PROSPECTIVE DIRECT USE ENTERPRISES IN KAPOHO, HAWAII

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Abstract

The Puna District of the island of Hawaii encompasses the only Known Geothermal Resource Area (KGRA) in the State of Hawaii. Its Kapoho region is also the location of the state's sole geothermal power plant, the 30 MW Puna Geothermal Venture (PGV) facility. Despite significant potential, there is negligible direct utilization of geothermal heat in Kapoho. Direct use development is primarily hampered by a lack of awareness regarding the availability of the resource and its benefits, and by the perceived cost of infrastructure. A regulatory framework for geothermal development has been established, although County regulations do not specifically address direct use.

The resources potentially available to direct use enterprises in Puna include thermal groundwater from shallow wells and excess heat from PGV's operations. Water wells in the area with depths less than 230 meters (750 ft) have recorded temperatures ranging up to 89°C (193°F). PGV is supplied by several deep wells that have encountered fluids at temperatures up to 342°C (648°F). Hot brine from the separator, at approximately 204°C (400°F), could be tapped for direct use or additional power generation prior to reinjection.

Economic activity in Kapoho is primarily based on agriculture. Direct use offers value-added opportunities for existing enterprises such as papaya farming, nursery operations and commercial fishing, and can also provide the basis for new businesses. Direct use opportunities are especially promising in Hawaii because of the exceptionally high costs of conventional energy supplies, and because they can improve profitability, add value to products, increase productivity and expand job opportunities in an environmentally benign manner.

Narrative

Although several areas with geothermal potential have been identified in the State of Hawaii, the Big Island of Hawaii is the only island where geothermal resources have been developed and where the community is actively engaged in geothermal issues. The island's Puna District encompasses the only Known Geothermal Resource Area (KGRA) in the State and is the location of the 30-MW Puna Geothermal Venture (PGV) power plant.

There is significant potential for geothermal direct use development in the Kapoho region of Puna that is primarily hampered by a lack of awareness regarding the availability of the resource and its benefits to business ventures, as well as the perceived high capital cost of wells and other infrastructure. Direct use development in Puna could encourage activities elsewhere in Hawaii and other Pacific island jurisdictions such as the Commonwealth of the Northern Mariana Islands and American Samoa.

Puna Geothermal Venture, Hawaii's sole geothermal power plant, has been operating since 1993. However, despite the prevalence of shallow thermal groundwater in the area and the willingness of PGV to provide hot fluid for non-electric uses from its system, the only current direct uses of the abundant geothermal resource are a small aquaculture operation and some steam vents and warm springs on public and private properties used for recreational and/or therapeutic purposes.

Direct Use Working Group

To raise awareness of and interest in non-electric uses of geothermal energy, the State of Hawaii Department of Business, Economic Development, and Tourism and the County of Hawaii, along with PGV, the University of Hawaii Center for the Study of Active Volcanoes (CSAV), and the Oregon Institute of Technology Geo-Heat Center, are establishing a Hawaii County Geothermal Direct Use Working Group with support from the U.S. Department of Energy's GeoPowering the West program. The Working Group will have broad representation including: residents, businesses and landowners in the community; PGV; agricultural commodity groups and extension agents; government representatives; and geothermal experts.

The professionally facilitated Working Group will focus on disseminating information on direct use applications as well as collecting and transmitting community comments to the County. A proactive, collaborative approach to gathering input, with both informal networking and formal meetings, will be applied. This collegial method will increase the acceptability of direct use development to the community by reflecting its needs and preferences.

Public, non-technical educational workshops, to which all interested parties are invited, will be convened to supplement the Working Group's information dissemination and public input functions. Topics such as geothermal technology, the economics of geothermal development, access and permitting will also be addressed.

The County can benefit from the Working Group's input regarding the existing Geothermal Asset Fund and Royalty Fund requirements. Although both are intended to benefit the community adjacent to geothermal development and mitigate its impacts, there are strict guidelines for determining eligibility and release of monies. Each fund currently holds approximately $1.2 million. PGV pays $50,000 annually to the Asset Fund, and a portion of its annual revenues goes to the Royalty Fund (Mizuno, pers. comm., 2004). To date, only $6,500 of the Asset Fund has been granted for a resident's claim and the maintenance of a community group's emissions monitoring equipment.

The intent of the Geothermal Relocation Program is to relocate certain owner-occupants residing near the geothermal power plant, if they so request. It is funded by proceeds from the geothermal royalties received from the State Department of Land and Natural Resources, the sale of properties purchased, and rental fees from any of the properties purchased under this program. The fund was debited approximately $209,000 for net expenses after the purchase and resale of four homes under this program between 1999 and 2004 (Kawaha, pers. comm., 2004).

Available Geothermal Resources in Kapoho

PGV has acquired permits allowing eventual expansion to 60 MW, and can add up to seven new wells under existing permitting. Many direct use applications are quite modest, implying that PGV's excess thermal resource could support a fairly extensive range of activities. For instance, depending on the size of the operation and the local climate, geothermally heated greenhouses in other states require from 0.6 MWt to 1.5 MWt per acre, and aquaculture operations can require 2 to 4 MWt per acre (Lund, pers. comm., 2004). Hawaii's subtropical climate would substantially reduce the thermal demands for similar enterprises of equivalent scale.

In 2001, PGV leased Noi'i O Puna (NOP), the former Puna Research Center, from the State's Natural Energy Laboratory of Hawaii Authority (Boyd et al, 2002). NOP is a 1.6-hectare (4 ac) facility adjacent to the approximately 324 hectares (800 ac) PGV has leased for its operations. The research center has been inactive since the HGP-A well was closed in 1989 and is currently used by PGV for storage. NOP is a potential geothermal direct use incubator park site. PGV is willing to provide heat to NOP for direct utilization, as long as it does not negatively affect power plant operations (Mizuno, pers. comm., 2004).

PGV's power plant is supplied by several deep wells having total depths greater than 1,372 meters (4,500 ft) (GeothermEx, 2000). These wells have encountered fluids at temperatures ranging between 335°C and 342°C (635°F – 648°F). Other deep wells in the vicinity of the PGV lease have encountered temperatures as high as 373°C (703°F).

Fluids from these deep wells are now utilized by PGV's power plant. After electricity generation, the fluids—a mixture of condensate and brine from the separator—are reinjected at temperatures ranging between 149°C and 204°C (300°F - 400°F). Brine from the separator is at the higher end of that range, and could be tapped for additional uses prior to mixing and reinjection.

The Kapoho region overlies the Kilauea East Rift Zone (KERZ). The State Department of Land and Natural Resources has designated four Geothermal Resource Subzones statewide. There are three Subzones in KERZ—the Kapoho, Kamaili, and Kilauea Middle East Rift Subzones—as well as the Haleakala Southwest Rift Subzone on Maui. The Kapoho Subzone lies mainly within an area that is estimated to have a 95% probability of a high-temperature resource (GeothermEx, 2000). Water wells in the area having depths less than 229 meters (750 ft) have recorded temperatures ranging up to 89.4°C (192.9°F) as well as elevated mineral content indicative of limited ocean water intrusion (GeothermEx, 1999). There are approximately one dozen known wells and springs in the Kapoho area with measured groundwater temperatures of at least 26°C (78.8°F), and ranging up to 55°C (131°F) (Moreau, 1980). It is possible that a direct use enterprise park, or an individual enterprise, could utilize hot groundwater from independent wells, not part of PGV's operations.

Kapoho's Current Economic Activities and Direct Use Opportunities

Economic activity in Kapoho is primarily agricultural. Direct use offers value-added opportunities for existing enterprises, and can also provide the basis for new businesses. Direct use opportunities are especially promising in Hawaii because of the exceptionally high costs of conventional energy supplies such as electricity and propane gas. The community discussions are expected to reflect a broad spectrum of entrepreneurial interests, such as those below.

1) Fruit dehydration

Geothermal heat can be used for fruit dehydration or other processing, providing value-added options which can improve the farmers' profitability. Of the roughly 810 agricultural hectares (2,000 ac) in Kapoho, up to 70% is cultivated, mostly in papaya (Hopkins, pers. comm., 2004). The average production of salable fruit in 2001 was 30,000 kg per hectare (26,500 lb/ac) (Data Book 2003), resulting in an estimated 14.4 million kilograms (31.8 million lb) of marketable fresh papaya for the region that year.

However, an equivalent amount of papaya is not salable as fresh fruit due to reasons such as small size or irregular shape (Hopkins, pers. comm., 2004). Most of these culls are currently discarded. The dehydration of cull fruit would provide a value-added option. Dried papaya slices and chunks are marketable as snack foods, while dehydrated papaya powder can be sold as a nutritional supplement and digestive aid due to the enzyme, papain, which it contains.

An earlier study estimated that the capital cost of a papaya drying facility would be $200,000 for a plant with a 1,000 pound per day capacity (Okahara/Shigeoka, 1982). A larger capacity plant, processing between one and two million pounds of papaya annually for a national market, was reported to be only marginally economic (Chen, 1982). However, market conditions today are substantially different, and the distribution network for these products has become more diffuse through e-commerce. A local fruit producers' cooperative may find that it can transform unmarketable culls into a significant revenue stream.

Besides papaya, other crops are grown in Kapoho, mostly the products of small, diversified farming operations. They include organic tropical fruits such as avocado and rambutan, as well as banana and macadamia nuts. Some of these crops could be dried.

2) Cold storage, refrigeration, and ice making

Puna District is known for its flowers and ornamental plants. A sizeable vanda orchid farm is located approximately eight kilometers (5 mi) east of PGV, and some small businesses in the area are devoted to flower packing and sales. Cool storage is necessary to preserve the freshness of flowers prior to shipping.

Pohoiki Bay, eight km (5 mi) to the southeast of PGV, is the County's third largest commercial fishing port. In 2002, 149,371 kg (329,302 lb) of fish were landed at Pohoiki, valued at $667,932 (Data Book 2003). However, the nearest source of ice is in Hilo, over 42 km (26 mi) away. Ice, which is necessary to keep both bait and the catch fresh, can melt as much as 20% during transport from the Hilo ice plant (Hirai & Assoc., 1983). A nearby icehouse and cold storage facility would improve the quality of the fish and the productivity of the fishermen.

3) Aquaculture

The only current business utilizing warm groundwater in Kapoho for direct use is an aquaculture enterprise, Tropical Ponds Hawaii, which raises tropical ornamental fish such as swordtails, platys, guppies, endlers and gourami. They operate 32 ponds on roughly 0.8 hectares (2 ac), and plan to add another 40 ponds in the near future. The water source is 43°C (110°F) groundwater from a 213-meter (700 ft) shallow well adjacent to PGV's power plant. Between 35,000 and 70,000 gallons per week are utilized. Although most of the water is cooled to ambient temperatures—which range from the low 70s to low 80s Fahrenheit— before entering the ponds, water at approximately 38°C (100°F) is added to breeding ponds and hatchery tanks to stimulate breeding. The slightly saline water is also conducive to fish health by promoting the growth of protective "slime coats" and controlling algae in the ponds (Kern, pers. comm., 2004).

Even in Hawaii's mild climate, aquaculture pond temperatures can fluctuate approximately 5.5°C (10°F) seasonally. Using geothermal fluids to stabilize the temperature within 2-3°F of optimum can significantly increase the growth rates of many species of fish.

4) Greenhouse bottom heating

Raising nursery products, including foliage, potted flowering plants, bedding plants, and landscape plants, is a major activity in the Puna District. In 2002, the value of these products in the County—excluding cut flowers, orchids and lei flowers—exceeded $23.8 million (Data Book 2003).

From 1986 to 1989, a small demonstration greenhouse, using a geothermal bottom heating system, operated at the NOP research center. The growing medium was kept at 29°C to 32°C (85°F – 90°F) at the heated greenhouse, while at a nearby control facility it was approximately 21°C (70°F). The nursery operator identified over a dozen species of ornamental palms that grew significantly better in heated media (Beck, 1989). Not only did the seedlings reach transplant size more quickly—sometimes several months before non-heated controls—but germination rates also improved.

5) Processing other agricultural products

Geothermal heat can dry lumber. Having a limited number of operating lumber kilns handicaps the State's forest industry, which is centered in Hawaii County. Existing kilns' energy costs are discouragingly high. Many businesses choose to air dry their lumber, which may take months or even years, or export wood for kiln drying out of state. Providing a cost-competitive local kiln would offer opportunities for adding value to the timber crop.

Geothermal heat can also be used to dry macadamia nuts, a major crop in Puna District. Currently, the Mauna Loa Macadamia Nut processing plant in Keaau, approximately 24 km (15 mi) west of PGV, utilizes its waste biomass for drying, roasting and other process heat. A smaller-scale dryer at a direct use enterprise park could allow small operators to independently process their crops for market.

Heat could also be used to process animal and fish feed for local animal husbandry and aquaculture operations. A 1980 study investigated the feasibility of a cattle feed mill that would process dehydrated feed from sugarcane leaves for export (Moreau, 1980). Other products, such as cacao beans, coffee, kukui nuts, fish or meat could also utilize a dehydration facility.

6) Pasteurization or sterilization of growing media

Hawaii's extensive nursery industry raises foliage, flowers, ornamentals and other plants in shade houses and greenhouses. If the plants are intended for export, special steps must be taken to avoid the transport of soil organisms such as nematodes. Plants must be grown on raised benches in sterile or pasteurized media, essentially all of which is currently imported. Mushroom culture, a small facet of Hawaii agriculture that is increasing in importance, also requires uncontaminated media.

If local materials could be pasteurized for growing media, imports could be reduced. Growing media pasteurization has been demonstrated on a small scale using raw geothermal steam (Beck, 1989). Locally available materials such as volcanic cinder, shredded green waste, and sawdust could be steamed until extant pathogens were killed.

7) Balneology

Warm springs near Kawaihae, on Hawaii's western coast were mentioned by the explorer and missionary William Ellis in 1826 as being used by the local residents, some of whom attributed medicinal qualities to the water (Woodruff & Takahashi, 1990). Currently, natural geothermally heated brackish ponds are attractions at a County coastal park in the Kapoho region, as well as in private residential developments along the Puna coast.

In part due to the popularity of "onsen," naturally heated pools and bathing facilities in Japan, and the large number of Japanese visitors to Hawaii, geothermal spas have been the subject of several studies and have been proposed for the Kapoho area by at least one private developer. An analysis performed for the State in 1988 noted that Hawaii is ideally suited for the health spa industry, and that a major potential market for health spas exists among typical Hawaii visitors (GrantThornton, 1988).

The temperature and chemical composition of the naturally heated groundwater in the Kapoho region are within the range of spas developed elsewhere in the world (Woodruff & Takahashi, 1990). Other regions on the island of Hawaii, notably the area around the town of Pahala near Kilauea's southwest rift zone, as well as other Hawaiian islands may also have suitable thermal groundwater resources (GeothermEx, 1999).

8) Other ventures

Other ideas for the direct use of geothermal heat in Hawaii have been suggested or investigated. These have included the production of cement bonded wallboard, ethanol distillation, freeze drying of Kona coffee or other products, protein recovery from green leaf crops for animal feed, and milk pasteurization (Moreau, 1980). Geothermal heat has also been suggested as a method to disinfest papayas of fruit flies prior to export (Beck, 1989) or to supply heat to a community incubator kitchen (Mizuno, pers. comm., 2004).

Heat pumps, one of the most extensive uses of geothermal energy in the U.S., can provide both space heating and cooling. Cooling is a major load for most commercial buildings in Hawaii.

Untreated geothermal steam has also been used to fix dyes in hand painted silk, while hand blown glass formulae and cast bronze refractory materials utilized the silica byproduct of the now-closed HGP-A well (Beck, 1989). Other artistic uses of the geothermal resource may be identified.

Current Regulatory Environment

There are six major aspects of geothermal regulations in Hawaii: 1) the definition of a geothermal resource; 2) land use districts, including Geothermal Resource Subzones; 3) Geothermal Resource Permits; 4) drilling permits; 5) underground injection control permits; and 6) air quality permits.

According to the Hawaii Revised Statutes (HRS) Section 182-1, a “geothermal resource” is defined to exclude water having a temperature of 150°F or less. Thus, low-temperature resources are exempt from the specific regulations governing Subzones and State geothermal drilling permits.

Groundwater in excess of 65.5°C (150°F) could also be tapped for geothermal direct use. State law allows these higher-temperature direct uses to be located regardless of Subzone boundaries, as long as the development is within urban, rural, or agricultural land use districts. If the development is within a conservation district, it must then be located within a Subzone.

If the direct use developer is working with groundwater that is no hotter than 65.5°C (150°F), the State permitting process is the same as for a normal water well. The Commission on Water Resource Management, within the Department of Land and Natural Resources (DLNR), would handle the permits (GeothermEx, 1999). If it is expected that groundwater hotter than 65.5°C (150°F) will be encountered, the well would be considered a geothermal well, and the developer will need to obtain a Geothermal Exploration Permit and a Geothermal Well Drilling Permit, pursuant to the terms of HRS Chapters 174C and 182, and the corresponding set of DLNR Administrative Rules (Title 13, Chapter 183). The Land Division, Engineering Branch of DLNR is responsible for regulating geothermal development.

The County of Hawaii requires that a Geothermal Resource Permit (GRP) be secured from the Planning Commission for any geothermal development activities in a Geothermal Resource Subzone within a State agricultural, rural or urban land use district. Geothermal development activities include research or commercialization purposes, exploration development or production of electrical energy from geothermal resources, or as otherwise defined in HRS, Section 205-5.1. Further review of the Planning Commission rules would need to be conducted in order to determine whether a GRP would be required for any geothermal direct use development.

Injection wells are regulated by the State Department of Health (DOH) under HRS Chapter 340E and the corresponding DOH Administrative Rules (Title 11, Chapter 23). Water from some direct use applications, such as spas, might require an injection well permit (GeothermEx, 1999).

For many direct use developments, an air quality permit would not be required. It is unlikely that hydrogen sulfide, present in deep geothermal fluids, will be a significant factor in shallow groundwater. The ambient air quality standards for the State are given in HRS 342B and the corresponding DOH Administrative Rules (Title 11, Chapters 59 and 60). Under these rules, the limit for hydrogen sulfide in ambient air is 25 parts per billion, averaged over a one-hour period (GeothermEx, 1999).

Expected Results

The following actions are among the public information program's expected results.

A) Investment in individual direct use enterprises. Private businesses, after learning the benefits of direct use to their operations, may make independent investments in infrastructure and facilities to take advantage of geothermal heat.

B) Investment in an incubator/enterprise park. Public and private entities may choose to jointly or independently establish a geothermal direct utilization enterprise park.

C) Modification of County and/or State regulations to encourage the direct utilization of geothermal resources. Public discussion and input are expected to generate ideas regarding appropriate permitting for direct use projects. These ideas will be considered by the appropriate government agencies.

D) Use of public funds to support direct use. The outreach efforts may result in local businesses taking advantage of existing public funding programs, including those managed by the U.S. Department of Agriculture. Furthermore, community input may suggest that the County modify its regulations to appropriate portions of the Geothermal Asset Fund and/or Geothermal Royalty Fund to support direct use activities.

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References

Beck, Andrea Gill, 1989. "Experiments in Direct Use at Noi'i O Puna." Geothermal Resources Council *Transactions*, vol. 13; October 1989, p. 3-9.

Boyd, Tonya L., D. Thomas and A. Gill, 2002. "Hawaii and Geothermal, What Has Been Happening?" *Geo-Heat Center Quarterly Bulletin*, v. 23, no. 3, p. 11-21.

Chen, Bill H. et al, 1982. *Utilization of Geothermal Heat in Tropical Fruit Drying Process*. State of Hawaii Department of Business, Economic Development and Tourism.

Data Book 2003. County of Hawaii. Online. <http://co.hawaii.hi.us/databook_current/dbooktoc.htm>.

GeothermEx, Inc., 1999. *Development Opportunities for Geothermal Spas in the State of Hawaii*. State of Hawaii Department of Business, Economic Development and Tourism.

GeothermEx, Inc., 2000. *Update of the Statewide Geothermal Resource Assessment of Hawaii*. State of Hawaii Department of Business, Economic Development and Tourism.

GrantThornton, 1988. *Business Opportunity Report Hawaii: Health Spas*. Prepared for Hawaii Department of Business and Economic Development, and the Chamber of Commerce of Hawaii.

Hirai, W.A. & Associates, Inc., 1983. *Final Report. Feasibility of an Ice-Making and Cold Storage Facility Using Geothermal Waste Heat in Puna District, Island of Hawaii.* County of Hawaii Department of Research and Development.

Hopkins, Margarita; County of Hawaii Research and Development Department. Personal communication; 9 February 2004.

Kawaha, Alice and S. Gagorik; County of Hawaii Planning Department. Personal communication; 17 February 2004.

Kern, Robert; Tropical Ponds Hawaii. Personal communication; 3 March 2004.

Lund, John; Oregon Institute of Technology Geo-Heat Center. Personal communication; 29 March 2004.

Mizuno, Barry; Puna Geothermal Venture. Personal communication; 20 February 2004.

Moreau, James W., 1980. *Final Report. Pahoa Geothermal Industrial Park. Engineering and Economic Analysis for Direct Applications of Geothermal Energy in an Industrial Park at Pahoa, Hawaii.* Prepared by Hawaiian Dredging and Construction Company for the U.S. Department of Energy.

Okahara/Shigeoka & Associates, 1982. *A Cost Structure for a Tropical Fruit Drying Pilot Plant Utilizing Geothermal Waste Heat*. State of Hawaii Department of Business, Economic Development and Tourism.

Woodruff, James L. and P. Takahashi, 1990. "Geothermal Spas: A New Business Opportunity in Hawaii." Geothermal Resources Council *Transactions*, v. 14, Part I, p. 819-825.