# THE FINANCING OF A DEMONSTRATION GEOTHERMAL PROJECT

Gerald O. Lesperance
Alternate Energy Specialist

Department of Planning and Economic Development
335 Merchant Street, Room 110
Honolulu, Hawaii 96813

## ABSTRACT

The State of Hawaii started a geothermal exploration program, focused in the Kilauea East Rift Zone of the Island, in the late 1960's. The urgent demand for alternate energy created by the global petroleum disruptions of the 1970's encouraged Federal agency energy agencies to join the Hawaii team to drill, on the first attempt, a successful deep well, and construct a 3-megawatt wellhead generator. The costs were high, especially for the generator, but this timely demonstration of a viable geothermal resource has encouraged private developers.

The 3,218 kilometer Hawaiian Island chain developed in a southeasterly direction with the Island of Hawaii, at the southeast end of the archipelago, is the youngest and most volcanically active island. Because of its volcanic origin, no indigenous fossil fuel reserves exist in the chain. The dislocations that occurred in the global oil market in the 1970's were particularly critical for Hawaii which, even today, are dependent on imported petroleum for over 90% of its energy. Over $1 billion leaves the State annually for petroleum. If Hawaii could develop more of its abundant natural energy resources, considerable more money could stay at home working for its people.

Hawaii had begun to take a serious look at its alternate energy options in the late 1960's and early 1970's. Four shallow geothermal exploratory wells had been drilled in the Puna region of the Kilauea East Rift Zone in the 1960's. This exploration indicated that, if any geothermal reservoirs existed, they were at considerably greater depths and could be exploited only at great cost. In 1971, the University of Hawaii's Center for Engineering Research completed a report of new energy sources that had been requested by the Legislature. There was general concensus that geothermal offered the most promising, near term baseload indigenous alternate energy resource.

In 1972, the same Center for Engineering Research submitted an ambitious $2.7 million research proposal, called Project Pele, to the National Science Foundation (NSF). The multidisciplinary proposal included: a geophysical program consisting of surface studies, a series of shallow wells and one deep well; an engineering program of reservoir engineering and conceptual power plant design; and an environmental/ socioeconomic program. The Hawaii State Legislature and the County government of the Island of Hawaii each granted the project $100,000 contingent upon its receiving NSF matching funds. However, the project was not immediately funded by NSF.

Instead, in mid 1972, NSF awarded a smaller geothermal research grant of about $400,000 to George Keller, a professor of geophysics at the Colorado School of Mines, for a 1,067 meter exploratory well in the Hawaii Volcano National Park near the Kilauea Caldera.

By late 1972, the proposal to NSF had been restructured because it was decided that the project would have a better chance of being funded if it included R&D that led directly to the conversion of geothermal energy into electricity. Renamed the Hawaii Geothermal Project (HGP), it requested $5 million over a two-year period to: perform short-range exploratory and applied technology research leading to drill sites; drilling one deep hole that would hopefully tap a reservoir; and well testing and design of a 10 megawatt prototype geothermal plant. In 1973 and 1974, NSF provided $469,000 which with $100,000 from the State and from the County, permitted a constructive start into

the initial phases of the HGP, particularly relating to geophysical surveys.

In early 1974, the National Liaison Board (NLB) recommended that HGP proceed rapidly with an experimental drilling program at either Pahoa or Opihikao in the Kilauea Lower East Rift Zone. The NLB was composed of geologists, geophyics, and engineers from the U.S. Mainland. Experts on geothermal power development, they monitored and advised HGP on its progress and direction. Key agencies such as the NSF and the U.S. Geological survey were represented on the NLB.

Another HGP advisory group, the Hawaii Advisory Committee (HAC), encouraged the organization of a drilling program. The HAC was composed of leaders from Hawaii's business, political, and community sectors that were influential in formulating Hawaii's energy policy. Their support was critical for the successful development of geothermal energy. Within a few months the Hawaii State Legislature had appropriated $500,000 contingent upon Federal matching funds for a single-deep well.

A $2 million proposal including $1.2 million for a drilling program was submitted to NSF in July 1974.

The U.S. Energy Research and Development Administration (ERDA), predecessor to the U.S. Department of Energy, was briefed on the proposal in February 1975. In late April 1975, ERDA informed John Shupe, the Executive Director of HGP, that the project would receive over $1 million for the period May 1975 - April 1976. With the $500,000 from the State and $45,000 from the Hawaiian Electric Company, the project amounted to a total of over $1.6 million.

Although there was no unanimous agreement, the site selection committee selected the Pahoa area for drilling based on the geological evidence.

The drilling consultant was the New Zealand firm of Kingston, Reynolds, Thomas and Alardice (KRTA). Only one drilling bid was received, from Water Resources International, the Hawaii-based company that had previously drilled Hawaii's only deep geothermal well. The actual drilling commenced December 10, 1976 and was completed on April 27, 1975 at the target depth of 1,951 meters. Since the drilling mud at 1,829 meters was about 63°C, and heating up as time passed, it was certain that the well was hot. Various tests through May 9, 1977 indicated that the well output had stabilized and extrapolations indicated that the well could generate 3 megawatts of electricity over a 30-year period. Tests revealed that the downhole temperature approached 350°C, one of the highest temperatures ever recorded in a geothermal well.

As with most research projects, the drilling and well testing programs ran into delays and problems that increased costs. ERDA was called upon several times during the project for additional financial assistance. ERDA and its successor, the U.S. Department of Energy, provided a total of sightly more than $2 million during the exploratory drilling and well testing phases. The State of Hawaii provided another $66,000 to its initial $600,000. Water Resources International donated $60,000 of its time to finish the well to 1,951 meters. The total cost of the project from 1973 through 1978 amounted to $3,387,000.

Although the cost was high, it funded numerous activities ranging from geophysical surveys to socioeconomic assessments. The project was intended to provide basic research and development that would lead to the commercialization of the geothermal resources in Hawaii. It was not intended to be an exploration for geothermal resources or to be an eventual profit-making venture. The project did discover a productive geothermal well and a potentially large geothermal reservoir. Estimates of the reservoir generating capacity ranged up to 500 megawatts of electricity for a century. The well was designated HGP-A ... Hawaii Geothermal Project - Abbott. Professor Agatin T. Abbott was the initial drilling program coordinator. It was through his tenacity that the Pahoa area was selected over the Opihihao site in early 1975. He died before the drilling actually started.

As the attention of key HGP personnel turned to the potential of a demonstration geothermal power plant at HGP-A, it was recognized that ERDA's financial participation was essential. ERDA was understandably reluctant, having already made concentrated support to Hawaii's geothermal program.

In 1977, a consortium called the HGP-A Development Group (HGP-A/DG) and consisting of the State of Hawaii's Department of Planning and Economic Development, the University of Hawaii's College of Engineering, and the County of Hawaii, was formed for the purpose of planning and implementing a coordinated program of geothermal research and development, with its first objective being the design, construction and operation of a small demonstration plant powered by the HGP-A well. Because of legal constraints, neither the Hawaii Electric Light Company (HELCO) on the Island of Hawaii nor its parent organization, the Hawaiian Electric Company (HECO) of Honolulu, became full partners of

the HGP-A/DG. The formally stated purposes of the project were:

a. To prove the technical feasibility of baseload power production with a small geothermal electric generator system.

b. To collect data to be used in the comparison of small electric generating systems using other conversion technology.

c. To obtain data on the economics of using a small geothermal electric generator system.

d. To obtain data on the existing geothermal well to further the development of geothermal resources.

Preliminary negotiations between the HGP-A/DG and the U.S. Department of Energy were completed on June 9, 1978, with the signing of a four-year, over $6 million contract to install and operate a three-megawatt wellhead generator. The State of Hawaii provided an initial $400,000, the County of Hawaii $100,000 and HECO $25,000. The consultant in this project, Rogers Engineering, Inc., of San Francisco assisted by Hirai and Associates of Hilo, Hawaii, performed the engineering design and construction management. The "front end" equipment, including the wellhead valves, liquid/vapor separator, and the steam bypass to the rock muffler was built during late 1979; the site work, involving grading, equipment foundations, and the turbine generator building were constructed in 1980; the final phase of work including the installation of all the electrical, mechanical and instrumentation equipment, piping and wiring, was essentially completed in May 1981. The well was opened on June 12, 1981 and initial power was generated on July 18, 1981. We understood that Hawaii became the second State in the United States (California was first) to have an operating geothermal plant. These events did not take place without significant difficulties including the failure of the turbine. The U.S. DOE by this time had provided $2.1 million more than its original commitment, the State of Hawaii $1.2 million more, and the private sector $30,000 more. The total cost exceeded $10 million. An additional million dollar advance was provided by HELCO to cover shakedown costs and to make the plant fully operationable. It was clearly understood that the HGP-A/DG would pay off the debt with net income from the plant operation.

In late August 1981, the well was shut-in for about three months while the turbine was reworked. In December 1981 the plant was brought back on line. However, another delay of three months developed when rebalancing of the generator was required by the manufacturer because of deficiencies noted in other generators of this type at other locations. In March 1982, HELCO put the plant on commercial operation producing 2.4 megawatts net, and assumed responsibility for the day to day operation and maintenance of the plant.

The cost of the completed project exceeded original estimates by about 25%. High construction cost was the biggest contributing factor to the overrun but equipment ran 15% over estimate as did the unit cost for engineering services.

Between March 1982 and March 1985, the State of Hawaii provided additional funds toward the plant: $300,000 in March 1982 for modifications and improvements; $80,000 in July 1982 to install a hood and stack system for the muffler; $150,000 in 1983 to modify the brine system and perform an overhaul including replacement of the turbine bearings; and $400,000 in two installments in 1984 to expedite liquidation of the debt acquired by the Development Group to HELCO for plant start up costs. That original debt of about $1 million in May 1982 increased to $1.2 million in September 1982. It never did fall appreciably below $1 million until December 1983. Monthly interest was pegged to prevailing interest rates which exceeded 15% in early 1982.

About the same time that the State applied appropriated funds toward the debt, the monthly revenues in excess of plant operating costs became consistently favorable. On February 1, 1985 the debt was down to $234,000 with a good potential of being liquidated by year-end.

Table A shows some of the key plant operating cost, revenue and production data for 1983 and 1984.

TABLE A
HGP-A OPERATING DATA

| | 1984 | | 1983 | |
|---|---|---|---|---|
| | $000 | % | $000 | % |
| Operating Labor and Overhead | 194 | 21 | 184 | 18 |
| Maintenance (excl. overhauls and abatement) | 118 | 13 | 115 | 11 |
| Abatement Chemicals | 299 | 32 | 298 | 30 |
| Other Abatement | 100 | 10 | 32 | 3 |
| Environmental Monitoring | 125 | 13 | 131 | 13 |
| Security | 40 | 4 | 46 | 5 |
| Overhauls | 45 | 5 | 139 | 14 |
| Miscellaneous | 17 | 2 | 56 | 6 |
| TOTAL | 981 | 100% | 1,001 | 100% |
| Debt Servicing | 44 | | 74 | |
| Net MWH Produced | 20,661 | | 19,328 | |
| Revenues ($000) | 1,260 | | 1,041 | |

In early 1984, the Development Group recognized that the original goals for establishing a wellhead generator plant at HGP-A had been realized. An inquiry revealed several local private comapnies were interested in pursuing negotiations leading toward transfer of the plant to the private sector. However, there were some serious constraints. There were a number of strict licensing and permitting requirements that had been waived, deferred, or reduced because the plant was a government-owned demonstration facility. As a privately-owned "commercial" facility the regulatory requirements would necessarily have to be enforced.

In mid-1984, State funds that were identified for economic development on the Island of Hawaii were made available to design and construct a "Puna Geothermal Research Facility" at HGP-A for research, development, and demonstration especially in direct (non-electric) geothermal applications. Completion of the research facility scheduled in 1985 suggests that government-ownership of the HGP-A generator plant would better ensure a platform for continuing RD&D.

1985 marks a real crossroads for the HGP-A Development Group. Goals are being re-evaluated. Strategies are being defined. Major improvements and deferred maintenance are needed if the plant is to be operated a "few more years." It would be highly desirable to continue to demonstrate for potential geothermal developers that geothermal energy in Hawaii is viable.

## SUMMARY AND CONCLUSIONS

The volcanic origin of Hawaii has forced the State to import fossil fuel for its energy needs. Fortunately, the State government, academia and private sector started to take a serious look at the potential for indigenous geothermal energy immediately before global petroleum disruptions of the 1970's. The receptivity of the Federal Government to seek alternate energy resources in the 1970's brought in a very welcome partner to Hawaii's team.

It cost about $3.4 million for exploratory surveys, drilling of a deep well, and well testing and analysis. Another $10 million was spent to build a 3 megawatt (gross) demonstration wellhead generator plant and another $1 million to make it work right.

It appears that the HGP-A Development Group now has the option of continuing to operate the plant at no additional cost to the government, transfer it with or without renumeration to the private sector, or close it down. The first-named option appears to be the likely choice.

Was the venture worth the financial cost? As far as the exploration, drilling and testing between 1973 and 1978, the answer is yes. $3.4 million proved there was a viable geothermal resource capable of producing up to 500 megawatt-centuries of electricity in the Kapoho Reservoir. Was the $10 to $11 million expended for the demonstration 3 megawatt wellhead generator plant a good investment? The plant did and does graphically demonstrate to potential developers and skeptical residents that the geothermal resource in Hawaii can produce electricity. The plant has been adapted so that in the words of a spokesman for the near subdivision, "it has become a good neighbor." The government and private sector have learned more about the specific nature

of the geothermal fluids and their appropriate disposal.

TABLE B
HGP-A CAPITAL COSTS ($000)

| | Fed'l | State | County | Private | Total |
|---|---|---|---|---|---|
| Exploration | 588 | 100 | 100 | 39 | 827 |
| Drill & Initial Test | 1,472 | 500 | - | 105 | 2,077 |
| Well Test & Anal | 417 | 66 | - | - | 483 |
| Install Generator | 8,314 | 1,621 | - | 55 | 9,999 |
| Post Start Up | - | 930 | - | - | 930 |
| TOTAL | 10,791 | 3,217 | 100 | 199 | 14,307 |
| PERCENT | 75.4 | 22.5 | 0.7 | 1.4 | 100 |

## REFERENCES

Baughman, E.C., Chen, B., Farrington, R., Lam, K.F.P., Thomas, D., Lopez, L., and Uemura, R., 1983 (Unpublished). Report on Hawaii Geothermal Power Plant Project. Prepared by the Research Corporation of the University of Hawaii.

Goodman, L.J., and Love, R.N., 1980. Energy Projects: Planning and Management, Pergammon.

Shupe, J.W., 1984 (Unpublished), Evolution of the HGP-A Power Plant. Delivered at the conference, An overview of Geothermal Development in Hawaii.