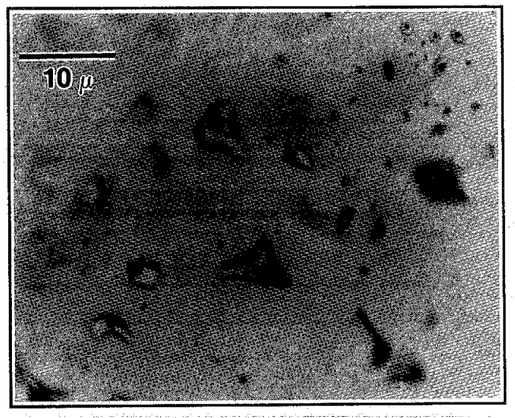
"Fluids that circulate through hydrothermal systems are commonly preserved in small irregularities on the growing surfaces of the minerals they deposit and in microfractures formed after initial growth of the minerals (Fig. 1). Because fluid inclusions provide the most direct means of obtaining information on the compositions and temperatures of these fluids as they existed during mineral deposition, they have proven to be an important tool to the geothermal and mineral explorationist. Recent studies conducted at UURI have demonstrated that fluid-inclusion analysis can also provide essential data to the geothermal reservoir engineer.

"Chemical and thermal data can be obtained routinely on fluid inclusions contained in millimeter-sized cuttings of samples through microthermometric measurements. The trapping of a single-phase fluid consisting of either liquid or steam will produce an inclusion that contains both liquid and vapor phases when cooled to room temperature. Heating the inclusion to homogenize the fluid into a single phase yields an estimate of the trapping temperature. Variations in trapping temperatures provide information on the thermal history, size, and shape of a hydrothermal system.

"Information on the salinities and gas content of the inclusion fluids can be obtained from low-temperature phase changes since there is a direct relationship between the total dissolved solids content of a fluid and its freezing temperature. The relationship between the heating and freezing measurements yields information on the physical processes that have affected the thermal fluids. Processes such as boiling and mixing in the reservoir have a strong affect on the output of a geothermal power plant, and knowledge of these processes can be crucial in the siting of geothermal wells. Boiling and mixing have also been recognized as primary depositional mechanisms of precious metals in fossil hydrothermal systems."

Further information can be obtained from Dr. Moore at(801)524-3428.

Figure 1. Fluid inclusions in vein fluorite from a depth of 164m in the Baca geothermal system. The inclusions are secondary, occurring along healed fractures. Microthermometric measurements indicate that the inclusions in this crystal formed at temperatures between 1,500° and 2,150°C from fluids with apparent salinities that ranged from 0.0 to 0.5 equivalent weight percent NaCl. The large compositional range of these inclusions is probably due to variations in the gas content of the fluids. Compositional and thermal data on inclusions as small as 2- to 3-microns across can be obtained routinely.



Chemical Tracers for Geothermal Reservoir Analysis

Good geothermal chemical tracers have a number of important characteristics: (a) they are chemically stable under the high temperature and pressure conditions of geothermal reservoirs; (b) they are conservative (i.e. they are not adsorbed by and do not react with reservoir rocks); (c) they are detectable in very low concentrations, allowing dilution factors of 10^6 to 10^8 during transit through the reservoir; (d) they are environmentally safe; and, (e) they are inexpensive to use.

It is important to have a number of different tracers available so several injection wells can be tagged independently. In the past, the primary tracers used by the geothermal industry were radioactive nuclides, halide ions, and organic dyes. Because of toxicity problems, government permitting, high natural background concentrations, and undocumented thermal instability, these compounds are either not suitable as tracers or are too difficult to use.

Excerpted, with permission, from UURI Outlook, August-October 1989

Chemical tracers can be used to detect previously injected fluid in producing wells and to quantify transit time of a fluid packet. If the tracer is chemically conservative and stable in the reservoir, the shape of the tracer return curve can also be interpreted in terms of such reservoir parameters as relative amount of fracture permeability compared with intergranular permeability. Also, information derived from tracer tests can be used to help predict thermal breakthrough, which refers to the point when production-well temperatures decline because nearby reservoir heat is absorbed by cold injection fluids. Thermal breakthrough follows tracer breakthrough.

While chemical breakthrough of injected fluids can constitute a problem if it alters production chemistry too much, it is thermal breakthrough that usually poses the larger problem. Prediction of thermal breakthrough using tracer and other data is a topic of current research in the Hydrothermal Reservoir Technology program of the U.S. Department of Energy and the University of Utah Research Institute. For further information on the Institute's tracer research program, contact Joe Moore at (801) 524-3428.

The Effect of Ambient Temperature on Geothermal Binary-Plant Performance

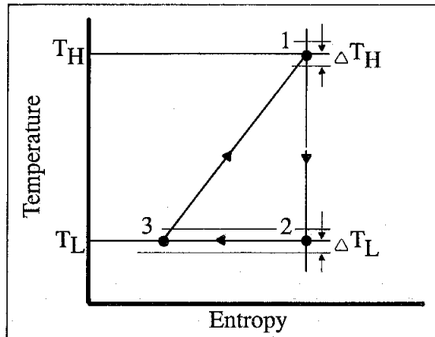
by Ronald DiPippo, Ph.D.
Southeastern Massachusetts University
North Dartmouth, MA 02747

The power output of geothermal binary plants is very sensitive to changes in the temperature of the surroundings. This phenomenon is often observed at such plants. Even though binary plants differ widely in the details of their designs, this effect can be easily understood for all binary plants with reference to an ideal binary cycle. Such a cycle appears as a triangle in a temperature-entropy diagram (Fig. 1).

The line from 1 to 2 in Figure 1 represents an isentropic expansion process (work output); the line from 2 to 3 stands for the isothermal heat rejection process (e.g., condensation); and the line from 3 to 1 is the heating process that occurs as the geothermal brine cools and transfers heat to a secondary liquid working fluid, such as isopentane.

All the processes are assumed ideal in this example (i.e., thermodynamically reversible). Hence, the brine cooling curve (not shown) would be coincident but countercurrent with the working fluid heating curve. Similarly, the external cooling medium would follow a path coincident but countercurrent with the heat rejection process, the line from 2 to 3.

Figure 1. Ideal geothermal binary cycle.



NOMENCLATURE

T_H — BRINE INLET TEMPERATURE (kelvins)
T_L — BRINE OUTLET TEMPERATURE (kelvins)

Cycle efficiency: the ratio of the net work output to the heat input:

$$\eta = \frac{T_H - T_L}{T_H + T_L}$$

The cycle performance is measured by the cycle efficiency, η, which is defined as the ratio of the net work output to the heat input. Alternatively, it may be thought of as the ratio of the net electrical kilowatts produced to the input thermal kilowatts. From elementary thermodynamics, the net work is the area inside the triangle 1-2-3, and the heat input is the area beneath the line 3-1. Thus, it is easy to show that

$$\eta = (T_H - T_L)/(T_H + T_L),$$

where: T_H = the brine inlet temperature (kelvins)
T_L = the brine outlet temperature (kelvins)

The effect of T_H on the ideal binary efficiency is shown in Figure 2 for several values of T_L. The dependency of the efficiency on T_L is shown in Figure 3 for several values of T_H.

To examine analytically how the cycle performance changes when the brine inlet temperature (T_H) or the brine outlet temperature (T_L) varies, we can imagine ΔT_H or ΔT_L imposed on the cycle as shown in Figure 1. The derivative of η with respect to T_L, holding T_H constant, is simply

$$-2T_H/(T_H + T_L)^2.$$

The derivative of η with respect to T_H, holding T_L constant, is

$$2T_L/(T_H + T_L)^2.$$

The ratio of the magnitudes of these two quantities reduces simply to T_H/T_L, which obviously must always be greater than one. Thus, for equal changes in T_H and T_L, the effect on η caused by a change in T_L at constant T_H will always be larger than that caused by a change in T_H at constant T_L.

If T_L is larger than the lowest available ambient temperature, T_0 (the "dead-state" temperature), then η will be less than the maximum possible cycle efficiency, η_{max}, where η_{max} is given by

$$\eta_{max} = (T_H - T_0)/(T_H + T_0).$$

Figure 2. Efficiency versus brine inlet temperature (T_H) with the brine outlet temperature (T_L) as a parameter.

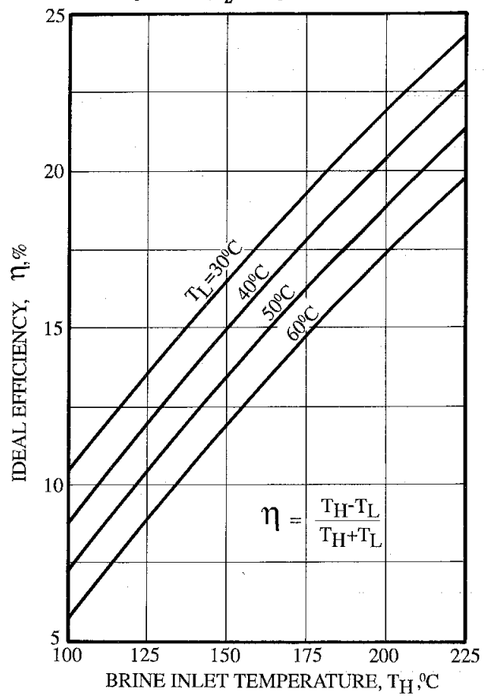
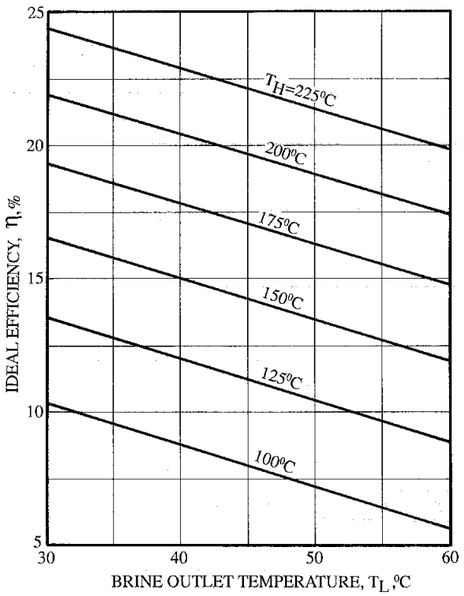
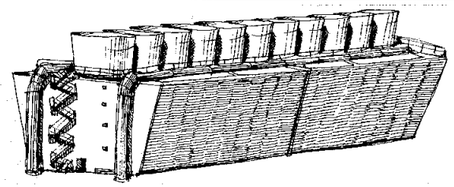


Figure 3. Efficiency versus brine outlet temperature (T_L) with the brine inlet temperature (T_H) as a parameter.



To achieve this thermodynamically maximum efficiency, the brine would have to be cooled down to the dead-state temperature reversibly (i.e., by an ideal, frictionless process) -- a practical impossibility.



Plant efficiency varies inversely with the outlet temperature.

In reality, therefore, T_L must always be greater than T_0, the difference being a function of the type of heat rejection system and of its design details. For any given system, T_L will just be a function of T_0 and will float as T_0 varies because of changes in climatic conditions. Thus, the power output will also float, even for a fixed brine inlet temperature and flow rate. Clearly, the best performance will be achieved when T_0 (and thus T_L) is the lowest. It follows then that a plant that just meets its design output when T_0 happens to be at its lowest expected value will not be able to produce its design output at other times -- unless the brine flow rate is increased.

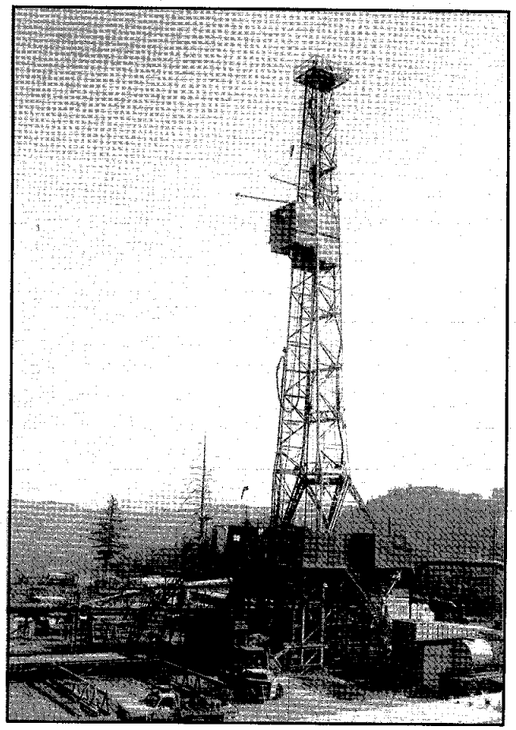
To summarize, the plant efficiency varies inversely with the outlet temperature. The effect on binary power plant efficiency from a change in outlet temperature at constant inlet temperature will always be greater than that from a change in inlet temperature at constant outlet temperature. If the outlet temperature decreases, power plant efficiency will increase. If the outlet temperature increases, power plant efficiency will decrease.

ENERGY

California Energy Sources

What were the sources for the total amount of energy used in California in 1988? To answer this question, these data were provided by Dale Rodman, California Energy Commission.

SOURCE	PERCENTAGE
Oil and natural gas	85%
Nuclear	5%
Hydropower	4%
Coal	3%
Geothermal	2.78%
Solar, wind, and biomass	.0007%



Current and Projected Domestic Energy Supplies (Quads)[1]

(Adapted from Power Surge, by Nancy Rader, reviewed in the *Publications* section.)

SOURCE	1988	ADDITIONAL	2000
Biomass	3.50	4.50	8.00
Geothermal	0.214	0.266	0.48
Hydro	2.29/3.08 [2]	0.62 [3]	3.70 [4]
Photovoltaics	0.0003	0.021	0.021
Solar Buildings	0.052	1.708	1.76
Solar Thermal	0.005	0.022	0.027
Wind	0.018	0.082	0.10
Total	6.08/6.87 [2]	7.219	14.09

Figures reflect the quads of primary fossil fuel energy displaced by each source.

[1] One quad refers to one quadrillion (10^{15}) British thermal units (Btu). The U.S. currently consumes approximately 83 quads. Electricity production (kWh) figures for solar thermal, wind, photovoltaics, and geothermal figure sources were converted into quads of primary energy displaced using the Department of Energy's monthly Energy Review (Oct. 1988, Table A-9) heat rate conversion figure for electricity (10,261 Btu/kwh).

[2] Note that 1988 was a low year for hydropower. The average annual generation for existing hydro capacity is about 3.08 quads, which would boost the total contribution of renewable energy in an average year for hydro to 6.87 quads. Also note that this is domestic production of hydropower. The U.S. also imports electricity from Canada that is generated from hydroelectric plants. In 1988, the U.S. imported 0.3 quads of Canadian hydropower, so that total use of hydropower in the U.S. that year was 2.59 quads.

[3] This is the approximate amount of energy that would be generated in an average year by the additional 18,000 MW of hydro capacity projected to be on line by 2000.

[4] This is the amount of energy that would be produced by the total hydro capacity in an average year.

U.S. Energy Reserve Data

The following U.S. energy reserve data are reprinted from *Characteristics of U.S. Energy Resources and Reserves,* prepared in 1989 for the Deputy Assistant Secretary for Renewable Energy, U.S. Department of Energy, by the Meridian Corporation.

U.S. Reserves of Energy

Energy Source	BBOE*
Coal	908.0
Photoconversion (Biomass)	57.7
Geothermal	42.5
Natural Gas	39.9
Petroleum	26.9
Hydropower	10.0
Uranium	7.3
Photoconversion (Solar)	3.0
Wind	< 1.0
Shale Oil	< 1.0
Peat	< 1.0
TOTAL	1,096.2

*BBOE = Billion barrels of oil equivalent.

The report states that the total energy reserve of 1,096.2 BBOE would provide for more than 78 years of United States national energy consumption at 1987 rates of usage.

The vast majority of this reserve (82.8 percent) is provided by coal, and the U.S. coal reserve is about 14 percent of the accessible resource of coal. (A "reserve" is defined as the economically viable portion of the "accessible resource.")

The report says that the geothermal reserve comprises 3.9 percent of the total U.S. energy reserve, or 42.5 BBOE. The value was derived from U.S. Geological Survey documents for hydrothermal convection systems including both vapor- and water-dominated reservoirs with temperatures greater than or equal to 150°C. This single geothermal energy source was used for power generation measurements because the technology needed to extract electricity from other geothermal systems is not yet economic at current energy prices. To this figure were added U.S. Geological Survey estimates of low-temperature (>40°C) geothermal hydrothermal energy that is economically recoverable at the wellhead for direct-use applications.

U.S. DOE Renewable Energy R&D Funding

The following table is reprinted from Power Surge, by Nancy Rader, which is reviewed in the *Publications* section.

U.S. Department of Energy Renewable Energy Research & Development Funding:
FY81 to FY90*, by Technology
In Adjusted, 1990 dollars (Millions)

	FY81	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89	FY90*
Solar Buildings	103.3	31.6	13.6	20.1	10.8	9.0	6.7	5.8	5.6	4.2
Photovoltaics	213.3	80.8	72.8	60.9	64.0	43.2	45.4	37.7	36.7	25.1
Solar Thermal	189.4	55.6	61.0	46.9	40.0	29.1	25.6	18.3	15.5	13.4
Biomass	69.9	39.5	24.5	34.3	35.1	30.8	26.9	18.4	13.9	9.1
Wind	109.0	21.8	39.5	32.0	33.3	31.2	18.7	9.1	9.1	8.4
Ocean Energy Systems	48.7	27.3	13.2	6.9	4.7	5.6	5.0	4.3	4.2	2.2
International	15.2	5.2	12.6	0.6	0.5	1.1	0.9	0.9	1.0	0.5
Technology Transfers	1.9	8.8	3.8	4.0	5.8	3.7	2.8	2.8	2.5	1.8
SERI	7.0	--	--	--	--	2.3	--	0.6	0.6	0.7
Program Direction	9.6	5.2	7.4	7.3	4.1	4.9	4.6	4.5	4.4	4.2
Program Support	--	4.6	0.5	1.0	1.2	1.5	0.8	1.0	1.0	0.9
Other	4.9	9.8	-1.1	--	0.1	1.1	0.9	0.8	0.8	0.7
SOLAR SUBTOTAL	772.2	290.2	247.8	214.0	199.6	163.5	138.3	104.2	95.3	71.2
Geothermal	219.5	74.0	71.2	36.7	36.6	30.3	23.2	22.5	20.3	15.4
Small Hydropower	4.5	-3.8	1.3	1.0	0.1	0.6	0.6	0.0	0.0	0.0
TOTAL RENEWABLES	996.2	360.4	320.3	251.7	236.3	194.4	162.1	126.7	115.6	86.6

* Proposed by Reagan Administration shortly before tenure ended and resubmitted by Bush Administration. Note: Figures are adjusted to 1990 dollars for purpose of comparison with FY90 proposed funding levels.

Source: Congressional Research Service (FY81-FY89) and Dept. of Energy (FY90).

Geothermal Facts from the BLM

The following information is published by the Ukiah District Office, Bureau of Land Management (BLM).

The Geysers Geothermal field, as of 9/89

I. Geysers KGRA: (Known Geothermal Resource Area)

282,002 acres total Federal acres leased: 10,929 acres
Federal acres producing: 7,941 acres

II. Geysers Production:

Total field production:	Federal production:
720 wells 1,988 megawatts	190 wells; 176 wells producing 725 megawatts (36.5 percent)

Assuming an average production requirement of 18,000 pounds of steam per megawatt, federal steam production equals 861,300 barrels of oil a month.

III. Federal Geothermal Operators/Lessees:

Geysers Geothermal Company; Northern California Power Agency; Santa Fe Geothermal, Inc.; Unocal; and the State of California, Department of Water Resources.

IV. Geothermal Well Data:

Average depth: 6,000 feet. Average drilling time: 45 days. Average cost: $150/foot. Average production: 150,000 pounds steam/hour at 375 pounds per square inch and 400°F (equivalent to 330 barrels of oil per day). Heat energy of steam is 1,205 BTU/pound.

Wells are drilled directionally from multiple well pads. Wells are drilled with mud to the casing depth, then drilled to total depth with air. Wells are completed barefoot (open hole). Generally, wells that are not producible commercially are plugged back inside the casing. Then, a window is milled, and the well is drilled directionally to a new target. If successive redrills fail, the well will be converted to an injection well.

V. Federal Drilling Activity Summary:

	Wells Drilled	Wells Worked Over	Wells Abandoned
FY '85	20	7	1
FY '86	24	5	0
FY '87	24	8	1
FY '88	14	5	1
FY '89 (to 9/89)	15	3	1

VI. Federal Royalties:

FY 1985	FY 1986	FY 1987	FY 1988	FY 1989
$12,300,000	$15,800,000	$13,000,000	$12,000,000	$12,000,000

VII. Financial Benefits of Geothermal Development to Local Economies:

Fifty percent of rents and royalties paid to the U.S. government are returned to the state in which the leases are located. The State of California distributes these monies as follows: (1) 40 percent to the county of origin, (2) 30 percent as grants to jurisdictions having geothermal resources, and (3) 30 percent to the Parklands and Renewable Resources Investment Fund.

Also from the BLM

Current Geothermal Production on or from Federal Lands

I. The Geysers, Northern California

- Northern California Power Agency 725 MW
  Units #1 and #2 240 MW
- Sacramento Municipal Utility District/
  Geysers Geothermal 72 MW
- Santa Fe International Corporation 80 MW
- Steam from federal leases is utilized by 20
  additional facilities. Federal portion 333 MW

II. East Mesa, Southern California 107 MW

- Ormat a) Ormesa I 30 MW
  b) Ormesa II 20 MW
  c) Ormesa IE 10 MW
- GEO Operator Corporation
  - GEM I 10 MW
  - GEM II & III 37 MW

III. Coso Hot Springs, Southern California 48 MW
- California Energy BLM East 48 MW

IV. Wendel - Amedee, Northern California 8 MW
- HL Power/GeoProducts 8 MW

V. Dixie Valley, Central Nevada 70 MW
- Oxbow Geothermal Corporation 70 MW

VI. Roosevelt Hot Springs, Central Utah 20 MW
- Chevron Resources Company 20 MW

VII. Beowawe, Northeastern Nevada 16 MW
- Chevron Resources Company 16 MW

VIII. Steamboat, Western Nevada 15 MW
- Caithness Power Company 15 MW

IX. Desert Peak, Northwestern Nevada 10 MW
- Chevron Resources Company 10 MW

X. San Emidio, Northwestern Nevada 4.8 MW
- Ormat 4.8 MW

XI. Soda Lake, Western Nevada 3.6 MW
- Chevron/Ormat 3.6 MW

XII. Cove Fort, Central Utah 2.2 MW
- Mother Earth Industries 2.2 MW

Total 1,029.6 MW

TRANSMISSION

Court Okays Federal Power Sales to Municipal Utilities

The right of the Western Area Power Administration (WAPA) to sell Bonneville Power Administration energy directly to municipal utilities has been confirmed by the U.S. District Court, Northern District of California.

The court's ruling adjudicates a dispute that began in 1982, when the Northern California Power Agency (NCPA) contracted with WAPA to purchase power for use by six of its member utilities, the Cities of Alameda, Healdsburg, Lodi, Lompoc, Ukiah, and Santa Clara.

"This decision is a significant endorsement for a high degree of open trade and common sense in the electric utility field," said Michael W. McDonald, NCPA General Manager. "The court has affirmed WAPA's right to market surplus federal power, Pacific Gas and Electric Company's obligation to transmit it, and the rights of municipal utilities, unless contractually restricted, to buy energy from WAPA as the lowest-cost resource."

PUC Studies Transmission Project

The California Public Utilities Commission (PUC) held a Public Workshop to describe how the state and the energy utilities who propose building the California-Oregon Transmission Project (COTP) intend to evaluate the project prior to presenting it to the PUC for evaluation and approval.

The COTP is a proposed transmission line that would carry electricity from the Pacific Northwest to California. It would provide an additional source from which utilities serving California electricity consumers could purchase power.

In an effort to provide a thorough analysis of the proposed project, the PUC's Division of Ratepayer Advocates (DRA), Southern California Edison, Pacific Gas & Electric Company, and San Diego Gas & Electric Company have signed an agreement to analyze jointly the proposed COTP project. The DRA is charged with participating in PUC proceedings to represent the best long-term interests of all classes of ratepayers.

Health Risks From Exposure to Electrical Facilities and Lines

The California Public Utilities Commission (PUC) announced the availability of its draft report on the possible health effects of exposure to electrical power systems. The report is part of a 3-year joint research program with the California Department of Health Services (DHS).

The report, prepared in cooperation with DHS, includes selected expert assessments of possible health risks from electrical and magnetic fields produced by electric utility facilities; discussions of further research needed to support possible regulatory consideration of the issue; a summary of recommendations and an introductory discussion by the PUC; and a chapter by the DHS outlining California's proposed 3-year research program.

The program is being undertaken to comply with Senate Bill 2519 (Rosenthal) to look into the possible health effects associated with exposure to electrical power systems, including generating plants, substations, and transmission and distribution power lines. The draft report, now available, will be issued in final form to the legislature by September 1989. SB 2519 also requires that a separate progress report on the status of California's 3-year research program be submitted to the legislature by December 1, 1990.

California's study of the issue should provide an improved scientific basis for determining whether electric and magnetic fields from electrical power facilities pose a significant threat to public health, and whether regulatory action is warranted. The legislature's decision to fund such a study was prompted by a series of studies reported by the State of New York in 1987, which suggested that power-line electrical and magnetic fields might cause adverse health effects besides those of burns, shocks, and electrocution.

The 500-page draft PUC report, Potential Health Effects of Electric Power Facilities, is available from the PUC for $20 (free to public agencies). Limit, 1 copy. Make check payable to the CPUC and send it to: Documents Section, California Public Utilities Commission, 505 Van Ness Avenue, San Francisco, California 94102.

Sierra Pacific Power Seeks 200 Megawatts

Sierra Pacific Power Company is seeking proposals from utility and nonutility sources to supply up to 200 megawatts of long-term firm capacity to meet its energy needs between 1991 and 1997.

The Reno-based energy utility issued a request for proposals (RFP) on November 15, 1989. The company's future energy requirements were identified in a 20-year Resource Plan approved in October by the Nevada Public Service Commission.

"We are encouraging parties to submit creative proposals that would be of mutual advantage to both the bidder and to Sierra Pacific," said Noreen Leary, manager of power and fuel contracts. The proposals must be submitted by January 15, 1990.

This is the second time Sierra Pacific has issued an RFP to fulfill its long-term additional capacity needs. The utility's first RFP was issued in the spring of 1989 and yielded 94 responses from 34 different bidders. As a result of the first RFP, Sierra Pacific successfully negotiated long-term contracts for about 163 megawatts, divided between Idaho Power Co., PacifiCorp, and Ormat Energy Services.

For more information or a copy of the RFP, contact Noreen Leary, manager of power and fuel contracts, Sierra Pacific Power Co., P.O. Box 10100, Reno, NV 89520, or call (702) 689-4889.

PG&E Undertakes Study

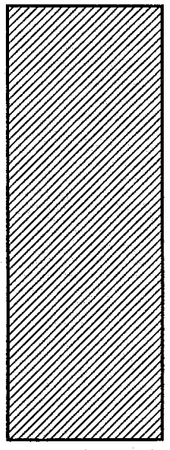
Pacific Gas and Electric Company is participating in a 3-year, $10 million study to improve efficiency in the use of electricity, according to an article in the *San Francisco Chronicle*. Also participating are the Natural Resources Defense Council, the Rocky Mountain Institute, and Lawrence Berkeley Laboratory.

LEGISLATION

Federal Legislation

The following material is a federal legislative report, with information on the status of geothermal and thermal power legislation from the 101st Congress, current as of November 15, 1989. The report was compiled by LEGI-SLATE.

Abstracts and excerpts from abstract summaries are included for *some* bills and resolutions on this list.



H.R.21 BY DELLUMS (D-CA) -- Anti-Apartheid Act Amendments of 1989
H.R.26 BY QUILLEN (R-TN) -- Geothermal Energy Control Act of 1989
H.R.658 BY ANDREWS (D-TX) -- Energy Security Incentive Act of 1989
H.R.664 BY ARCHER (R-TX) -- Domestic Energy Security Act of 1989
H.R.760 BY SMITH, LAMAR (R-TX) -- Energy Tax Reform Act of 1989
H.R.780 BY LEVINE, MEL (D-CA) -- California Desert Protection Act of 1989
H.R.991 BY SKEEN (R-NM) -- Waste Isolation Pilot Plant Land Withdrawal Act of 1989
H.R.1078 BY SCHNEIDER (R-RI) -- Global Warming Prevention Act of 1989; Vehicle Energy Efficiency Performance Standards Act of 1989 Act
H.R.1216 BY SHARP (D-IN) -- Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989
H.R.1240 BY CROCKETT (D-MI) -- Caribbean Regional Development Act of 1989
H.R.1344 BY DAVIS, ROBERT (R-MI) -- Uniform United States Vessel Definition Act
H.R.1472 BY KILDEE (D-MI) -- Grand Island National Recreation Area in the State of Michigan, Establishment
H.R.1473 BY LAGOMARSINO (R-CA) -- Wilderness and Wild and Scenic Rivers in the State of California, Designation

H.R.1549 BY UDALL (D-AZ) -- Nuclear Regulatory Commission Authorization Act for Fiscal Years 1990 and 1991
H.R.1761 BY ROSTENKOWSKI (D-IL) -- Internal Revenue Code of 1986, Amendment
H.R.2066 BY VUCANOVICH (R-NV) -- Nevada Wilderness Act of 1989
H.R.2067 BY VUCANOVICH (R-NV) -- Transfer of Real Property to the City of North Las Vegas, Nevada, Provision
H.R.2104 BY WYDEN (D-OR) -- Renewable Energy Trade Equity and Promotion Act of 1989
H.R.2272 BY BYRON (D-MD) -- California Military Lands Withdrawal Act of 1989
H.R.2395 BY THOMAS, WILLIAM (R-CA) -- Internal Revenue Code of 1986, Amendment
H.R.2461 BY ASPIN (D-WI) -- National Defense Authorization Act for Fiscal Years 1990 and 1991; Department of Energy National Competitiveness Technology Transfer Act of 1989
H.R.2535 BY OWENS, WAYNE (D-UT) -- Addition of Lands to the Gallatin National Forest, Provision
H.R.2696 BY BEVILL (D-AL) -- Energy and Water Development Appropriations Act, 1990 (Pub. L. 101-101, approved 9/29/89)
H.R.2719 BY CLINGER (R-PA) -- Surface Mining Control and Reclamation Act of 1977, Amendment
H.R.2788 BY YATES (D-IL) -- Department of the Interior and Related Agencies Appropriations, 1990 (Pub. L. 101-121, approved 10/23/89)
H.R.2939 BY OBEY (D-WI) -- Foreign Operations, Export Financing, and Related Programs Appropriations Act, 1990
H.R.3143 BY AUCOIN (D-OR) -- National Energy Policy Act of 1989
H.R.3150 BY ROSTENKOWSKI (D-IL) -- Social Security Administrative Reform Act of 1989; Medicare Omnibus Budget Reconciliation Act of 1989; End Stage Renal Disease Patient Protection and Quality Assurance Act of 1989; Human Resource Amendments of 1989; Caribbean Basin Economic Recovery Expansion Act of 1989; Revenue Reconciliation Act of 1989; Improved Penalty Administration and Compliance Tax Act
H.R.3402 BY FASCELL (D-FL) -- Polish and Hungarian Democracy Initiative of 1989
H.R.3448 BY SMITH, ROBERT F. (R-OR) -- Conveyance of Railroad Grant Lands in Oregon and California, Provision
H.R.3460 BY LEWIS, JERRY (R-CA) -- California Desert Conservation Act of 1989
S.11 BY CRANSTON (D-CA) -- California Desert Protection Act of 1989
S.234 BY BOREN (D-OK) -- Energy Security Incentive Act of 1989
S.324 BY WIRTH (D-CO) -- National Energy Policy Act of 1989; Solar Development Initiative Act of 1989; Renewal Energy and Energy Efficiency Technology Competitiveness Act of 1989
S.449 BY BOREN (D-OK) -- Domestic Energy Security Act of 1989
S.452 BY WILSON, PETE (R-CA) -- California Military Lands Withdrawal Act
S.468 BY REID (D-NV) -- Real Property to the City of North Las Vegas, Nevada, Conveyance
S.488 BY FOWLER (D-GA) -- Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989
S.507 BY SIMON (D-IL) -- Anti-Apartheid Act Amendments of 1989
S.603 BY BOSCHWITZ (R-MN) -- Global Warming Response Act of 1989
S.624 BY REID (D-NV) -- Apex Project, Nevada Land Transfer and Authorization Act of 1989
S.871 BY GORE (D-TN) -- Ozone Layer Conservation Act of 1989
S.914 BY MATSUNAGA (D-HI) -- Internal Revenue Code of 1986, Amendment
S.964 BY FORD, WENDELL (D-KY) -- Civilian Energy Programs Authorization for Fiscal Years 1990 and 1991
S.1059 BY HATFIELD (R-OR) -- Renewable Energy Trade Equity and Promotion Act of 1989
S.1113 BY BAUCUS (D-MT) -- Waste Minimization and Control Act of 1989

S.1352 BY NUNN (D-GA) -- National Defense Authorization Act for Fiscal Years 1990 and 1991; Department of Energy National Competitiveness Technology Transfer Act of 1989
S.1569 BY RIEGLE (D-MI) -- Establishment of the Grand Island National Recreation Area in Michigan, Provision
S.1582 BY SIMON (D-IL) -- Support for East European Democracy (SEED) Act of 1989
S.1611 BY LEAHY (D-VT) -- International Climate Change Prevention Act of 1989
S.1738 BY HATFIELD (R-OR) -- Certain Lands in Oregon to the Rogue Community College District, Conveyance

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H.R.26 by QUILLEN (R-TN) -- Geothermal Energy Control Act of 1989

Abstract

Establishes the National Geothermal Energy Commission to grant exclusive licenses for the exploration for and commercial development of geothermal resources and for the marketing of such energy in its natural state.

S.914 by MATSUNAGA (D-HI) -- Internal Revenue Code of 1986, Amendment

Abstract

Amends the Internal Revenue Code to extend the investment tax credit in connection with certain energy property.

Digest

Amends the Internal Revenue Code to extend for five years, through 1994, the investment tax credit in connection with depreciable: (1) solar energy property; (2) geothermal property; and (3) ocean thermal property.

H.R.658 by ANDREWS (D-TX) -- Energy Security Incentive Act of 1989

Abstract

Amends the Internal Revenue Code to establish tax incentives, including tax credits, for domestic oil and gas exploration and production.

Repeals provisions that tax as ordinary income any gains from dispositions of oil, gas, or geothermal wells.

H.R.2395 by THOMAS, WILLIAM (R-CA) -- Internal Revenue Code of 1986, Amendment

Abstract

Amends the Internal Revenue Code with respect to the investment tax credit in connection with certain energy property.

Digest

Amends the Internal Revenue Code to: (1) extend for three years, through 1992, the investment tax credit in connection with depreciable solar energy property and geothermal property; and (2) permit this credit against the taxpayer's entire regular tax liability and minimum tax liability.

H.R.3143 by AUCOIN (D-OR) and

S.324 by WIRTH (D-CO) -- National Energy Policy Act of 1989; Solar Development Initiative Act of 1989; Renewal Energy and Energy Efficiency Technology Competitiveness Act of 1989

Abstract

Establishes a comprehensive national energy policy to reduce global warming and promote energy conservation and efficiency, including measures for international energy cooperation and world population reduction.

Digest

National Energy Policy Act of 1989 - Establishes as national goals: (1) that the amount of carbon dioxide in the atmosphere be reduced from 1988 levels by at least 20 percent by the year 2000 through a mix of Federal and State energy policies; and (2) the establishment of an international global agreement on the atmosphere by 1992.

Title I: National Energy Plan

Requires the Secretary of Energy (the Secretary) to transmit to the Congress a "least cost national energy plan" with forecasts, priorities, inventories, and targets for meeting such national goals. Sets forth the

plan's contents. Mandates revision and resubmission of the Plan to the Congress every two years.

Title II: Office of Climate Protection

Establishes the Office of Climate Protection which shall be responsible for: (1) participation by the Department of Energy in various domestic and international agencies involved in global climate change analysis; and (2) the monitoring of U.S. energy policies for atmospheric and global warming effects, with annual reports on such effects.

H.R.1216 by SHARP (D-IN) -- Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989

Abstract

Sets forth national goals and priorities for renewable energy and alternative energy resources programs.

Digest

Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989 - Sets forth specified national goals for the wind, photovoltaics, and solar thermal energy programs.

Requires the President's budget requests for FY 1991 to contain the recommendations of the Secretary of Energy for specified Department of Energy research and development programs for 1993, including biofuels energy systems, solar buildings energy systems, ocean energy systems, and geothermal energy.

S.488 by FOWLER (D-GA) -- Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989

Abstract

Sets forth national goals and priorities for renewable energy and alternative energy resources programs.

Digest

08/04/89 (Reported to Senate from the Committee on Energy and Natural Resources with amendment, S. Rept. 101-107)

Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989 - Confers general authority upon the Secretary of Energy (the Secretary) to pursue joint ventures with the private sector in energy renewal and energy efficiency technologies. Specifies national goals for the wind, photovoltaics, and solar thermal energy programs.

Requires the Secretary to report to the Congress on goals for other specified renewable energy technologies at the time the President's budget request is submitted for FY 1992.

Authorizes appropriations for FY 1991 through 1993 for: (1) the wind energy research program; (2) the photovoltaic energy systems program; (3) the biofuels energy systems program; (4) the solar buildings energy systems programs; (5) the ocean energy systems program; and (6) the geothermal energy programs.

S.964 by FORD, WENDELL (D-KY) -- Civilian Energy Programs Authorization for Fiscal Years 1990 and 1991

Abstract

Authorizes appropriations to the Department of Energy for various civilian energy programs for FY 1990 and 1991.

Digest

Civilian Energy Programs Authorization for Fiscal Years 1990 and 1991

Title I: Research and Development

Authorizes appropriations for FY 1990 for Department of Energy civilian research and development programs relating to: (1) general science and research activities; (2) energy supply research and development; (3) the Geothermal Resources Development Fund; (4) fossil energy research and development; (5) energy conservation; (6) the Strategic Petroleum Reserve; and (7) the Strategic Petroleum Reserve Petroleum Account.

H.R.1078 by SCHNEIDER (R-RI) -- Global Warming Prevention Act of 1989; Vehicle Energy Efficiency Performance Standards Act of 1989 Act

Abstract

Establishes a comprehensive national energy policy to reduce global warming including measures for international energy cooperation and world population reduction.

Directs the Secretary of State to convene an international meeting in the United States by the end of 1992 to adopt a global climate protection agreement with measures at least as stringent as those in this Act. Sets forth a percentage reductions schedule for emissions of specified gases.

S.603 by BOSCHWITZ (R-MN) -- Global Warming Response Act of 1989

Abstract

Establishes the Office of Global Warming.

Amends the Foreign Assistance Act of 1961 to provide assistance to specified agencies for environmental response and assessment, forestry programs, and energy projects.

Sets forth global warming response requirements for specified agencies and departments.

Digest

Title I: Establishment of a Single Coordinating Body on Global Warming

Global Warming Response Act of 1989 - Establishes the Office of Global Warming within the Department of State to serve as the single coordinating point for the United States on all global warming policy and response matters. Provides that the Office shall be headed by a Deputy Assistant Secretary for Global Warming to be appointed by the President. Requires the Office to establish an interagency team for ongoing formulation of policy and response mechanisms to global warming to be coordinated with the Intergovernmental Panel on Climate Change. Directs the Office to develop, annually update, and transmit to the President and the Congress a Global Warming Strategy Plan to coordinate policy, research, and response efforts.

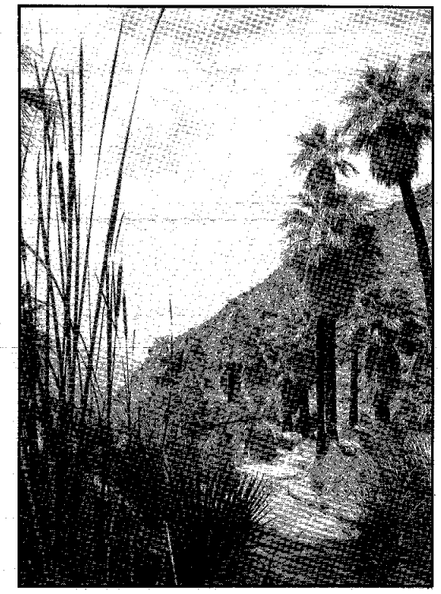
LEASING

BLM Issues Amendments to Geothermal Leasing Regulations

On April 10, 1989, the Department of the Interior's Bureau of Land Management (BLM) issued an interim rule implementing the Geothermal Steam Act Amendments of 1988, which were enacted September 22, 1988, to amend the Geothermal Steam Act of 1970. The rulemaking was published in the April 6, 1989, issue of the Federal Register.

The new regulations will allow extension of geothermal leases under certain conditions, and include a list of specific lands named in the legislation to be excluded from geothermal exploration, development, and utilization.

Geothermal development can be a very expensive initiative because the remote locations of many geothermal sources may force a developer to plan for construction of not only the geothermal steam production facilities, but also the means to convert the steam



Geothermal country: Palm Canyon, on the reservation of the Agua Caliente Band of Cahuilla Indians, near Palm Springs, California. Photo by Susan Hodgson.

to electricity and then transport it to market. Even a small project may well take longer than the 10-year lease term.

Prior to the passage of the Geothermal Steam Act Amendments, geothermal leases could be extended only under two conditions -- if geothermal energy was being produced at the end of the 10-year term, or if there was a well capable of production and a contract to sell that production within 5 years from the end of the 10-year term.

Many developers have been unable to meet those criteria within the initial 10-year term of their geothermal leases, and have faced losing substantial investments. Congress has provided relief several times by legislating temporary extensions for leases about to expire. These temporary extensions expired December 31, 1988.

Passage of the Geothermal Steam Act Amendments last September provides permanent relief by allowing lessees to continue holding geothermal leases as long as diligent efforts are being made to reach steam production and utilization. The September 22 legislation removed the requirements for a contract for the sale of production, or for commencement of utilization within a specific period of time.

The new regulations will allow lease extensions of up to 10 years, in two 5-year blocks. In order to qualify for an extension, a lessee must show bona fide efforts to produce geothermal resources in commercial quantities given the current economic conditions for marketing geothermal steam.

The lessee must also choose either to make "payments in lieu of commercial quantities," or to make "significant expenditures" toward development of the lease.

- Payments in lieu of commercial production are at least $3.00 per acre for the first 5-year extension, increasing to $6.00 per acre for a subsequent extension. These payments are in addition to annual rental fees of the customary $1.00 per acre for noncompetitive leases and $2.00 per acre for competitive leases.

- Significant expenditures must be at an annual rate of at least $15.00 per acre during the initial extension, and $18.00 per acre during a subsequent extension. Examples of significant expenditures include funds spent on actual drilling operations, geochemical or geophysical surveys for exploratory or development wells, road or generating facility construction on the lease, and environmental studies required by state or federal law.

The interim rule also specifies that geothermal leases shall not be issued or extended if geothermal development would result in a significant adverse effect on a significant thermal feature within a unit of the National Park System.

The rulemaking is being published on an interim basis so that leases scheduled for expiration may be extended if they meet the qualification requirements of the Geothermal Steam Act Amendments. For those leases in effect upon enactment of the Geothermal Steam Act Amendments (September 22, 1988), with expiration dates of September 22, 1988, through July 31, 1989, lessees will be allowed until July 31, 1989, to submit specified reports or applications.

For further information, see the Federal Register, Vol. 54, No. 65, April 6, 1989, page 13,884.

Federal Geothermal Leasing Operations in California, 1989

These data are from the Bureau of Land Management, California.

Geothermal energy development on federal lands in California produced 918 megawatts of electrical power in 1989, the equivalent of 695,454 barrels of oil per month, or enough to supply the power needs of almost 920,000 people.

This alternative energy source also earned $13.56 million in rents and royalties for the federal, state, and county treasuries from federal leases covering 374,225.7 acres.

	FY 1986	FY 1987	FY 1988	FY 1989
Total number of leases	365	293	268	241
Competitive leases issued	2	0*	12	2
Noncompetitive leases issued	39	0*	0	9
Federal production (megawatts)	735	754	795	918
Producing leases	14	15	16	19
Producing wells	132	167	186	222
Plans of operation approved	11	14	16	4
Drilling permits issued	50	64	93	39

* No leases were issued, due to a Congressional moratorium.

Leases on California Federal Lands, 10/1/88 to 9/30/89

Number of existing, noncompetitive geothermal leases	111 (158,386.855 acres)
Number of existing, competitive geothermal leases	130 (215,838.85 acres)
Number of geothermal leases in actual production	19 (21,479.4 acres)
Number of noncompetitive leases issued	9 (8,334.63 acres)
Number of competitive leases issued	2 (1,676.19 acres)

Seven Parcels Leased in Nevada Geothermal Sale

Seven parcels of public land totaling about 15,078 acres of land attracted the interest of bidders on April 20, 1989, as the Nevada Bureau of Land Management (BLM) held a geothermal competitive lease sale in Reno, Nevada.

A total of $175,808.71 was offered in "bonus bids" (one-time bid to gain the opportunity to lease an area). In addition, successful bidders will now pay $2 an acre for the first year's lease on the parcels they hope to develop.

Ed Spang, Nevada State Director for the BLM, says the April 20 sale was offered pursuant to the Geothermal Steam Act of December 1970 and regulations issued since the Act. A total of 61 parcels totaling about 121,733 acres was offered at the geothermal competitive lease sale. Twelve bids were received, with seven being successful. The successful bidders will have an opportunity to lease their parcels for ten years.

All parcels are on public lands that have been declared to be Known Geothermal Resource Areas (KGRA's). The parcel location, successful bidder, and high bonus bid are:

Parcel 32 of the Gerlach KGRA, Washoe County: Michael B. Stewart, Yerington. $7.13/acre.

Parcel 34 of the Gerlach KGRA, Washoe County: Michael B. Stewart, Yerington. $15.13/acre.

Parcel 35 of the Gerlach KGRA, Washoe County: Michael B. Stewart, Yerington. $4.13/acre.

Parcel 48 of the New York Canyon KGRA, Pershing County: Union Oil Co. of Calif. $20.35/acre.

Parcel 49 of the New York Canyon KGRA, Pershing County: Union Oil Co. of Calif. $20.35/acre.

Parcel 50 of the New York Canyon KGRA, Pershing County: Union Oil Co. of Calif. $7.65/acre.

Parcel 53 of the San Emidio Desert KGRA, Washoe County: Ormat Energy, Sparks. $7.00/acre.

In accordance with federal regulations, royalties will be paid to the United States should any of the parcels go into production for heat or energy. The State of Nevada receives half of all royalties on public lands and will also receive half of the revenue from the bonus bids and rental.

FINANCES

Scholarships for Women in Science

Clare Booth Luce has created a $70 million scholarship fund, the largest private scholarship fund ever established to aid women in science. The fund will endow professorships, fellowships, and scholarships. Its purpose is "to encourage women to enter, study, graduate, and teach" physics, chemistry, biology, meteorology, engineering, computer science, and math. For further information, write to the Henry Luce Foundation, 111 W. 50th St., New York, New York 10020.

Prudential Power Funding Completes Financing for Four Geothermal Power Plants

Prudential Power Funding Associates has provided $287 million in debt financing for four geothermal power plants in Nevada and California -- representing the first time The Prudential has invested in geothermal power production.

Of the total, $180 million consisted of permanent financing for the recently completed Oxbow Geothermal Power Plant in Dixie Valley, Nevada. The 55-megawatt plant, developed by Oxbow Geothermal Corporation, is expected to produce 392 million kilowatt-hours of electricity per year, which will be sold to Southern California Edison Company under a 30-year sales contract. The financing also covers a 210-mile transmission line developed by Oxbow.

Another $81 million was provided for the Ormesa Geothermal I and Ormesa IE plants in Imperial Valley, California. Ormesa Geothermal I, a 29.5-megawatt facility, has been operating since October 1987; the 10-megawatt Ormesa IE was completed in February 1989. Both were developed by Ormat Energy Systems, Inc. and have contracted to sell a total expected annual output of 260 million kilowatt-hours of electricity to Southern California Edison.

The remaining $26 million was allocated to finance a 13.5-megawatt plant called Stillwater Geothermal I, that is scheduled to be completed in the spring of 1989 in west-central Nevada. This project, also developed by Ormat Energy Systems, is expected to produce 91 million kilowatt-hours of electricity annually, which will be sold to Sierra Pacific Power Company.

"We have been closely following the development of geothermal power production for some time, and believe it presents a viable and increasingly attractive way to supplement existing energy resources," said Martha Clark Briley, president and chief executive officer of Prudential Power Funding.

Prudential Power Funding Associates was formed in January to consolidate all of Prudential's private placement investments and financing activities in the electrical power industry. The unit's portfolio includes financing for more than 40 electric utilities and 60 alternative energy projects, making it one of the largest providers of capital to this industry.

The ETAP Program

In September 1989, the California Energy Commission (CEC) released separate Requests for Proposals for the Fourth Local Jurisdiction Solicitation and the Fifth-Round General Solicitation of the Energy Technologies Advancement Program (ETAP). The Fourth Local Jurisdiction Solicitation is open only to local jurisdictions. The Fifth-Round General Solicitation is open to both the private and public sectors.

Through ETAP, the CEC co-funds advanced energy projects that will increase the energy efficiency or cost effectiveness of energy technologies, or help to develop new, cost-effective alternative sources of energy. Projects must include hardware development. Nearly any type of advanced energy technology is eligible for ETAP funding, including those based on energy production, energy conservation (including advancements in recycling technology), and load management.

About $5.2 million is anticipated to be available in fiscal year 1989-90 to co-fund qualifying proposals for both solicitations. Projects submitted under both the Fourth Local Jurisdiction Solicitation and the Fifth-Round General Solicitation will compete for this funding. At least $520,000 and up to $5.2 million will be available to qualifying projects through the Fourth Local Jurisdiction Solicitation.

Individual projects for either of these solicitations may request up to 25 percent of the total funding available (i.e., up to about $1.3 million) for co-funding.

Projects can qualify for one of two types of ETAP funding: loans or repayable research contracts. The CEC will allocate for loans between 50 to 70 percent of the available funds. The remainder will be allocated for repayable research contracts. In prior fiscal years, the competition for loans has been much less than for research contracts. Up to 80 percent of the total project cost can be funded by an ETAP loan. For research contracts, ETAP can co-fund up to 50 percent of the total project cost. Loans are repayable at about an 8 percent interest rate. Research contracts are also repayable under certain conditions, and also accrue interest at about 8 percent.

The CEC has completed four General Round Solicitations and three Local Jurisdiction Solicitations, resulting in 35 projects that total about $10.6 million dollars in ETAP funding. Among the list of ETAP projects approved as of June 30, 1989, is the following project:

Research Contract to Luz International Limited for Direct Steam Generation in Parabolic Trough Solar Collector Fields. Advanced solar thermal/parabolic troughs, $395,359.00.

The tentative schedule for the Fourth Local Jurisdiction Solicitation is:

Request for Proposals Released ---- August 31, 1989
Proposals Due ---------- October 20, 1989
Commission Funding Decision ------ May - June 1990
Projects Begin ---------- As early as July 1990

The tentative schedule for the Fifth-Round General Solicitation is:

Request for Proposals Released ---- August 31, 1989
Proposals Due ---------- October 20, 1989
Commission Funding Decision ------ May - June 1990
Projects Begin ---------- As early as July 1990

For further information, contact the ETAP staff at (916) 324-3490.

TECHNOLOGY TRANSFER

CONFERENCES

II Reunión Nacional Sobre la Energía y el Confort, Universidad Autónoma de Baja California, Instituto de Ingeniería, Mexicali, B.C., May 23-25, 1990.

An efficient use of electricity is the subtitle for this national conference on Energy at the Autonomous University of Baja California. All papers will be presented in Spanish.

Conference organizers would welcome papers on geothermal topics.

For further information, contact the Universidad Autónoma de Baja California, II Reunión Nacional sobre la Energía y el Confort, Instituto de Ingeniería, Quim. María de la Paz Carpio, Tel. 91 (65) 66-41-50 o bien a, Lupita Ortega, Telex No. 569888, Fax: 529761.

Circum-Pacific Energy and Mineral Resources Conference, Hilton Hawaiian Village, Honolulu, Hawaii, July 29 to August 3, 1990.

The conference theme is Circum-Pacific Region: Resources for an Expanding Economy. Emphasis will be placed on newly identified, significant energy and mineral resources of the Pacific and new technological and methodological developments. Geothermal energy will be included.

For a brochure, contact the AAPG Convention Department, P.O. Box 979, Tulsa, Oklahoma 74101-0979. Phone: (918) 584-2555.

Geothermal Resources Council - 1990 International Symposium on Geothermal Energy, Kona Surf Hotel, Kailua Kona, Hawaii, August 20 to 24, 1990.

This symposium will provide a forum for exchange of new and significant information on all aspects of the exploration and use of geothermal resources. Country updates and international R & D will be featured.

There will be four special sessions:

1. Geothermal Development in Hawaii,
2. Groundwater Problems Associated with Geothermal Development,
3. Geothermal Energy and the Global Environment, and

4. Geothermal Public Information: Issues and Program Responses.

Two courses will be offered:

Pre-Symposium Course - Geothermal Energy Conservation Technology and Power Plant Operating Experience - Comparative reviews of the different strategies available for power production from different types of geothermal systems, and case histories of long-term geothermal power plant operations. Dates: August 17 and 18, 1990. Cost: $300.00.

Post-Symposium Course - Assessment and Evaluation of Geothermal Reserves - Case histories on how geothermal reserves have been evaluated and their potential power production assessed. Comparisons will be made between predictions and actual experience in specific geothermal fields. Dates: August 25 and 26, 1990. Cost: $300.00.

MAPS

Distribution, Composition, and age of late Cenozoic volcanic centers in Hawaii. Map I 1091-G. $3.50. Published by and available from the USGS, Map Distribution, Federal Center, Box 25286, Denver, Colorado 80225.

The map is one of a series designed primarily as a guide for exploration and evaluation of igneous-related geothermal resources. The map illustrates oceanic shield volcanoes. It supplies basic data for evaluating volcanic hazards and for studies of magmatism, tectonism, and the general geology

The National Geophysical Data Center (NGDC) has a variety of publications and data sets which provide information on the location, magnitude, and potential uses of geothermal resources.

Regional Geothermal Maps

In 1979, NGDC produced three maps for U.S. Geological Survey Circular 790, *Assessment of Geothermal Resources of the United States, 1978.* **The maps are available from NGDC.**

- *Geothermal Energy in the Western United States* (scale 1:2,500,000) **(Product number: 641-B01-001).**
- *Geothermal Energy in Alaska and Hawaii* (scale: 1:5,000,000 for Alaska and 1:2,500,000 for Hawaii) **(641-B01-002).**

  These two maps show identified hydrothermal convection systems, igneous systems, low-temperature geothermal waters, regional heat flow, and Known Geothermal Resources Areas (KGRAs).

- *Geopressured-Geothermal Energy in Reservoir Fluids of the Northern Gulf of Mexico Basin* (scale 1:1,000,000). This map includes contours showing depth to top of geopressured zone, and thermal energy in sand beds; concentrations of methane energy in sand beds; areas with higher potential for energy use; and temperatures at 15,000 feet in selected wells **(641-B01-003).**

The complete U.S. Geological Survey Circular 790, which includes 163 pages plus maps, is available from the U.S. Geological Survey, Books and Open-File Reports, Federal Center, Box 25425, Denver, CO 80225. An additional report, U.S. Geological Survey Circular 892, *Assessment of Low-Temperature Geothermal Resources of the United States, 1982,* may also be obtained from the same address.

State Geothermal Resources Maps

Between 1980 and 1984, NGDC produced geothermal maps for eighteen western states as part of the State Geothermal Resource Assessment Program, funded and managed by the U.S. Department of Energy:

Product Number	Title	Date	Scale	Size (inches)
641-A01-001	*Geothermal Resources of Alaska*	1982	1:2,500,000	35 x 56
641-A01-002	*Geothermal Resources of Arizona*	1982	1:500,000	47 x 63
641-A01-003	*Geothermal Resources of California*	1980	1:750,000	49 x 60
641-A01-004	*Geothermal Resources of Colorado*	1980	1:500,000	41 x 52
641-A01-005	*Geothermal Resources of Hawaii*	1983	1:500,000	35 x 50
(out of print)	*Geothermal Resources of Idaho*	1980	1:500,000	42 x 65
641-A01-006	*Geothermal Resources of Kansas*	1982	1:500,000	40 x 55
641-A01-007	*Geothermal Resources of Montana*	1981	1:1,000,000	27 x 39
641-A01-008	*Geothermal Resources of Nebraska*	1982	1:500,000	37 x 60
641-A01-009	*Geothermal Resources of Nevada*	1983	1:500,000	45 x 69
641-A01-010	*Geothermal Resources of New Mexico*	1980	1:500,000	48 x 55
641-A01-011	*Geothermal Resources of North Dakota*	1981	1:500,000	40 x 49
641-A01-012	*Geothermal Resources and Temperature Gradients of Oklahoma*	1984	1:500,000	53 x 41
641-A01-013	*Geothermal Resources of Oregon*	1982	1:500,000	59 x 49
641-A01-014	*Geothermal Resources of Texas*	1982	1:1,000,000	53 x 41
(out of print)	*Geothermal Resources of Utah*	1980	1:500,000	39 x 55
641-A01-015	*Geothermal Resources of Washington*	1981	1:500,000	43 x 51
641-A01-016	*Geothermal Resources of Wyoming*	1983	1:500,000	42 x 59

The maps are designed to be of use to land planners, legislators, environmentalists, and entrepreneurs, as well as the geothermal community. Included on the maps are locations of thermal springs, thermal wells, areas with high potential for discovery of addtional geothermal resources, and land-status items such as urban areas, national forests, wilderness areas, and other state and federal reservations.

A digital data base containing more than 6,000 records of thermal springs and wells has been compiled from this state map series and is available on magnetic tape **(902-A07-001)**. Each record provides location of spring or well, temperature, flow, total dissolved solids, depth, and other significant data.

Technical Map Series

During the course of the State Geothermal Resource Assessment Program, technical geothermal maps were prepared for California and New Mexico:

- *Technical Map of the Geothermal Resources of California* (1983; scale 1:750,000). Presents tectonics, volcanism, and thermal spring and well data including temperature, location, geochemistry, and total dissolved solids **(641-C01-001)**.
- *Geothermal Resources in New Mexico: Scientific Map Series* (1983; scale 1:500,000). This map series includes a paper base map and three plastic overlays. The series may be ordered as a set **(651-A01-001)**, or in its separate parts:
  - *Late Tertiary and Quaternary Tectonics and Volcanism* (paper). Shows tectonics, volcanism, thermal spring and well locations, heat flow, areas favorable for the discovery of low-temperature geothermal waters, and Known Geothermal Resources Areas **(651-A01-002)**.
  - *Bouguer Gravity Anomaly Map of New Mexico* (plastic overlay). Depicts computer-contoured data at a 2-mgal contour interval and shows locations used for control **(895-A01-001)**.
  - *Composite Residual Total Intensity Aeromagnetic Map of New Mexico* (plastic overlay). Computer-contoured, geology-related local variations in Earth's magnetic field **(891-A01-001)**.
  - *Hydrology and Geochemistry* (plastic overlay). Shows temperature gradient contours, groundwater barriers and constrictions, sedimentary basins, and geochemistry **(651-A01-003)**.

Thermal Springs List

NGDC compiled a list of 1,700 thermal spring locations in 23 states while producing maps for the U.S. Geological Survey and the State Geothermal Resource Assessment Program. This list was published in 1980 as NOAA Key to Geophysical Records Documentation No. 12, *Thermal Springs List for the United States* **(640-A12-001)**.

Thermal springs are arranged alphabetically by state, and are organized by degrees of latitude and longitude within the state. Included are spring name and location, surface temperature, and topographic map coverage (either 7.5- or 15-min. quadrangle). Two index maps (one for Alaska and Hawaii, and one for the conterminous United States) are included with the list. The thermal springs list is also available in digital format **(902-E07-001)**.

Geothermal Gradients

NGDC and Los Alamos National Laboratory co-produced the *Geothermal Gradient Map of the United States, Exclusive of Alaska and Hawaii (*1982; scale 1:2,500,000) **(652-A01-001)**. This map presents a compilation of more than 1,700 wells for which temperature has been measured at depths greater than 50 m. Temperature/depth profiles are linear, or composed of linear segments which reflect changes in the thermal conductivity of the rocks, rather than hydrology.

The data are displayed on two sheets (eastern and western United States) in a format that shows the location, depth, and gradient of each well in a single color-coded symbol. Each well has a number that is keyed to a table giving latitude, longitude, well depth, gradient, heat flow and thermal conductivity (where available), and a reference. The map data are also available in digital format **(902-B07-001)**.

World Heat Flow

In 1976, NGDC published a map, *Terrestrial Heat Flow Data,* depicting world heat flow data compiled by the International Heat Flow Commission (of the International Union of Geodesy and Geophysics) **(901-A01-001)**. Digital data used to create the map are also available **(901-A07-001)**. Each of the 6,000 heat flow measurements includes location information, height of the temperature-measuring elements in relation to sea surface, temperature gradient, thermal conductivity, and heat flow value. In addition, each heat flow measurement is referenced to the source where it was first reported.

The data compilation is available in published form from the Department of Energy, Mines and Resources Canada, Earth Physics Branch, 1 Observatory Crescent, Ottawa, K1A 0Y3, Canada. (Ask for Catalogue No. M74-33/5, *The World Heat Flow Data Collection, 1975*).

An updated digital world heat flow data set is being compiled at this time. The revised data will be available in late 1989; please contact NGDC for details.

Thermal Aspects Data for North America

As part of the Geological Society of America's Decade of North American Geology (DNAG), a continental scale *Thermal Aspects Map (*scale 1:500,000) was produced. The data were compiled and mapped by John L. Steele and David D. Blackwell, Department of Geological Sciences, Southern Methodist University. The original sources for the data are the United States and Central America Geothermal Data Base (Southern Methodist University), the Canada Geothermal Data Base (Geological Survey of Canada), and the Canadian Cordillera Geothermal Data Base (Geological Survey of Canada). Professional papers about these data sources are included in Neotectonics of North America, edited by D.B. Slemmons, E.R. Engdahl, M.D. Zoback, D.D. Blackwell, and D. Schwartz, Geological Society of America Centennial Special Map Volume 1, in press, 1989.

The actual map and written reports (both in press), as well as companion maps (i.e., teotectonics, crustal stress, geology, earthquake seismicity, gravity, and magnetics) **are available from the Geological Society of America**. Inquiries can be addressed to GSA Publication Sales, P.O. Box 9140, Boulder, CO 80301; telephone 1-800-GSA-1988.

The digital data used to produce the map are available from NGDC on magnetic tape **(980-C07-001)** or floppy diskette **(980-C25-001)**. These data include hole location, minimum and maximum values, gradient and heat flow results per depth interval, lithologic information, and general comments. The digital data are also available on compact disc **(975-B27-001)**, as a part of NGDC's Geophysics of North America data set. This data set also contains gravity, magnetics, seismicity, topography, crustal stress, and satellite imagery data.

Volcanoes

Publications

Catalog of Submarine Volcanoes and Hydrological Phenomena Associated with Volcanic Events (by P. Hedervari, Georgiana Observatory, Budapest, Hungary) is in two volumes and covers the time span of 1500 B.C. through 1959 A.D. The information presented includes submarine eruptions, new volcanic islands, tsunamis, seiches, and base surges related to volcanic activity **(900-B12-001** and **900-B12-002)**.

Slide Sets

Two special sets of 35-mm slides provide a unique tool for presentation to both technical and nontechnical audiences. Each set includes 20 slides and a list of captions that provide date and location of the event, and description of damage or other effects.

- *Volcanoes in Eruption* (B&W/Color). Depicts explosive eruptions, nuee ardentes, lava fountains and flows, steam eruptions, and fissure eruptions from 20 worldwide volcanoes. Volcano types include caldera, cinder cone, complex, fissure vent, lava dome, shield, and island-forming **(739-A11-001)**.

- *Volcanic Rocks and Features* (Color). Illustrates eruption products and features resulting from volcanism in Australia, the Canary Islands, New Zealand, Scotland, and the United States. Pictured are examples of a lava flow, ash, cinders, bombs, necks, dikes, and sills **(739-A11-002)**.

Data and Publications Price List

Note: All maps priced at $5 are folded maps. Rolled maps are available for $10 each. Due to mailing restrictions, rolled maps are not available outside the U.S.A. Digital data prices are for standard magnetic tape copies: 9-track, ASCII, 1600 bpi. Floppy diskettes are high density, 5.25" IBM-PC compatible.

Product #	Price	Description
641-B01-001	$ 5	*Geothermal Energy in the Western United States*
641-B01-002	$ 5	*Geothermal Energy in Alaska and Hawaii*
641-B01-003	$ 5	*Geopressured Geothermal Energy in Reservoir Fluids of the Gulf of Mexico Basin*
641-A01-001	$ 5	*Geothermal Resources of Alaska*
641-A01-002	$ 5	*Geothermal Resources of Arizona*
641-A01-003	$ 5	*Geothermal Resources of California*
641-A01-004	$ 5	*Geothermal Resources of Colorado*
641-A01-005	$ 5	*Geothermal Resources of Hawaii*
641-A01-006	$ 5	*Geothermal Resources of Kansas*
641-A01-007	$ 5	*Geothermal Resources of Montana*
641-A01-008	$ 5	*Geothermal Resources of Nebraska* (folded map only)
641-A01-009	$ 5	*Geothermal Resources of Nevada*
641-A01-010	$ 5	*Geothermal Resources of New Mexico*
641-A01-011	$ 5	*Geothermal Resources of North Dakota*
641-A01-012	$ 5	*Geothermal Resources and Temperature Gradients of Oklahoma*
641-A01-013	$ 5	*Geothermal Resources of Oregon*
641-A01-014	$ 5	*Geothermal Resources of Texas*
641-A01-015	$ 5	*Geothermal Resources of Washington*
641-A01-016	$ 5	*Geothermal Resources of Wyoming*

641-C01-001	$	5	*Technical Map of the Geothermal Resources of California*
651-A01-001	$	55	*Geothermal Resources in New Mexico: Scientific Map Series* (complete set: 1 paper map and 3 plastic overlays)
651-A01-002	$	5	*Late Tertiary and Quaternary Tectonics and Volcanism* (paper)
895-A01-001	$	15	*Bouguer Gravity Anomaly Map of New Mexico* (plastic overlay)
891-A01-001	$	15	*Composite Residual Total Intensity Aeromagnetic Map of New Mexico* (plastic overlay)
651-A01-003	$	15	*Hydrology and Geochemistry* (plastic overlay)
640-A12-001	$	5	*Thermal Springs List for the United States*
902-E07-001	$	91	Digital thermal springs data
652-A01-001	$	10	*Geothermal Gradient Map of the United States, Exclusive of Alaska and Hawaii* (map set, folded; rolled set is $20)
902-B07-001	$	91	Digital geothermal gradient data
901-A01-001	$	10	*Terrestrial Heat Flow Data* (rolled map only)
901-A07-001	$	91	Digital world heat flow data
980-C07-001	$	141	Thermal aspects data for North America (magnetic tape)
980-C25-001	$	80	Thermal aspects data for North America (floppy diskette)
975-B27-001	$	580	*Geophysics of North America* compact disc
900-B12-001	$	5	SE-36, *Catalog of Submarine Volcanoes and Hydrological Phenomena Associated with Volcanic Events, 1500 B.C. to December 31, 1899*
900-B12-002	$	5	SE-42, *Catalog of Submarine Volcanoes and Hydrological Phenomena Associated with Volcanic Events, January 1, 1900 to December 31, 1959*
739-A11-001	$	20	*Volcanoes in Eruption* slide set
739-A11-002	$	20	*Volcanic Rocks and Features* slide set

Please refer to the product number when ordering.

The prices quoted here are valid through **September 30, 1989.** Prices applicable after that date may be obtained by calling (303) 497-6419.

Mention of a commercial company or product does not imply endorsement by NOAA or the Department of Commerce.

How to Order

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A ten-dollar ($10) handling fee is required on all orders; an additional ten-dollar ($10) charge is required for non-U.S.A. orders. If you elect to use RUSH service at an additional cost of sixteen dollars ($16), your order will receive priority processing and will be mailed First Class. Overnight delivery is available at an additional cost; please call for details.

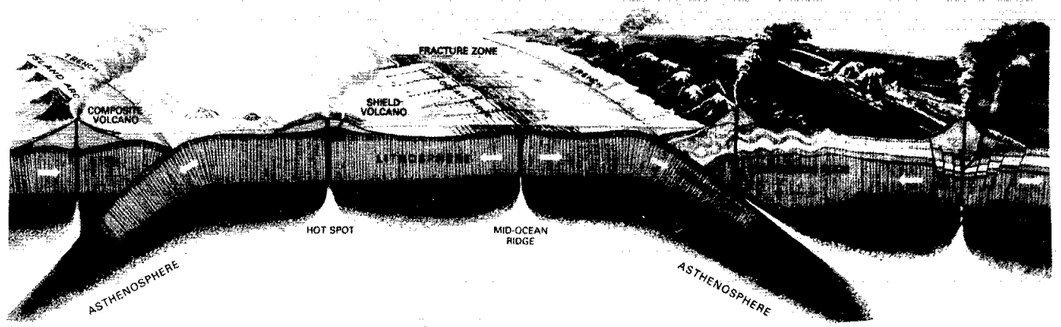
Please direct telephone inquiries to **(303) 497-6419** (Telex: 592811 NOAA MASC BDR). Inquiries, orders, and payment should be addressed to:

National Geophysical Data Center
NOAA, Code E/GC1
325 Broadway

For a complete listing of NGDC data services, request the free brochure: *Publications, Maps, and Data Services*

This Dynamic Planet

A World Map of Volcanoes, Earthquakes, and Plate Tectonics



Schematic cross section illustrating plate tectonics processes

Compiled by Tom Simkin, Smithsonian Institution; R.I. Tilling, J.N. Taggart, W.J. Jones, and Henry Spall, U.S. Geological Survey. Published jointly by the U.S. Geological Survey and the Smithsonian Institution to commemorate the 28th International Geological Congress in Washington, D.C., from July 9-19, 1989. This map serves as a contribution to the International Decade of Natural Disaster Reduction to begin in 1990.

The Earth's physiographic features overlain by its volcanoes, earthquake epicenters, and the movement of its major tectonic plates are shown in this map.

This computer-generated map of the world provides a base that shows the topography of the land surface and the sea floor; the additions of color and shaded relief help to distinguish the important features. From the Volcano Reference File of the Smithsonian Institution, nearly 1,450 volcanoes active during the past 10,000 yr are plotted on the map in four categories. From the files of the National Earthquake Information Center (U.S. Geological Survey), epicenters selected from 1,300 large events (magnitude $\geq$7.0) from 1897 onward and from 140,000 instrumentally recorded earthquakes (magnitude $\geq$4.0) from 1960 to the present are plotted on the map according to two magnitude categories and two depth categories.

This special map is intended as a teaching aid for classroom use and as a general reference for research. It is designed to show prominent global features when viewed from a distance; more detailed features are visible on closer inspection. The authors of this map encourage your comments and suggestions for improvement.

Copies of this map may be bought from the following distribution centers:

Over-the-Counter ($3)

The Smithsonian Institution Shop
National Museum of Natural History
10th and Constitution Avenue
Washington, DC 20560

USGS Earth Science Information Centers in Washington, DC; Reston, VA; Denver, CO; Spokane, WA; Menlo Park, CA; Salt Lake City, UT; Anchorage, AK; Los Angeles, CA; and San Francisco, CA.

By Mail ($3 + $1 handling)
Prepayment is required.

U.S. Geological Survey
Map Distribution
Federal Center, Box 25286
Denver, CO 80225

Name: _____

Address: _____

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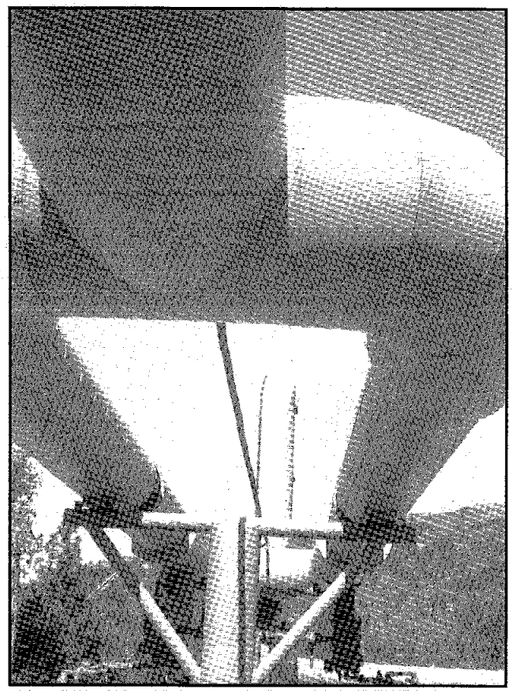
VIDEOS

Before the Drilling Begins

The environmental documentation process and wellpad engineering practices used at The Geysers Geothermal field are the topics of a videotape available from the Division of Oil and Gas. The videotape is about 13 minutes long and was taped on location at The Geysers Geothermal field.

The videotape, titled "Before the Drilling Begins," may be purchased for $25 in 1/2" VHS format.

Contact Susan Hodgson for further details at (916) 323-2731.



PUBLICATIONS

14th Annual Report of the State Oil and Gas Supervisor. 1988. Free. Published by and available from the Division of Oil and Gas, 1416 Ninth Street, Room 1310, Sacramento, California 95814.

Statistical and verbal summaries of 1988 California geothermal activity.

Injection wells, an introduction to their use, operation, and regulation. $5.00. 12 pages. Published by and available from the Underground Injection Practices Council, 525 Central Park Drive, Suite 304, Oklahoma City, Oklahoma 73105. Phone (405) 525-6146.

This useful and well-presented booklet is published by the UIPC in cooperation with the EPA. It summarizes EPA injection well classes, and gives useful information about each class.

Geothermal energy program, summary volume I: overview, fiscal year 1988, and Geothermal energy program, summary volume II: research summaries, fiscal year 1988. Free. Published by and available from the Geothermal Technology Division, US-DOE, Washington, D.C. 20585.

Volume I is a summary of the FY88 geothermal R & D program. It includes a description and status report of hydrothermal, geopressured, hot dry rock, and magma geothermal resources.

Volume II contains technical descriptions of each division-funded R & D activity. It is designed to maximize technology transfer of division activities.

Guide to obtaining USGS information. C0900. By K. Dodd et al. 1989. 34 pages. Free. Published by and available from the USGS, Books and Open-File Reports, Federal Center, Box 25425, Denver, Colorado 80225.

GEOTHERMAL IN CALIFORNIA, by Susan F. Hodgson. Illustrated by Jim Spriggs. 1988. No charge when distributed to students. Free classroom sets available. For nonstudent distribution: up to 50 copies free; then, $1 per copy. Published by and available from the Division of Oil and Gas, 1416 9th St., Room 1310, Sacramento, California 95814.

Illustrated summary of the formation, production, and uses of geothermal resources in California. Prepared for 4th- to 9th graders, but a useful overview for adults.

In 1988, the publication was awarded the Second Place prize for "Writing" by the California State Information Officers Council.

This useful guide, newly updated, includes addresses and telephone numbers for securing the wide range of USGS products.

LBL geothermal programs, list of publications, 1986-1989. Free. Published by and available from the Earth Science Division, Lawrence Berkeley Laboratory, Building 50-E, University of California, Berkeley, California 94720.

Publications and open-file reports lists, Earth Science Laboratory, University of Utah Research Institute. Free. Published by and available from Publications, Earth Science Laboratory, UURI, 391 Chipeta Way, Suite C, Salt Lake City, Utah 84108. Phone (801) 524-3422.

National energy resource issues. B 1850. By Bryant and Martin. 79 pages. $6.00. Published by and available from the USGS, Books and Open-File Reports, Federal Center, Box 25425, Denver, Colorado 80225.

The publication offers a geologic perspective and gives the role of geologic information in energy resource matters.

Energy...in demand. Published quarterly. $300 a year. Write to Energy...in Demand, 4281 Evergreen Avenue, West Vancouver, British Columbia, Canada V7V 1H2.

State of the world, by L.R. Brown and A.B. Durning, et al. 1989. $18.95, hard cover; $9.95, paper. Published by and available from the Worldwatch Institute, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036.

The World Bank atlas 1989. No. 11354. 28 pages. $5.95. (1988 data.) Published by and available from the World Bank Publications, 1818 H Street, NW, Washington, D.C. 20433.

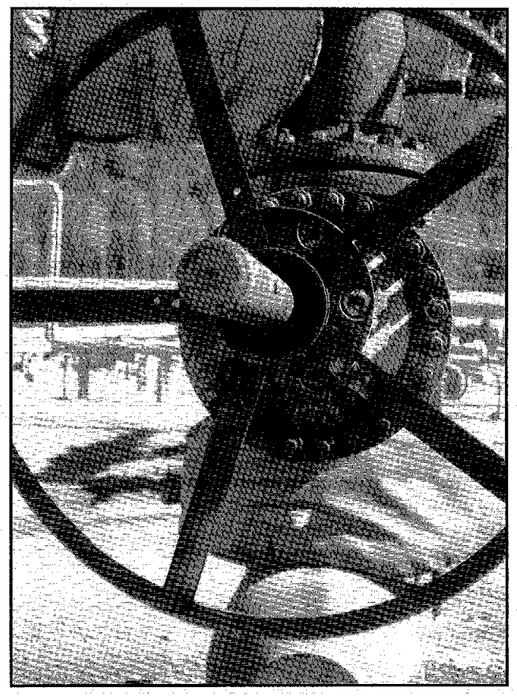
The atlas illustrates a wide range of social indicators for 185 countries and territories. Text in English, French, and Spanish.

PURPA lines, independent energy business news. Published every other week. Six-month trial subscription $137.50. Published by and available from HCI Publications, 410 Archibald St., Kansas City, Missouri 64111-9924.

Assuring our energy future. Proceedings of the symposium on electricity competition. P500-89-006. $6.75. Published by and available from the California Energy Commission, 1516 Ninth St., Sacramento, California 95814.

Electricity, 1988, the final electricity report seven. June 1989. P106-88-001. First copy free; subsequent copies $5.95. Published by and available from the California Energy Commission, Publications Unit, MS-13, 1516 Ninth Street, Sacramento, California 95814.

The report sections cover "Electricity Supply Planning for the 1990's," "Competitive Electricity Markets," "The Demand for Electricity," "Existing, Committed, and Uncommited Resources," "Policy and Planning Issues," "Integrated Assessment of Need," and "Determining Need for New Facilities."



Valuation of federal geothermal resources--electrical generation, June 1988. Free. Published by the U.S. Dept. of the Interior, MMS. For a copy, contact Dennis C. Whitcomb, Chief, Rules and Procedures Branch, Box 25165, MS662, Denver, Colorado 80225; phone (303) 231-3432.

The report describes the policies, guidelines, and methods used by the MMS to value federal geothermal resources used to generate electricity.

Nevada geothermal electric power production, 1984-88. Pamphlet. Free. Published by and available from the Dept. of Minerals, 400 W. King Street, Suite 106, Carson City, Nevada 89710.

The pamphlet offers a quick summary of Nevada geothermal development. Nevada stands seventh in the world for geothermal power generation, and second in the United States, behind California.

Power surge, the status and near-term potential of renewable energy technologies. By N. Rader. 1989. 100 pages. $50.00 paper. Published by and available from Public Citizen, 215 Pennsylvania Ave., SE, Washington, D.C. 20003. Phone (202) 546-4996.

Renewable energy technologies (including geothermal) have grown dramatically in the past 8 years. The technologies account for almost 10 percent of all domestic energy sources. Costs of these technologies have declined by as much as 75 percent since 1980. While hydropower accounts for about 40 percent of total U.S. renewable energy use, biomass, wind, geothermal, and direct solar technologies account for much of the current growth. These are some findings in this fact-filled study, of great interest to the geothermal community.

Proceedings: International symposium on development and exploitation of geothermal resources, Cuernavaca, Mexico, October 5 to 7, 1987. Prepared under the auspices of the Instituto de Investigaciones Eléctricas and the Comisión de Comunidades Europeas. Free. Available from IIE, Interior Internado Palmira, Apartado Postal 475, 62000 Cuernavaca, Mor. Mexico.

Proceedings: symposium in the field of geothermal energy, San Diego, California, April 1989. Ing. Miguel Ramírez (CFE) and Dr. John E. Mock, principal coordinators. 289 pages. $28.95. Microfiche, $5.95. Available from the NTIS, U.S. Dept. of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

On April 7, 1986, a three-year agreement for geothermal research was signed by the U.S. Department of Energy and the Comisión Federal de Electricidad of the Mexican Federal Government. The major objectives of the agreement were to achieve a thorough understanding of the nature of geothermal reservoirs in sedimentary and fractured igneous rocks, and to investigate how geothermal resources can best be explored and utilized. To achieve these objectives, mutually agreed upon tasks were defined, encompassing a broad range of cooperative research activities. The scientific results of this highly successful research program are reported in this document.

Hot dry rock, geothermal energy, phase 2B final report of the Camborne School of Mines, 2 volumes. Edited by R. H. Parker. 1,096 pages. $180. Published by and available from Pergamon Press Inc., Fairview Park, Elmsford, New York 10523.

These volumes contain the main parts of 15 of the Camborne School of Mines Project's major reports from October 1983 to September 1986.

Contents: Volume I. Preface. Contents. Summary. Overview. The Granites of South West England. Lithology, mineralogy, and structure. Jointing in the Carnmenellis granite. The Drilling and Stimulation of the Third Well (RH15). The role of the third well in the CSM HDR Project. Drilling operations 1984. Viscous stimulation of Well RH15. Circulation Results 1983-1986. Logging Results. Proprietary logging results. Production logging results. Volume II. Preface. Contents. Seismics. Microseismic results. Crosshole seismic results. Vertical seismic profiling. Geochemistry Results. Tracer Results. Preliminary Views on the Development of a Deep System. Drilling and casing. Other considerations. Seismic Hazard Assessment. Index.

Geothermal direct-use engineering and design guidebook. Prepared through cooperative efforts of the Oregon Institute of Technology, Idaho National Engineering Laboratory, University of Utah Research Institute, Battelle Pacific Northwest Laboratories, Radian Corporation, and the Washington State Energy Office. 401 pages. $20 domestic orders; $27 foreign orders. Distributed by the Geo-Heat Center, OIT, 3201 Campus Drive, Klamath Falls, Oregon 97601.

The publication contains comprehensive technical data on space-heating and cooling buildings, district-heating systems, greenhouse-heating systems, and aquaculture- and industrial-processing using low-to-moderate temperature (50° to 300°F) geothermal resources. It covers geology, exploration, well drilling, reservoir engineering, materials selection, well pumps, piping, heat exchangers, space-heating equipment, heat pumps, absorption refrigeration, applications, engineering cost analysis, regulatory codes, and environmental aspects.

Striking a balance, the environmental challenge of development. No. 11271. 52 pages. $4.95. Published by and available from World Bank Publications, 1818 H Street, NW, Washington, D.C. 20433.

The report describes how developmental strategies can give more attention to the environment, and how the World Bank integrates environmental considerations in its work, including pollution control.

Development of mineral, energy, and water resources and mitigation of geologic hazards in Central America. USGS Circular 1006. 272 pages. In English and Spanish. Free. Published by and available from the Books and Open-File Section, USGS, Federal Center, Box 25425, Denver, Colorado 80225.

The publication is the result of a workshop held in 1985 in Guatemala on the Development of Mineral, Energy, and Water Resources and Mitigation of Geologic Hazards in Central America.

Potential hazards from future volcanic eruptions in California. B-1847. By C.D. Miller. 1989. 17p. $4.25. Published by and available from the USGS, Books and Open-File Reports, Federal Center, Box 25425, Denver, Colorado 80225.

Over 500 volcanic vents have been identified in California. At least 76 have erupted in the last 10,000 years. The nature and probable distribution of potentially hazardous volcanic phenomena and their threats to people and property are described.

Discovery, location, recordation, and assessment work for mining claims and sites in California - 1989. $4.00. Published by and available from the BLM, 2800 Cottage Way, Room E-2845, Sacramento, California 95825. Phone (916) 978-4754.

Evaluation of a hydrothermal anomaly near Ennis, Montana. P1044-K. By R.B. Leonard and W.A. Wood. 1988. $3.50. Published by and available from the USGS, Books and Open-File Reports, Federal Center, P.O. Box 25425, Denver, Colorado 80225.

Maps and diagrams illustrate the results of test drilling and geophysical and geochemical studies near Ennis Hot Spring in southwestern Montana. The spring has a temperature of about 83°C.

Geothermal energy: list of available technical reports, and Renewable Energy Enquiries Bureau, general publications. Both lists are free. Available from the Renewable Energy Enquiries Bureau, Renewable Energy Promotions Group, Energy Technology Support Unit, Building 156, Harwell Laboratory, Didcot, Oxfordshire OX11 ORA, Great Britain.

A wide variety of British publications are included in this list.

Entech, newsletter of the E.C. Joule Energy R & D Programme. Two issues a year. Published by and available from the Commission of the European Communities, Directorate General XII/E, Attn: ENTECH Editor, Rue de la Loi, 200, B-1049 Brussels, Belgium.

Atlas of geothermal resources in the European Community, Austria, and Switzerland. By the Commission of the European Communities, Directorate-General XII: Geothermal Energy Research. Price: DM198, including postage. Available from Verlag Th. Schafer, Gmbtt, Postfach 5469, D-3000 Hannover l, Germany.

Geoscience resources, 1989-90 catalog. Free. Published by and available from Geoscience Resources, 2990 Anthony Road, Burlington, North Carolina 27215. Phone (800) 742-2677.

Minutes pass effortlessly while you read through this wonderful catalog. There are hundreds of descriptions for books on geology--books about geologic hazards, physical processes, space, weather, nature guides, the complete Roadside Geology series, atlases, a Time-Life series on The Planet Earth--I've never seen so many listed in one place.

Another equally good feature is the section on Geoscience Maps. Many maps (and geologic books) are listed for countries all around the globe, and for many U.S. states. Here is the place to go for geologic, topographic, mineralogical, geophysical, satellite image, city, and travel maps. From Afghanistan to Zimbabwe, they're all here.

Imprints of time, the art of geology. By B.B. Van Diver. 1988. 151 pages. $19.95, paper. Published by and available from Mountain Press Publishing Company, P.O. Box 2399, Missoula, Montana 59806-9987.

Geology is based on calendars, and rocks are the imprints of time, with their millions of shapes, colors, textures, sizes, and varieties--from the saw-toothed grandeur of mountain ranges to the surreal smoothness of hot spring terraces and the stained-glass configurations of crystals. All these moments are captured in this volume in exceptional photographs.

Roadside geology of Alaska. By C. Conner and D. O'Haire. 1988. $12.95, paper. 250 pages. Published by and available from Mountain Press Publishing Company, P.O. Box 2399, Missoula, Montana 59806-9987.

Alaska is a mosaic, a collage of continental scraps swept in from the Pacific and added one by one onto the far northwestern corner of the continent. Although the authors state that "...unraveling Alaska's complex and fragmented geologic history would have baffled Sherlock Holmes," this roadside geology is a good first stop for clues.

Both armchair and traveling detectives will be well satisfied with the extensive descriptions of volcanoes and other geothermal surface manifestations, and with information about the geology of this beautiful state.

Roadside geology of Idaho. By D.D. Alt and D.W. Hyndman. 1989. $14.95, paper. 393 pages. Published by and available from Mountain Press Publishing Company, P.O. Box 2399, Missoula, Montana 59806-9987.

The ancient sedimentary formations of northern Idaho, the Idaho batholith in the central part of the state, the continental hot spot track, the just-discovered meteorite impact crater of the volcanic Snake River Plain, and the active faults of the Basin and Range province are all chapters in Idaho's exciting geologic story, recounted in this roadside geology.

The authors write that the Snake River Plain and Columbia Plateau formed after an enormous meteorite exploded in southeastern Oregon 17 million years ago. The impact formed a crater that probably extended into southwestern Idaho. The crater, perhaps 200 miles wide, filled with molten basalt and turned into a lava lake. The lake overflowed in a series of enormous flood basaltic flows, building the Columbia Plateau of Oregon, Washington, and westernmost Idaho. The same explosion started a column of hot rock rising deep within the Earth, which generated the long row of volcanoes that became the Snake River Plain and, now, the Yellowstone volcano. Basin and range faulting, too, began with the meteorite impact.

Oregon geology. Vol. 51, No. 51, September 1989. $2.00 an issue, or $6 per year. Published by and available from DOGAMI, 910 State Office Bldg., 1400 SW Fifth Ave., Portland, Oregon 97201.

This issue includes an excellent summary article, "Geothermal exploration in Oregon, 1988."

Ground subsidence. By A.C. Waltham. 1989. 202 pages. $95.00. Published by and available from Routledge, Chapman and Hall, 29 West 35th St., New York, New York 10001.

Geological mechanisms behind subsidence, except slope failure, are covered, and the worldwide extent and frequency for each type are assessed. For each type of subsidence, site investigation methods are reviewed and evaluated, and remedial actions are summarized. Included are illustrative photos and line drawings.

Foundations of structural geology, 2nd edition. By R.G. Park. 1989. 147 pages. $57.50 hardback, $27.50 paper. Published by and available from Routledge, Chapman and Hall, 29 West 35th St., New York, New York 10001.

The book is written for a beginning geology student and divided into three sections: morphology, deformation, and geotectonics. Discussions are included on extensional set-

tings, strike-slip tectonics, and collage tectonics. Many illustrations are included.

Ore deposit geology. By R. Edwards and K. Atkinson. 1986. 466 pages. $33.00 paper. Published by and available from Routledge, Chapman and Hall, 29 West 35th St., New York, New York 10001.

Major ore deposit types are covered in this book, as well as mining districts--mostly those in North America, Australia, Africa, and Western Europe. The most effective exploration methods are described. Emphasis is on assessing the relative importance of genetic models in determining exploration strategy.

Glacial geologic processes. By D. Drewry. 1986. 276 pages. $28.50 paper. Published by and available from Routledge, Chapman and Hall, 29 West 35th St., New York, New York 10001.

The book focuses on the processes of glacial erosion and sedimentation, with emphasis on physical quantities and relationships. Erosion is treated from the viewpoint of applied rock mechanics, tribology, and fluid mechanics.

Geophysics of North America, a compact disc with access software. #975-B27-001 data set: $580; #975-B27-002 additional compact disc: $235; #975-B13-001 additional documentation book: $65. There is a $10 handling charge and an additional $10 charge for foreign orders. Compiled by and available from the National Geophysical Data Center, 325 Broadway, E/GCI, Dept. 720, Boulder, Colorado 80303-3328. For information, call Allen M. Hittelman, (303) 497-6591.

CALIFORNIA WELLS

Division Well Data Available

A computer-generated file of geothermal production and injection statistics for wells and records open to public inspection is available from the Division of Oil and Gas. All data are in metric units. The file may be purchased at cost from the Division of Oil and Gas in Sacramento.

Drilling Permits for Geothermal Wells Approved in 1989 by the Division of Oil and Gas

Date Notice Received	Operator and Well Name & No.	API Number	Sec. T. R.	Location & Elevation
	DISTRICT G1			
		Plumas County		
	PLUMAS COUNTY COMMUNITY DEVELOPMENT			
09/07/89	"PC" 1	063-90039	30 22N 13E	Fr SE cor 152m N, 274m W, el 1375m gr
09/07/89	"PC" 2	063-90040	32 22N 13E	Fr SW cor 116m N, 91m E, el 1370m gr

Date Notice Received	Operator and Well Name & No.	API Number	Sec. T. R.	Location & Elevation
		Sierra County		
	SIERRA COUNTY			
04/27/89	"SCGP" 1	091-90008	8 21N 15E	Fr SE cor 265m N, 495m W, el 1497m gr
	DISTRICT G2			
		Imperial County		
	RED HILL GEOTHERMAL, INC.			
03/03/89	"River Ranch" 16	025-91076	25 11S 13E	Fr SE cor 41m N, 53m W, el -68m gr
03/16/89	"River Ranch" 9	025-91087	25 11S 13E	Fr SE cor 736m N, 1404m W, rl -69m gr
	UNION OIL CO.			
03/20/89	"LEV" 1	025-91098	7 12S 13E	Fr SE cor 1219m N, 579m W, el -70m gr
	RED HILL GEOTHERMAL, INC.			
05/08/89	"River Ranch" 17	025-91104	25 22S 13E	Fr SE cor 735.8m N, 847.3m W, el -68m gr.
07/20/89	"SW" 7	025-91152	30 11S 14E	Fr SE cor 778m N, 44m W, el -69m gr
07/20/89	"SW" 8	025-91153	5 12S 14E	Fr SW cor 91m N, 112m E, el -69m gr
	FOUNTAIN OF YOUTH SPA			
09/19/89	"Spa" 2	025-91158	7 9S 13E	Fr SW cor 280m N, 250m E, el 33m gr
	UNION OIL CO.			
10/31/89	"ALO" 1	025-91169	26 11S 13E	Fr SE cor 448m N, 107m W, el -67m gr
10/31/89	"SEV" 1	025-91164	8 12S 13E	Fr SE cor 387m N, 6.1m W, el -66m gr
10/31/89	"HAT" 1	025-91167	11 12S 13E	Fr SE cor 817m N, 792m W, el -63m gr
10/31/89	"VAL" 1	025-91165	21 12S 13E	Fr SE cor 9.1m N, 1,280m W, el -68m gr

Date Notice Received	Operator and Well Name & No.	API Number	Sec. T. R.	Location & Elevation
10/31/89	"NEW" 1	025-91166	25 12S 13E	Fr SE cor 1,539m N, 76m W, el -68m gr
10/31/89	"COX" 1	025-91168	30 12S 13E	Fr SE cor 579m N, 805m W, el -66m gr
11/06/89	ENGLER, WILLIAM "Niland" 3	025-91163	1 9S 12E	Fr SW cor 456m N, 350m E, el -30m gr
11/27/89	UNION OIL CO. "IID" 4	025-91170	5 12S 13E	Fr NW cor 205m S, 100m E, el -66m gr
12/15/89	"Elmore" 100	025-91171	5 12S 13E	Fr SW cor 844m N, 441m E, el -70m gr

DISTRICT G3

Lake County

02/05/89	FGRC "Davies Estate" 8	033-90708	36 11N 8W	Fr NW cor 813m S, 778m E, el 529m kb

Sonoma County

01/26/89	GEOTHERMAL ENERGY PARTNERS, LTD. "Aidlin" 4	097-90804	32 11N 9W	Fr SE cor 46m N, 210m W, el 617m kb
08/07/89	COUNTY OF SONOMA "Sonoma Valley Geo" 1	097-90809	35 6N 6W	Fr SE cor 838.2m N, 548.6m W, el 61m RT
08/18/89	UNION OIL CO. "S" 1	097-90810	34 11N 8W	Fr SW cor 275m N, 170m E, el 870m kb

DIVISION OF OIL AND GAS
GEOTHERMAL OFFICES AND MAPS

OFFICES

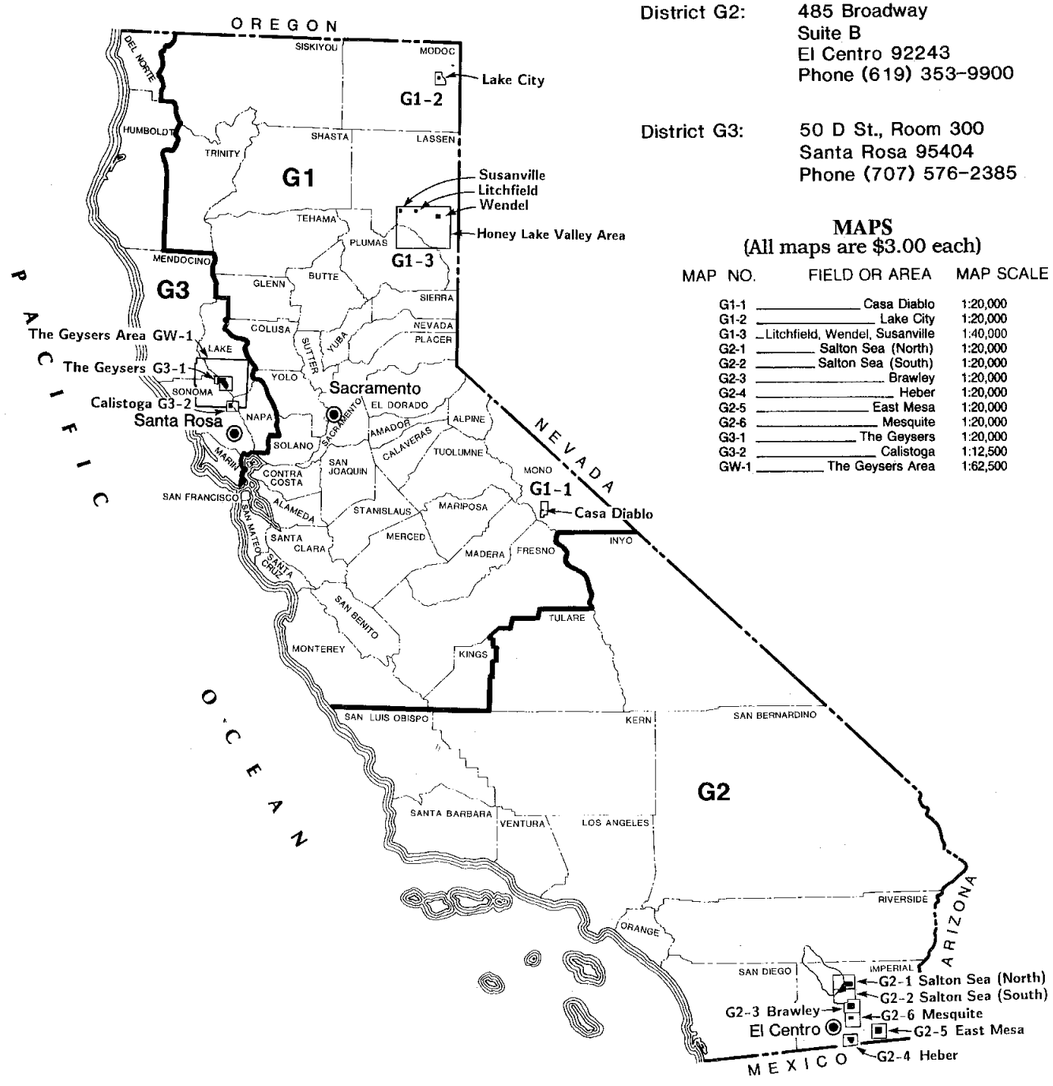
Headquarters & District G1: 1416 Ninth St., Room 1310, Sacramento 95814, Phone (916) 323-1788

District G2: 485 Broadway, Suite B, El Centro 92243, Phone (619) 353-9900

District G3: 50 D St., Room 300, Santa Rosa 95404, Phone (707) 576-2385

MAPS
(All maps are $3.00 each)

MAP NO.	FIELD OR AREA	MAP SCALE
G1-1	Casa Diablo	1:20,000
G1-2	Lake City	1:20,000
G1-3	Litchfield, Wendel, Susanville	1:40,000
G2-1	Salton Sea (North)	1:20,000
G2-2	Salton Sea (South)	1:20,000
G2-3	Brawley	1:20,000
G2-4	Heber	1:20,000
G2-5	East Mesa	1:20,000
G2-6	Mesquite	1:20,000
G3-1	The Geysers	1:20,000
G3-2	Calistoga	1:12,500
GW-1	The Geysers Area	1:62,500



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GEOTHERMAL DICTIONARY
DICCIONARIO GEOTÉRMICO
DIZIONARIO GEOTERMICO
CHINETSU YOGOSHU

By
Susan F. Hodgson
California Department of Conservation
Division of Oil, Gas, and Geothermal Resources

Spanish by
Mario César Suárez Arriaga
Comisión Federal de Electricidad

Italian by
Raffaele Cataldi
ENEL International

Japanese by
Mitsuru Sekioka
Department of Geoscience
National Defense Academy

The Languages: The English, Spanish, Italian, and Japanese languages were chosen for this dictionary because they are spoken in countries producing the most megawatts of electricity from geothermal resources. The Philippines, which is among this group, uses English for scientific and technical matters; thus, no separate entry was created.

ENGLISH Inglés Inglese Eigo	Spanish **ESPAÑOL** Spagnolo Supeingo	Italian Italiano **ITALIANO** Itariago	Japanese Japonés Giapponese **NIHONGO**
GEOLOGY	**GEOLOGÍA**	**GEOLOGIA**	**CHISHITSUGAKU**
alluvium	terreno aluvial	alluvioni	chusekiso
andesite	andesita	andesite	anzangan
basalt	basalto	basalto	gembugan
basement	basamento	basamento	kiban
bed	lecho	letto	chiso
clay	arcilla	argilla	nendo
consolidated	consolidado	consolidato	sekika
deep	profundo	profondo	fukai
deposit	sedimento	deposito	taisekibutu
displace	desplazar	dislocare	ido

ENGLISH Inglés Inglese Eigo	Spanish ESPAÑOL Spagnolo Supeingo	Italian Italiano ITALIANO Itariago	Japanese Japonés Giapponese NIHONGO
fault	falla	faglia	danso
fracture	fractura	frattura	hasai, wareme
granite	granito	granito	kakogan
gravel	grava	ciottolo	reki
greywacke	grauvaca	grovacca	gureiwakke
lava	lava	lava	yogan
limestone	caliza	calcare	sekkaigan
overlie	sobreyacer	sovrastare	~no ueni yokotawaru
reservoir	yacimiento	serbatoio	choryuso
sandstone	arenisca	arenaria	sagan
shale	esquisto arcilloso	scisto argilloso	ketsugan
siltstone	limolita	arenaria a grana fine	shirutogan
slate	pizarra	ardesia	nembangan
strata	estratos	strato	chiso
trap	trampa	trappola	torappu
tuff	toba	tufo	gyokaigan
underlie	infrayacer	sottostare	~no shitani yokotawaru
volcano	volcán	vulcano	kazan
GEOTHERMAL	**GEOTÉRMIA**	**GEOTERMICO**	**CHINETSU**
aquifer	acuífero	acquifero	taisuiso
boiling	ebullición	bollente	futto
brine	salmuera	salamoia	ensui
cold	frío	freddo	tsumetai
dry steam	vapor seco	vapore secco	kawaki joki
fluid	fluido	fluido	ryutai
fumarole	fumarola	fumarola	funkiko
geyser	géiser	geyser	kanketsusen
groundwater	agua subterránea	acqua di falda	chikasui
hot	caliente	molto caldo	atsui
hot dry rock	roca seca caliente	rocce calde secche	kanso koon gantai
hot spring	agua termal	sorgente calda	onsen
hydrogen sulfide	sulfuro de hidrógeno	idrogeno solforato	ryukasuiso
hydrothermal	hidrotermal	idrotermale	nessuikei
liquid	líquido	liquido	ekitai
mineral	mineral	minerale	kobutu
mixture	mezcla	miscela	kongobutu
noncondensable gas	gas incondensable	gas incondensabile	higyoshukuseigasu
parts per million	partes por millón	parti per milione	pipiemu
salinity	salinidad	salinità	enbunryo

ENGLISH Inglés Inglese Eigo	Spanish ESPAÑOL Spagnolo Supeingo	Italian Italiano ITALIANO Itariago	Japanese Japonés Giapponese NIHONGO
silica	sílice	silice	nisankakeiso
steam	vapor	vapore	suijoki
sulphur	azufre	zolfo	iwo
temperature	temperatura	temperatura	ondo
vapor	vapor	vapore	joki
warm	cálido	caldo	atatakai
water	agua	acqua	mizu
TEST	**PRUEBA**	**PROVA**	**SHIKEN**
flow test	prueba de flujo	prova di erogazione	funkishiken
geochemical	geoquímica	geochimico	chikyuukagaku
geophysical	geofísica	geofisico	chikyubutsurigaku
logging	registro geofísico	registrazione	kenso
pressure test	prueba de presión	prova di pressione	atsuryoku sokutei
WELL	**POZO**	**POZZO**	**KOSEI**
exploratory	exploratorio	esplorazione	tansa
injection	inyección	iniezione	kangen
observation	observación	osservazione	kansoku
production	producción	produzione	seisan
slim hole	agujero reducido	piccolo diametro	shokokeisei
temperature-gradient	gradiente de temperatura	gradiente di temperatura	ondokobai
DRILLING	**PERFORACIÓN**	**PERFORAZIONE**	**KUSSAKU**
blowout	reventón	erogazione	buroauto
blowout preventer	preventores de rompimiento	valvola di prevenzione	funshutsuboshisochi
to blow out	reventar	erogare	buroautosuru
casing	tubería de revestimiento	tubazione di rivestimento	keshingu
cement	cemento	cemento	semento
completion	terminación	completamento	shiage
drilling bit	barrena de perforación	scalpello	bitto
drilling rig	equipo de perforación	impianto di perforazione	kussakusochi
to drill	perforar	perforare	kussakusuru
liner	"liner"	"liner"	raina
mud	lodo	fango	deisui
perforation	perforación	perforazione	kantsu
pipe	tubería	tubazione	paipu
separator	separador	separatore	bunriki
valve	válvula	valvola	barubu
wellhead	cabezal del pozo	testa pozzo	koko

ENGLISH Inglés Inglese Eigo	Spanish ESPAÑOL Spagnolo Supeingo	Italian Italiano ITALIANO Itariago	Japanese Japonés Giapponese NIHONGO
POWER PLANT	**PLANTA ELÉCTRICA**	**CENTRALE ELETTRICA**	**HATUDENSHO**
binary	binario	binario	bainari
capacity	capacidad	capacità	setsubiyoryo
cooling tower	torre de enfriamiento	torre di raffreddamento	reikyakuto
dual flash	"flasheo" doble	doppio flash	daburu furasshu
electricity	electricidad	elettricità	denki
generator	generador	generatore	hatsudenki
heat	calor	calore	netsu
pipeline	tubería	tubazione	paipurain
pump	bomba	pompa	pompu
separator	separador	separatore	kisuibunriki
single flash	"flasheo" simple	flash semplice	shinguru furasshu
transmission line	línea de transmisión	linea di trasmissione	yusokan
turbine	turbina	turbina	tabin
ENVIRONMENT	**MEDIO AMBIENTE**	**AMBIENTE**	**KANKYO**
air	aire	aria	kuki
animal	animal	animale	dobutsu
discharge	descarga	discarica	haishutsu
emission	emisión	emissione	shashutsu
field	campo	campo	yagai
land	terreno	terreno	riku
plant	planta	impianto	shokubutsu
road	camino	strada	doro
solid waste	desecho sólido	residuo solido	kotaihaikibutsu
subsidence	subsidencia	subsidenza	chinka
waste water	agua de desecho	acqua di scarico	haisui
DIRECT USE	**USO DIRECTO**	**USO DIRETTO**	**CHOKUSETURIYO**
aquiculture	acuacultura	acquacultura	suikosaibai
to dehydrate	deshidratar	disidratare	dassuisuru
dry	seco	secco	kanso
to dry	secar	essiccare	kansosaseru
fish farm	criadero de peces	itticultura	yoshokujo
greenhouse	invernadero	serra	onshitsu
heat exchanger	intercambiador de calor	scambiatore di calore	netsukokanki
heat pump	bomba de calor	pompa di calore	hitopompu
lumber	madera	legname	zaimoku
nursery	vivero	allevamento	yoshokujo
residual heat	calor residual	calore residuale	yonetsu
space heating	calentamiento del espacio	riscaldamento di ambienti	dambo

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