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.

THE PUNA GEOTHERMAL VENTURE PROJECT POWER FOR THE ISLAND OF HAWAII

By

Maurice A. Richard

ORMAT ENERGY SYSTEMS, INC.
Puna Geothermal Venture

ABSTRACT

Puna Geothermal Venture (PGV) was conceptually formed in 1980 and proceeded with local community, county and state cooperation to establish and develop a geothermal industry in Hawaii on the Big Island. The decade that followed, produced significant accomplishments in County and State rule making, Business Development and Exploration with commitments toward Geothermal Power Generation for Hawaii Electric Light Company (HELCO). Ormat acquired the PGV interest in 1988 and triggered a Fast Track Development Plan based on employing Ormat proprietary technology. Ormat Energy Converter played a significant role in meeting the most stringent environmental condition, to date, in the geothermal industry. The process and progress made is described in this paper.

INTRODUCTION

Puna Geothermal Venture was formed in 1981 by Thermal Power Company (Thermal), the operator, and Amfac and Dillingham as minority partners. In 1986, Thermal purchased Dillingham's interest. In 1988, Ormat Energy Systems, Inc. (Ormat), purchased both Amfac's and Thermal's 100% interest in Puna Geothermal Venture (PGV), which consisted of a strategic land position in the Kapoho section of the Kilauea East Rift Zone, three exploratory geothermal wells, an approved exploration permit, an approved Environmental Impact Statement, and a Public Utilities Commission approved Energy contract with Hawaiian Electric Light Company (HELCO), the Big Island utility. Following the acquisition closing, Ormat reviewed all of the environmental, engineering, and business information and modified elements of the project to meet Ormat's corporate management policy on environmental protection, reliability criteria, and in-house approved engineering specifications and extensive construction experience.

The objective of this paper is to review the merits of employing Ormat's technology to meet Hawaii's environmental constraints, while remaining economically competitive by providing HELCO with firm, reliable power. In addition, when comparing alternatives, "geothermal is compared to what" will be discussed.

PUNA GEOTHERMAL VENTURE PROJECT

The Facility is located approximately 21 miles southeast of the city of Hilo in the Puna District of the Island of Hawaii. The Facility will occupy about 25 acres of surface area within a dedicated 500-acre project area in the Kapoho section of the Kilauea Lower East Rift Geothermal Resource Subzone. This Subzone was established in 1984 (Act 151) under Chapter

205, Hawaii Revised Statutes, which mandates the designation of geothermal resource subzones for geothermal exploration and development.

The Facility is designed to generate 206,035 Mwh of electrical energy per year from geothermal fluids supplied from the Puna geothermal field. The Project will consist of the following:

- ten (10) integrated backpressure steam turbine and air-cooled binary cycle turbine power generating modules with air-cooled condensers;
- production wells capable of providing a geothermal flow rate of 500,000 lbs/hr and injection wells capable of reinjecting such geothermal fluids;
- brine and steam pipelines - steam gathering system - well casings and tubular goods;
- electrical substation and project switchyard;
- ancillary facilities such as office, warehouse, workshop and control buildings;
- access roads, landscaping and site development; and
- auxiliary system facilities and equipment such as air compressor, fire protection, pollution control equipment, etc.

The Project will deliver its electrical output to the grid interconnecting point at the switchyard, where the power will be purchased by HELCO to provide electricity to the Island of Hawaii.

The geothermal fluids to be utilized will have bottom hole temperatures in excess of 600°F and are located at depths generally greater than 4,000 feet beneath impermeable caprock. The geothermal fluids produced from the Puna geothermal field are expected to contain a mixture of approximately 80 percent steam and 20 percent liquid at a pressure of about 200 psig and a wellhead temperature of approximately 390°F. After extracting the heat from the geothermal fluids, the condensate, brine and non-condensible gases will be reinjected back into the reservoir. Figure 1 is an artist's rendition of the project. Figure 2 presents the power cycle proposed for the project.

PROCESS AND COMMITMENTS

Prior to Ormat's acquisition of the Puna Geothermal Venture Project, an Environmental Impact Statement (EIS) was submitted by Thermal Power on November 20, 1987 and accepted by the Planning Department on December 28, 1987. In addition, a Special Use Permit application was accepted by the Hawaii County Planning Commission on October 15, 1980. This permit, along with 12 special conditions, allowed the drilling of two wells on 4± acres of land for geothermal exploration and evaluation.

In September 1986, the Hawaii County Planning Commission adopted a Geothermal Resource Permit process known as Rule 12 which was incorporated into the County's Rules of Practice and Procedures. This rule, in fact, replaced the Special Use Permit for all geothermal projects in the County of Hawaii. By December 10, 1986, Thermal Power had submitted an application of the new geothermal resource permit.

The next two years following submittal reflected many changes to the partners of the Puna Geothermal Venture project. Soon after Ormat acquired the PGV project, substantive changes in the technology proposed for the project were made, and an amended application was filed with the County of Hawaii on December 31, 1988. Realizing that numerous clarifications were needed, the application was withdrawn and resubmitted on March 28, 1989. The first of four public hearings held by the Planning Commission on this permit application began on June 6, 1989 in Hilo.

After the first public hearing was closed, mediation was requested by 17 individuals in accordance with the newly adopted amendment to Rule 12. Under the new amendment adopted in February 1988, the provision for contested case

hearings was replaced by an approximately two month-long mediation process. An extended mediation session was held between July 5, 1989 and August 16, 1989.

Subsequent public hearings were conducted on August 8, 1989 in Kona; August 28, 1989 in Hilo; and lastly, on September 19, 1989 in Kona. Faced with a 180-day deadline as stipulated in Rule 12, the final public hearing took almost an entire day to complete but resulted in the granting of the second geothermal resource permit for Hawaii County. When issued on October 3, 1989, this permit had 51 special conditions attached. Soon after the granting of the geothermal resource permit, a motion to appeal was filed with the Planning Department. At the time of this writing, the appeal has been forwarded to the State Supreme Court for a decision.

The Department of Health Authority to Construct applications were submitted on March 28, 1989. Applications for both the wellfield and power plant were submitted at this time. Two informational hearings were held on June 14, 1989 in Kona and on the following day (June 15, 1989) in Hilo. Following a lengthy review period, the Department of Health determined a public hearing was appropriate. The first public hearing was held in Kona on November 7, 1989 to a very sparse audience. The public hearing in Hilo was conducted the following day with 30 oral testimonies presented. The majority of the testimonies concerned the lack of proper enforcement or monitoring procedures. These permits were issued on February 9, 1990 with 28 special conditions attached to the wellfield permit and 20 special conditions attached to the power plant permit.

In addition to these permits, Thermal Power filed the Puna Geothermal Venture's Plan of Operations with the Department of Land and Natural Resources (DLNR) on January 23, 1981. This plan, which encompassed work on two geothermal wells, was approved March 13, 1981. The first amendment to the Plan of Operations which added another well was submitted on December 19, 1984 and accepted on January 23, 1985. The second amendment was submitted on December 1, 1986 and approved on April 25, 1987 with 7 special conditions. With the change in ownership of PGV, a revised Plan was submitted to the Department on January 18, 1989. This revision reflected the technological changes of Ormat. The plan was approved by the Board of Land and Natural Resources (BLNR) on March 10, 1989.

The Underground Injection Control Permit was submitted to the Hawaii State Department of Health on June 26, 1989. This permit underwent a month-long review which ended on November 3, 1989. This permit received only a single letter of comment. Puna Geothermal Venture is currently awaiting a decision from the Department of Health.

ENVIRONMENTAL BENEFITS

The benefits to the Big Island of the Puna Geothermal Project are numerous. Geothermal energy will reduce the heavy reliance on and high costs of imported oil in this state. It can provide the State with the first steps to energy self-sufficiency. More importantly, the use of renewable geothermal energy will reduce the need to deplete and, possibly exhaust, the very limited quantities of oil resources throughout the world.

The impacts on the nearby residents during the drilling and construction of the facility have been of the highest concern to Ormat. As a result, many plans and procedures have been developed to mitigate possible resident discomforts. Air, water and noise monitoring programs have been developed to continuously monitor for any possible negative impacts. Stringent conditions were attached to the permits to help mitigate any adverse effects of this project.

Environmental considerations are a design concern for the Puna Geothermal Venture project. This includes the additional design work needed to produce the least amount of impact to the community. It is expected that the total cost of meeting the various permit conditions throughout the life of the project will be in excess of $5 million. However, Ormat and Puna

Geothermal Venture believe these costs associated with geothermal development will benefit not only the County and State of Hawaii by providing a means to energy self-sufficiency, but will also reduce the amount of air pollution and environmental degradation caused by the burning of fossil fuels.

GEOTHERMAL VERSUS ALTERNATIVE ENERGY SOURCES

As discussed above, the Puna Geothermal Venture Project will provide the Island of Hawaii with 25 MW of continuous, reliable electrical power. Based upon the current level of electrical consumption on the Island (120 MW peak daytime consumption and 50 MW minimum nighttime consumption), the PGV Project will provide nearly 20 percent of the Island's daytime peak energy needs and approximately 50 percent of the Island's nighttime energy requirements. Because the Island of Hawaii currently has only approximately 140 MW of installed peak electrical generation capacity, the current peak energy demands of approximately 120 MW result in very low reserve generation margins, and planned and unplanned outages of generation facilities have historically created frequently unacceptable disruptions in electrical service throughout the island. Although there are opportunities for reducing the peak electrical demand through energy conservation, as there are with any electric utility, even the most optimistic projections of available conservation opportunities do not foresee sufficient demand reduction in the immediate future (12 to 18 months) sufficient to eliminate the need for the electrical capacity and energy to be generated by the PGV Project.

The PGV Project is currently scheduled to commence the production of electrical energy during the first quarter of 1991. For various reasons, other alternative technologies for generating this needed electrical energy are simply not able to do so in the same time period. Conventional fossil-fuel technologies (coal, oil or gas) typically require longer planning, design and construction periods than do geothermal facilities, and no fossil-fueled facility of comparable size is currently being proposed for the Big Island, which would be available to generate the needed electrical energy by the first quarter of 1991. Similarly, there are no proposals for equivalent sized non-fossil energy technologies (such as solar thermal or photovoltaic power plants, wind energy facilities, or hydroelectric power plants) which could be designed, approved and constructed over the same time period. Thus, from the simple perspective of immediate need, the PGV Project is the only viable alternative for producing the energy urgently required by the Island of Hawaii.

Even if one or more other projects using alternative generation technologies were able to be completed in the time period of the PGV Project when the energy is needed, the PGV Project would be the environmentally preferred project. Because the PG Project will inject back into the geothermal reservoir all of the produced fluids and gases, the atmospheric emissions resulting from normal operation of the power plant and wellfield are reduced to essentially zero. If one assumes that the PGV Project will displace the equivalent amount of energy generated by a typical fossil-fuel facility, enormous reductions in the potential emissions of atmospheric pollutants are achieved. Figure 3 shows the annual quantity of pollutants displaced by the 25 MW PGV Project for carbon dioxide, sulfur dioxide and nitrous oxides over that from equivalently sized coal-, oil- and gas-fired units.

Based upon recent studies conducted for the California Energy Commission, the economic benefit for the reduction in emissions of sulfur dioxide and nitrous oxides of the PGV Project over an equivalent 25 MW oil-fired power plant are estimated at $1.4 to $14 million annually (Therkelson, 1989). In addition, annual emissions of approximately one-third of one trillion pounds of carbon dioxide would be avoided by construction and operation of the PGV Project over an equivalently sized oil-fired power plant, which is roughly equivalent to the amount of carbon dioxide fixed (consumed) by 2,300 acres of managed forest (San Martin, 1989). Because the PGV Project system is a closed cycle, normal operation of the project will also not result in the emission of particulate matter or those gases which lead to the production of acid rain or

stratospheric ozone depletion (Traeger, 1989).

Because the geothermal energy resource used by the PGV Project is an indigenous resource found on the Big Island, and the entire fuel extraction/energy conversion cycle will be completed at one site, there is no need for transporting the project's "fuel" any great distance. This differs markedly from any of the alternative fossil-fuel cycles, such as oil or coal, which have no deposits located within the island and must be imported by ship. This transportation cycle created the potential for accidents which could release these fuels into the ocean or onshore environments, resulting in significant environmental impacts.

Non-fossil alternatives, such as solar thermal, photovoltaic, wind or hydropower are also resources indigenous to the Island of Hawaii, through with more limited application because of their higher generation costs or lower availability factors. In addition, comparisons of environmental impact based on the total energy cycle demonstrate that geothermal projects such as the PGV Project, which inject all of the produced non-condensible gases and other geothermal fluids back into the geothermal reservoir, have lower emission rates for atmospheric pollutants per unit of produced electrical energy than the other non-fossil, renewable electrical generation technologies (San Martin, 1989).

Thus, in comparing the PGV Project and potential alternatives, the PGV Project, with its closed-cycle design and injection of all of the produced geothermal fluid and non-condensible gases, results in the more timely production of desperately needed, reliable electrical energy than the available alternatives, and at a modest to extremely significant level of reduction in potential environmental emissions.

CONCLUSIONS

Ormat has made a significant social contribution to the State of Hawaii and the Big Island of Hawaii. The contribution of Ormat's proprietary technology demonstrates the commitment to improve air quality, reduce fossil fuel dependency, reduce the need for strategic storage reserves, and reduce the potential for catastrophic oil spills. Ormat participated in an extensive mediation process where unprecedented costly commitments were agreed to by Ormat. These costs are not recoverable in present avoided costs or credit recompense formulas. Throughout Ormat's regulatory and business proceedings, management has been dedicated to the philosophy of cooperation and goodwill and continues to practice the good neighbor approach. The benefits of geothermal over other options is eminent and justified for the Big Island.

Acknowledgement

Dwight Carey with Environmental Managements Associates, Inc. and Christine Iha, Environmental Coordinator with Puna Geothermal Venture provided support documentation to make this paper complete.

References

Bronicki, L. *Testimony Submitted on Behalf of Ormat Energy Systems, Inc. to the U.S. Secretary of Energy, Chairman, National Energy Strategy Public Hearing*, Honolulu, Hawaii, January 1990.

California Energy Commission. *Valuing Emission Reductions for Electricity,* Report 90, November 1989.

DeAngelis, M. and Rashkin, S. *Social Benefits and Costs of Electricity Generation.*

Favinger, W., Graduate Fellow, University of Nevada, Reno. *Economic Impacts of the Nevada Geothermal Industry, published for the Nevada Department of Minerals,* 1989.

Goddard, W.B., Goddard, C.B. and McClain, C.W. *Future Air Quality Maintenance and Improvements through the Expanded Use of Geothermal Energy, Geothermal Resources Council, TRANSACTIONS, Vol. 13, December* 1989.

Patterson, R.A. and Associates. *Hawaii Provides Plenty of Challenges for Geothermal Developers,*

Geothermal Resources Council Bulletin, Vol. 18, No. 7 - July 1989.

Pietruezkievicz, J. and Richard, M. *Puna Geothermal Venture Project - Preliminary Plant Concept,* 1984.

Ram, Y. *East Mesa Geothermal Power Plants - Commercially Successful Large Scale Binary Applications,* May 1988.

Ram, Y. and Krieger, Z. *Innovative Geothermal Power Plants - The Solution to Geothermal Resource Constraints - The Ormat Way,* Geothermal Resources Council, TRANSACTIONS, Vol. 13, October 1989.

Richard, M., Carey, D., and Russell, S. *Environmental Mediation and the Development of the Puna Geothermal Venture Project: Hawaii Tries a New Regulatory Process to Unlock a Decade of Confrontation,* Geothermal Resources Council, TRANSACTIONS, Vol. 13, October 1989.

San Martin, Robert L. *Environmental Emissions from Energy Technology Systems: The Total Fuel Cycle,* U.S. Department of Energy, Washington, DC, 1989.

Traeger, R. *The Role of Geothermal Energy in Minimizing Global Environmental Problems,* Proceedings of the 1989 Department of Energy Geothermal Program Review VII.