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A PACIFIC-WIDE GEOTHERMAL RESEARCH LABORATORY: THE PUNA GEOTHERMAL RESEARCH FACILITY

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ABSTRACT

The Hawaii Geothermal Project (HGP-A) well, located in the Kilauea volcano east rift zone, was drilled to a depth of 6450 feet in 1976. It is considered to be one of the hottest producing geothermal wells in the world. This single well provides 52,800 pounds per hour of 371°F and 160 pounds per square inch-absolute (psia) steam to a 3-megawatt power plant, while the separated brine is discharged in percolating ponds. About 50,000 pounds per hour of 368°F and 155 psia brine is discharged.

Geothermal energy developnent has increased steadily in Hawaii since the completion of HGP-A in 1976:

- a 3 megawatt power plant at HGP-A was completed and has been operating since 1981;
- Hawaiian Electric Company (HECO) has requested that their next increment in power production be fran geothermal steam:
- three development consortia are actively, or in the process of, drilling geothermal exploration wells on the Big Island: and
- engineering work on the development of a 400 megawatt undersea cable for energy transmission is continuing, with exploratory discussions being initiated on other alternatives such as hydrogen.

The purpose for establishing the Puna Geothermal Research Facility (PGRF) is multi-fold. PGRF will provide a facility in Puna for high technology research, development, and demonstration in geothermal and related activities: initiate an industrial park development: and examine multi purpose dehydration and biomass applications related to geothermal energy utilization.

INTRODUCTION

The Hawaii Geothermal Project (HGP) began in 1972 when the state legislature allocated $200,000 for geothermal research to identify and utilize geothermal resources in Hawaii. The initial effort, which was also funded by the National Science Foundation started in mid-1973 on the Island of Hawaii with the University of Hawaii at Manoa (UHM) and Hilo campuses conducting geophysical, geochemical, engineering, environmental, and socio-economic programs.

After the researchers identified a well site in the Puna District on the east rift of Kilauea Volcano (see Figures 1 and 2), a drilling program was initiated in 1975 with funding from the Energy Research and Development Agency, State, and County of Hawaii.

HGP-A well, named after the late Agatin T. Abbott, Professor of Geology at UHM, was completed to a depth of 6,450 feet in April

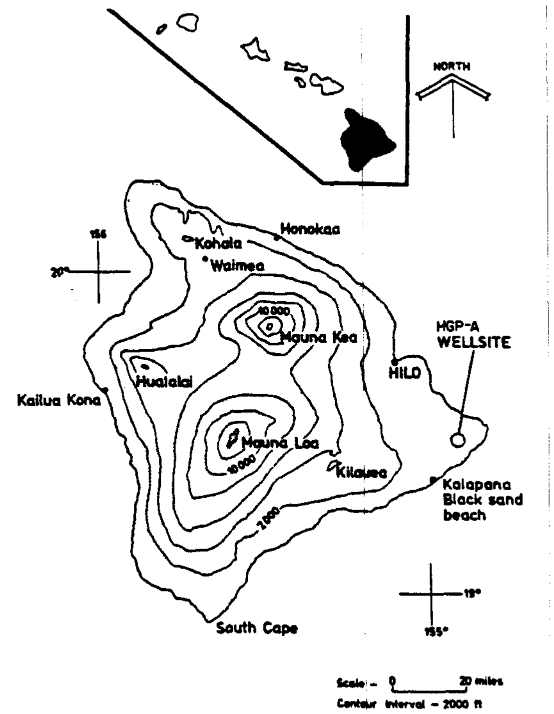

Figure 1. Map of Hawaii

1976. A bottomhole temperature of approximately 676°F makes HGP-A one of the hottest geothermal wells in the world. Scientist have conservatively predicted that the available energy in the Kilauea east rift zone is in the order of about 50,000 megawatt-years [12].

During 1976 and 1977, several sets of flow tests were conducted to gather data on water source, solids content, and to make prelim inary predictions of the reservoir's size, shape, and production capacity [12]. In order to obtain additional information on the characteristics and extent of the geothermal resources as well as to demonstrate the feasibility of geothermal energy utilization, the HGP-A Wellhead Generator Feasibility Project was then proposed. This project, funded in June 1978 by the U.S. Department of Energy (USDOE) and supported by the State, UHM, the County of Hawaii, and Hawaii Electric Light Company (HELCO), was for design, construction, operation, and maintenance of a geothermal power plant at HGP-A [2].

Construction was completed in June 1981, and after some initial shakedown period, the plant started to generate electricity in early 1982 [1,4]. Since then, the power plant has been on line 95 percent of the time generating approximately 2.8 megawatt of electricity. Two-tenths of a megawatt are used in plant and the remaining power is transmitted to HELCO's electric grid as the first geothermal electricity in Hawaii. In August, 1983, the first scheduled routine maintenance was conducted and the turbine showed very little wear and scale buildup. The actual maintenance work was finished in half of the scheduled time. Geothermal energy, thus, is technically viable in Hawaii.

To date, over $14 million has been spent to explore, drill, and develop the HGP-A facility. Approximately $10 million has come from various federal agencies, with the remainder from State, County of Hawaii, and HELCO [9].

With the success of the HB-A geothermal power plant, several wells were drilled by private companies within a mile of the HGP-A site (see Figure 2). Even though no data have been released by these companies, all indications point to the availability of geothermal resources in these wells comparable to the HGP-A well. The private companies are currently in the resource confirmation phase of building a power generating facility to provide electricity to HELCO by 1987 [11].

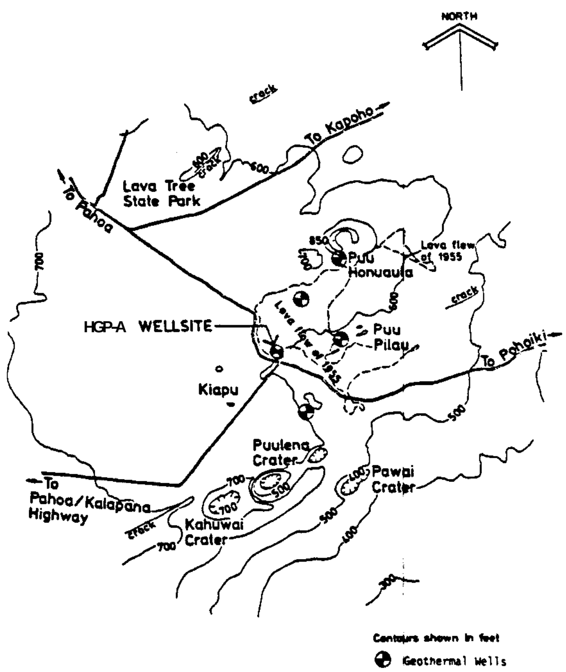

Figure 2. Geothermal Locations

GEOTHERMAL APPLICATIONS PROGRAMS

The majority of the geothermal resources in the world are used for non-electric purposes. Most of these uses are in space heating/cooling, agriculture/aquaculture, and industrial processes. The leading user of geothermal energy for space heating is Iceland where 75 percent of the population use geothermal heat in their homes. District heating is also being seriously considered by as m y as 40 different sites in the U.S. Space cooling has been successfully applied in New Zealand and at the Oregon Institute of Technology. Extensive agri-business related geothermal energy utilization occurs in the Soviet Union and in Hungary. Industrial applications can be seen in the wood and paper processing plant in New Zealand and the diatomaceous earth drying plant in Iceland. Some U.S. examples are the onion dehydration plant at Brady Hot Springs, Nevada and milk pasteurization at Klamath Falls, Oregon [7].

The future development of geothermal energy is not without problems. For example, the silica in the liquid phase of the geothermal fluid makes the disposal extremely difficult [10]. Work has been done in New Zealand to seek optimum temperature and pressure for reinjection. The Electric Power Research Institute will be testing a flash crystallizer separator this year in Imperial Valley. A similar unit by Union Oil is also in operation at Salton Sea [11].

In addition, there is a great 'deal of heat wasted in using geothermal fluid only for electric generation. For example, at HGP-A approximately 50,000 pounds per hour of 368°F and 155 psia geothermal water is disposed. This is about 17 million BTU per hour or equivalent to 3 barrels of oil per hour. With the private companies also developing geothermal power plants, there will be an abundance of geothermal water for direct heat applications.

The state with federal support has also embarked on examining methods to transport this potentially abundant energy to the island of Oahu where the vast majority of the state's population and subsequent energy **demand** is needed. One method is via an underwater electric cable to transmit the surplus geothermal energy to Honolulu. Other energy bridges include liquid fuels production and hydrogen.

THE PUNA GEOTHERMAL RESEARCH FACILITY

HGP-A is the only operating geothermal well in Hawaii, making this site unique in gaining expertise about the Hawaiian geothermal well fluids and reservoir. In April 1984, Governor George Ariyoshi released $325,000 of capital improvement funds to build a facility to conduct geothermal applications research on the grounds of the **HGP-A** wellsite (see Figure 3). **A** local engineering firm has been selected to design and manage construction of the **Puna** Geothermal Research Facility (PGRF). **The PGRF** should be installed and ready for use in the summer of 1985.

The design features include a wet chemistry laboratory, a smaller laboratory room, and an office. **An** *open* area has been designated for geothermal research in which high pressure brine (160 psia) will be provided for various experiments. Low pressure steam and brine (15 psia) from a small flash separator is expected to be installed in the second phase of this project. **This** facility **will** be housed in a 40 foot by **50** foot prefabricated building. Electricity (120 volts and 240 volts), sunning water, lights, Urainage, sanitation, compressed air, and telephone will also be provided. Table 1 is an equipment list for PGRF.

PGRF thus will:

1) provide **a** facility in **Puna** for high technology research, development, and demonstration in geothermal and related activities; and

2) initiate an industrial park develop ment.

Use of the facility will be directed by the Hawaii Natural Energy Institute **(HNEI)** in ***co***operation with the University of Hawaii at Hilo, with the support of the County of Hawaii, which has also appropriated $26,500 in cast-sharing funds, and the State Department of Planning and Economic Development **(DPED),** which will cost share capital improvement project monies as justified.

PGRF will enable vital research and development to be carried out in both geothermal electrical and non-electrical applications such as dehydration, agriculture, aquaculture, by-product recovery, etc. The research program at PGRF will build on the presently known results at various research institutions throughout the world. **A** *Geo*thermal Research Advisory Task Force (Table 2) **has** been formed, consisting of representatives from academia, a utility company, gov-

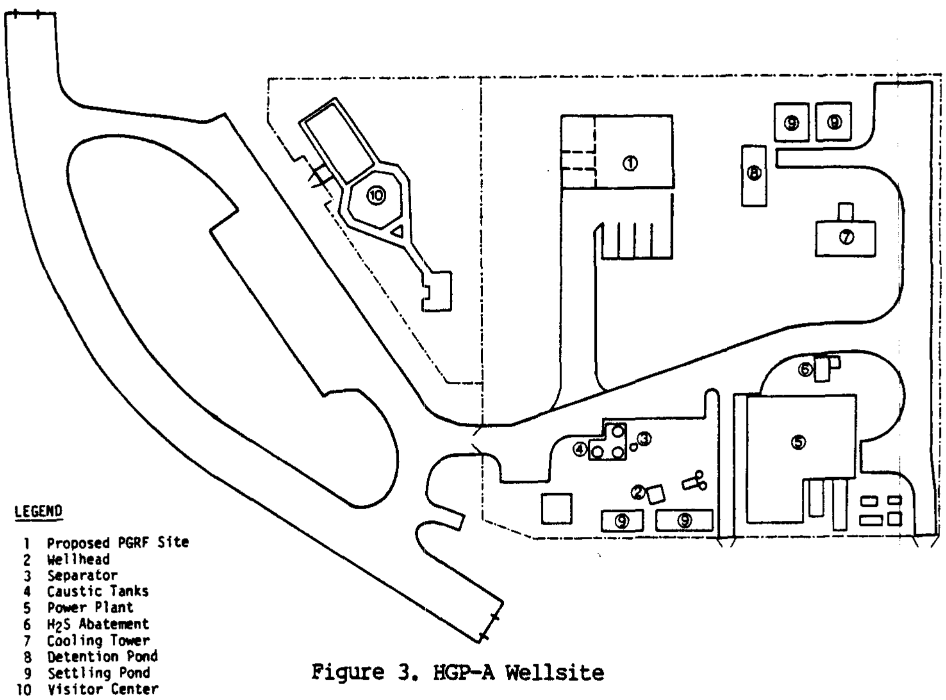

Figure 3. HGP-A Wellsite

ernment, private sector, and general community, and has identified the following areas as desirable for research emphasis:

1) Well and reservoir analysis of Kapoho Reservoir
2) Silica inhibition, extraction, and utilization
3) Sulfur removal and utilization
4) Dehydration and food processing
5) Cold storage and ice making
6) Geothermal water and gas chemistry monitoring
7) Effect of H_2S on plant and animal life
8) Liquid-fuel-from-biomass and geothermal heat process
9) By-products from H_2S
10) Hydrogen production stimulation with geothermal heat
11) Geothermal brine reinjection

Table 1. Equipment List for the Puna Geothermal Research Facility

Available Equipment

- Miscellaneous tools
- Temperature sensors
- Pressure gauges
- Flowmeters
- Data acquisition system and controller
- Boresocope
- Pumps
- valves
- Tubing
- Portable data mnitor system
- Scale
- Microscope
- Humidity meter
- Sample preparation equipment
- pH meter
- Lab bench with sink and hood
- Gas chromograph
- Miscellaneous lab supplies
- H_2S continuous mnitor with recorder
- Centrifuge
- Filter system
- Dilution meter
- Flash separator
- Compressor

Pending Equipment (From other proposals and procurements)

- Rankine engine
- Ammonia compressor
- Hot-air dryer/geothermal heat exchanger
- Osmotic-vacuum dryer
- Activated charcoal column
- Atomic analyzer

The facility could initiate industrial park or small business development utilizing the potential electrical power and heat available from the geothermal fluid. Table 3 is a summary of the kinds of applications anticipated

Table 2. Geothermal Research Advisory Task Force

- Robert Bethea, Big Island, Hilo
- Bill Chen, University of Hawaii, Hilo
- David Hess, Big Island, Puna
- Stuart Kearns, County of Hawaii
- Deane Kihara, Engineering Advisor, UHM
- Ralph Masuda, County of Maui
- Rod Moss, Geothermal developer
- Richard O'Connell, Hawaiian Electric Co.
- *Sandy* Siegel, Environmental Advisor, UHM
- M. Ray Smith, Tropical Agriculture Advisor, UHM
- Patrick Takahashi, Chairman, UHM
- Donald Thomas, Geophysical Advisor, UHM
- *Tak* Yoshihara, Department of Planning & Economic Development

from the waste effluent alone. As this area is suffering economically through the recent closing of Puna Sugar company,, which cultivated 15,000 acres of land, the initiation of possible new industries is of especial importance. Some initial studies have been conducted examining the use of geothermal energy in commercial/industrial applications in Hawaii [3,5,6].

The College of Engineering and HNEI at the University of Hawaii at Manoa are initiating the Fellows in Renewable Energy Engineering (FREE) program. This program involves corporate and foundation endowment of teaching and research positions to advance the development of renewable energy technologies. The position and salary (provided by UHM) will be augmented to draw top level researchers to develop what is hoped to be the finest of engineering faculty conducting research on critical renewable energy engineering problem in the most ideal of natural laboratories, Hawaii. Hawaiian Electric Industries has donated $250,000 specifically to support a FREE researcher in geothermal energy.

The Pacific International Center for High Technology Research (PICHTR), currently housed at the College of Engineering, established renewable energy research as one of the three research focal points. At the PICHTR meeting held in Honolulu, Hawaii in August 1984, researchers from the United States, Taiwan, and Japan concluded that geothermal energy applications research would be fruitful to all the participants and was identified as a high priority area of emphasis. Taiwan has subsequently followed up and has recommended a joint effort [8].

COMMUNITY GEOTHERMAL TECHNOLOGY PROGRAM (CGTP)

In addition to the more traditional research projects to be conducted by university researchers, the Community Geothermal Technology Program has been proposed to provide the opportunity for small businesses to use geothermal energy for non-electric purposes.

Table 3. Potential Geothermal Applications at the Puna Geothermal Research Facility [7]

Application	°F	°C
Drying of fish meal, timber	320	160
Drying of farm products at high rates, food canning	284	140
Sugar processing, extraction of salts	266	130
Freshwater by distillation	248	120
Drying and curing light aggregate cement slabs, saline solutions for intravenous injection	230	110
Dehydrated potato processing, drying organic materials, seaweed, grass, vegetables, etc.	212	100
Drying fish stock, intense deicing operations	194	90
Milk pasteurization, space heating	176	80
Refrigeration by low temperature	158	70
Poultry processing, animal husbandry	140	60
Poultry hatching, brooding, mushroom growing, balneology	122	50
Papaya double dipping	120	49
Soil warming	104	40
Biodegradation, fermentation, deicing	86	30
Fish hatching, fanning	68	20

The following is: a summary of the key features of the program.

1) Objective: The Community Geothermal Technology Program will provide starter grants to individuals and small businesses which would like to make use of the Puna Geothermal Research Facility (PGRF). As necessary or requested, university faculty members will be assigned to assist grantees conduct research at PGRF. By providing financial sup port and guidance throughout the project, uses of geothermal energy perceived as important by the community would be encwraged.

2) Grant Awards: Grants will be awarded upon the review and approval of a written proposal by a review board consisting of representatives from the university, State Energy Division, 'peer' reviewers fran *the* Hilo/Puna communities who are familiar with the needs and desires of the businesses and residents of the area, and contributing sponsors. Grants shall not exceed $10,000, and may be awarded in any smaller amount.

3) Proposals: A request for proposal shall be publicized periodically. The review board shall provide guidelines keeping paperwork as simple as possible and limiting the length to a few pages. A format similar to the one employed by the USDOE in its Appropriate Energy Technology Small Grants Program would be used, requiring information on the qualifications of the proposer, a description of the work to be done, a detailed budget and schedule, a brief narrative on the importance of the project to the community, and other pertinent information.

4 Eligibility: Any individual, nonprofit organization, community group, small business, native Hawaiian organization, or fanner is eligible for the program. Preference will be given to those living or working in geothermal districts.

5) Coordination and Assistance: To ensure the quality of the work and facilitate the solution to any problems encountered by the grantee, who may be inexperienced at submitting proposals and performing work under a grant, a member of the University of Hawaii faculty could be asked to assist each grantee to provide guidance and technical assistance.

The groundwork has been established by the State Department of Planning and Economic Development and HNEI to formulate a CGTP effort to maximize community use of PGRF. The State Energy Division of DPED, HNEI, and the County of Hawaii have collectively committed $234,990, would like to secure another $75,000 from private companies, and has requested funds from the USDOE to accelerate the transference of information and technology to industry.

The program calls for individuals and small businesses in the community to submit grants to CGTP to use the brine and facility at HGP-A to examine uses of the fluid. As necessary or requested, UHM f?lty members will be assigned to assist t? award winners. Grants will be reviewed by the Geothermal Research Advisory Task Force and will not exceed $10,000. A request for proposal will be publicized and workshops providing assistance with proposal development will be held. A simple formatted proposal will be used, consisting of information on the qualification of the proposer, description of the work to be done, a detailed budget and schedule, and the importance of the project to the community.

Through these means, ideas important to local small businesses would be represented in the research program at PGRF. It is anticipated that the "seed" grants from CGTP would result in new or expanded business opportunities in the district, with a resultant increase in jobs. The potential for geothermal heat-related activities would encourage the efficient use of the region's substantial geothermal resources, as well as making further geothermal development more attractive.

Reinforcing the research priority list mentioned earlier, the Island of Hawaii business and agricultural community have also identified projects of importance. These include cold storage, ice making, and food processing. The Puna area is predominantly agricultural, with commercial fishing also of some importance, so projects in these fields excite the most community interest. However, the awards would not necessarily be limited to these subjects. It is hoped that CGTP will spawn a variety of proposals, including some in subjects which may have been overlooked by the established research community.

SUMMARY

A sum exceeding $30 million has thus far been expended to develop geothermal energy in Hawaii. Very little of this amount has gone towards applications.

One of the main purposes of PGRF is to develop means by which waste and nuisance can be converted into worth. A second objective is to involve the community help themselves build the kinds of industries they most desire. PGRF could be the model from which similar natural energy laboratories can be established for other technologies.

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