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NOI'I Θ PUNA - THE PUNA RESEARCH CENTER

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ABSTRACT

Construction for a high technology research facility has been completed on the grounds of HGP-A, the only operating geothermal well in Hawaii, making this site unique for gaining expertise about Hawaiian geothermal well fluids. The research facility includes a wet chemistry laboratory, additional laboratory space, and a supervisory office. *An* open area has been designated for geothermal research in which high pressure brine will be provided for various experiments.

Noi'i Θ Puna, The Puna Research Center (PRC), will enable vital research and development to be carried out in both geothermal electrical and non-electrical applications, such as dehydration of agriculture and aquacultural products and recovery of the special silica particles/gel from the fluid. The research program at PRC will build on the presently known results at various research institutions throughout the world, and began with a cooperative research workshop held on August 23, 1985, in Hilo, sponsored by the Hawaii Natural Energy Institute through U.S. Department of Energy funding. Primary problems at the HGP-A site such as silica removal and hydrogen sulfide abatement are being looked upon as resource material for innovative geothermal industries. While silica poses to be a potentially major problem because increased geothermal development around HGP-A will cause a need for re-injection, the work to be accomplished at PRC will hopefully not only cure or alleviate this concern, but generate revenues to support the R&D program.

INTRODUCTION

The Hawaii Geothermal Project (HGP) began in 1972 when the Hawaii 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 Figure 1), a drilling program was initiated in 1975 with funding from the Energy Research and Development Agency and State and County of Hawaii. Geothermal consultants from New Zealand were selected to provide drilling management and guidance during this period.

HGP-A well, named after the late Agatin T. Abbott, Professor of Geology at UHM, was completed to a depth of 1,966 meters in April 1976. A bottomhole temperature of approximately 358°C makes HGP-A one of the hottest geothermal wells in the world. Geophysicists have ,predicted that the available energy in the Kilauea East Rift Zone is in the order of about 50,000 megawatt-years [1].

During 1976 and 1977, several sets of flow tests were conducted to gather data on water source, solids content, and to make preliminary predictions of the reservoir's size, shape, and production capacity [1]. 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].

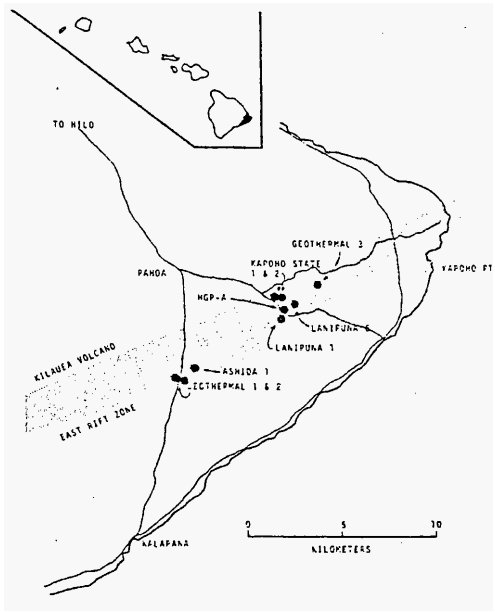

Figure 1. Map of Geothermal Locations

Construction was completed in June 1981, and after an initial shakedown period, the plant started to generate electricity in early 1982 [3,4]. Since then, the power plant has been on line 95 percent of the time generating approximately 2.8 megawatts 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, where the turbine showed very little wear and scale buildup. The actual maintenance work was finished in half the scheduled time. Geothermal energy, thus, is technically viable in Hawaii.

To bate, 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 the State, County of Hawaii, and HELCO [5].

With the success of the HGP-A geothermal power plant, several wells were drilled by private companies within a mile of the HGP-A site (see Figure 1). Even though relatively little data have been released by these companies, all indications point to the

availability of geothermal resources in these wells, at a suspected higher steam quality relative to the HGP-A well. The private companies are currently in the resource confirmation phase. HELCO, in January 1985, rejected three proposals to build a geothermal plant [6]. However, a utility-private sector partnership is anticipated to bring additional geothermal power on-line by 1990.

GEOTHERMAL APPLICATIONS PROGRAMS

The majority of the geothermal resources in the world are used for non-electric purposes. Most of these applications are in space heating/cooling, agriculture/aquaculture, and industrial processes. The leading consumer 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 many as 40 different sites in the United States. Space cooling has been successfully applied in New Zealand and at the Oregon Institute of Technology. Extensive agribusiness 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 [8]. 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 [9].

In addition, there is a great deal of heat wasted by using geothermal fluid only for power production. For example, at HGP-A, approximately 22,722 kilograms per hour of 187°C and 10.9 kilogram per square centimeter (kg/cm^2) geothermal water is disposed. This is about 17.9 million kilojoule 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 RESEARCH CENTER

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 2). The facility was dedicated as Noi'i O Puna - Puna Research Center (PRC) - on August 24, 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 (11.25 kg/cm^2) will be provided for various experiments. Low pressure steam and brine (1.05 kg/cm^2) from a small flash separator is expected to be installed in phase two of this project. This facility is a 12.2 meter by 15.2 meter pre-fabricated building. Electricity (120 volts and 240 volts), running water, lights, drainage, sanitation, compressed air, and telephone will also be provided.

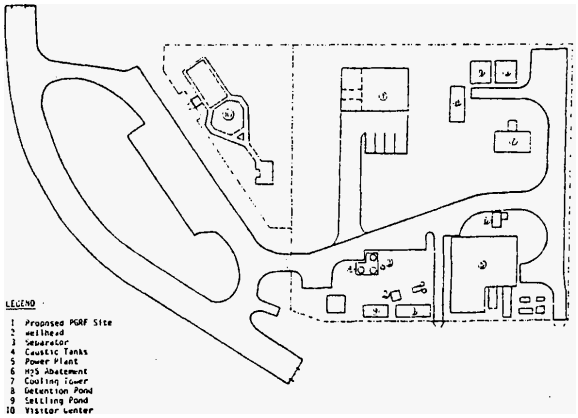

Figure 2. HGP-A Wellsite

Use of the facility will be directed by the Hawaii Natural Energy Institute (HNEI) in cooperation with the University of Hawaii at Hilo, with the support of the County of Hawaii, which has also appropriated $51,500 in cost-sharing funds, and the State Department of Planning and Economic Development (DPED), which will cost share capital improvement project monies as justified.

PRC will enable research and developnent 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 PRC will build on the presently known results at various research institutions throughout the world. A Geothermal Research Advisory Task Force has been formed, consisting of representatives from academia, the local utility company, government, private sector, and general comunity, 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) Hydrogen sulfide 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) Hydrogen production stimulation with geothermal heat
10) Geothermal brine re-injection

The general proximity of private wells from HGP-A make brine re-injection research a strong possibility with the wells that are non-producers. The area, located just a few miles from the coastline, is absent of freshwater wells at the lower elevations, therefore the concern for water table contamination is unnecessary.

The facility could initiate industrial park or small business development utilizing the potential electrical power and heat available from the geothermal fluid. Table 1 is a summary of the kinds of applications anticipated from the waste effluent alone. As this area is suffering economically through the recent closing of Puna Sugar Company, which cultivated 6070 hectares 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 [10,11,12].

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 problems 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 deadline Eor applications is October 31, 1985.

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 che 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 [13].

A cooperative research workshop, sponsored by HNEI with USDOE funding, was held in Hilo, Hawaii, on August 23, 1985, to discuss common problems with geothermal development and avenues for their solution. Scientists, technologists, and government officials throughout the world attended this event. The three main categories addressed were process chemistry design, reservoir testing, and agri-aquaculture applications.

The main advantages of PRC were:

1) Information is non-proprietary
2) Three-megawatt power plant operational
3) Research center installed
4) Research center is university operated
5) Geothermal wells potentially available for private developer
6) FREE program
7) Strong State, County, and utility support

Based on these factors, the following recommended projects were made in each category:

1) Process Chemistry Design
   - SiO_2 destabilization using transitional metals
   - H_2S removal
   - Fluid correlation between HGP-A and other geothermal wells
   - Minimal by-product extraction.

2) Reservoir Engineering
   - Drill a second well to conduct multi-flow and tracer tests along with standard geophysical, geological, geochemical, and other tests
   - Conduct interference testing with a new well
   - Conduct research and development of new high-temperature downhole equipment
   - Study aquifer source, age, etc.

3) Agri-aquaculture applications
   - Food processing experiments with papaya, guava, and other locally grown fruits, as well as cattle feed preparation
   - Refrigeration or ice-making to serve fishermen
   - Greenhouse operations
   - Dehydration of local crops such as papaya, banana, macadamia nuts, and coffee
   - Aquaculture applications with shrimp or fish.

COMMUNITY GEOTHERMAL TECHNOLGGY 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.

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 Research Center. As necessary or requested, university faculty members will be assigned to assist grantees conduct research at PRC. By providing financial support and guidance throughout the project, uses of geothermal energy perceived as important by the community would be encouraged.

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 from 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 farmer 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 PRC. Matching funds have been received from U.S. Department of Energy and the deadline for applications is early November 1985.

Through these means, ideas important to local small businesses would be represented in the researcn program at PRC. 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 geotherinal 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

Table 1. Potential Geothermal Applications at the Puna Geotnermal 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, farming	68	20

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 to help itself build the kinds of industries it most desires. PRC could be the model from which similar natural energy laboratories can be established for other technologies.

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