

FINAL REPORT

PAHOA GEOTHERMAL INDUSTRIAL PARK

ENGINEERING AND ECONOMIC ANALYSIS

FOR

DIRECT APPLICATIONS OF GEOTHERMAL ENERGY

IN AN

INDUSTRIAL PARK AT PAHOA, HAWAII

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A Dillingham Company
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ABSTRACT

This engineering and economic study evaluated the potential for developing a geothermal industrial park in the Puna District near Pahoa on the Island of Hawaii. Direct heat industrial applications were analyzed from a marketing, engineering, economic, environmental, and sociological standpoint to determine the most viable industries for the park.

An extensive literature search produced 31 existing processes currently using geothermal heat. An additional list was compiled indicating industrial processes that require heat that could be provided by geothermal energy. From this information, 17 possible processes were selected for consideration. Careful scrutiny and analysis of these 17 processes revealed three that justified detailed economic workups.

The three processes chosen for detailed analysis were: an ethanol plant using bagasse and wood as feedstock; a cattle feed mill using sugar cane leaf trash as feedstock; and a papaya processing facility providing both fresh and processed fruit. In addition, a research facility to assess and develop other processes was treated as a concept.

Consideration was given to the impediments to development, the engineering process requirements and the governmental support for each process. The study describes the geothermal well site chosen, the pipe line to transmit the hydrothermal fluid, and the infrastructure required for the industrial park. A conceptual development plan for the ethanol plant, the feedmill and the papaya processing facility was prepared.

The study concluded that a direct heat industrial park in Pahoa, Hawaii, involves considerable risks. If a developer wishes to proceed, he should be assured of the viability of tenant processes. No processes were discovered which would obviously benefit by moving immediately to a geothermal industrial park near Pahoa.

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FOREWORD

Hawaiian Dredging and Construction Company, a Dillingham Company, completed this study in late 1980. The study was to examine the feasibility of an industrial park in Pahoehoe, Hawaii, utilizing the geothermal heat believed to be available in that area. The work was performed under a contract for the U.S. Department of Energy, Geothermal Energy Division, and was directed by Ms. Hilary Sullivan, Program Coordinator. Significant cost sharing in the study was contributed by Hawaiian Dredging and Construction Company, the County of Hawaii, Amfac, Inc. and GeoProducts, Inc.

The study was under the direction of Mr. Jim Moreau, Principal Investigator. He was assisted by the following staff: Ms. Jennifer Harris, Mr. Dien Truong, Mr. Russell Luke, Ms. Janice Kuwahara and Ms. Heather Garlutzo. The principal subcontractors were:

- ° Planning & Community: County of Hawaii; Mr. A. Nakaji, Mr. D. Black
- ° Agriculture: University of Hawaii, College of Tropical Agriculture; Dr. R. Stanley, Dr. J. Brewbaker, Mr. J. Maloney.
- ° Geothermal Engineering: W. A. Hirai & Associates; Mr. W. Hirai, Mr. Curt Beck
- ° Ethanol Production: GeoProducts, Inc.; Mr. K. Boren
- ° Animal Feedmill: Darrow Sawyer, Inc.; Mr. H. Sawyer
- ° Papaya Processing: University of Hawaii, Hilo; Dr. R. King
- ° Engineering Analysis: University of Hawaii, Hilo; Dr. W. Chen
- ° Ethanol Engineering: Parsons Hawaii; Mr. W. Siegrist
- ° Sugar & Papaya: Puna Sugar Company; Mr. J. Humme
- ° Direct Heat Applications: Oregon Institute of Technology; Dr. P. J. Lienau, Geoheat Utilization Center

As well as assisting in the study, appendices were prepared by the following:

- ° Resource: Hawaii Institute of Geophysics; Dr. C. Helsley
- ° Legal: Carlsmith, Carlsmith, Wichman & Case;
Mr. S. Okura
- ° Social Impact: University of Hawaii, Department of Sociology;
Dr. P. Canan
- ° Labor & Economic Impact: Puna Hui Ohana; Mr. E. Kinney
- ° Environmental: Ecotrophics; Dr. S. Siegel
- ° Financial: Bank of Montreal; Mr. K. McNerney
Merrill Lynch; Mr. W. Laskey

An Advisory and Review Board representing a cross section of Hawaiian industry and community leadership concerned with the appropriate development of the Kilauea east rift geothermal resource was briefed twice during the study.

Finally, Mr. Lloyd Jones, Manager of the Hawaiian Dredging & Construction Company Advanced Projects Department, provided study participants guidance, counseling, insights and continuing support throughout the study period.

EXECUTIVE SUMMARY

Introduction

The increasing high cost of imported oil has created a favorable economic and political climate for geothermal development in Hawaii. Today, "energy self-sufficiency" is a major concern of Hawaii State and County governments and the business community.

The long term benefit of geothermal development as part of that energy self-sufficiency plan for Hawaii can be substantial. Geothermal electric power generation appears to be assured for at least the first 25 Mw of electric power. However, direct heat applications enjoy no similar assurance of success.

This study addresses the potential for success of the conceptual use of geothermal heat in an industrial park near Pahoa, Hawaii.

MARKET IDENTIFICATION

A literature search of geothermal direct heat applications resulted in 31 processes. Separately and together, selected team members submitted their assessment for each process. Selection criteria dictated that potential processes:

- Be heat intensive.
- Relate to Hawaiian raw materials or low-cost imports.
- Be technologically proven.
- Be free from any known limiting barriers.
- Have a potential market.

The principle conclusions reached from these assessments were:

- No one process stood out as an assured success

- There would be problems associated with all developments
- It is difficult to penetrate complex Hawaiian markets
- Transportation to and from Pahoa is a critical factor
- Transfer of mainland technology to Hawaiian application must be done carefully.

Through repeated review with increasingly stringent criteria for inclusion in the industrial park, the list was narrowed to eight potentially promising industries. In addition, a research facility was conceived for the park with the intent to test and prove additional processes.

The eight potential processes selected for an initial economic viability analysis were:

- Aquaculture oriented to the production of tilapia (freshwater fish)
- Cement bonded wallboard
- Ethanol plant using a cellulose feedstock
- Cattle feedmill using sugar cane trash and/or bagasse
- Freeze drying of Kona coffee
- Koa lumber processing using a geothermal heated kiln
- Papaya processing
- Protein recovery plant
- Geothermal applications research laboratory (concept only)

SITE DEVELOPMENT

For the purpose of this study, a site located about 1 mile southwest of Pahoa in the Puna District on the Island of Hawaii was used. (See Figure 1.1.)

However, the actual implementation of the industrial park concept developed in this study may be equally feasible on other sites near the geothermal field.

GEOHERMAL RESOURCE

The primary geothermal resource in the State of Hawaii is found in the Kilauea Volcano east rift zone that trends in a north easterly direction two miles south of Pahoa. The surface geological expressions suggest that geothermal resources are likely to be found more or less continuously through this zone. Thus, a proposed drilling site 2-1/2 miles south of the industrial park site has a good probability of success. The dry hole risk of drilling at the proposed well site is 3 in 10; the probability of attaining adequate resource for the industrial park is estimated at 70%.

Two geothermal resource development scenarios were originally developed to provide heat for the industrial park:

1. Development of geothermal wells as a primary energy source for a 25 MWe power plant, with the residual steam being used by the industrial park. The cost for hydrothermal fluid transmission and the cost for the well development would be apportioned between the electric application and the direct heat applications.
2. Development of geothermal wells and transmission facilities dedicated to the industrial park and thus independent of direct electric power generation.

Under either scenario, the hydrothermal fluid would be converted to steam at the wellhead and transported 2-1/2 miles to the 800 acre industrial site located at the edge of the rift zone. Geothermal brine would be re-injected at the well site.

Initially, a price of \$2.67/MBTU was calculated for geothermal steam based upon three producing wells assuming 1000 BTU is obtained per pound of steam. This price is comparable to fossil fuel steam costs at \$7.46/MBTU.

As the study progressed and the specific industrial processes and their associated geothermal requirements were known, the geothermal steam price was recomputed to \$5.934/MBTU if only one industry operates.

INITIAL TEST FOR ECONOMIC VIABILITY

An initial economic viability test assessed the differential costs of locating each of the eight potential industries in the industrial park at Pahoa versus the industry's current location. Freight, logistics, energy and distribution costs were found to be the primary variables.

ENGINEERING AND ECONOMIC ANALYSIS

Three industries appeared to be economically viable when located at the park after this initial analysis. These were the ethanol plant, the cattle feed mill and the papaya processing plant. Each industry was then subjected to detailed engineering and economic analyses.

BARRIERS AND CONCERNS

Potential barriers to and concerns about developing a geothermal industrial park at Pahoa, Hawaii were evaluated.

These issues involved the major social, environmental and legal matters impacting on the proposed conceptual park development. Permitting procedures were addressed.

FINAL CONCEPT

From the foregoing, a most feasible concept for the park was developed. This is:

1. The anchor industry would be a commercial ethanol plant designed to produce 20,000 gpd of fuel-grade ethanol and other energy

products. Initial feedstock would be bagasse and wood from ohia forests and wastes from lumber operations. In the future, eucalyptus and leucaena trees would be considered for nearby energy tree farms to serve as feedstock.

2. A cattle feedmill would produce a roughage component for cattle feed using sugar cane leaves (trash) which would be combined with a binder and then cubed and dehydrated. The primary market for this product would be in Japan.
3. A papaya processing facility would include a refrigeration cooled warehouse for fresh fruit, a puree production line, and a vacuum dehydration process for making papaya snacks. Papaya is currently the mainstay industry in the lower Puna District, and such a plant could offer an opportunity for cooperative ownership by the local Hawaiian farmers.
4. A research facility to test the feasibility of other direct heat applications and develop additional promising processes including small scale low temperature applications would also be considered.

FINANCING PLANS

At such time a developer and/or investor becomes interested in commercialization of geothermal energy based on the final park concept, lending institutions actively involved in geothermal development will develop financing plans and sponsor a credit facility to finance 75% of the estimated project costs based on the Federal Government's geothermal loan guarantee program.

CONCLUSIONS

The establishment of an industrial park utilizing geothermal heat is possible but involves considerable risk. This industrial park concept requires a developer willing and capable of assuming those risks. Such a developer should be fully satisfied that the anchor industry and the other proposed park industries are technically and economically viable with assured markets. In this study no processes were discovered which would either significantly benefit by relocation or would be guaranteed reasonable success if initiated as a new industry.