HGP-A WELLHEAD GENERATOR FEASIBILITY PROJECT

INTRODUCTION

For decades the United States has been relying heavily on coal, oil, and gas which are becoming scarce and more costly. In addition, the use of these fossil fuels has produced undesirable environmental effects that have proved difficult and expensive to control.

It is very fortunate that the United States has an alternate energy resource available—that of geothermal energy. Although geothermal energy is already contributing to U.S. energy supplies at various locations, its development must be accelerated if it is to assist in any significant fashion in meeting the urgent and mounting energy needs.

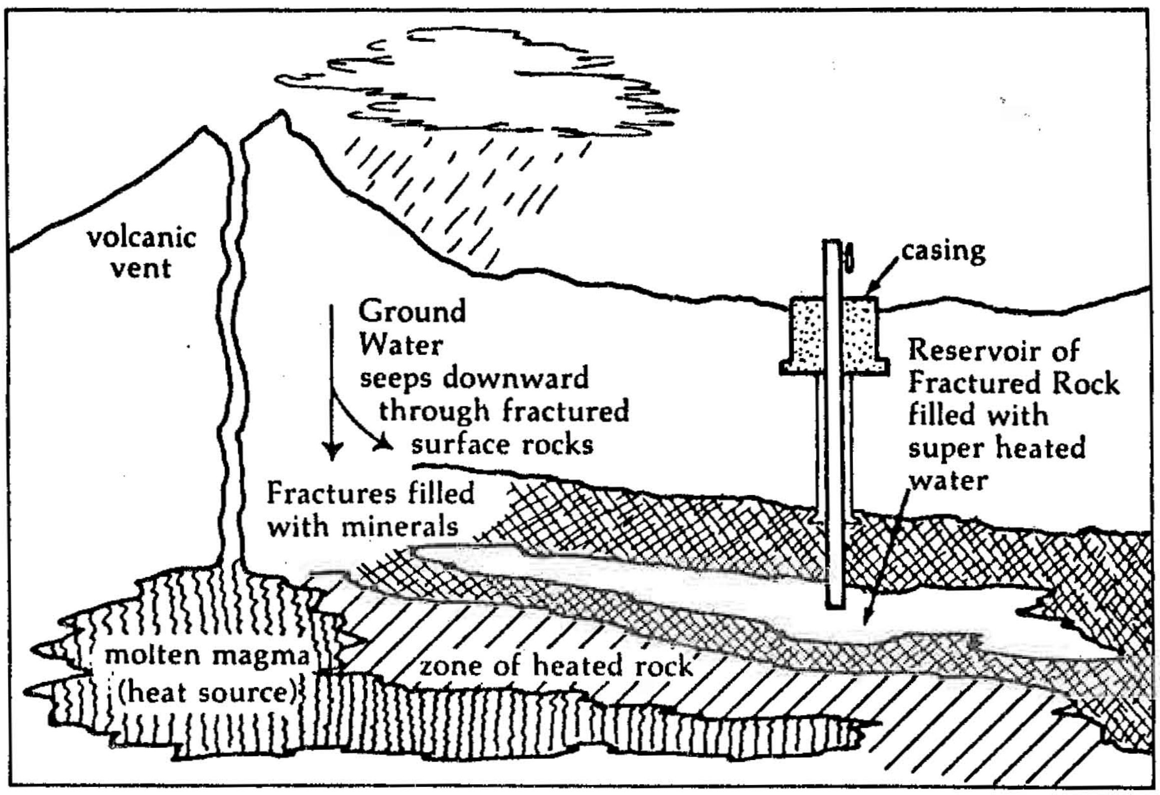
WHAT IS GEOTHERMAL ENERGY?

The energy from the earth's interior is evident most dramatically by volcanic eruptions. The sight of hot molten rock pouring from the earth, and the sensation of its intense heat, brings a realization of the fantastic quantity of energy that is below the earth's surface.

Geothermal energy is produced when ground water penetrates the earth's crust through fractures and faults and is heated by the molten rock—called magma—to temperatures far above its normal boiling point. This water will not boil or vaporize while under the pressure of thousands of pounds of earth above. When this reservoir is tapped by drilling a well, the pressure is released and the water spontaneously boils, or "flashes," into steam which may then be used to generate electricity.

HAWAII'S GEOTHERMAL EXPLORATION

Drilling for geothermal energy in Hawaii started in the early 1960's on the Big Island. The first four wells were drilled in the Puna District to relatively shallow depths and were unsuccessful in locating a producing geothermal resource. The fifth well was drilled in 1973 near Halemaumau Crater to a depth of 4,140 feet where a temperature of 279°F (137°C) was reached. This well



had a high rate of temperature increase with depth near the bottom which suggested much higher temperatures at greater depths.

In the early 1970's the University of Hawaii organized the Hawaii Geothermal Project to pursue the exploration. With Federal, State, county and private assistance, a well sited near Kapoho in Puna was drilled to a depth of 6,450 feet. This well, named HGP-A, had a bottom hole temperature of 676 degrees F. (358 degrees C.) making it one of the hottest geothermal wells in the world.

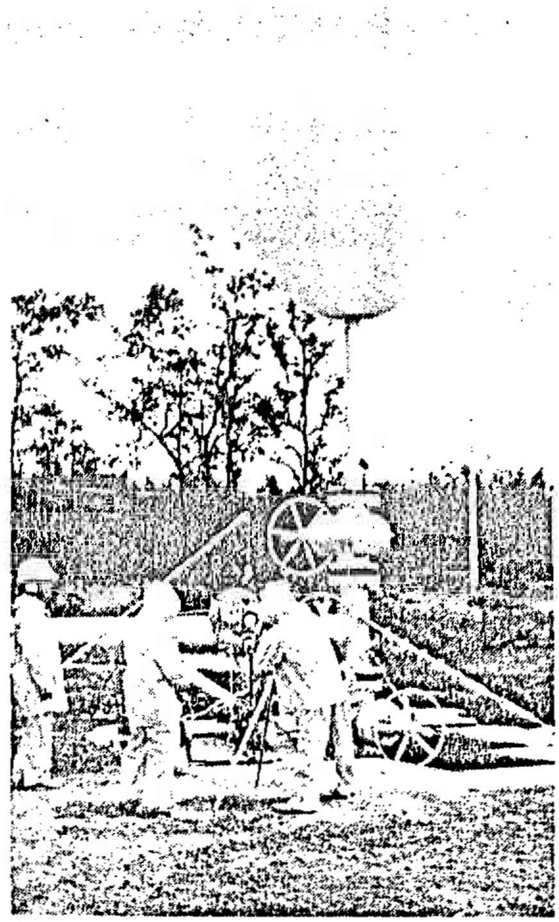
WELLHEAD GENERATOR DEMONSTRATION PROJECT

In order to obtain additional information on the characteristics and extent of the geothermal resource and to demonstrate the feasibility of geothermal energy utilization, the HGP-A Development Group was formed to promote and manage the Wellhead Generator Project. This group, represented by the State of Hawaii (Department of Planning and Economic Development), County of Hawaii, and the University of Hawaii (Hawaii Geothermal Project) obtained over 90% of the funding for this project from the U.S. Department of Energy with the remaining funds coming from the State of Hawaii, County of Hawaii and the Hawaii Electric Light Company (HELCO), a subsidiary of the Hawaiian Electric Co. (HECO).

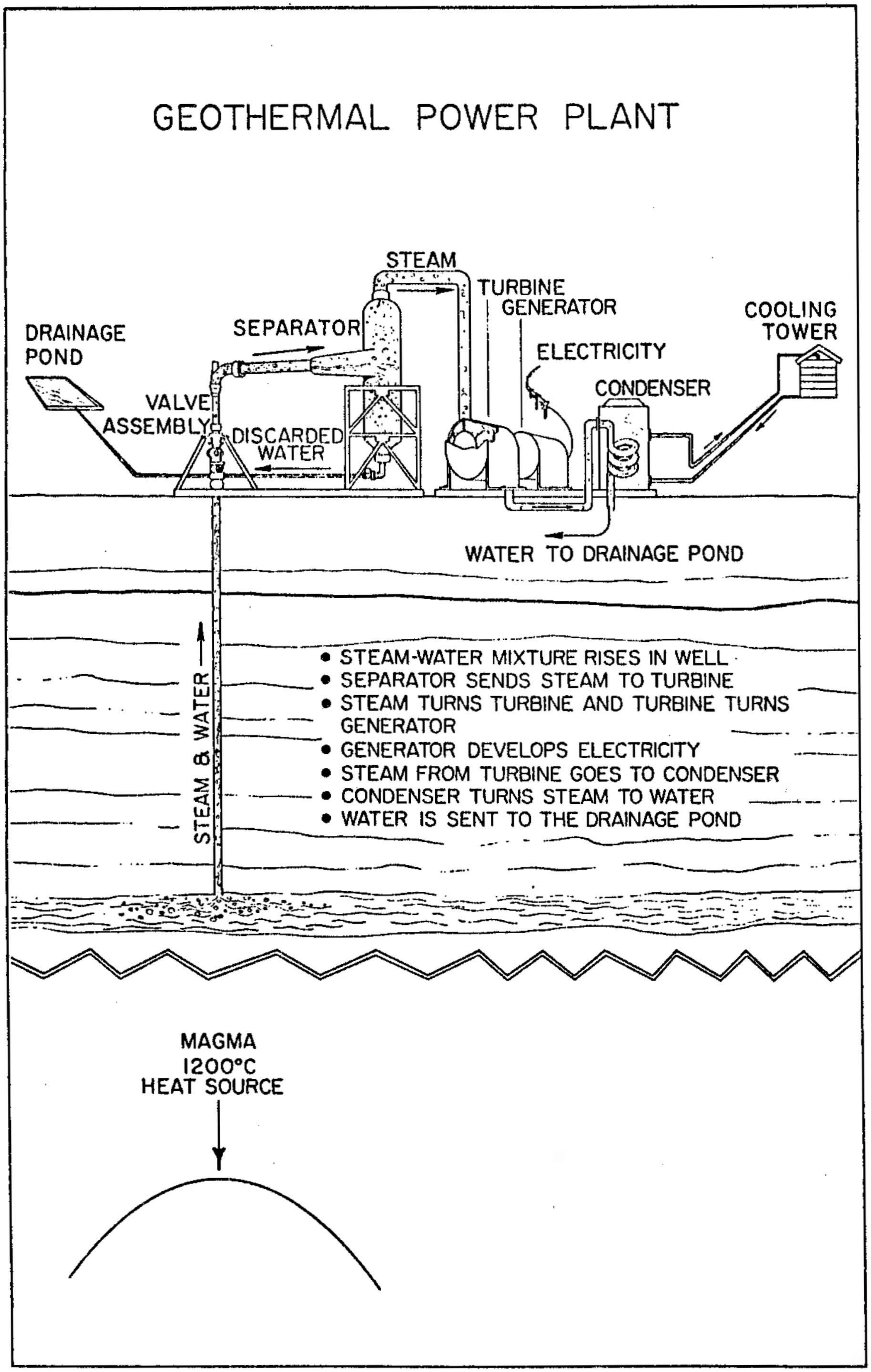
The Research Corporation of the University of Hawaii (RCUH) is managing the design, construction, operation, and maintenance of the geothermal power plant on behalf of the HGP-A Development Group.

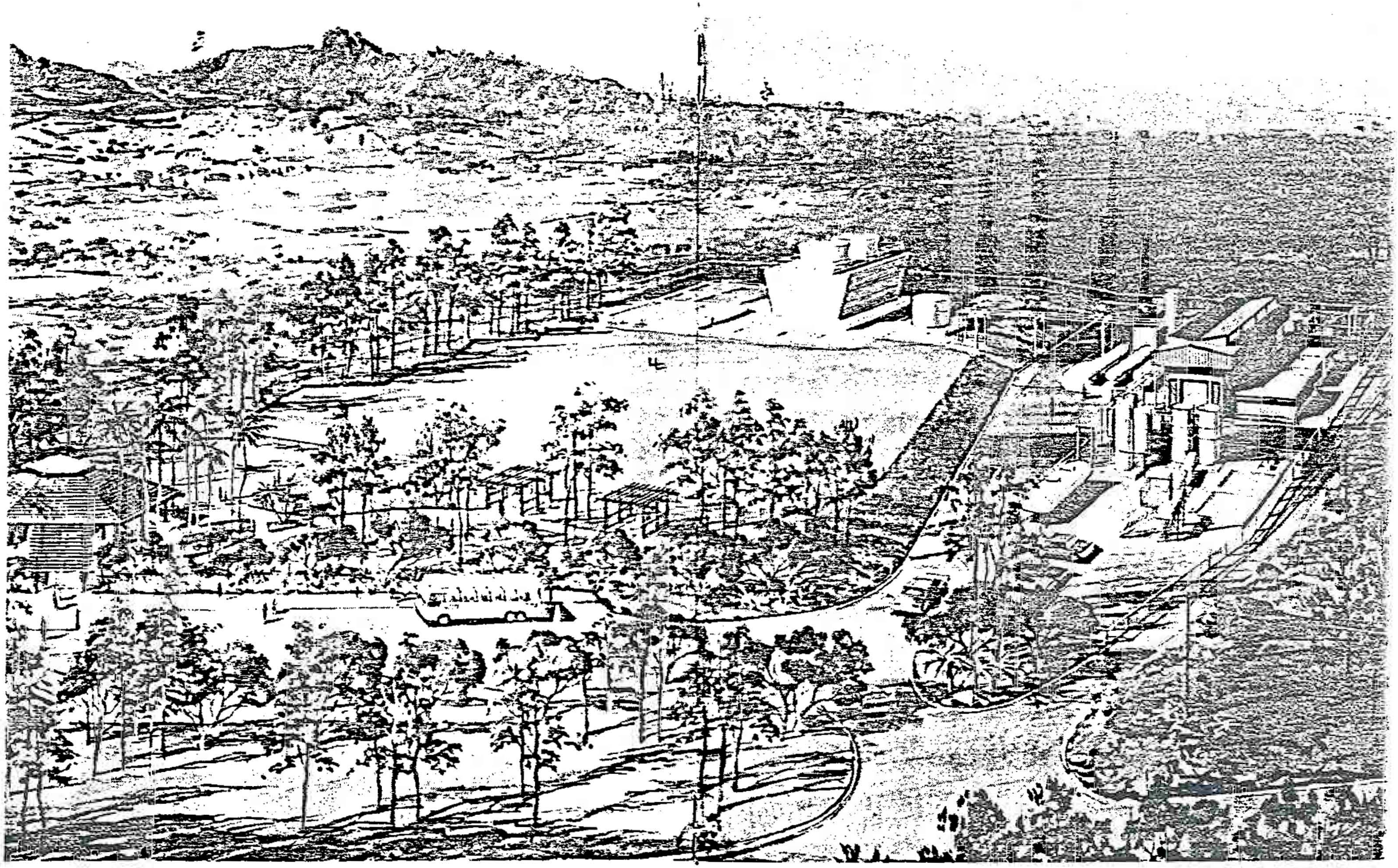
Rogers Engineering Company, Inc. of San Francisco was selected to design the geothermal power plant and to provide construction management services with W.A. Hirai & Associates, Inc. of Hilo as their subcontractor.

The power plant will produce 3 megawatts of electrical power. The main power plant equipment and flow cycle is depicted on the next page. On the following two pages is an artist's concept of the power plant arrangement including the Visitor's Center.



First flashing of HGP-A, July 1976
Photo by John Shupe


GEOTHERMAL POWER PLANT
STEAM
TURBINE
GENERATOR
COOLING TOWER
DRAINAGE POND
SEPARATOR
ELECTRICITY
CONDENSER
VALVE ASSEMBLY
DISCARDED WATER
WATER TO DRAINAGE POND
STEAM & WATER
• STEAM-WATER MIXTURE RISES IN WELL
• SEPARATOR SENDS STEAM TO TURBINE
• STEAM TURNS TURBINE AND TURBINE TURNS GENERATOR
• GENERATOR DEVELOPS ELECTRICITY
• STEAM FROM TURBINE GOES TO CONDENSER
• CONDENSER TURNS STEAM TO WATER
• WATER IS SENT TO THE DRAINAGE POND
MAGMA
1200°C
HEAT SOURCE



HGP-A WELLHEAD GENERATOR
PROOF-OF-FEASIBILITY PROJECT

_SEARCH CORPORATION OF THE UNIVERSITY OF HAWAII
ROGERS ENGINEERING CO. INC. ENGINEERS • ARCHITECTS SAN FRANCISCO

SPONSORS:
U.S. DEPARTMENT OF ENERGY
STATE OF HAWAII
COUNTY OF HAWAII
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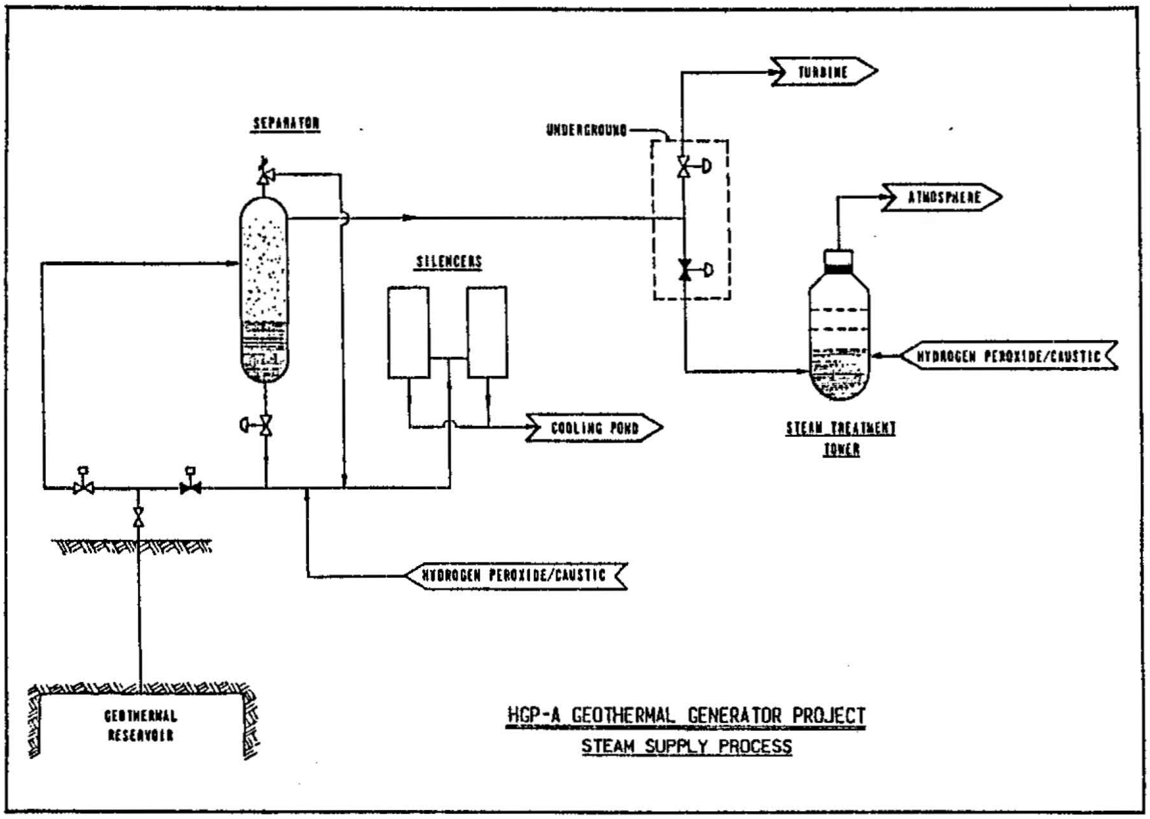
HAWAII ELECTRIC LIGHT CO.



HGP-A GEOTHERMAL GENERATOR PROJECT
STEAM SUPPLY PROCESS

DESIGN CONSIDERATIONS

Risk of Volcanic Eruption

Because there is a risk of volcanic eruption occuring near or at the site, the plant is designed so that specific pieces of equipment will be easily removable and transportable to avoid lava flows. The wellhead assembly is also designed so that it can be protected from lava flows.

Environmental

Every effort has been made to provide the necessary environmental controls to limit air, water and noise pollution. Furthermore, the architectural treatment and landscaping characteristics will be compatible with the natural surroundings of the site. Of particular concern is the rotten eggs odor of hydrogen sulfide gas which is typically present in geothermal fluids.

In order to insure the effectiveness of the environmental controls, a comprehensive monitoring program will be carried out by Environmental Analysis Laboratories of Richmond, California.

Plant Operation

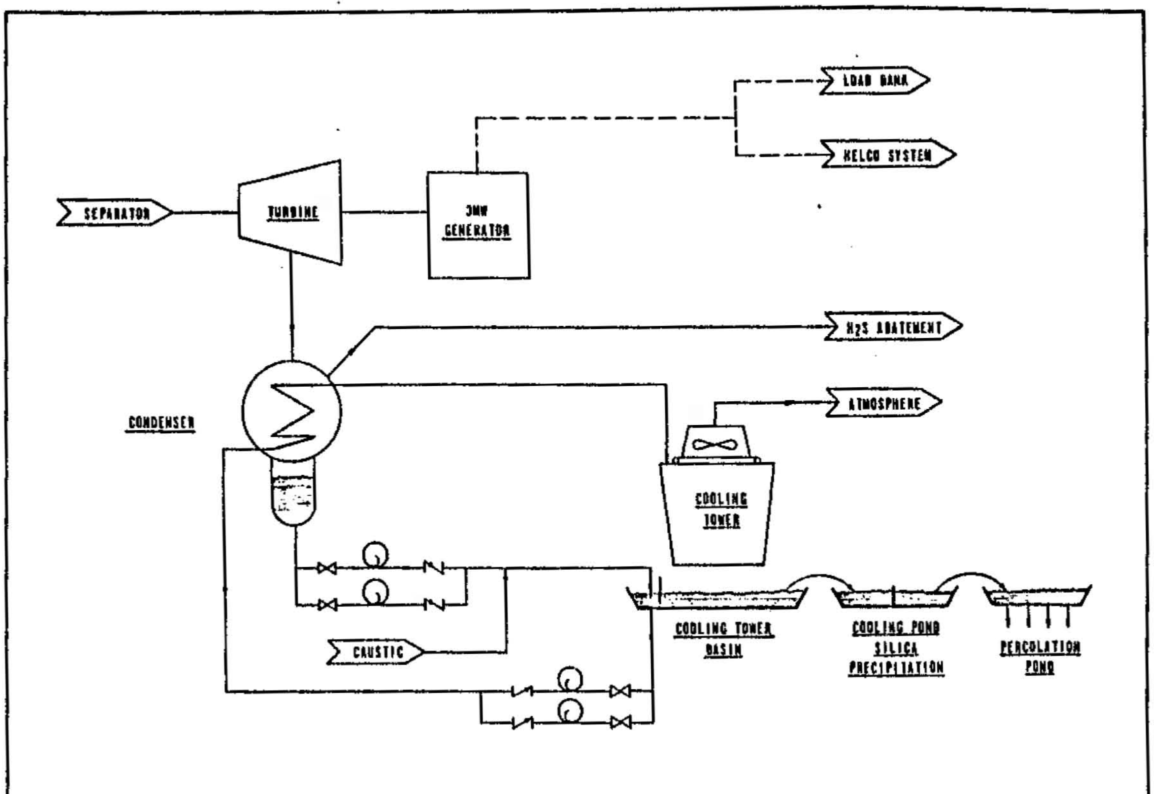
The power plant is designed to operate remotely from HELCO's control room in Hilo. HELCO will provide personnel at the plant one shift per day for routine operation and maintenance of the plant. The electrical output of the generator—2.8 megawatts—will be fed into the HELCO distribution and provide electricity for the residents throughout the Puna District. HELCO will pay for the power and the revenue will be more than adequate to offset operating and maintenance costs.

DESCRIPTION OF THE SYSTEMS

Steam Supply System

This system consists of the wellhead, the steam flash separator to separate the steam and water phases and another in-line separator to remove the last bit of liquid that is contained in the steam due to condensation formed by heat loss through the piping.

Steam is supplied to the power plant at 52,800 lbs/hr at 371°F and 160 psia. This steam will drive a turbine-generator which will produce 3 megawatts of electrical power. The plant will



HGP-A GEOTHERMAL GENERATOR PROJECT

OUTPUT AND HEAT REJECTION

use about 0.2 megawatts of the generated electricity for its auxiliary equipment. The remaining 2.8 megawatts will then be transmitted into HELCO's electrical system.

A caustic soda/hydrogen peroxide treatment system is provided to abate the hydrogen sulfide odor during startup and shutdown operations.

Condenser

The steam is exhausted from the turbine into a condenser. A vacuum is created in the condenser when the steam condenses to liquid.

During this process the noncondensable gases are separated from the liquid in the condenser and then removed by a two stage ejector system. The gases flow to an incineration system where the hydrogen sulfide gas is treated.

Cooling Water System

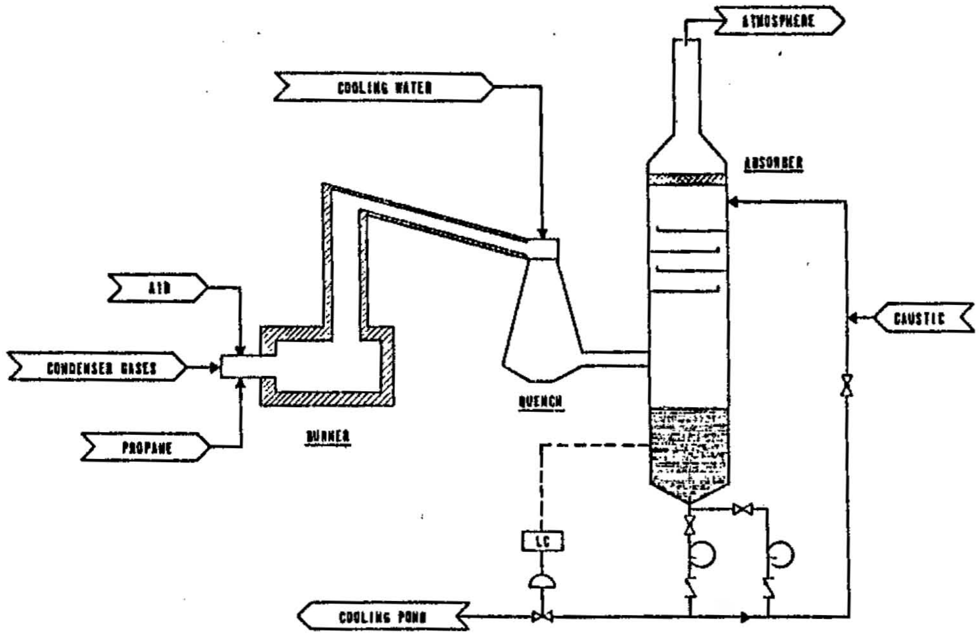
The cooling water that is used to condense the steam in the condenser is from the geothermal fluids.

The water absorbs the heat from the steam and is sent to a cooling tower where this heat is dissipated into the atmosphere by evaporative cooling. This cooling process occurs when the warm water that is sprayed down the tower is contacted by cool air flowing through the water.

About 100 gals/min of the cooling water is lost by the evaporation cooling process. The water that is lost is replenished by the condensate formed by the geothermal steam. The excess condensate water is combined with the liquid phase of the well fluid from the separator and then percolated into the ground after silica is removed.

Hydrogen Sulfide Abatement

The H_2S and other non-condensable gases extracted from the main condenser by a two stage ejector system are burned in an incinerator. The result of this burning process forms sulfur dioxide gas which is quenched and absorbed by water before the flue gases are vented to the atmosphere.



HGP-A GEOTHERMAL GENERATOR PROJECT

H_2S ABATEMENT PROCESS

FUTURE OF GEOTHERMAL DEVELOPMENT

1. The Hawaii Geothermal Project of the University of Hawaii is continuing their effort to determine the characteristics and boundaries of the Kapoho Geothermal Reservoir. Geoscientists have estimated that this reservoir may have the capacity of 500,000 kw for 100 years. Since this vast potential is located on an active volcanic rift zone, methods of minimizing or eliminating the hazards are being explored.
2. Other potential geothermal areas on the Big Island include regions near South Point and Mt. Hualalai. Haleakala on Maui has great potential. Furthermore, hot water sources have been found on West Maui, Molokai, and at Lualualei and Waimanalo on Oahu.
3. Geothermal energy could be used for energy intensive industries as the processing of manganese nodules, aluminum, copper, and producing hydrogen by the hydrolysis of water.
4. Other uses of geothermal energy include health spas, agriculture and aquaculture, sugar processing and papaya processing.

SUMMARY

Geothermal energy has been shown to be among the most economical and one of the least polluting of all fuels for producing electricity. If commercialized it would greatly improve the State's balance of trade by reducing the outflow of over $600 million for imported fuel oil annually.

At this time geothermal energy shows exciting promise as a feasible alternative to fossil fuels and nuclear energy. The next few years of operation of the HGP-A Generator will be important in demonstrating the extent of the resource and its practical applications.