

NOTICE CONCERNING COPYRIGHT RESTRICTIONS

This document may contain copyrighted materials. These materials have been made available for use in research, teaching, and private study, but may not be used for any commercial purpose. Users may not otherwise copy, reproduce, retransmit, distribute, publish, commercially exploit or otherwise transfer any material.

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted material.

Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specific conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

This institution reserves the right to refuse to accept a copying order if, in its judgment, fulfillment of the order would involve violation of copyright law.

BUILDING GEOTHERMAL RESEARCH AND DEVELOPMENT PARTNERSHIPS: THE CALIFORNIA ENERGY COMMISSION'S GEOTHERMAL PROGRAM

Robert Hare, Valentino Tiangco, Kelly Birkinshaw and Mary Johannis

Research and Development Office, Energy Technology Development Division
California Energy Commission, 1516 9th Street, MS-43
Sacramento, CA 95814-5512

ABSTRACT

The California Energy Commission's Geothermal Program (Assembly Bill 1905, Bosco) has built cost-shared Research, Development and Demonstration (RD&D) partnerships with over 150 public and private entities. The Geothermal Program promotes the development of new geothermal resources and technologies for both direct-use and electricity generation while protecting the environment and promoting energy independence. This is accomplished by providing financial and technical assistance in the form of contingent awards which, depending on project success, can become either a loan or a grant. Some of the cost-shared RD&D accomplishments are presented. The process and requirements to obtain financial assistance through the Geothermal Program are summarized.

INTRODUCTION

The mission of the Geothermal Program is to promote the research, development, demonstration, and commercialization of California's enormous earth heat energy sources. The Geothermal Program works to overcome financial, technical, and institutional barriers by providing financial and technical assistance, gathering and disseminating geothermal development information, and supporting geothermal policy development. The Geothermal Program was created by Assembly Bill 1905 (Bosco) and has been in operation since 1981. During its first decade, it promoted California geothermal energy development by extending financial and technical assistance to public entities. In 1992, the program was expanded to include financial assistance to private entities.

This paper reviews the significance of geothermal energy development to California, how the Geothermal Program supports this development, and the terms and conditions of financial support offered by this program.

CALIFORNIA'S GEOTHERMAL POTENTIAL

California has the largest geothermal potential of any state in the nation. Geothermal energy occurs in four forms in California: hydrothermal resources, geopressured resources, hot dry rock, and magma. Currently, only hydrothermal resources are being used commercially. California's potential high- and low-temperature hydrothermal resources are estimated to total 119×10^{15} Btu or the equivalent of 1,190 billion therms of natural gas. Currently, only a small part of California's available geothermal reserves are being utilized.

In December of 1993, 1,952 MW of hydrothermal electric generation capacity (as opposed to name plate rating) was on-line in California. This capacity consisted of 1,216 MW of dry steam capacity and 736 MW of liquid geothermal capacity. The present capacity of the Geysers is only 65% of its installed capacity of 1,866 MW. This is due to the cumulative effect of extensive steam withdrawal at the Geysers. This situation might be reversed if and when sufficient water is found to recharge the reservoir by injection. No additional capacity will be added in the Geysers area in the near future due to steam decline. However, California's liquid-dominated hydrothermal resources can support continued development.

With increased incentives, Californians could tap into much more of geothermal energy's tremendous potential. California has over 3,800 MW of potential megawatt capacity available to develop for electricity generation (Table 1). Approximately 94% of U.S. hydrothermal capacities are located in California. A high percentage of hot dry rock, magma, and geopressured geothermal energy resources also occur in California. Table 2 shows the Department of Energy's projected geothermal electricity capacities for the U.S. through the year 2030.

SIGNIFICANCE OF GEOTHERMAL DEVELOPMENT TO CALIFORNIA

The development of geothermal energy has greatly benefited California's economy. Over the last thirty years approximately \$5 billion (1992 dollars) was invested in constructing geothermal electrical and direct-use facilities in California. This expenditure supported approximately \$10 billion in Gross State Product, \$3 billion in payroll, \$300 million in state tax revenues, and 96,000 jobs (Table 3). Based on an average operational life of thirty years, operating and maintaining California's existing geothermal facilities should support an additional \$5 billion in Gross State Product, \$1.5 billion in payroll, \$700 million in state tax revenues, and 4,000 jobs.

California leads the nation in the development and export of high temperature geothermal technology. This growing California industry exports high value-added goods and services which reduce California trade deficits.

Geothermal energy use improves air quality by displacing fossil fuel use. Geothermal energy production emits no nitrogen oxides and emissions of carbon dioxide and hydrogen sulfide are relatively low (Tiangco et al., 1995). Use of geothermal resources displaced 1.6 billion therms of natural gas in 1992, valued at about \$1.6 billion.

As a domestic renewable energy source, geothermal energy reduces reliance on imported fuels. Geothermal energy use contributes to California's long-term energy flexibility and diversity.

BARRIERS TO GEOTHERMAL ENERGY DEVELOPMENT

The growth of California's geothermal industry toward sustainable development is constrained by a combination of: lack of demand for new power, expiration of Standard Offer 4 contracts, low conventional fuel prices, uncertainty and complexity of the utility power plant bidding process, uncertainty brought about by the proposed deregulation of the electrical utility industry, remote location of many geothermal resources, declining federal financial support, lack of awareness among energy policy makers of the potential for users of low-temperature geothermal energy resources, and other technical barriers. If some of these barriers could be eased, California could harness much more of its tremendous geothermal energy potential.

GEOTHERMAL PROGRAM ACHIEVEMENTS

The Geothermal Program helps private and public entities overcome financial, technical, and institutional barriers to geothermal development in California. This program facilitates the transfer of competitive geothermal technologies to the marketplace through creating effective industry/government partnerships. Technology transfer activities and public/private partnerships are critical to

promote commercialization of demonstrated geothermal technologies.

In fourteen years, the Geothermal Program has awarded funds to 154 geothermal projects that span the full length of the state. Geothermal Program-funded projects annually utilize over 160 billion Btu of geothermal energy, establishing California as the United States leader in geothermal direct-use applications. Many of the direct-use projects funded through the Geothermal Program continue to expand and the annual energy figures will likely increase.

Since 1981, the Geothermal Program has awarded \$29 million and leveraged \$93 million, totalling \$122 million for geothermal projects. Table 4 shows the cumulative projected economic impacts of this investment from 1988-1999. Capital cost investments support approximately \$219 million in Gross State Product, \$63 million in payroll, over \$6 million in state tax revenues, and almost 2,000 jobs. Ongoing investments annually support an additional \$4 million in Gross State Product, \$1 million in payroll and \$1 million in state tax revenues.

The Geothermal Program emphasized planning, mitigation, and direct-use projects in its early years. As the development of geothermal power plants slowed in the mid-1980s, program emphasis shifted to the exploration and development of low-temperature resources. These early awards supported geochemical, geophysical, and hydrological assessments, well drilling, and construction of geothermal resource distribution systems. With its development partners, the Geothermal Program has co-invested \$26 million to develop 84 geothermal commercialization projects.

With assistance from the Energy Commission, the San Bernardino Municipal Water Department has connected 37 customers and created one of North America's largest geothermal heating systems. Currently, we are co-funding a project to evaluate the geothermal reservoir for sustainability and potential for increased production. If the evaluation shows that production could be increased, the District heating System could be extended to new customers. The Energy Commission award for the reservoir assessment project is \$378,000.

THE GEOTHERMAL PROGRAM NOW EMPHASIZES RD&D PROJECTS

Recently, the Geothermal Program has shifted its focus from developing direct-use projects to creating R&D partnerships with the private sector. A major program goal is to establish a portfolio of near to long-term R&D projects in California.

The Geothermal Program is currently supporting a drilling project in Siskiyou County with Calpine Corporation. If

successful this project could result in the construction of a 30 MW power plant and leverage an additional \$120 million. This project would produce 120 construction jobs for 1 year, 25 permanent jobs, property tax revenues of 1.1 million beginning in 1998, and \$400,000 annually in geothermal royalties to the state.

The Energy Commission is co-funding the design and construction of a 26-mile, 20-inch diameter buried pipeline that will carry secondarily treated wastewater from two Lake County Sanitation District treatment plants in Clearlake and Middletown to the southeast Geysers steamfield for injection. Injection of the treated effluent is projected to create steam supplies equivalent to approximately 50 megawatts of capacity at existing geothermal power plants operated by PG&E and NCPA. The Energy Commission has approved a \$554,000 conditional award to assess the feasibility of alternative solutions to the decline of the Geysers geothermal resource and \$1 million from the Petroleum Violation Escrow Account toward the construction of the pipeline.

The Geothermal Program is working with the Department of Energy, the California Energy Company, and Biphase de Mexico to demonstrate an advanced biphase turbine. The advanced biphase turbine separates the steam and brine, generates power from each phase, and internally pressurizes the separated brine. The first phase demonstrated the performance of a sub-scale turbine with a single rotor and steam blades from a geothermal well at Coso Hot Springs. The second phase will consist of operating a full size commercial unit at Cerro Prieto geothermal field in Mexico. The full-size biphase turbine is predicted to generate 4,150 kW from the two phase well flow. The additional power is projected to increase power production at the selected well by 45% with no additional well flow.

The Geothermal Program is working with the Sacramento Municipal Utility District (SMUD) and the Truckee-Donner Public Utility District (TDPUD) to demonstrate the performance of geothermal heat pumps (GHP) in single family residences and a commercial facility. The two utilities, homeowners, and the federal Department of Energy will provide approximately \$1 million over three years to purchase and install geothermal heat pump and monitoring equipment and to co-fund the monitoring program. The Geothermal Program's contribution will help fund the collection and evaluation of the performance data. Commercialization of GHPs would result in a significant reduction in heating and cooling costs to utility customers. SMUD staff estimates a 50 percent reduction in energy need by each GHP customer, and savings to the utility of \$2650 per customer for demand and energy. TDPUD staff estimates up to a 75 percent reduction in energy needed by each GHP customer. Since these two utilities differ widely in soil type, climatic conditions, and summer/winter electrical peak-load demands, the collected performance data and subsequent analysis should be applicable to other California utility service areas. Successful demonstration in these two utility districts would likely create jobs in the manufacture and installation of GHPs.

THE GEOTHERMAL PROGRAM SUPPORTS BOTH NEAR-TERM AND LONG-TERM R&D

The development of some of the state's geothermal resources has moved California toward greater energy security. To compete with other energy sources in the near-term, geothermal developers need R&D that lowers operation and maintenance costs. The Geothermal Program invites such project proposals.

The Energy Commission will also continue to support the development of long-term R&D such as advanced generation technologies, expansion of geothermal heat pump use in California, and the utilization of previously unusable sources of geothermal energy. The Geothermal Program has supported R&D projects with potential for long-term benefits such as hot dry rock and magma energy in partnership with the U.S. Department of Energy. These technologies may greatly expand the availability of geothermal energy to generate electricity in California. The Geothermal Program is committed to creating both near-term and long-term R&D partnerships involving industry, academia, and government.

GEOTHERMAL PROGRAM FINANCIAL ASSISTANCE

The California Energy Commission has built funding partnerships with many public and private entities to promote the development of new geothermal resources and technologies. These partnerships often involve the U.S. Department of Energy.

The funding source is revenue paid to the United States government by geothermal developers from production on federal leases in California. Generally, there is approximately \$2 million available each fiscal year in the Geothermal Resources Development Account for awarding to qualifying applicants.

The Geothermal Program has an open and continuous solicitation process. A program opportunity notice is issued just after the beginning of each fiscal year announcing the amount of available funds.

The following summary of terms and conditions will help you decide whether to apply for assistance from the Geothermal Program. Full details are found in the application manual, which you can receive by request.

Both private and public entities can apply

Universities, national laboratories, and state and federal agencies can also participate in this program when in partnership with an eligible local jurisdiction or private entity.

Most types of geothermal projects in California qualify

Practically all aspects of geothermal resource development, commercialization, planning, research, and impact mitigation are eligible for funding. Research,

Hare, et. al.

development, and commercialization proposals are particularly encouraged. To qualify, your project must directly relate to geothermal energy and be located in California, or be sponsored by a California-based company. All projects must have a hardware component (e.g., well drilling; resource assessments; small-scale electricity production; direct-use systems; or testing or demonstration of innovative geothermal assessment techniques, components, or systems).

Repayment of award only if project is successful

At project completion, a contingent award is converted into either a loan or a grant. If the Commission finds that the completed project is producing, or is capable of producing, savings or revenues such that the award can be repaid in full or in part, the award becomes a loan. If the Commission finds that the project is not capable of producing energy savings or revenues, the award becomes a grant.

A match contribution is required

A match contribution is cash, equipment, and/or in-kind services provided by the applicant toward completion of the awarded project. Staff time, laboratory space, equipment, and other grants, loans, or contracts can also count toward the match contribution. Most public entities must provide a match contribution of at least 20 percent of the overall project cost. Private entities must provide a match contribution of at least 50 percent of the overall project cost.

You may request any amount of funding

There are no predetermined limits on the funding that can be requested for a project. Awards are limited by the availability of funds in the Geothermal Resources Development Account. The account balance varies from year to year.

Funds are issued by reimbursement

Commission funds are paid on a reimbursement basis. Payment will be made approximately 60 days after the Commission receives and approves your completed invoice supported by documentation of project expenses.

Paperwork is minimal

Recipients must submit quarterly progress reports, reimbursement requests, and a final report. Some projects may also require technical reports and other documentation specific to that project.

Technical assistance is also available

The Commission may provide staff support and/or private consultants to help resolve technical problems relating to a planned or ongoing project.

You may apply at any time

Funding is awarded to approved proposals in the order that complete applications were received. We invite you to contact us and apply for funding. To receive an application packet, call the Geothermal Program at (916) 654-5129 or fax us at (916) 653-6010.

CONCLUSIONS

California has the largest level of geothermal energy development in the nation. This development generates important economic, environmental, and energy security benefits. Significant economic, technical, and institutional barriers currently constrain further development of California's enormous geothermal potential. Since 1981, the Geothermal Program has co-funded 154 geothermal projects totalling \$122 million in state and match funds.

In the current fiscal year, the Geothermal Program has approximately \$3 million to award to help private and public entities overcome barriers to developing the state's geothermal resources.

ACKNOWLEDGEMENTS

The accomplishments of the Geothermal Program would not have been possible without the interest, energy, and professionalism of the people from the many public and private institutions with whom we have built partnerships. The authors thank Mike Batham, Richard Kishi, Michael Kramer, Roger Peake, and Sanford A. Miller for their contributions to this paper.

REFERENCES

Tiangco, Valentino, Robert Hare, Kelly Birkinshaw and Mary Johannis, 1995. *Emission Factors of Geothermal Power Plants in California*. Geothermal Resources Council - 1995 Annual Meeting. Reno, Nevada. October 8-11.

U.S. Geological Survey Report: *Assessment of Geothermal Resources in the United States*, Circular 790, 1978. (California potential hydrothermal reserves calculated from data found on pp.18-49)

U.S. Geological Survey Report: *Assessment of Low-temperature Geothermal Resources of the United States*, Circular 892, 1982. (California potential hydrothermal reserves calculated from data found on pp. 43-44)

Table 1. Proven capacity, estimated total potential capacity, and available capacity for potential development of liquid-dominated geothermal resources in California.

LOCATION/KGRA	PROVEN CAPACITY		ESTIMATED POTENTIAL CAPACITY (C) MW	POTENTIAL MW AVAILABLE FOR POTENTIAL DEVELOPMENT (D) = (C) - (A) - (B) MW
	DUAL-FLASH POWER PLANTS (A) MW	BINARY POWER PLANTS (B) MW		
Coso Hot Springs, Inyo Co.	272	0	431	159
East Mesa, Imperial Co.	38	64	254	152
Heber, Imperial Co.	47	32	144	65
Salton Sea, Imperial Co.	240	0	1242	1002
Mammoth Lake, Mono Co.	0	35	294	260
Wendel, Lassen Co.	0	8	13	5
Lake City, Suprise Valley, Modoc Co.	0	0	502	502
Glass Mt., Medicine Lake, Siskiyou Co.	0	0	750	750
Brawley, Imperial Co.	0	0	463	463
East Brawley, Imperial Co.	0	0	57	57
South Brawley, Imperial Co.	0	0	277	277
Westmorland, Imperial Co.	0	0	135	135
Total	597	139	4562	3827

Table 2. Projections of U.S. Geothermal Electric Capacity and Generation, 1988-2030 (MW electric)

	1988	2000	2010	2020	2030
Hydrothermal	2,565	3,234	5,242	6,581	6,246
Hot Dry Rock	0	112	223	1,227	3,011
Magma	0	112	112	223	558
Geopressured	0	0	335	558	781
TOTAL	2,565	3,458	5,912	8,589	10,596

Table 3. Total Impact of Geothermal Facility Construction and Operation/Maintenance on California's Economy (\$1992)

	Gross State Product	Payroll	State Tax Revenues	Jobs (PY)
Const.	\$9.8 billion	\$2.9 billion	\$306 million	96,200
O/M	\$5.4 billion	\$1.5 billion	\$711 million	4,250
Total	\$15.2 billion	\$4.4 billion	\$1 billion	100,450

Table 4. Total Economic Impact of Geothermal Program Supported Projects: Capital and On-going Investments (1988-1999)

	Gross State Product	Payroll	State Tax Revenues*	Jobs (PY)
Capital	\$219.0 million	\$63.4 million	\$6.7 million	1856
On-going	\$4.2 million	\$1.2 million	\$1.3 million	39
Total	\$223.2 million	64.6 million	\$8.0 million	1895

* Includes State Income, Sales, and Property Taxes