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HAWAII'S GEOTHERMAL DEVELOPMENT

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INTRODUCTION

On July 2, 1976, an event took place in the desolate area of Puna, on the island of Hawaii, which showed great promise of reducing Hawaii's dependency on fuel oil. This great event was the flashing of Hawaii's first geothermal well which was named HGP-A.

The discovery of geothermal energy was a blessing to Hawaii since the electric utilities are dependent upon fuel oil for its own electric generating units. Over 50% of their revenues pay for imported fuel oil. Last year (1979) about $167.1 million left the state to pay for this precious oil.

The HGP-A well was drilled to a depth of 6,450 feet and the temperature at the bottom of the hole was measured at 676°F, making it one of the hottest wells in the world.

HGP-A WELLHEAD GENERATOR PROJECT

In order to determine the feasibility of generating electricity with a small geothermal power plant in a rift zone and to obtain additional information on the characteristics of the resource, a consortium called the HGP-A Development Group was formed. The members of this group consist of the following:

1. State of Hawaii, Department of Planning and Economic Development.
2. County of Hawaii
3. University of Hawaii, Hawaii Geothermal Project.

Hawaiian Electric Company, Inc. (HECO) and its subsidiary, the Hawaii Electric Light Company, Inc. (HELCO), serve as advisors to this group. HELCO will be contracted to operate and maintain the power plant facilities including the well. Also, HELCO will purchase the electricity generated from the station.

The Development Group was successful in obtaining over 90% of the funding for this project from the U. S. Department of Energy. The balance of the funding will be provided from the State and County of Hawaii and HELCO. The Development Group contracted the Research Corporation of the University of Hawaii to manage the project.

PROJECT SCOPE

The scope of the project is to design and construct a 3 mw geothermal power plant with full environmental controls. The plant is to be operated and maintained for approximately 14 months. The electrical energy generated will be connected to the HELCO grid system for purchase by HELCO.

HGP-A WELLHEAD GENERATOR
PROOF-OF-FEASIBILITY PROJECT

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

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

In addition, a Visitor Information Center will be constructed at the plant site to educate the public on geothermal energy. The public will also be able to view the geothermal power plant from a vantage point at the Visitors Center.

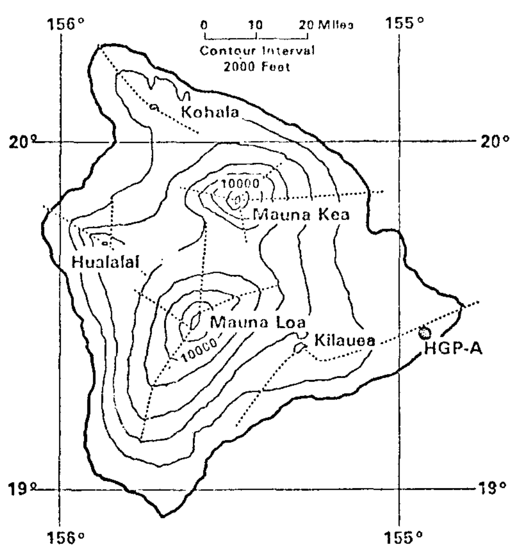
DESIGN CONSIDERATIONS

The major design consideration of this project are the risk of volcanic eruption, the environmental impact, and the remote operation of the plant.

1. Risk of Volcanic Eruption

   HGP-A is located on the eastern end of the east rift zone on the island of Hawaii. Because there is a risk of volcanic eruption occurring near or at the site, the plant is designed so that specific pieces of equipment could be easily removed and transported to a safe area to avoid lava flows. The wellhead assembly is also designed so that it can be protected from lava flows by covering it with an insulating layer of cinders when the need arises.

Locations of HGP-A, Volcanoes and Rift Zones on the Island of Hawaii



2. Environmental

   Every effort has been made to provide the necessary environmental controls to limit air, water and noise pollution. Of particular concern is the rotten egg 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 an independent company.

   Furthermore, the architectural treatment and landscaping characteristics will be compatible with the natural surroundings of the site. The area along Pohoiki Road will be landscaped with trees and shrubs to provide a buffer-screen of the plant facilities from the road and would maintain the natural character of the environment in that area. The buildings will be painted so that they will also blend with the area.

3. 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 electric system grid and provide electricity for the residents throughout the Puna District. Since HELCO can only accept 2 mw during low load periods, load banks are being provided to consume the excess generation that the system cannot accept. HELCO will pay for the power fed into its system and the revenue will be more than adequate to offset the operating and maintenance costs.

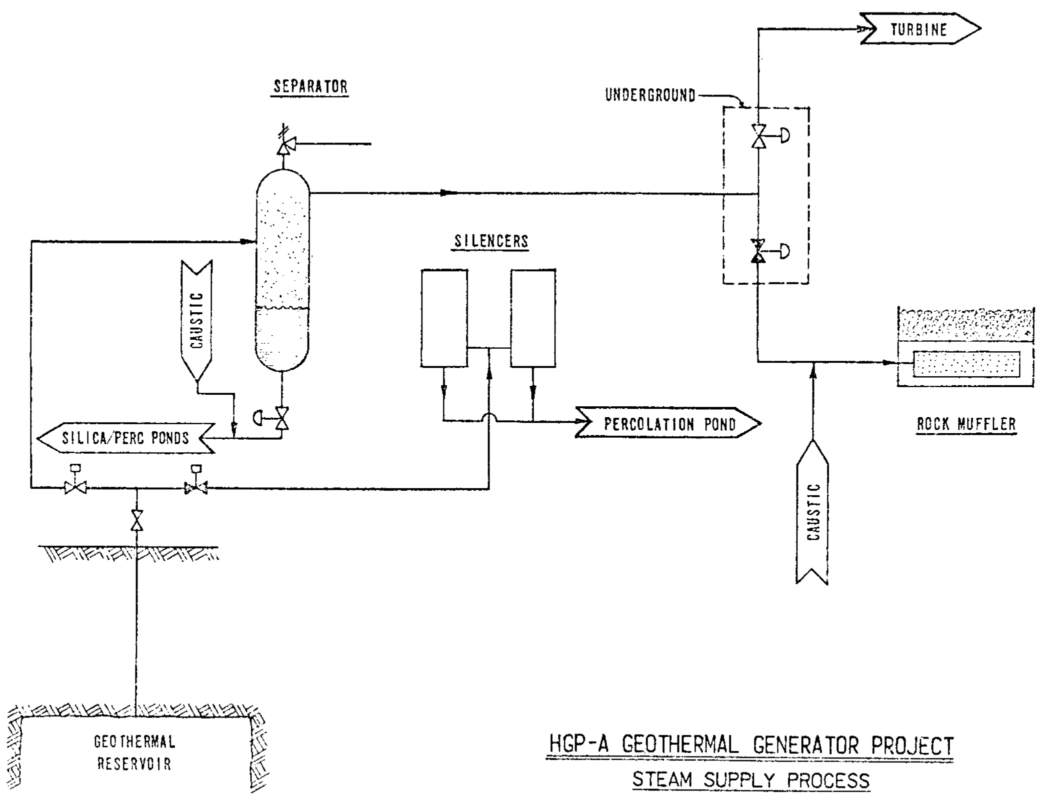
DESCRIPTION OF THE SYSTEM

Steam flows from the well into a steam flash separator where the steam and water phases are separated. The steam then enters the turbine-generator at 52,800 lbs/hr at 371^{o}F and 160 psia to produce 3,000 kilowatts of electrical power. The plant will use about 200 kilowatts for its auxiliary equipment and the remaining 2,800 kilowatts will be transmitted into HELCO's electrical system.

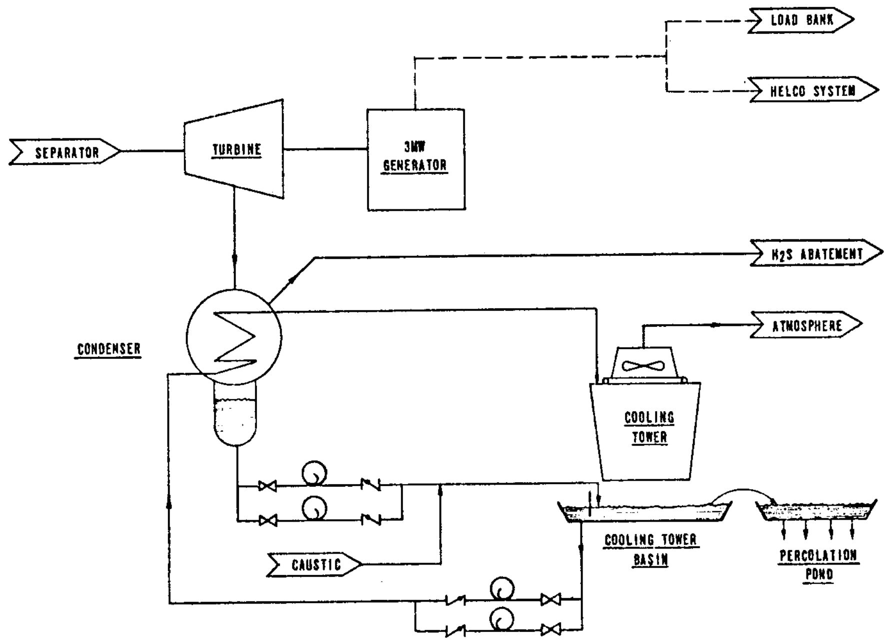
The steam that flows through the turbine is condensed to obtain maximum useful energy from the steam. The condensate formed is used as make-up water for the cooling water system. This make-up water is important since about 100 gals/min of cooling water is lost by the evaporative cooling process in the cooling tower. The excess condensate will be disposed by percolating it back into the ground. Before this can be done, however, silica is precipicated out of the water by allowing it to cool in a retention pond which is designed for a residence time of about an hour.

The hydrogen sulfide and other non-condensable gases are extracted from the main condenser by a two-stage ejector system and burned in an incinerator. The result of this burning process forms sulfur dioxide gas--another pollutant. The flue gas is therefore piped to an absorber column where the sulfur dioxide is removed by absorption in a diluted caustic soda solution before the flue gases are vented to the atmosphere.

The net generation is 2.8 mw since 0.2 mw is required for the plant auxiliaries. Regulation for lower loads will be accomplished by using the load bank which has a capacity of 1.6 mw and the steam dump valve. Therefore, the turbine-generator could be operated continuously in the event of a transmission line failure. In this event, the generator would be cut back to 1.8 mw (0.2 mw for the auxiliaries and 1.6 mw to the load

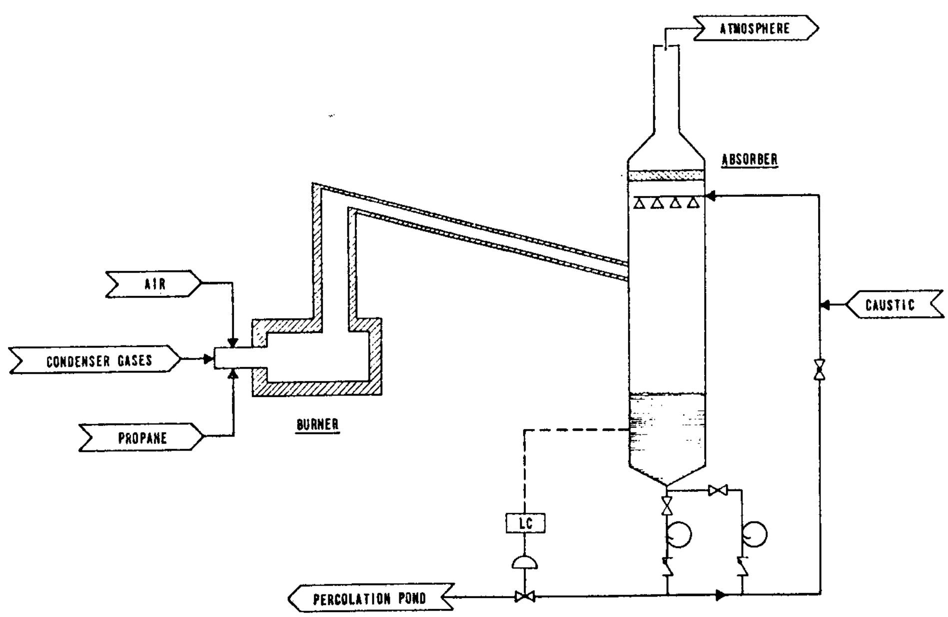


HGP-A GEOTHERMAL GENERATOR PROJECT
STEAM SUPPLY PROCESS



HGP-A GEOTHERMAL GENERATOR PROJECT

OUTPUT AND HEAT REJECTION



HGP-A GEOTHERMAL GENERATOR PROJECT

H_2S ABATEMENT PROCESS

bank) and 1.2 mw equivalent steam flow would be dumped.

Upon turbine trip, 100% of the steam flow will be dumped through the emergency dump valve and the steam treated for H_2S and silenced.

Since this plant is being supplied by only one well, steam flow from the well is not regulated. Flow from the well is maintained at a continuous rate. It is not desirable to shut off the well since it takes about a month to bring the well up to normal operating condition after it is shut off. Therefore, unless major work is required the well will be allowed to flow.

REPAIR OF HGP-A WELL

This project had its first major problem this past summer. A rapid increase of static wellhead pressure with a corresponding increase in the temperature profile of the well indicated that the integrity of the cement bond on the well casing had deteriorated. This suspicion proved to be true after cement bond logs were taken.

The original 9-5/8" casing was installed from a depth of approximately 2,200 feet to the surface. The casing was repaired by first perforating holes in the casing and squeezing cement through these holes to attempt filling the voids on the outside of the casing. Since only 80% bond was achieved by this method, a new string of 7-inch casing was installed and cemented-in solid from the 3,000 foot depth to the surface. This process required cutting and removing 800 feet of the existing 7-inch slotted liner from 2,200 foot to the 3,000 foot depth. This improved the integrity of the cement bond and prevented the intrusion of an undesireable zone of lower temperature fluids from entering the well.

WELL FLOW TEST

A well test was conducted in January 1980 to confirm the well flow characteristics. This test was required before committing the power plant condensing and gas removal equipment. The repairing of the well added to the necessity of conducting the well flow test.

Since a commitment was made to the residents of the adjoining subdivision that noise and the smell of H_2S would be abated during operation of the well, these abatement processes were also tested during this period.

The noise from the discharged steam was abated by the use of a rock muffler. The rock muffler is a concrete box with a plenum chamber at the bottom in which the steam enters through a perforated pipe. The steam velocity is reduced and dispersed through a five-foot bed of 1"-1½" crushed rock. The rock muffler proved so effective that the noise level at the road fronting the well site, about 100 feet away, was only 44 DBA.

The H_2S odor was controlled by injecting caustic and hydrogen peroxide into static in-line mixers made of steel baffles installed in the discharge pipe. The caustic reacts with the H_2S to form sodium sulfide and water, thus removing the smell of the rotten egg odor of this gas. The hydrogen peroxide oxidizes the sodium sulfide to a sulfate to prevent it from reverting back to H_2S.

The total amount of H_2S from the well was found to be about 806 ppm. Of this amount, 790 ppm was present in the steam line downstream of the steam separator. The remaining 16 ppm was found in the liquid line from the separator.

About 97% overall abatement was achieved with this process. An injection rate of 3.2 moles of caustic solution per mole of H_2S was found to be effective, reducing the H_2S level in the discharged steam from the rock muffler to less than 10 ppm. The liquid drained from the rock muffler was the black sulfides with a PH in excess of 11.

The rock muffler also contributed to the effectiveness of the H_2S abatement process since the rock surfaces provided an extremely large wetted surface contact area for the H_2S and caustic. Also, it served as an effective coalescence which prevented the caustic mist from discharging in the steam plume.

Since the caustic treatment proved to be effective by itself, the additional treatment of hydrogen peroxide was not necessary and will not be used in the emergency abatement process. The liquid from the rock muffler drains into a percolation pond giving little opportunity for it to be acidified and reverting back to H_2S.

The well test confirmed the steam flow rate and condition to adequately produce 3 mw of electricity at the design conditions. Preliminary results of the well test for non-condensable gases and dissolved solids are as follows:

Total Non-condensable Gas in Steam	-	1940 ppm
H_2S in Steam	-	790 ppm
H_2S in Brine	-	16 ppm
Total Dissolved Solids in Brine	-	5000-6000 ppm
Silica in Brine	-	840 ppm

SCHEDULE

Construction of the plant facility is in progress. The mechanical, electrical, and instrumentation work will be out for bids in mid-June 1980. The plant is scheduled to start-up on March 31, 1981.

FUTURE OF GEOTHERMAL DEVELOPMENT IN HAWAII

Several geothermal development groups have shown interest in developing geothermal energy in Hawaii. HELCO is preparing a Request for Proposal (RFP) in order to solicit their proposals and to fairly evaluate their financial standings and their technical knowledge and experience in the geothermal field.

Presently, HELCO is only interested in purchasing the electricity that is generated from geothermal power plants. However, HELCO wants the option to purchase the plant at a later date after the resource is proven.

Two major problems that face the geothermal developer are the volcanic hazards in the Puna District and the market for geothermal energy.

The east rift zone in Puna, Hawaii is subject to the highest risks from volcanic hazards in the State. Several eruptions have occurred along the east rift zone in recent years, the most recent being the Pahuahi crater which erupted in November 1979. Wells, piping and power plants installed on the lower slope of the east rift zone must be carefully located and protected from the volcanic hazards. These hazards include volcanic eruptions, lava flows, earthquakes, subsidence, and surface ruptures.

The electrical demand on the island of Hawaii is small. The system peak for 1980 is projected to be 88.4 mw. The average load growth is 3.5% per year. Therefore, any additional capacity would probably be in small increments. Large capacity units would necessitate HELCO to cycle or even shut down their steam units since their loads could drop to about 30 mw during low load periods.

The price for the energy should be economically attractive to HELCO as compared to power purchased from the sugar plantations and to the price of fuel oil and its availability.

Development of geothermal energy in the islands could be accelerated if a submarine cable could be laid from the island of Hawaii to Oahu where the largest load center is located. This cable, however, would have to be capable of being installed on the ocean floor in the 6,000 to 7,000 foot deep channel between the islands of Hawaii and Maui.

CONCLUSION

HECO and its subsidiaries are dependent upon fuel oil for its own electric generating units. Geothermal energy offers the best alternative to fuel oil since it is among the most economical and least polluting of all fuels. Being a natural resource, it could improve the State's balance of trade by reducing the outflow of millions of dollars annually for imported oil.

Developers of geothermal energy must prove the reliability of the resource, provide protection from the volcanic hazards, and be economically competitive with the conventional oil-fired units before geothermal energy could make a large contribution in the generation of electricity in Hawaii.

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