Hawaii Geothermal Assessment and Roadmap

REPORT COMPILED BY

Pacific International Center For High Technology Research (PICHTR)
under contract to Hawaii Natural Energy Institute, University of Hawaii

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PICHTR

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I. EXECUTIVE SUMMARY

Geothermal energy is an important part of the resource mix that can lead Hawaii to greater energy independence and economic security, but new geothermal has not been developed in Hawaii in 20 years. This report was undertaken to assess whether there is interest and the extent of that interest in developing new geothermal energy resources on the part of the state, industry, and utilities.

This assessment consists of summaries of interviews with 65 individuals from 27 organizations, conducted from April to October 2012, cataloging progress and opportunities related to geothermal. The interviews confirmed that there is significant industry, utility, and government interest in expanding geothermal resource development throughout the State of Hawaii. From the interviews, we offer recommendations for state and county agencies to prepare for potential development scenarios, and suggest a roadmap for where and how geothermal development should proceed in Hawaii. A brief summary of some of our conclusions is below. The interviews summaries, the full set of recommendations, and the suggested development roadmap, as well as the list of resources provided in the report's final section, contain more detailed information for backup and explanation of these conclusions.

While development efforts have been pursued for decades, interest in geothermal energy has increased recently because of two key drivers: 1) **price**: electricity prices on all of the Hawaiian Islands have been escalating in the wake of rising oil prices, and 2) **policy**: a redoubled effort to reduce the state's dependence on imported fossil fuels. Geothermal energy has the potential to bring down and stabilize electricity prices and to help fulfill public policy goals.

GEOTHERMAL RESOURCE INFORMATION AND ROYALTIES – INVEST IN DEVELOPING PUBLICLY AVAILABLE RESOURCE DATA. The quality of geothermal resource information for Hawaii is currently relatively low, and the basic information available is decades old. An effort is underway to develop new publicly available resource information, and should be expanded. Developing a robust geothermal industry in Hawaii requires accurate resource assessments compiled either by private industry or government. A mix of public and private investment is needed, because public information supports and encourages the competitive landscape. Royalties can be an enabler if a portion was dedicated, along with other public funds, to early stage exploration efforts. As resource exploration proceeds, public access to the information will help attract industry participants to the Hawaii market.

EXPANDING DEVELOPMENT OPPORTUNITY – REACH OUT TO INDUSTRY GLOBALLY TO EXPAND COMPETITION IN HAWAII. Contrary to initial assumptions, the Hawaii market opportunity is not too small to attract serious industry participants from within the U.S. and internationally. Competition has the potential to reduce costs and offer a range of technical solutions. The state can take an active role in drawing global development leaders to Hawaii and fostering increased competition. This requires direct outreach to industry, well-structured utility solicitations that allow a variety of technologies and approaches, and increased regulatory clarity to reduce barriers to market entry and help private investors better manage risk.

TECHNICAL ASPECTS OF FUTURE GEOTHERMAL DEVELOPMENT – HIRE STAFF AND CONSULTANTS WITH UP-TO-DATE TECHNICAL EXPERTISE. Technology has advanced significantly since geothermal was last developed in Hawaii, with new approaches for exploration, commercial energy production, financing, and everything in between. Local organizations, particularly those in government with a responsibility to plan, oversee, and regulate geothermal development, need to have knowledge of the latest developments in technology, and access to technical consultants in specialized areas, to be able to seek the best solutions for Hawaii — for our unique island grids and for our particular geophysical resources.

KEEPING COSTS LOW – SUPPORT POLICY THAT LOWERS COST OF DRILLING AND DRILLING RISK; TARGET PROJECTS IN RANGE OF $0.07-0.16/KWH. In addition to encouraging competition and facilitating the use of new technologies, there are a number of other factors that can help keep costs low. Federal incentives such as the production tax credit and accelerated depreciation are important factors, but the state plays a role as well. Almost half the cost of a geothermal plant over the life of the plant is in the upfront drilling, which is a high-risk endeavor — since millions of dollars are spent before knowing if there is a commercially developable resource. Increasing the speed of drilling and the increasing the proportion of successful wells can lead to significantly lower costs over the lifetime of the project, and thus lower electricity rates. The second biggest driver is the financial structure of the project and the rate of return needed for investors. The larger the risk, regulatory and resource, the greater the return required. Enacting rules and regulations that are mindful of these cost drivers – especially drilling costs and regulatory risk – are likely to result in lower prices for geothermal electricity.

GEOTHERMAL AS PART OF A PORTFOLIO SOLUTION – UTILIZE SYSTEMS SOLUTIONS TO LOWER COST WHILE INCREASING RENEWABLE ENERGY UTILIZATION. Geothermal will be part of a portfolio energy solution for Hawaii, and needs to fit into a systems solution dictated by Hawaii's isolated electricity systems. Planning on the utility scale should focus on how to integrate geothermal at the lowest reasonable cost for the ratepayers, and finding system solutions where they most make sense — whether that includes requirements for the geothermal plant, upgrades to existing oil-fired units, additional investments in the grid, new energy storage, novel methods to dispatch geothermal electricity, or other solutions.

IMPORTANCE OF PLANNING – ALIGN STATE, COUNTY, AND UTILITY PLANS INTO ONE CLEAR VISION FOR HAWAII'S ENERGY FUTURE. One theme that echoed among stakeholders and industry was the desire to see the state's overall plan for energy, and an articulation of where geothermal fits in that vision. This would be especially helpful in understanding the stages of planned development for geothermal. Many stakeholders emphasized their preference to competently develop new geothermal for the benefit of the host island first, i.e. Hawaii Island or Maui, and then explore the feasibility of developing larger geothermal projects for interisland transmission. In addition, the effort to develop this complex resource would benefit from coordination among state agencies and among the state and counties, especially in the areas of providing timely and credible information, sharing technical expertise, and aligning local, county, and state plans and regulations.

LAND USE AND PERMITTING – CLARIFY RULES OF ENGAGEMENT FOR GEOTHERMAL ON PUBLIC LANDS; CONTINUE PERMIT FACILITATION ACTIVITIES. Land control is one of the key barriers to the development of the geothermal industry, but the state can also deploy land as an important enabler. Providing regulatory clarity for the use of state lands would open up significant opportunities for geothermal development, while also providing a potential revenue stream to the state. It is also important to recognize and foster co-benefits, for example, geothermal enables landowners to maintain adjacent lands in ranching, agriculture, and open space. The state's regulatory agencies are well positioned to permit and regulate geothermal based on their previous experience. They also plan to hire additional expertise. The agencies should also continue to update online permit guides and pursue more effective permit facilitation, as these are still very important services for potential developers.

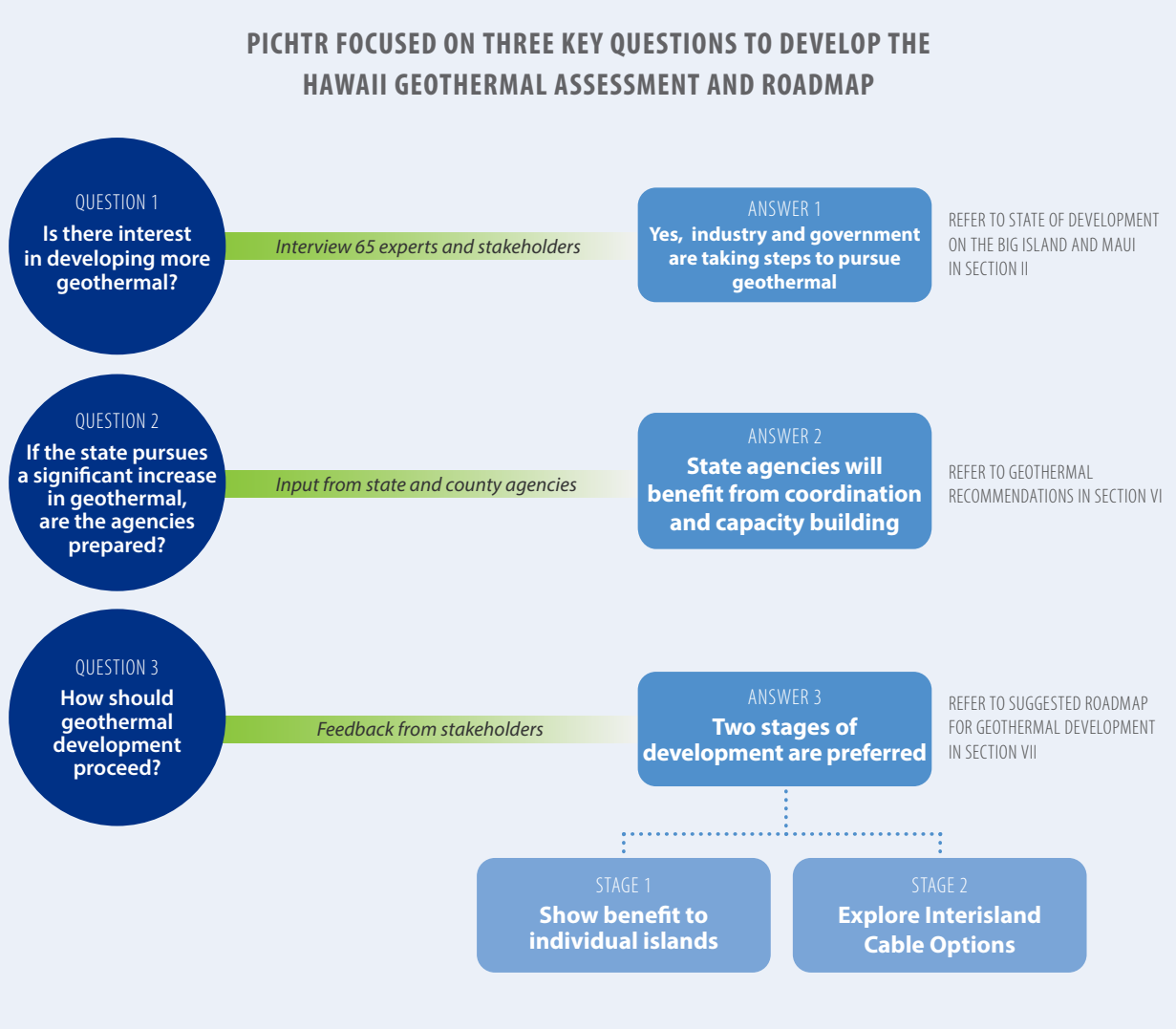
EDUCATION AND OUTREACH – PROVIDE TIMELY, FACTUAL INFORMATION TO COMMUNITIES. A recurring theme through the interviews was the need for education and outreach to policymakers and the general public – providing credible, factual information related to geothermal technology, health effects, and local impacts. Misinformation within communities, in the absence of factual communication, has been creating confusion and mistrust.

COMMUNITY BENEFIT – EMPHASIZE LOWER ELECTRIC RATES AND OTHER DIRECT COMMUNITY BENEFITS IN PLANNING AND REQUESTS FOR PROPOSALS. Stakeholders stressed the need to obtain meaningful community benefit from geothermal projects. Reduced electricity rates would count as one significant benefit, but there was also a desire for visible infrastructure or quality of life improvements for the neighborhood and island hosting the project. This can be achieved through explicit treatment in utility solicitations and also proactive efforts on the part of developers. Explicit community benefits obtained from the collection and disbursement of geothermal royalties was also

emphasized, as well as the use of geothermal heat for small-scale enterprises and business endeavors that could use low-cost heat. The successful realization and demonstration of reduced rates and community benefits would likely result in broader public support of and demand for additional geothermal development.

RECOMMENDATIONS FOR GOVERNMENT – HELP REDUCE DEVELOPMENT COSTS THROUGH SMART POLICY, PERMITTING, AND PLANNING, AS WELL AS THROUGH INVESTMENT IN RESOURCE CHARACTERIZATION. Based on the information gathered throughout this report, there is significant interest in and benefit to developing new geothermal energy facilities in the state. If the state decides to take this path, investments need to be made in acquiring the right expertise, revising and simplifying regulations, funding resource exploration and information dissemination, and aligning local, county, and state plans. The detailed recommendations towards the end of the report are designed to provide policymakers and decision makers with the information and tools needed to make these investments. Major private investment of the variety needed to expand geothermal capacity is highly dependent on investor confidence in the public sector's ability to competently plan for and regulate sound development strategies.

Figure 1. Summary of Research Process.



II. INTRODUCTION

A. Drivers for Exploring Hawaii's Geothermal Resources

Geothermal energy is an important part of the resource mix that can lead Hawaii to greater energy independence and economic security. While development efforts have been pursued for decades, interest in geothermal energy has increased with two key drivers: **1) price:** electricity prices and costs to consumers on all of the Hawaiian Islands have been escalating in the wake of rising oil prices, and **2) policy:** a redoubled effort to reduce the state's dependence on imported fossil fuels. One cornerstone of this effort is the Hawaii Clean Energy Initiative, a public-private partnership initiated in 2008 that led to the passage of increased Renewable Portfolio Standards and other policies that support the transition to clean energy.

In addition to the two key drivers above, geothermal is a potentially important resource for several additional reasons:

- **HAWAII HAS GEOTHERMAL RESOURCE.** Geothermal for electricity production is only feasible in limited parts of the world, most notably in the Western U.S., the Pacific Rim, and areas with some level of volcanic activity such as Iceland and East Africa
- **GEOTHERMAL IS A RENEWABLE RESOURCE.** Through proper reservoir management, the rate of energy extraction can be balanced with a reservoir's natural heat recharge rate [1]
- **BASELOAD.** Geothermal power plants produce electricity consistently, with the capability of running 24 hours per day / 7 days per week [2]
- **SMALL FOOTPRINT.** Geothermal power plants are compact; using less land per GWh than coal or photovoltaics (PV)[3]
- **CLEAN.** Modern closed-loop geothermal power plants emit no greenhouse gasses; life cycle GHG emissions (50 g CO2 eq/kWhe) are four times less than PV, and six to 20 times lower than natural gas. Geothermal power plants consume less water on average over the lifetime energy output than most conventional generation technologies[4]
- **OPEN SPACE.** Revenue from geothermal plants can enable landowners to keep adjacent land in ranching, agriculture, and open space
- **ENABLES OTHER ECONOMIC ACTIVITY.** Geothermal has the potential to contribute to local economic activity through energy-intensive, value-added, industries that can support local agriculture and other enterprises. Geothermal heat, provided at low cost, can be used for greenhouses, aquaculture facilities, and commercial uses such as food dehydration, laundries, milk pasteurizing, spas, and others — significantly reducing operating costs and enabling small businesses[5]

1 U.S. **DOE Geothermal Technologies Program**. 2012.

2 U.S. **DOE Geothermal Technologies Program.** 2012.

3 Geothermal Energy Association. **A Guide to Geothermal and the Environment**. 2007.

4 Argonne National Laboratory. **Life Cycle Analysis Results of Geothermal Systems in Comparison to Other Power Systems**. 2010.

5 According to the U.S. DOE, 38 greenhouses and 28 aquaculture facilities are operating across ten states utilizing waste heat from geothermal resources, reducing fuel costs by up to 80%. **U.S. DOE Geothermal Technologies Program**. 2012.

B. State of Development on the Big Island and Maui

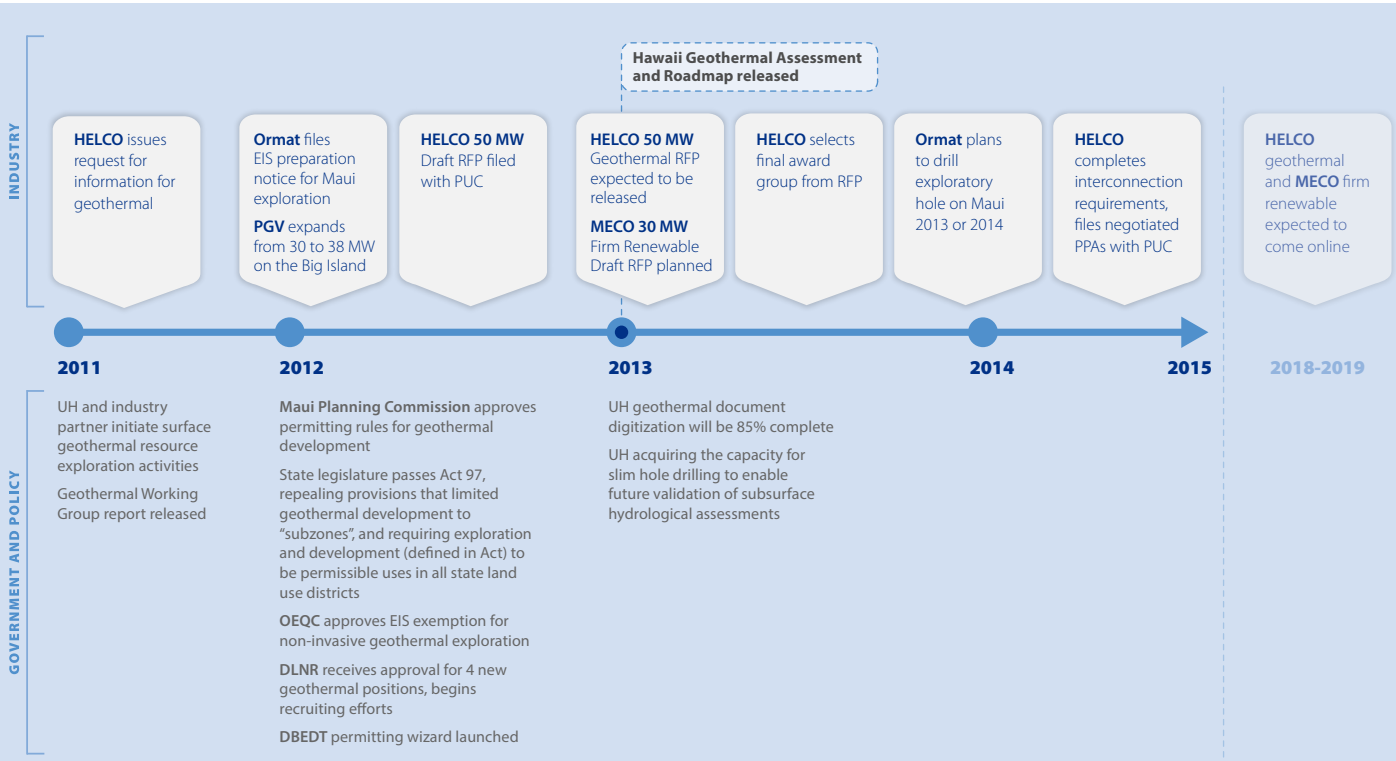
In short, these attributes of geothermal energy production can be particularly attractive to an island economy like Hawaii, which is aggressively orchestrating a transformation switch to clean energy, while protecting natural assets and reducing the outflow of dollars to purchase imported fossil fuels.

Currently, there is limited geothermal development in Hawaii. Hawaii Island has an operating 38 MW geothermal plant, providing more than 20% of the island's annual energy needs, and is exploring the development of additional geothermal capacity. Maui is in the early stages of exploring potential geothermal opportunities. However, in the past couple of years there has been significant activity driven by the resurgent interest in geothermal utilization, including:

1. Electric utility signaling the intention to accept proposals for geothermal energy
2. Increased business development activities of several private geothermal developers
3. Addition of 8 MW to existing Puna Geothermal Venture plant on Hawaii Island in 2012
4. Completion of a report in early 2011 by the Hawaii County Geothermal Working Group which was requested by SCR 99
5. Removal of "subzone" geographical restriction on geothermal projects by the 2012 Hawaii State Legislature
6. Federal funding awards for resource exploration on Maui and Hawaii Island
7. Policy changes to enable geothermal development, including legislative changes and permitting coordination activity

This activity and others learned through interviews and described in this assessment have created significant momentum and interest in geothermal. A sense of this momentum can be achieved by a review of the recent government and industry milestones achieved in this sector in Hawaii (*Figure 2*).

Figure 2. Timeline of Geothermal Activities.



C. What the State is Doing to Enable Geothermal

In order for geothermal development to proceed at an increased level at the commercial scale, public sector agencies must be prepared for the complex planning, assessment, regulatory, and permitting activities housed principally in the Department of Business, Economic Development, and Tourism (DBEDT), Department of Land and Natural Resources (DLNR), and the County planning departments on Hawaii Island and Maui. The Hawaii Public Utilities Commission (PUC) and the Department of Health (DOH) also have utility and environmental health regulatory responsibilities, respectively.

Internal capacity in these agencies was established ca. 1980 to 1995, during the active pursuit of the initial Puna Geothermal Venture project and during the State's pursuit of a 500 MW geothermal-cable project, but with the hiatus in active geothermal development since, that capacity no longer exists, especially within DBEDT and DLNR. Recognizing that there are costs associated with redeveloping the public sector capability to facilitate and regulate geothermal development, an updated assessment of the seriousness of development interest by the private sector is needed. An updated understanding of current gaps can inform a plan to address needs and provide a roadmap for development of this sector.

As the agency with overall responsibility for planning and strategizing the development of energy resources, DBEDT sought assistance for a strategic development plan for geothermal energy. The Hawaii Natural Energy Institute at the University of Hawaii, with a mission to study and advance alternative energy in the state, offered to sponsor this assessment in collaboration with DBEDT. PICHTR, the Pacific International Center for High Technology Research, was retained in the spring of 2012 to complete such an assessment and plan for HNEI and the State of Hawaii.

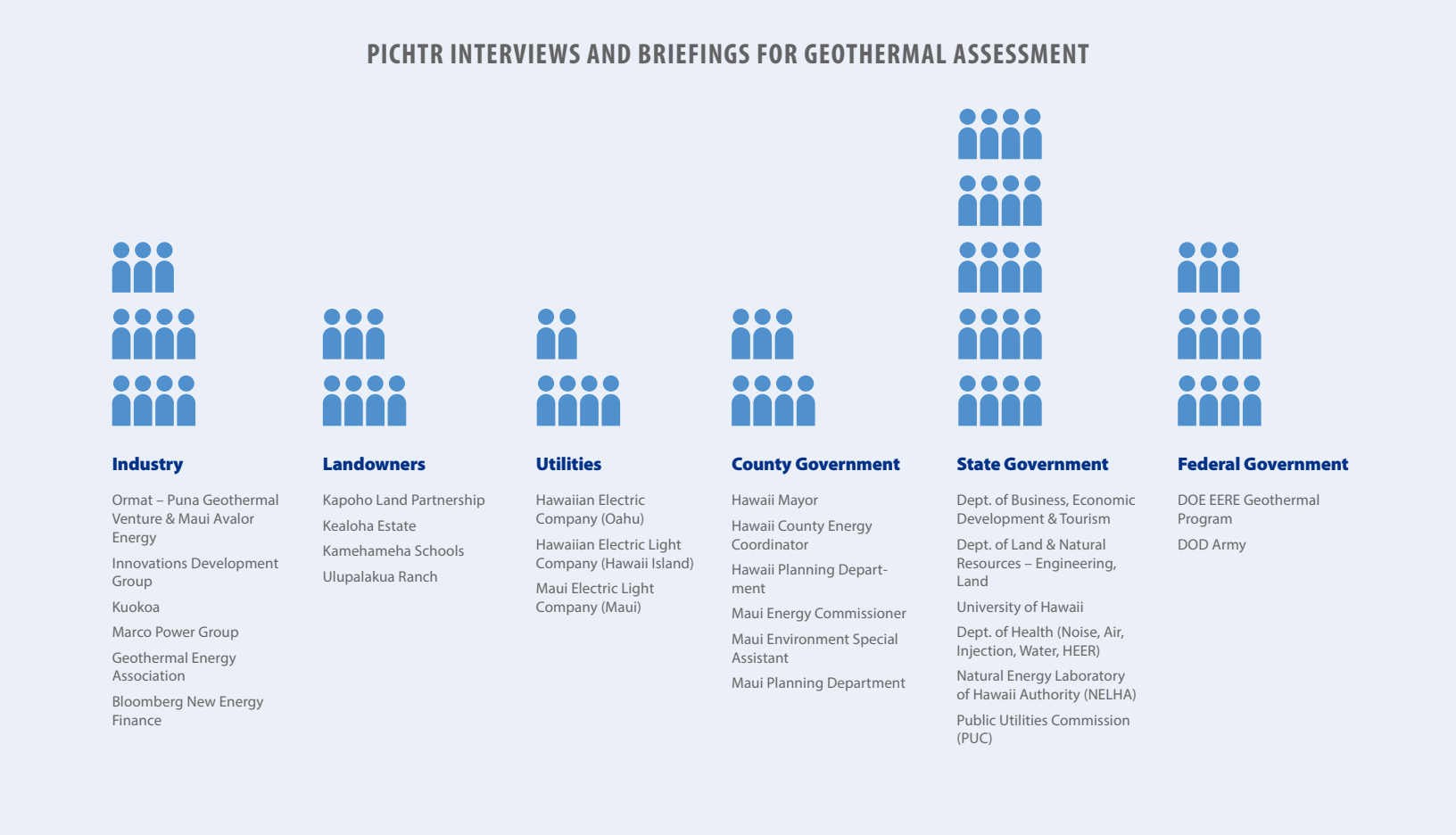
D. Scope of this report

SUMMARY OF RESEARCH STRATEGY: The research team conducted over two dozen in-depth interviews (*Figure 3*) to ascertain potential geothermal development scenarios and identify needs of the lead state agencies in order to support geothermal development. The report also attempts to identify perceived needs of other state agencies and the counties, but recognizes that the ultimate decision to pursue and establish such capacity resides with those individual agencies. Those decisions could be better informed by the effort described herein.

The investigation was limited to geothermal energy for commercial-scale electrical energy production, and does not include community- or household-scale geothermal energy utilization or non-electric applications. The work for this assessment was conducted in four discrete tasks:

1. First, PICHTR reviewed and updated the knowledge of geothermal development in the state though a review of published literature, and initial interviews with public agencies.
2. Second, PICHTR interviewed geothermal stakeholders including developers, landowners, electric utilities, and industry associations, to ascertain the level of industry interest, the seriousness of that interest, and the perceived needs from a private sector perspective regarding government capability.
3. Third, PICHTR interviewed government officials at the county, state, and federal levels to understand the level of interest in geothermal development, discuss the possible likely scenarios for geothermal development based on Task 2 information, review the existing assets available to the organizations, and then ascertain what organizational changes and additional support might be needed to adequately perform their public sector function for anticipated geothermal development.
4. Finally, PICHTR compiled this information into a strategic plan and development roadmap for review and for public release.

Figure 3. PICHTR Interviews Conducted April to October 2012.



E. Goal of this Report

The goal of this document is to inform government decision makers and geothermal energy stakeholders about potential development scenarios; assess what is needed to plan, permit, regulate, and otherwise oversee commercial-scale geothermal development; record agency needs and concerns; and recommend actionable strategies to address such gaps. The recommendations towards the end of the report are designed to provide policymakers and decision makers with the information and tools needed to support industry in a complex undertaking. Since major private investment is expected to complete any geothermal development scenario, such investment is highly dependent on the confidence investors have about the abilities of the public sector to competently plan for, regulate, oversee, and at times, facilitate sound development strategies.

III. TODAY'S BASELINE: A STATUS OF GEOTHERMAL DEVELOPMENT

A. Literature Review

An assessment of baseline conditions regarding the state of geothermal development in Hawaii shows extensive documentation, dating back decades, in the public record.

ACCESSING THE PUBLIC RECORD: An extensive library of geothermal documents is available online through a digitization process being undertaken by the University of Hawaii. This effort is led by Dr. Donald Thomas at the University of Hawaii, who is in the process of systematically categorizing, digitizing, and facilitating access to this information. A more detailed description of this important effort is described later in the report. While many documents exist, only a few are widely used by current geothermal developers and analysts. Until updated information on geothermal resource potential is obtained, catalogued, and published, generally held public knowledge of geothermal development potential is based on these documents. A summary of the two documents most commonly referenced today, as learned through our interviews, is provided below.

Synopses of the most commonly referenced studies are provided below to provide context for the rest of the report.

GEOTHERMAL WORKING GROUP REPORT 2011: The 2010 Hawaii Legislature requested a working group through SCR 99 to assess whether geothermal is a feasible resource to be the primary power source on Hawaii Island: the Big Island. In January 2011, the Geothermal Working Group – County of Hawaii issued the following findings:

- Multiple geothermal plants are the most prudent approach
- Historically, geothermal is a lower-cost energy resource
- Geothermal has the potential to supply baseload electricity, although it has not yet demonstrated baseload consistency in its application in Hawaii
- Geothermal is a renewable resource indigenous to the Big Island and can neutralize the price volatility of petroleum fuel for the county, both in terms of the electrical grid and in terms of transportation
- Additionally, products that assist island agriculture can be cost-effectively produced with geothermal and replace the importation of products made on the mainland from fossil fuels
- Geothermal has a significant potential to be the Big Island's primary energy resource

ASSESSMENT OF ENERGY RESERVES AND COSTS OF GEOTHERMAL RESOURCES IN HAWAII 2005: Industry representatives agree that current public opinion and analysis around geothermal resource are largely based on the 2005 GeothermEx Resource Assessment commissioned by the State of Hawaii. The conclusions of this assessment are largely based on data obtained in 1985 or earlier. This data provided the basis for Monte Carlo simulations that estimated potential for geothermal. Key resource findings include:

- The five geothermal resource areas on Hawaii Island have a combined minimum MW capacity of 488 MW and a combined most likely MW capacity of 1,396 MW
- The two geothermal resource areas on Maui have a combined minimum MW capacity is 38 MW and the combined most likely MW capacity is 139 MW
- It is important to note that these estimates of reserves reflect the amount of recoverable heat energy anticipated to be present at drillable depths, without implying that this energy can necessarily be exploited commercially

- For this assessment, GeothermEx delineated two scenarios for the development of geothermal electrical generation capacity through 2025: a likely scenario and an upside scenario
- The likely scenario consists of a base case for the Lower Kilauea East Rift Zone (KERZ) alone. This scenario reaches a geothermal generation capacity of 82 MW by 2025
- The upside scenario consists of the sum of an upside case for the Lower KERZ and the three development projections for areas outside the Lower KERZ (Hualalai and the Mauna Loa Southwest and Haleakala Southwest Rift Zones). By 2025, this scenario reaches a geothermal generation capacity of 180 MW for the Island of Hawaii, and 205 MW for the islands of Hawaii and Maui combined
- GeothermEx employed a probabilistic approach to estimate costs of a geothermal plant using anecdotal information and data from published sources; proprietary data from actual Hawaii experience was not available to the analysis
- With a cumulative probability of 90%, levelized cost is expected to be higher than $0.07/kWh but lower than $0.087/kWh. Of this total, wells are expected to cost $4-7 M each to drill, and expected to produce 5-30 MW. (Ormat's experience seems closer to 5 MW). Ongoing operations and maintenance accounts for $0.04 - 0.06/kWh. This cost estimate is specific to a 30 MW plant located in the Kilauea East Rift Zone

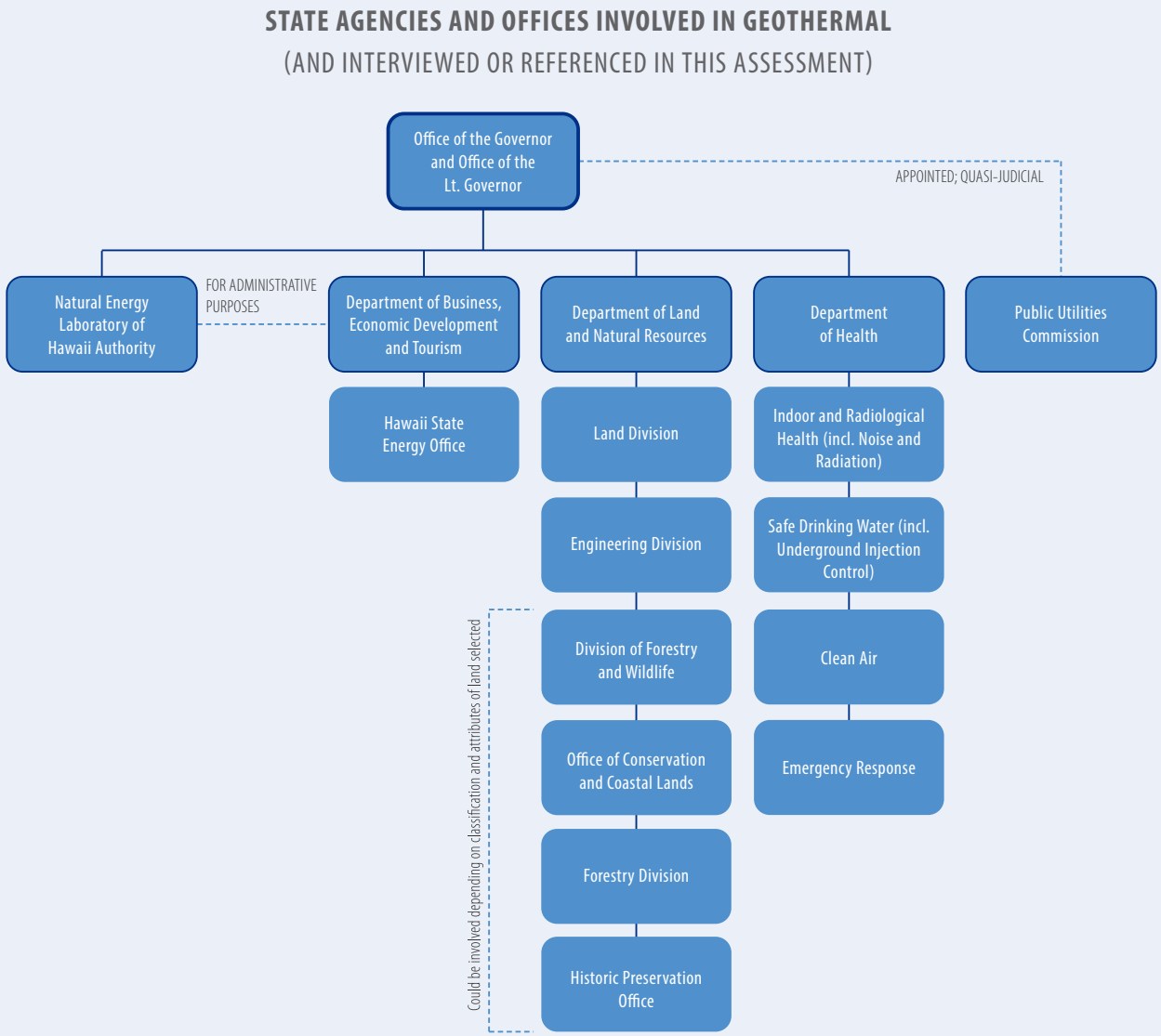
Much of the current state of geothermal knowledge is not well documented in formal reports, but rather is resident in the university, government agencies, utilities, developers, and other industry participants. Thus, while this assessment refers to existing documents, the findings and recommendations herein draw mainly on interviews conducted in 2012 as part of this project. Findings from those interviews follow.

B. Interviews: State Agencies and Organizations

The interviews in this section were mainly conducted in April and May 2012, with some follow-up interviews throughout the summer of 2012. The interview summaries represent portions of conversations we had with the parties interviewed, but are not official statements nor are they representative of views other than the interviewees. The content does not necessarily reflect the views of the consultants compiling the information. The intent of this report is to provide valuable information for those interested in geothermal, and not to define official organizational positions related to geothermal or energy development in Hawaii.

In interviews with state government, the overall impression was a desire to see geothermal development proceed and to achieve a pronounced increase in the level of geothermal activity over 2011 and 2012. State agencies and organizations interviewed included DBEDT, DLNR, DOH, the Public Utilities Commission, the Natural Energy Laboratory of Hawaii Authority (NELHA), and the University of Hawaii. Below is a summary of the role, priorities, key activities, and needs of each agency.

Figure 4. State Agencies and Divisions that Relate to Geothermal.



1. *Department of Business, Economic Development, and Tourism (DBEDT), University of Hawaii, Hawaii Natural Energy Institute (HNEI)*

AGENCY RESPONSIBILITIES RELATED TO GEOTHERMAL: The Department of Business, Economic Development and Tourism (DBEDT), through its Energy Resources Coordinator, has the responsibility to plan and coordinate energy programs for the State of Hawaii. These programs establish long-range plans and facilitate and accelerate the state's transition from an oil-dependent economy to local, clean energy resources. The Hawaii State Energy Office within DBEDT has the primary responsibility for the planning and execution of these programs.

WHERE GEOTHERMAL FITS: DBEDT views geothermal development work as a long-term, sustained effort that is of high priority for the administration. As related in this interview, the administration's top energy technology priorities are: **1) Geothermal**, **2) Smart Grid**, and **3) Biofuels**. DBEDT believes that geothermal could be a game changer for the state, providing very significant benefit to Hawaii residents. The role of the Hawaii State Energy Office is evolving from general project assistance, policy, and analysis to targeted assistance to the "Top 40" projects, which are determined by defined criteria. To realize its mission, the Hawaii State Energy Office is providing a "business integration" function, rather than focusing on specific geothermal expertise or assigning specialists to one technology. The agency envisions geothermal as being handled in the same way as other high-priority renewable energy projects throughout the state.

Specific activities of the Hawaii State Energy Office include:

- Industry analysis summaries / white papers
- Permitting tools, coordination, and clarification
- Helping projects with a pragmatic, financially sound approach

LOOKING FORWARD: DBEDT expressed that successful development of the resource will require iterative studies of not only the technical aspects of the resource, but also the broader policy-related roadblocks to geothermal. Beyond the scope of this report, future study areas may be needed, including: electric utility options for integrating geothermal; transmission and distribution on-island as well as undersea; permit coordination and facilitation; and agency capacity. Taken together, these efforts would help to shape a vision of what geothermal could do for Hawaii.

Because DBEDT is also exploring the viability and economic benefit of an inter-island cable, the geothermal initiative can be related to efforts to pursue the inter-island cable, but there is also a need to investigate, justify and pursue the first steps of geothermal development, e.g., ensuring that the needs of each individual county are prioritized and benefits realized locally before any interisland cable development is pursued.

The main questions DBEDT wants answered out of this analysis are: are there real roadblocks to geothermal? How real is the prospect of geothermal development and at what scale?

OUTREACH AND EDUCATION: The importance of outreach was discussed. The purpose of outreach as described in the interviews would be to educate prior to and during each legislative session, and to address issues with the public and community. It was agreed that a broad outreach effort would be required to ensure that the most factual, current information is accurately communicated to policymakers, community leaders, and the public.

THE ROLE OF HNEI: While DBEDT is responsible for energy planning and industry outreach, HNEI has a role in resource assessment and information dissemination. HNEI is supporting UH Center for the Study of Active Volcanoes geothermal resource assessment activities (discussed in the UH section of this assessment) with state and federal funds. In particular, the HNEI funding is helping purchase some of the equipment needed, and expanding the surface exploration efforts — originally just funded for Hawaii Island — to areas of Maui and Oahu. HNEI does not currently test geothermal technologies, but this may be an area of future activity given the institute's expertise validating energy technologies. NEI coHNEI expressed concern about unrealistic expectations and the need to communicate the fact that the state still presents serious challenges for successful geothermal development. An execution plan, with buy-in from government, utilities, and stakeholders, could help to manage unrealistic expectations.

2. *Department of Land and Natural Resources, Land Division and Engineering Division (DLNR)*

AGENCY RESPONSIBILITIES RELATED TO GEOTHERMAL: DLNR is the lead permitting agency for geothermal in the State of Hawaii. The two key divisions in the agency that share responsibility for geothermal are the Land Division, which administers leasing of geothermal resources, and the Engineering Division, which oversees the regulation of geothermal exploration and development activity, including but not limited to, the issuance of drilling permits, compliance with leasing and drilling regulations, and providing overall technical and program support to the department. The Division of Forestry and Wildlife oversees projects affecting public or private forest reserve lands, Habitat Conservation Plans, and "incidental take" licenses if there are endangered species present, and weighs in if the proposed activity is in close proximity to a natural area reserve. Other programs/divisions that may be involved include the Office of Conservation and Coastal Lands for development affecting conservation lands and the State Historic Preservation Division. DLNR is proactively assessing its geothermal expertise needs as well as the policy and regulatory framework for geothermal.

ENABLING GEOTHERMAL THROUGH REGULATORY CHANGES: On matters related to rulemaking and the environment, DLNR is moving to simplify and facilitate geothermal exploration in support of the administration, while maintaining strong environmental protection and oversight. There are three points at which the geothermal permitting processes can be streamlined to reduce exploration and development costs, and therefore future project costs:

1. Legislative change in statutes
2. Rulemaking
3. Environmental requirements administered by Office of Environmental Quality Control (OEQC)

In the agency's view, existing environmental law has comprehensive and well-established checks and balances, and it is not necessary to have a separate slate of rules and regulations to govern, and therefore complicate, geothermal. To that end, DLNR has retained a consultant, GeothermEx, Inc., to review DLNR's administrative rules and recommend program improvements, if any, to simplify/streamline current permitting processes while maintaining appropriate oversight and regulation of geothermal development activities.

DLNR supports the objectives of this report and believes a clearer "roadmap" will benefit the state's overall renewable energy plan, the industry, and the respective advocacy and regulatory agencies. DLNR is moving to increase its geothermal program staffing to enhance its current regulatory program measures and in part to prepare for anticipated interest in and potential for expanded geothermal exploration and development. Renewable energy is a clear priority for the administration and is supported by DLNR, however, such development must also be balanced with the responsibility vested with the Board of Land and Natural Resources to protect and manage the state's natural, cultural, and historic resources. DLNR hopes this report will identify critical gaps, if any, as well as provide practical recommendations to improve and support current and future program activities.

MAKING LAND AVAILABLE FOR GEOTHERMAL: DLNR offered a number of thoughts on developing geothermal on state lands. DHHL is active as a landowner, and there was some discussion that the Public Land Development Corporation (PLDC) may get into geothermal resource development. DLNR understands that this move may be supported by some industry participants, but other interviewees expressed that PLDC is unlikely to become actively involved in geothermal development in the short term.

Inquiry was made whether there were any special provisions in DLNR's Chapter 13-183, Hawaii Administrative Rules (HAR) applicable to renewable energy projects involving geothermal. A comparison was made to Section 171-95.3, Hawaii Revised Statutes (HRS) regarding renewable energy producers and the leasing of public lands without public auction. DLNR noted that Chapter 182, HRS, and the department's administrative rules, Chapter 13-183, HAR, currently provides for the issuance of mining leases without public auction only for reserved lands (and not state lands), as defined by HRS, Chapter 182. DLNR indicated that they were considering possible statutory amendments and subsequent administrative rule amendments to allow for the issuance of mining leases for Sate lands to renewable energy producers without public auction. However, until such time as appropriate statutory amendments are approved and implemented, renewable energy project mining leases on state lands cannot be directly negotiated and will be subject to a competitive bid process via public auction.

It was noted that Chapter 182, HRS, does include a provision whereby, if the person who discovers the mineral resource as a result of exploration, but who does not successfully acquire a mining lease via the currently prescribed public auction process, such unsuccessful party shall be reimbursed for their direct/indirect exploration costs from the successful bidder. DLNR shall have the authority to review and approve all expenses/costs that may be reimbursed.

The issuance of a surface lease for the use of state lands may require the preparation and submittal of a full Environmental Impact Statement (EIS). Certain activities may be exempted or require a lesser Environmental Assessment (EA). Such activities may include: limited and temporary right of entry to conduct certain research and scientific activity; the appropriate determination would be made by DLNR. BLNR has on occasion issued conditional surface leases based upon preliminary approval of the proposed activity but these are subject to the fulfillment of various conditions specified by BLNR.

For geothermal, establishing site control is the key component for any development, because once a party has site control it can go directly to DLNR for the mining lease for developments on reserved land.

Use of State lands requires a public process, generally before BLNR. DLNR thus is a key agency, because they manage most of the State lands. However, certain State parcels are under the jurisdiction of other State agencies (e.g., DHHL). The issuance of a surface lease by BLNR for the use of State lands does not authorize the development or extraction of mineral resources under such lands. It is DLNR's current position that this provision regarding mineral resources also applies to State lands that may be controlled by another department such as DHHL.

Compatible utilization of State lands (e.g., for the same parcel) may be approved by the BLNR, such as the issuance of a surface lease for ranching and mining lease for geothermal energy production.

UNDERSTANDING AND MANAGING THE RESOURCE: DLNR is very interested in developing higher quality geothermal resource data for public use. In order to augment and enhance its current understanding and management of the resource, DLNR has provided approximately $400K to support Dr. Donald Thomas's new resource identification efforts. Project funding includes both DLNR and U.S. DOE funds (more details in next section).

DLNR acknowledged the need and importance of monitoring and managing the withdrawal of the resource to ensure that it is developed in a sustainable manner. DLNR is looking to expand its knowledge and management expertise in this area.

DETERMINING AND COLLECTING ROYALTIES: Another important function of the Engineering Division is to evaluate and recommend a geothermal royalty calculation methodology for approval and implementation by BLNR. Current administrative rules provide that 10-20% of the gross amount or value of the geothermal resource produced shall be paid to the state. The methodology presently adopted by BLNR is based upon the federal Mineral Management Services' approach using accepted formulas of revenue less allowable deductions patterned after federal mining leases and experience.

With respect to surface leases on state lands, BLNR has approved the issuance of such leases based upon the general promise of fair market value, which is determined by an independent appraisal.

Statutes require royalties to be collected by DLNR. DLNR retains 50% of the royalties and disburses 30% to the county in which the mining operations occur and 20% to the Office of Hawaiian Affairs. Each year, DLNR prepares a report on royalties collected for submittal to the Hawaii State Legislature. In October 2012 DLNR reported on FY 2011-2012, which ended on June 30, 2012:

> *During FY 2011-2012, a total of $3,096,947.77 in geothermal royalties was received from Puna Geothermal Venture (PGV). In accordance with statutory provisions, $929,084.33 (30%) was distributed to the County of Hawaii. Additionally, $619,389.55 (20%) was distributed to the Office of Hawaiian Affairs. Geothermal royalties for FY 2011-2012 were based on power production and sale of 342,707 megawatt hours to Hawaii Electric Light Company (HELCO) at an annual hourly average production of 28.8 megawatts. The Department of Land and Natural Resources (DLNR) expended $916,571.43 on geothermal resources management activities.*

DLNR noted that the annual funding derived from the state's share of the geothermal royalties is not exclusively dedicated to the department's geothermal program, and that in some years the collections would not be enough to support its geothermal program activities. To the extent that royalties exceed what is required for the department's geothermal management and regulatory activities, DLNR has statutory authority to expend such revenue in support of other environmental management programs under the jurisdiction of BLNR (e.g., forestry management, ocean resources protection, etc.)

BUILDING INTERNAL CAPACITY: DLNR expressed a strong desire to address the need for additional capacity to permit and regulate geothermal, given the plans for new geothermal development in Hawaii. For many years DLNR's dedicated geothermal staff has consisted of one individual technical staff member stationed in Hilo with responsibility for operational oversight, well drilling and monitoring, and permit compliance over PGV's activities. The agency has added four positions, all approved by the Legislature and are currently under recruitment. The main challenge for technical positions is finding and successfully recruiting candidates with the appropriate expertise and experience. Positions approved are: Geologist, Engineer, Planner and Secretary.

DLNR estimates that at the current authorized staffing and workload, an annual budget of about $700,000 is required. This need would be reassessed as more geothermal development occurs.

DLNR works closely with DBEDT's energy program staff and utilizes their technical expertise and knowledge, as needed. DLNR plans to maintain this current coordination to ensure appropriate integration of program efforts and resources.

3. *University of Hawaii, Center for the Study of Active Volcanoes*

RESPONSIBILITIES RELATED TO GEOTHERMAL: Dr. Donald Thomas of the Center for the Study of Active Volcanoes, University of Hawaii, is generally acknowledged to be the foremost local expert on geothermal resources. His commentary on the state of geothermal resource exploration and the status on industry interest were of high value to this assessment.

DIGITIZING INFORMATION AND PROVIDING PUBLIC ACCESS: In an important ongoing initiative, Dr. Thomas has been digitizing as many of the public record geothermal documents as are known and available. He estimates that over 400 documents had been digitized by mid-2012, and that the effort would be 80 to 85% complete by the end of 2012. This effort is being funded by the U.S. Department of Energy via the Arizona Geological Survey, as part of an effort that encompasses data being collected from all 50 states.

Besides information collected from the extensive studies during the 500 MW geothermal cable project in the 1980s and 1990s, the following sources of documents are included in Dr. Thomas's efforts:

- DLNR cache (includes all water well files that contain geophysical data of possible relevance; files include Maui, Hawaii Island, Lanai, Molokai, and Oahu)
- Dr. Thomas's personal cache of documents accumulated over the years
- DOH reports that contain water chemistry data that may be of interest
- The state library and state archives have been approached, but those sources have not yet been made accessible

There is also a simple bibliography that Dr. Thomas wants to see improved, and ultimately, to see that all files are assembled and accessible online. Documents are available at **http://scholarspace.manoa.hawaii.edu/** in the "Geothermal Collection" and **http://evols.library.manoa.hawaii.edu/** in "Geothermal." Even though the effort is not complete, the documents are being made accessible online as they are digitized to facilitate research and development interests.

There is great value to increased public access to such information. Dr. Thomas would like to set up a user-friendly access and search interface through existing funding, but needs expertise in order to do that. He envisions mapping well data, indicators, and geologic mapping reports. Dr. Thomas believes that the creation of such a database is an appropriate role for UH.

LIMITATIONS OF CURRENT RESOURCE INFORMATION: Dr. Thomas observed that the bulk of public opinion at present is based on the report prepared by the Geothermal Working Group and the 2005 GeothermEx Resource Assessment. He expressed strong reservations about drawing any conclusions about resource information and development potential from the latter document, which identifies thousands of megawatts of potentially developable geothermal. Conclusions in the 2005 GeothermEx Assessment are based on old and limited data from 1985 or earlier. These data were originally used by the state for subzone designations and it is difficult to use that information to extrapolate with any confidence for commercial development purposes today.

Dr. Thomas acknowledged that more updated and proprietary data has been obtained (by Ormat) for the KERZ, and estimates that the heat resource within the rift could, in theory, produce 500 MW or more of electrical energy if it could be extracted efficiently. Other sites are lacking information, which is the basis for his current work using U.S. DOE funding for resource assessment updates.

NEW EFFORTS TO UPDATE RESOURCE KNOWLEDGE: Dr. Thomas's current project, awarded by U.S. DOE through Recovery Act funding, focuses primarily on non-invasive resource exploration. The project is also co-funded by the State through DLNR and HNEI. The project utilizes a technique extensively researched and refined by scientists from Lawrence Berkeley National Laboratory and the University of California at Berkeley, with whom Dr. Thomas has partnered under the US DOE project. The technique is called magnetotellurics (MT); it is an electromagnetic geophysical method of imaging the electrical conductivity of the earth's subsurface (and indicating likely geothermal resources) by measuring variations of electrical and magnetic fields at ground level.

UH has mapped out a priority scheme for this non-invasive exploration. For Hawaii Island the Kilauea summit and the East rift are priorities, including the area around where previous scientific slim observation holes (SOH) had been drilled. SOH4 and SOH2 (two slim holes drilled in the 1980s) are of interest to him since there is subsurface geologic information available from those bores. (He is not as interested in the area near SOH1 because of its proximity to electrical generation facilities and transmission lines that can interfere with the MT data capture.)

The Hawaii Electric Light Company (HELCO) 50 MW Geothermal RFP may reflect an interest in or preference for geothermal development on the west side of Hawaii Island, so Hualalai and West Mauna Kea flank are of interest to him. Dr. Thomas will need permission to access land, which he is relying on the project's industrial partner, Avalor Energy, to handle. Avalor is also a technology partner, and will be producing a data visualization software product from the DOE project. All data will be made available through the National Geological database.

The project also envisions looking at the East Rift of Haleakala on Maui. Dr. Thomas believes that geologic indicators actually point to greater heat deposit potential on the East Rift of Haleakala than on southwest Haleakala where the subzone had been designated and where the current Ulupalakua effort is concentrated.

The current research program under the DOE funding is a two-year effort. Dr. Thomas has received additional state funding to allow him to expand the number areas to be surveyed beyond those that were initially planned with the DOE funding. If Dr. Thomas can secure additional funding, he would like to deploy a more advanced technique called audiomagnetotellurics, which uses higher radio frequencies to allow for a more active detection scheme. MT is more passive, and limited to shallower depths.

Dr. Thomas confirmed that a good future role for UH is to continue exploration research on behalf of the state including possibly drilling more slim holes to gain better data. He is also involved with the DOD Army project at Pohakuloa Training Area to explore water resources and may be able to acquire equipment capable of drilling slim holes from that project.

4. Department of Health, Indoor and Radiological (Noise and Radiation), Clean Air, Safe Drinking Water (Underground Injection Control), and Emergency Response Branches (DOH)

AGENCY RESPONSIBILITIES RELATED TO GEOTHERMAL: DOH has significant regulatory responsibilities in health and environment that touch geothermal exploration and development. The interview with DOH consisted of a round-table on current responsibilities and issues among the represented programs. It was organized and facilitated by the DOH Deputy Director for Environmental Health Gary Gill. In general the functions were represented in the meeting by persons who already have experience with geothermal permitting (Noise and Radiation, Clean Air, Underground Injection Control, and Emergency Response). There have been significant retirements within the branches affected, but DOH is well positioned to handle likely issues by the individuals represented as they have direct experience with geothermal. The main concern that was expressed was the likelihood of increased workload adding to already overtaxed employee responsibilities, rather than the need for additional technical expertise, but that was considered "par for the course." A copy of a letter DOH sent to the Hawaii County Council in summer 2012, summarizing DOH permits and regulations related to geothermal as well as PGV's history of permit compliance, is provided in Appendix H of this report.

NOISE AND AIR PERMITS: The Noise and Clean Air staff generally felt what was required for the first PGV plant will be the same as for any new development. What has changed since the time PGV was developed, is the promulgation of statewide noise standards that were enacted in 1996 in Chapter 11-46, Hawaii Administrative Rules (HAR). Limits to allowable noise levels including geothermal are now established by state law, according to land zoning classification. PGV is in agriculture, for which the limit at the property line is 70 dBA. If future development occurs in residential, conservation, preservation, public space, open space, or similar type lands, the limit would be lowered to 55 dBA during the day, and 45 at night (*Figure 5*) at the property line. DOH is involved in checking noise levels now since PGV is drilling again. Residents or citizens can call a DOH hot line if there are any concerns. DOH responds to complaints of noise after checking and follows up with calls to the complainants; the operation has not exceeded the permissible noise levels nor violated its noise permit.

Figure 5. Table of Sound Levels from HAR Chapter 11-46.

Table 1. Maximum permissible sounds levels in dBA.

Zoning Districts	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)
Class A	55	45
Class B	60	50
Class C	70	70

UNDERGROUND INJECTION CONTROL: The UIC regulatory program has not changed since the early PGV project. UIC has an EPA Region IX contact, since EPA did not fully delegate oversight of the program to DOH. Only two UIC permits have been issued, one to PGV and the other to the Lahaina Sewage Treatment Plant. DOH UIC has a capacity concern for staff, particularly on their role in permit issuance and monitoring. In the past, UIC drafted a permit for geothermal based on what they interpreted was needed to address community concerns. Opponents of geothermal were not satisfied with DOH's approach regarding the PGV UIC permit, and they appealed to EPA for more oversight. EPA then opted to issue the UIC permit, waiving delegation of permit authority to DOH. So DOH believes it possible that because of this precedent, EPA will continue to issue or weigh in on any future geothermal-related UIC permit.

CLEAN AIR: The Clean Air Branch believed that a future air permit would be handled in a similar way to the PGV air permit. The current permit requires that DOH have three monitoring stations in place. Three more are operated and monitored by PGV. The past permitting process was difficult for them because they received thousands of comments. They feel they have the technical ability to permit future development but it will take a lot of effort and staff time again. Clean Air has no real need for EPA involvement as permit issuance has been delegated to the State. If future development employs a closed loop system, it is likely that a minor source permit would suffice, mainly addressing fugitive emissions of H_2S. There might be some emissions related to drilling, and also pentane is used in the PGV process, but may not be used in a future project. Any public hearing is discretionary on the part of DOH.

EMERGENCY RESPONSE: The emergency response branch coordinates with Hawaii County Civil Defense. Their on-scene coordinator for future development will likely be the District Health Office (DHO) in Hilo, who will field calls, respond to complaints, and coordinate with emergency response if needed.

As to any emergency release situation due to a well blowout, there must be a response plan prepared. Any new modeling information for emissions will have to be studied by staff. This issue is not dissimilar to the community concern about vog. Clean Air would work with the County through the DHO in Hilo.

PGV is also covered under the risk management plans under the Clean Air Act. Again any public hearing on such a plan for the future is discretionary on DOH's part, but those hearings are likely to be heavily influenced by EPA.

DOH is not the designated first responder under any emergency response plan; the county fire department is the first responder. DOH provides technical assistance as needed.

UNDERSTANDING PERMITTING REQUIREMENTS: For any developer, one of the biggest roadblocks is an understanding of all of the permitting requirements affecting geothermal. Consultants can help, especially those who already understand DOH's requirements. Adequately addressing project risk also involves a significant amount of community outreach.

If the community needs health information it must be initiated by the appropriate public agency, and DOH would promptly respond to any such requests.

5. *Hawaii Public Utilities Commission (PUC), Commissioners and Senior Staff*

RESPONSIBILITIES RELATED TO GEOTHERMAL: The Hawaii Public Utilities Commission has the responsibility to review and approve utility procurements, including requests for proposals, power purchase agreements, negotiated power contracts, and plans related to grid-connected geothermal energy.

The discussion with the PUC covered a range of issues regarding geothermal development and the regulatory structure around geothermal.

PRICE AS A DRIVER OF GEOTHERMAL DEVELOPMENT: A concern was expressed over the very high prices for electricity on Hawaii Island. There would be interest in seeing whether geothermal could be developed in such a way that provides immediate cost reduction to consumers. For example, there is currently 22 MW left on the permit approving the PGV geothermal plant, and, if the resource could be developed for a relatively low cost under that permit, could such expansion provide near-term benefits to ratepayers? If we can move quickly and inexpensively to develop more geothermal on the current site, would that be considered a prudent path forward while we wait for other resource exploration efforts and development plans to catch up? These types of questions were raised for discussion purposes and should not be interpreted as the official position of the PUC. In any event the PUC is interested in any prudent alternative to provide long-term ratepayer benefits, and is interested in the approach that will be proposed by the electric utility and any private geothermal power producer, which ultimately they must approve.

HOW AND WHY TO FOSTER COMPETITION: Part of the open discussion focused on the idea of competition, and how to foster and view competition. Is competition the enemy of affordability — and speed — for near term development? Or is competition necessary to set up a viable geothermal industry for the long term? There would be significant value in doing it right, which would mean showing clear benefit to the community, giving people confidence that Hawaii can safely develop geothermal, and providing low cost energy that also results in rate relief and stabilization for neighbor island residents. Success with the first few geothermal projects could set the stage for future political and community support of geothermal development.

The idea of how to structure competition, and whether competitive bidding is meeting our needs with regard to this and other projects, was also discussed. This was raised in particular because of the recognition that PGV is so much farther along than other potential developers in addressing the two biggest hurdles to geothermal development: 1) understanding the resource, and 2) obtaining land position.

LOCATION, LOCATION, LOCATION: We also discussed how to weigh the risks of having the majority of geothermal generation in one location versus the value of multiple locations - i.e. on the West side of Hawaii Island, which would likely be a costlier resource to explore and ultimately develop.

RECOGNIZING THE UNIQUENESS OF THE GEOTHERMAL RESOURCE: Geothermal is a "different" resource — the risk and cost involved in even assessing whether there is a developable resource is immense. Utilities and regulators understand that the RFP process that is in place for wind, solar, biomass, and other renewable energy projects may have to be adjusted for geothermal, which is a wholly different type of resource that requires significantly more at-risk development capital. For example, if the utility were to select one developer based on competitive cost proposals, appropriate technology, and a capable team, it could prove problematic if the land the developer has rights to turns out not to have a sufficient geothermal resource. It could take years to come to that conclusion, and in the meantime we will have foreclosed other development opportunities. In that context, various RFP structures were discussed to consider the commission's and the consumer advocate's ability to analyze and approve non-traditional, more complex structures for geothermal. For example:

- A two-part RFP (one stage for the existing site and one for other new sites)
- A down-select process of selecting multiple credible participants and setting milestones that developers would have to achieve
- A phased approach under which different bidders would participate in different phases

The recently initiated utility IRP process might help set priorities and clear development goals and plans for geothermal, particularly in terms of how it relates to other renewable resources. One of the most important elements of this process is that there is a consistent message coming out of state leadership.

On the question of interfacing with HCEI, there was discussion that the HCEI roadmap and scenarios were meant to be evolving documents. This vision has been fairly clear/constant and has served us well, but we need an updated vision and plan that is consistent among today's policymakers and leaders. The PUC understood that DBEDT is undertaking an update of the HCEI scenario analysis to help inform that discussion.

LEARNING FROM OTHER MODELS: The PUC expressed interest in learning more about how other states and jurisdictions handle the uncertainty around geothermal resource exploration and development, and if there were helpful models that the PUC could use to inform their RFP and planning processes. One option that was raised was whether it would be beneficial for the public sector to help fund exploration efforts, in order to reduce the risk for developers and enhance the competitive landscape in the state.

6. Natural Energy Laboratory of Hawaii Authority (NELHA)

RESPONSIBILITIES RELATED TO GEOTHERMAL: NELHA leases a 4.4 acre site in Kapoho on Hawaii Island, adjacent to the PGV site. The property is owned by the state, and NELHA currently leases it from DLNR for no fee. As part of the lease, there is the agreement that the state will not use the site for commercial purposes. The Kapoho site is sub-leased by NELHA to PGV for $25,000 per year, a fee that has remained the same for several years. According to NELHA, the arrangement has no price adjustment mechanism. It is based on a previous Memorandum of Understanding. The use and long-term disposition of the property will be governed by exiting lease conditions. Any extension or change of use shall be subject to approval by BLNR.

PAST, PRESENT, AND FUTURE OF THE KAPOHO SITE: The Kapoho site was the source of the first geothermal test well, and hosted a 3 MW demonstration geothermal power plant, which was operated by HELCO for nearly a decade, despite its design life of three years. The site was later transferred to NELHA. The site has not been a top development priority for NELHA, which focuses its limited resources mainly on its Kona operations. At present, the organization employs four professional staff, including a chemist, engineer, operations manager, and a leasing/marketing/procurement specialist.

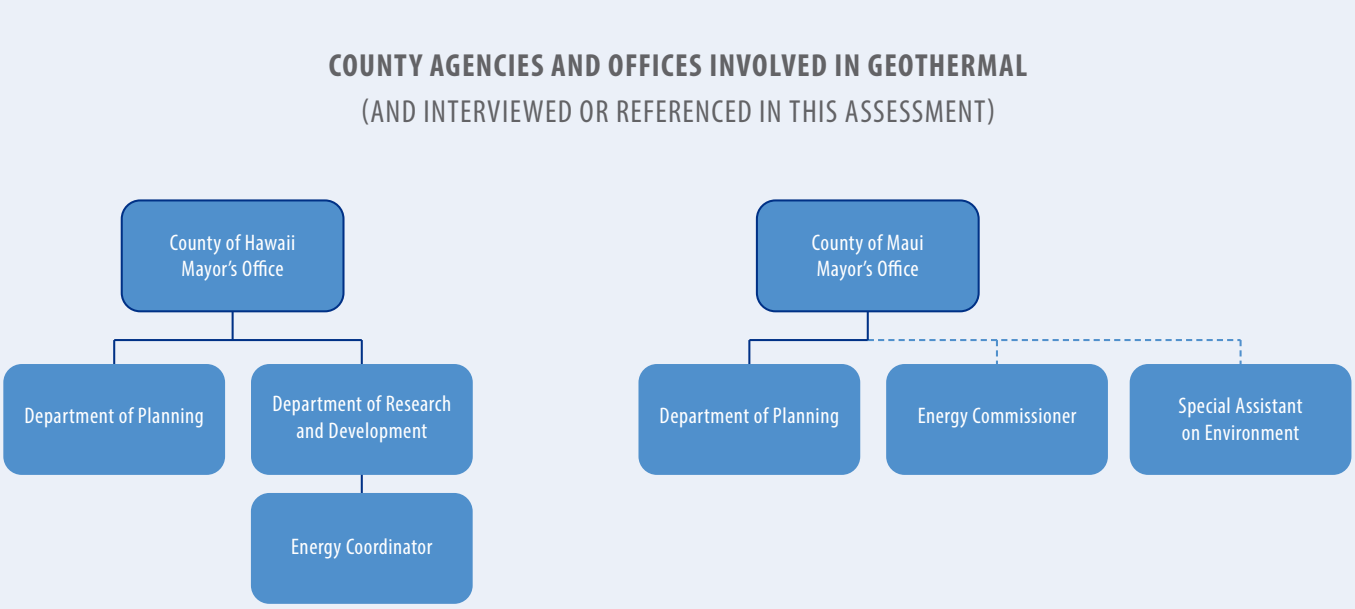
NELHA's current vision for the site is to use it to test new geothermal technologies (e.g., PowerTube), but they do not have the capacity to spend significant resources developing the site. One major question is whether new drilling or technology testing would be able to come under the existing EIS. One strategy for attracting technology testing would be to use a "Request for Information" similar to how NELHA handled a solicitation for Ocean Thermal Energy Conversion (OTEC) at the Keahole, Kona, site. In both instances, NELHA would be able to offer use of a valuable physical asset, but would not be able to contribute any financial equity for the project.

THE CONTEXT FOR GEOTHERMAL: NELHA knows that geothermal is a current priority for the Administration. Geothermal was a subject of discussion at a 2012 meeting of the Kona-Kohala Chamber of Commerce. The Governor stated that it is possible to develop thousands of megawatts of geothermal. The Mayor has said that he would like to see 100% renewable energy for Hawaii Island by 2015.

C. Interviews: County Agencies

Hawaii Island agencies that were interviewed included the Mayor, Departments of R&D (Energy Coordinator), and Planning. Maui County agencies included the Energy Commissioner and Mayor's Assistant for Environmental Concerns, along with the Planning Department.

Figure 6. County Agencies that Relate to Geothermal.



7. Hawaii County, Mayor's Office and Energy Coordinator

THE ROLE OF GEOTHERMAL IN THE FUTURE OF HAWAII ISLAND: The County has a goal to be 100% renewable by 2015.

The Mayor's office participated in a recent Hawaii Island delegation to the Philippines, and the participants came away with a very positive impression of geothermal potential and the economic development benefits it could provide to a community. The County believes that the current assessment work could be the "mortar" that holds development together, ensuring that there is alignment among Oahu, Maui and Hawaii. In our discussion, we heard that priority must go to meeting Big Island needs first before any earnest development of exporting geothermal via undersea cable is pursued.

The Mayor's office is being proactive regarding geothermal. They believe that leaders need to communicate the "why" and the vision for geothermal for Hawaii Island. They are currently constrained in their capacity to conduct meaningful energy planning for the island due to resource limitations and will seek help in the future.

8. Hawaii County, Department of Planning

The Planning Department recognizes that the County administration supports geothermal development. They understand that there is interest in possible development at Hualalai which is welcome, since they can anticipate public opposition for projects proposed in Puna.

PERMITTING CAPACITY: Planning Department leadership does not foresee any impediments with their ability to execute their permitting responsibilities. They understand the need in the county for baseload power.

Regarding the Geothermal Resources Permit, Hawaii County recognizes that there is some ambiguity in the wake of Act 97 (with the goal of removing barriers to geothermal development) language and is waiting to see how that might impact County processes. In the 2012 legislative session, Act 97 effectively removed the Geothermal Resources Permit (GRP), a well-established process, while removing the state subzone designation for geothermal. The Act therefore has raised some questions as to the validity of a County issuing Geothermal Resources Permits for future development.

PRICE IS THE MAJOR DRIVER: There is an open question as to whether and in what timeframe geothermal energy would lead to lower costs. Current experience with geothermal has resulted in questions regarding the disparity between the publicized cost of the recent PGV expansion at $0.08-0.10/kwh compared to the $0.40+ people pay for electricity on Hawaii Island. To provide real public benefit, future projects must show reduced cost. These are the types of comments they are hearing from their planning and permit public hearings.

Some people on Hawaii Island are feeling that Oahu needs to be taking care of its own needs with renewable energy, including reducing demand, though there is a recognition that we need to all work together. The vision of the future may include a cable, but we need to address local issues first. The vast majority of people view geothermal as superior to oil generated electricity – especially if people can see real savings in the near term.

They feel HELCO is good for the community and is doing a good job communicating with residents; HELCO has also been visible on the need for geothermal, which is positive.

VISIBLE BENEFITS: For geothermal to be viable and easier to permit, people must see more direct benefits. Since Hawaii Island is the area most impacted by geothermal development, the royalties collected should clearly benefit Hawaii Island. Benefits could also be tied more directly to the impacted areas. Overall, there should be a more transparent accounting of how state and county royalty funds are spent.

As a condition of its Geothermal Resources Permit, PGV contributes $50,000 per year to the Asset Fund. This fund is used only for contingency planning. The Relocation Fund, which is funded through the royalties, pays to relocate residents who meet certain criteria, which are discussed later in the report. Excess funds that are not needed for relocation can be used for repaving roads and other community benefit projects. Those funds are used for projects initiated by the Council District in Puna, and are approved by the planning director.

CULTURAL ISSUES: The Department discussed their concerns about the need to address cultural issues. They cannot explicitly regulate that, but developers must be aware of cultural sensitivities, as they invariably come up during permit hearings and proceedings, and if not handled competently, can pose major impediments to approval.

There may be specific cultural landscapes or locations that pose impediments. The Planning Department strongly suggests that cultural studies be done before any site is chosen, and they recommend that developers have respected cultural practitioners on the project team. For example, if a project is proposed in an area where native lineage has historical use, have those who understand concerns from that lineage advise the developers. The planning staff is able to handle the reviews and permitting from a technical and legal framework adequately, but cultural issues pose challenges for them and are best incorporated proactively on the developer side. Whether it's geothermal or telecommunications towers, informed cultural treatment using respected and knowledgeable advisors can help facilitate development.

The state can help by understanding how important this cultural aspect to development is, and can advise potential developers that it is cheaper to invest up front in cultural understanding and acceptance than fix it later through litigation.

9. *Maui County, Energy Commissioner, Special Assistant for the Environment, and Department of Planning*

The Mayor's office was represented by his advisors for energy and environment, and the discussion included a representative from the Planning Department. Maui County is new to dealing with many of the geothermal issues. In their view, Ormat is the only real prospect on Maui right now; much of the activity at the government level is directly related to the activities being pursued by that project developer.

GEOTHERMAL RESOURCES PERMIT AND COUNTY RULES: Regarding any potential complications resulting from Act 97, Maui County recognizes that there is some ambiguity but does not believe that Act 97 would remove the Geothermal Resources Permit or county permitting process.

In February 2012, Maui County approved rules for their Geothermal Resources Permit process. The rules attempt to combine the HRS requirements with existing county hearing rules. The key elements are mediation and discrete decision points. These processes are designed to avoid the courts and long, drawn-out processes to get to a mutually agreeable outcome in the event of any challenges.

The main driver to provide county-level rules, rather than just issue a generic permit and leave the HRS to govern the process, was developers and their consultants. Developers believe that a stable, predictable approval process through clear rules would be less objectionable or subject to reversal later on, as could happen in the absence of rules.

GEOTHERMAL AS PART OF MAUI'S FUTURE: The Mayor is supportive of geothermal and is interested in positioning Maui as a hub for a future cable system that could link the Hawaiian Island electrical grids. The Mayor's openness to the cable is based on the recognition that the cable can enable Maui as a hub for renewable energy development, benefiting the Maui economy and providing high-skill jobs.

Currently on Maui, the utility has control over what comes onto the system and what resources are pursued. The publicly announced intent by MECO to issue a 50 MW RFP for firm renewable generation has been in discussion for years, and may be revised or downsized. It was supposed to be issued in December 2012, but it may be delayed again. [*Note: as of September 2012, MECO announced intent to issue a draft renewable energy RFP in the first quarter of 2013. According to MECO, the RFP would seek one increment of up to 30 MW of firm capacity in the 2019 timeframe.*]

There is some feeling that a more free market approach, where MECO only operated the transmission system and generation would not be owned by MECO, might provide a better energy outcome for the county. A significant concern is there is not enough room on the grid for all the good projects, and geothermal would crowd out waste to energy or biomass, or vice versa. A question was raised whether it would be preferable to go to a more distributed energy generation system. The Maui peak load is down to 197 MW due to the recession, distributed generation, and successful energy efficiency efforts.

The County felt that the State should better articulate the fact that many cables already interconnect the islands, and that inter-island power is not that different from inter-island travel and inter-island communications. The state needs to articulate that we are all part of Hawaii rather than individual "tribes" on different islands. Rather than have the other islands turn against Oahu, it would make sense to show that it is not Oahu profiting from the status quo, but rather Saudi Arabia, Indonesia, and Big Oil.

COMMUNITY ACCEPTANCE AND BENEFITS: Environmental concerns have been limited so far on Maui. The environmental community is generally optimistic that geothermal will provide viable renewable firm power. One or two people feel that Ormat should have moved more quickly with public outreach, but most people are not upset with the process thus far. Most of the comments on the rulemaking were positive (in favor of the rules) and only one person raised concerns at the Maui Planning Commission. The Kula Community Plan is the only one that mentions geothermal, and the language in that plan suggests that the project should avoid adverse impacts on surrounding areas. Maui is watching what is happening with opposition on the Big Island with interest. There was some trepidation that those who actively oppose geothermal on the Big Island would start to organize opposition efforts on Maui.

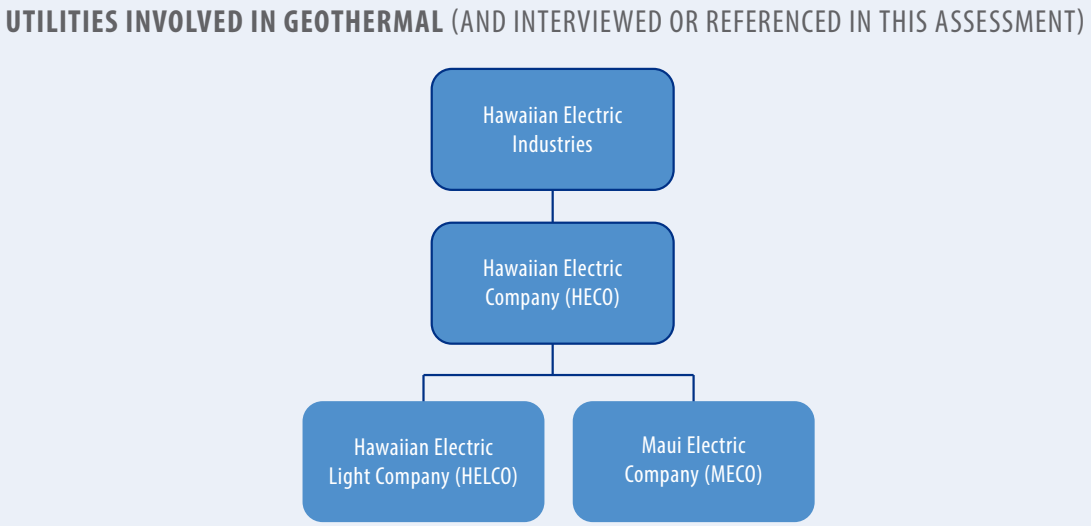
The proposed footprint of about ten acres would actually be less impactful (on view) than wind, and Maui has already gotten used to and even embraced wind.

PRICE AS A DRIVER: Concern about energy prices is growing, and becoming more of a topic of discussion within government and communities. Cost stabilization is a significant driver and goal. People generally want more renewable energy but do not yet see the direct price benefits of renewable energy on their bills, largely as a result of a legacy contracting system that based contracts on the avoided cost of oil. New renewable energy contracts are not structured in this way, and thus should return greater and more transparent savings to ratepayers.

D. Interviews: Electric Utilities

Interviews with electric utility companies are included in this section. While they are private companies, their business is largely driven by regulatory decisions made by a state agency, the Hawaii Public Utilities Commission. Interviews included the three investor-owned utilities that are involved in geothermal development: Hawaiian Electric Company (HECO) on Oahu, Hawaii Electric Light Company (HELCO) on Hawaii Island, and Maui Electric Company (MECO) on Maui.

Figure 7. Hawaii Utility Companies Involved in Geothermal.



10. Hawaiian Electric Company (HECO)

HECO envisions the state government taking a lead role in future geothermal development. In particular, this includes finding resources, promoting development of resources, and facilitating development on state lands.

PREPARING FOR THE RFP FOR HELCO: In 2011, HECO issued a request for information (RFI) to explore the possibility of adding more geothermal energy to the HELCO system on Hawaii Island. The intent on Hawaii Island is to displace existing assets, namely oil fired units. HECO received about twenty responses to the RFI, ranging from serious to somewhat less serious and offering comments and suggestions. The respondents included a number of prospective geothermal developers. The utility received enough positive input to judge they could successfully issue a request for proposals (RFP).

The utility's website (**www.HECO.com**) has copies of the applicable documents. On March 16, 2012, the utility sent the PUC a request letter for approval to proceed with an RFP. They are proposing an independent observer for the RFP process to ensure objectivity.

The HELCO RFP will follow the existing competitive framework established by the PUC for new resources and generation. However, this process for geothermal generation must be realistic and recognize the development peculiarities of geothermal and its potential developers. HECO anticipates a draft RFP being developed by June and a final being issued by the end of 2012. HECO would like some guidance (and a decision) on cost deferral from the PUC for running the RFP process. They must expend funds to run the RFP and they do not wish to carry the costs indefinitely. A decision allowing them to recover the costs in a timely manner is desired, and not deferred until the resource is acquired.

The structure of the RFP is still to be determined. For example, the utility may select a few developers and get to a term sheet for each without a formal PPA. This is driven by the recognition of the extended development timetable for geothermal, resource identification needs, and the time to obtain surface leases, mining leases, and secure permitting. In the interest of competition, the timeframe and contract awards may have to be extended.

They are therefore not close to choosing a firm service date for geothermal. The utility could offer multiple contracts to different developers, recognizing that the developers' timeframes for development might vary.

They suggested that the PUC must understand that the geothermal RFP may need to be developed in a unique way, and it may not look like a conventional RFP. HECO expressed some concern that the Consumer Advocate and PUC staff may struggle to deal with this.

ADDING GEOTHERMAL TO THE MECO SYSTEM: MECO seeks near term, firm, fully dispatchable renewable energy in two 25 MW increments. This is for renewable energy resources in general, and not exclusive to geothermal — unlike HELCO. For MECO, geothermal can qualify and bid in, but must meet their criteria. MECO is driven by anticipated capacity need driven by future demand needs and changes in the generation mix, unlike HELCO which is driven mainly by the desire to reduce costs.

PRICE AS THE MAIN DRIVER: It was noted that HELCO does not need additional firm generation, nor does it need additional capacity. The desire to acquire geothermal is driven by an attempt to achieve lower electricity prices on the Big Island. HELCO also needs the new geothermal plant's performance to complement their fossil based assets; 50 MW is viewed as the upper limit that can be achieved through displacing existing assets while maintaining system reliability.

PLANNING FOR THE FUTURE: HECO's upcoming integrated resources planning process will be important. They will be doing a joint three company IRP. Geothermal on the Big Island and Maui can roll up collectively with other renewable energy on neighbor islands to allow HECO companies to meet the RPS. HECO believes that public education will remain a big need for geothermal to succeed.

11. Hawaii Electric Light Company (HELCO)

PRICE AS THE MAIN DRIVER: For HELCO, the key driver for adding geothermal is the expectation that it could lower electricity costs on Hawaii Island. However, it is important to create realistic expectations, and combat the notion that geothermal will be very cheap. People think it can be developed for $0.10/kWh or less, but that is unlikely to be the case. Managing expectations about the cost of geothermal and its potential impact on rates is crucial.

The major community benefit is expected to come from lower cost energy. Community benefits packages and royalties may be more attractive to local communities, but would result in a higher bid price — potentially eroding the main community benefit.

DESIGNING THE RFP PROCESS: HELCO believes that a RFP is preferable to dealing with individual negotiations, specifically in the area of geothermal, which is technically and developmentally complex. The RFI has helped provide industry perspective and input. Before the RFI, the utility believed that the government should partner with the utility to get updated resource information. Now, based on the feedback from the RFI, the utility understands that the developers want the full opportunity to identify and develop the geothermal resource privately, as this would be important from a competition perspective.

The key with the RFP will be how to make early selections without the resource being fully characterized. It is possible that the development and progress will have to be done in phases, or perhaps the utility will select a small group of qualified firms to explore the resource and have the opportunity to produce power at a later date. It may take two years to demonstrate the viability of the resource; geothermal is very different from solar and wind in terms of resource identification.

There is some uncertainty about whether the 50 MW of geothermal can replace oil fired power plants in terms of the desired technical capabilities. The RFP will set out the requirements and it will be up to the industry to meet them. Once a draft RFP is filed with the PUC, a technical conference and revisions would follow.

LESSONS LEARNED FROM THE PGV EXPANSION: HELCO shared some lessons learned from the PGV load following contract in the recent expansion to add 8 MW to the Puna plant. The ability to provide ancillary services, e.g., load following, comes from secondary heat extraction, and not from direct conversion. This is different than the technical approach with a new plant, since it is felt that would be too expensive to do with a new plant.

LOCATION PREFERENCE: HELCO is open to development on the west or the east side of the island, but the west potentially has more value because such a site coincides with location of higher demand, reduced transmission line losses, avoided transmission and distribution costs, and risk mitigation compared to a project sited wholly at the KERZ.

INTEGRATING GEOTHERMAL INTO THE SYSTEM: HELCO accompanied the Mayor's delegation to Ormoc City in the Philippines. One question HELCO had for the Philippines that was not answered is: how was the technical transition made from providing geothermal for one island to sending the electricity off island. How does the system get maintained in the meantime?

The utility believes that it has been pretty well aligned with the PUC. One area where there may be differences is in how to manage the system. Traditionally, the utility has a reputation for being very conservative, protectionist of power plants, and protective of the status quo business model. The PUC appears frustrated that the utility has not done enough to reduce costs. HELCO believes that it has been running lean, but now has huge needs to install new technologies and do new things (e.g., interconnect solar) that require internal capacity and investment.

FITTING INTO THE UTILITY BUSINESS MODEL: One challenge with geothermal is there is nothing in it for the shareholders (under the current regulatory model). It would be better if there were a way to extract shareholder benefit from renewable energy contracts, to give the utility the incentive to develop more alternative resources. The current decoupling mechanism does not address this matter.

The utility does not want to develop its own plant, but would be very open to acquisition if the plant were de-risked by initial private investment and after a period of successful operations. After such a period, there may be confidence that the risk profile matches the utility business model. Geothermal is still important for shareholders, though, because high prices make for customer unhappiness, and that is ultimately a significant problem for shareholders.

COORDINATED PLANNING: The IRP process has been delayed for too long a time. A master plan for electricity generation is sorely needed, largely to communicate the grander plan to the PUC and show how things fit in. Internally, the utility is looking at biomass and geothermal to provide firm generation and manage electricity rates. In 2011, HELCO was 41% renewable, as geothermal and wind both had strong years.

In terms of the potential of a cable, the focus right now is to prove to people that we can do 50 MW first. It is best to prove the first steps first, rather than to talk big from the start. However, HELCO does acknowledge that state policymakers and planners need to think big and do what is best for the whole state for the long-term.

The utility feels that better communication could definitely help, especially when it comes to the fine points of the laws and regulations. The lack of communication is clearly evident in some areas, such as the county stepping in at community meetings and with pursuing subsequent mitigation funding without consulting State DOH.

12. Maui Electric Company (MECO)

DESIGNING THE RFP PROCESS: MECO confirmed that they are planning to issue a 50 MW firm renewable energy RFP. The timetable anticipates the first 25 MW increment in the next couple of years, driven by the need to address expiration of the Hawaiian Commercial and Sugar (HC&S) biomass contract. MECO expects 2015 to be the service date for the first increment, with the second 25 MW increment to follow. They would like to enter into "fixed rate" contracts.

[*Note: as of September 2012, MECO announced intent to issue a draft renewable energy RFP in the first quarter of 2013. The RFP would seek one increment of up to 30 MW of firm capacity in the 2019 timeframe*.]

Their view is that MECO can bid into these contractual RFPs as well, with the process overseen by the PUC and their independent observer. Because of a firewall that is needed, HECO is expected to decide on the bidder, but MECO will be involved in some way in the evaluation of bidders as well.

MECO's RFP will seek renewable energy providers that meet certain priority criteria. Two examples of such attributes specifically mentioned included: 1) contribute to reduction and/or stabilization of electricity prices, 2) ensure that any new renewable energy acquired increases the reliability of the MECO system.

Any geothermal project could bid into Maui's firm RFP as well, so long as the project meets the parameters established by the utility and approved by the PUC.

MECO believes that any Maui geothermal project can learn from the community concerns encountered on Hawaii Island and with HELCO. In particular, developers need to engage directly with the community. MECO believes that the utility can support any development initiative that covers education and outreach, but is not in a position to take the lead.

THE ROLE OF THE STATE IN FACILITATING GEOTHERMAL: The state needs to understand that the risk profile for geothermal is unique. Given the uncertainty and risk around geothermal drilling, it would be helpful to get more state support for expediting the process and permits required to obtain geothermal energy. The state needs to make the process "developer friendly," and PUC approval must be obtained more quickly.

There needs to be articulation of an overall energy plan for the state, and MECO believes that a portfolio approach has significant value for the state and its residents.

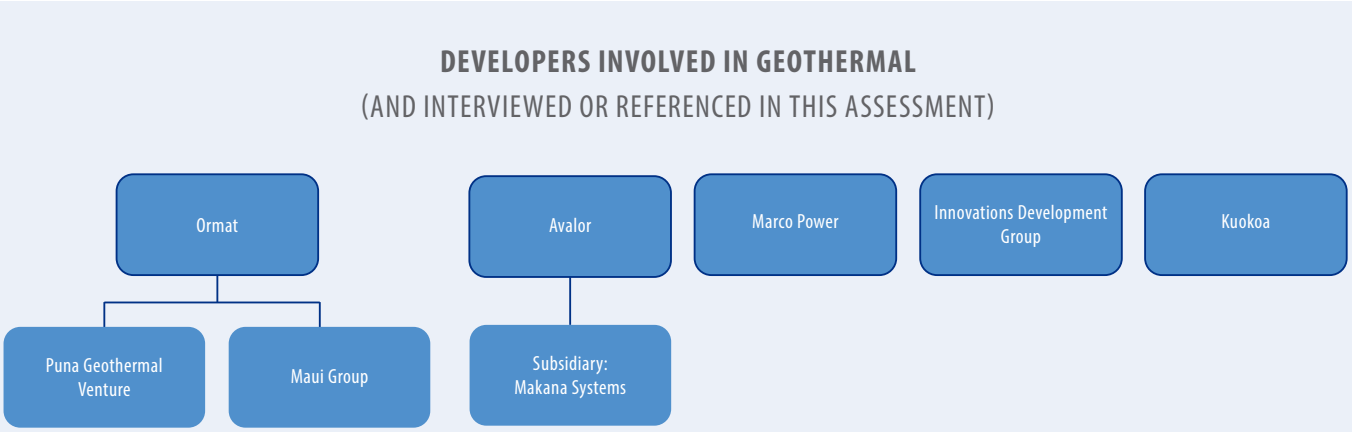
IV. TODAY'S BASELINE: INDUSTRY AND OTHER STAKEHOLDER INTEREST

The interviews in this section were mainly conducted in April, May, and June 2012, with some follow-up interviews throughout the summer of 2012. The interview summaries represent portions of conversations we had with the parties interviewed, but are not official statements nor are they representative of views of other than the interviewees. The content does not necessarily reflect the views of the consultants compiling the information. The intent of this report is to provide valuable information for those interested in geothermal, and not to define official organizational positions related to geothermal or energy development in Hawaii.

This section describes interviews with potential developers of geothermal energy, landowners, federal agencies (U.S. Department of Energy and U.S. Department of Defense), and business and trade organizations. The selection of firms and organizations interviewed was based on discussions with the State of Hawaii, UH, and in some cases, from recommendations from other interviewees as this process was conducted.

A. Interviews: Potential Geothermal Developers

Figure 8. Geothermal Development Companies Active in Hawaii.



13. Ormat, Puna Geothermal Venture (PGV)

Puna Geothermal Venture's 38 MW geothermal facility in Puna is the only operating geothermal electricity plant in Hawaii. It has been in operation for almost two decades. In this wide ranging interview a number of topics informative to the future of geothermal energy were raised and discussed.

PROVIDING COMMUNITY BENEFIT: PGV pays royalties to DLNR, OHA, and Hawaii County. In addition, the PGV operating permit requires that the project contribute to two community benefit funds.

PGV described the Relocation Fund that was set up by the County to address nearby residents who can demonstrate they have been negatively affected by the project. To date there have been only a few approved residences relocated under the Relocation Fund. Under the fund criteria, people need to demonstrate three things to claim relocation funds: 1) Building permit started before PGV permit was issued, 2) Be within one mile of the facility, and 3) Want to relocate. [*Note: there have been some recent efforts to change these criteria and to allow people who built homes after the PGV plant was constructed to also claim relocation funds.*]

The second fund is the Asset Fund. This fund was a condition of the Geothermal Resources Permit (GRP), issued by the County of Hawaii, and the estimated fund balance is now around $2 M, little of which has been spent. (*See also discussion of these funds above in the interview with the County of Hawaii Department of Planning*.)

PGV EXPANSION POSSIBILITIES: PGV completed an 8 MW facility expansion addition that went into commercial operation on March 19, 2012. The 8 MW expansion did not require new transmission lines or infrastructure; just some new transformers. HELCO has control of the daily technical operations of the plant and automatic generation control. If there is a problem at the plant, PGV is notified and can resume control of the plant to fix the issue. The expectation for the 8 MW expansion plant is to provide the same grid services as HELCO's oil plants, and PGV believes that this is the first geothermal plant with such capabilities in the world. The actual capacity of the current plant is 34.6 MW (defined as the minimum production over a 24 hour period. The maximum production was somewhat more). The HELCO RFI of 2011 made it clear that HELCO is looking for additional dispatchable geothermal generation.

PGV's current state and county permits allow them to expand to 60 MW; PGV could develop the additional capacity anywhere on the 800+ acre leasehold interest that they control. PGV is interested in possible expansion at that level. PGV would need to amend the existing permit in order to develop more than 60 MW.

PGV estimates that 100-200 MW of geothermal would be possible on its current leased land parcel. More will be known in mid-2012, when drilling of a new well at a site somewhat away from the current field is completed. The well is being drilled on a nearby hill, and this location could also provide information about a potential future plant site. The purpose of the new well is backup and supplement for the current operation, but it will provide valuable resource information as well. In 2005, PGV drilled into the magma and found good heat, which is the current backup plan for the new well.

HELCO says that it wants new geothermal development to be on the west side, but the utility is also doing a transmission and distribution study to determine what upgrades would be needed if all 50 MW is obtained from the East Rift zone. Also, if HELCO ends up retiring some of the oil-fired units, they would most likely be on the east side of the island. So it would appear that HELCO is not fixed on a west side location for geothermal. Ormat is looking for land on the west side and talking to large landowners, but so far they are not able to disclose any information about land position.

CURRENT AND FUTURE PERMITS: The state (DLNR) permit allows up to 30 active wells on the PGV site. Once the new well is done, PGV will have ten active wells (six production, four injection). In PGV's estimation, 30 wells would be enough to develop 60 MW. *[Note that plugged wells do not count toward the total.]*

Their limitation on underground injection control wells allows only five wells under the current permit.

The air permit is also an important consideration. Geothermal requires a NSP (non-covered source permit). Key concerns are H_2S and noise, which DOH monitors continuously. DLNR and DOH are both very knowledgeable and have been excellent resources for PGV throughout the course of development.

PGV sees the established Geothermal Resources Permit (GRP) administrative process as less politically risky than a process that could include the County Council. For example, in the County of Hawaii the Hawaii County Council has influence over the Asset Fund and Relocation Fund, but the GRP is in the purview of the Hawaii County Planning Commission – a body that is viewed as less politically risky.

PGV CONTRACTS: PGV is open to looking at different contract structures with HELCO. They could conceive of a fixed price contract model. They are also concerned about very high electricity costs on Hawaii Island and want to do their share to control those costs as long as it makes business sense for them.

They expressed a strong desire to help solve the Hawaii Island electricity cost problem, calling it urgent. Solutions are needed now, and geothermal can be part of the solution.

NEED FOR EDUCATION AND OUTREACH: It would be helpful to have somebody at DBEDT dedicated to geothermal, but this is not viewed as critical for Ormat. In the early days, DBEDT's role was essential. PGV now feels their approach and knowledge is mature. However, if significant expansion is contemplated, then it would be appropriate for DBEDT to ramp up its advocacy activities. It would be helpful to have more clarity within DBEDT regarding who is doing what and the various roles. One significant need DBEDT could fill would be education and outreach.

PGV expressed a strong view about the need for outreach and education. For example, there are issues arising now with statewide vs. Hawaii Island geothermal use. There is a misperception in the community about development plans. When there is talk about thousands of megawatts of geothermal without a clear articulation of how we might get there, it causes alarm about the scale and speed of geothermal development.

OPPORTUNITIES ON MAUI (more below from the direct discussions with Ormat's Maui development team): MECO is looking for firm renewable (not necessarily geothermal) generation to come online in the next 5-10 years. Ormat has land position on Ulupalakua Ranch through a long-term lease, and they have a person on the ground there. They secured the lease in 2007 and have been doing extensive community outreach since that time.

In addition, Ormat has been helping get Geothermal Resources Permit (GRP) rules established in Maui County. GRP rules are in place as of the first quarter of 2012, and Ormat has started the preliminary EIS for exploration. Ormat is now relatively comfortable with the new permitting scheme, including the GRP going through the Maui Planning Commission.

Ormat was awarded DOE Recovery Act funding for exploration; the $5 M award includes funding for surface exploration as well as funding to drill an exploratory slim hole on Maui. The grant includes a partnership with NREL.

Ormat's approach would be to take care of individual islands first. The company's priority is to develop geothermal energy for on-island use before serving future inter-island needs.

14. Ormat, Maui Project Development Team

OPPORTUNITIES ON MAUI: Ormat employs consultants on the island of Maui to explore the possibility of developing geothermal energy there. Right now, the team is in an exploration phase to determine whether there is a commercially developable resource.

Ormat is working on private land rather than public land because they don't have as many development rights there, and there is also more uncertainty to the process of leasing public land. Ormat is not excluding public lands, but wants to keep the site control process simple. DLNR has limited resources to deal fully with the mining leases as well as the public lands process.

The State should ensure that the GRP process remains intact, especially in the wake of Act 97. The GRP was a well-understood process that eliminated the contested case by laying out a process in which parties had to go directly to mediation and then direct appeal to the court of appeals. This reduced uncertainty for developers, as contested cases can be long and drawn out, complicating uncertainties for project planning and execution.

ENVIRONMENTAL REVIEW FOR GEOTHERMAL: At present Ormat is helping the state and county figure out the processes for mining leases, permitting, and other requirements. The permitting questions for exploratory work that OEQC has been considering are important. Currently, the process for environmental review is the same whether you're looking for a resource or developing a plant. It would be good for DBEDT and DLNR to be able to successfully make the case that slim hole drilling can also be included in the EIS exemption, since it is difficult to create a meaningful EIS when the extent of the resource is as yet unknown.

Ormat issued an Environmental Impact Statement Preparation Notice (EISPN) for exploration on Maui's Ulupalakua Ranch, and received comments back on the EISPN in April 2012. The EISPN covers exploratory work, including slim holes, but no commercial development. So far, the EIS input shows the need for the state to do education and outreach, for example, quantifying and communicating the benefits of geothermal and renewable energy development.

Ormat's non-invasive work on Maui is already done, and the company is looking for test well sites on Ulupalakua to confirm and refine non-invasive work. Ormat's Maui exploration work requires that the first hole be drilled by 2013 or 2014.

NEED FOR EDUCATION AND OUTREACH: At the community meetings, the main driver for the public is concern over electricity costs. Since this is a PUC rather than a developer issue, the developer and landowner have limited tools and information to address concerns in this area. It is really the role of the state to be leading that discussion, so high quality information is coming from credible sources. The state also needs one clear message from the Administration about aspirations for geothermal.

For Ulupalakua, the main community stakeholders to work with include the Kula, Kihei, and Wailea community associations, the Hawaiian community (Native Hawaiian chamber, Kupuna groups), the environmental community (Maui Tomorrow, Sierra Club), and the Chamber of Commerce. Ulupalakua Ranch's experience with wind development also provides useful information for that community and how developers should approach community involvement.

15. Avalor Energy

TEAM AND CAPABILITIES: Avalor Energy is interested in geothermal development in Hawaii. Avalor Energy has created a subsidiary, Makana Systems, for its current development work. The company's plan is to develop a subsidiary for each subsequent geothermal plant that it develops. Avalor is partnered with Geoglobal Energy LLC, which has developed 4000 MW of geothermal and derives much of its expertise from the former UNOCAL geothermal group. They have previous development experience in New Zealand, which could be relevant for Hawaii developments. They have added experienced board members including former executives at the local utility, and AES Corporation. This talent brings project development and finance expertise to Avalor.

CURRENT ACTIVITIES: Avalor is currently involved with the DOE-funded project in coordination with Dr. Donald Thomas at UH to conduct geophysical survey work at Mauna Kea summit, Kilauea, the Kilauea East Rift zone, Haleakala, and other sites as funding allows. Previous core samples will be correlated to computational results to validate the modeling techniques that should lead to more robust knowledge about potential developable resources. Avalor's subsidiary, Makana Systems, is submitting a proposal to ARPA-E for high-temperature materials research with UH and a national lab that will be focused on energy production close to or within the magma layer. This is possible because of significant advancements in materials science. Makana Systems' R&D efforts are designed to support eventual commercial operations.

SECURING LAND FOR GEOTHERMAL DEVELOPMENT: Avalor's key priority at present is securing land position. The company is in the process of identifying land resources to support a 50 MW plant for the HELCO RFP. The HELCO and Maui RFPs form the basis for their commercialization plans and timetable. They have encountered misinformation in the community, and resultant unrealistic expectations, as one barrier in coming to favorable terms with potential landowners. Some of these include discussion on royalties and community benefits programs, and expected levelized cost of energy from geothermal production.

Avalor is approaching private landowners, but has concerns about working with the state as a landowner. In particular, there is a concern about making an investment for resource assessment on state lands only to lose out on any future competitive lease bid.

The company's communications with the electric utility indicate a strong desire for competitors for geothermal proposals.

FINANCING A COMMERCIAL PLANT: Avalor does not see project financing as a significant barrier because of the caliber of the partners on their team. Boilerplate commercial lease terms will be an important ingredient for securing plant financing. A 25 MW plant would cost $160-180 M; a 50 MW plant $330 M. Right now, Avalor is focused on characterizing the Hawaii and Maui resources; the company is not yet looking toward an inter-island cable in its development plans. The company's view is that the initial focus should be on resource development to first satisfy local needs as more definitive experience is gained with the resource and technology development. In the meantime, they are seeking working capital to support the development efforts. Their current development efforts are largely self-funded with some government R&D support.

They offered the following needs and recommendations:

- Education of the community is needed regarding what is required for a geothermal power plant. Avalor supports investments in local capacity building
- On the environmental side, waivers for geophysical exploration — which would come before any commercial production – would be very helpful to reduce risk and therefore cost of future production
- A lower royalty structure (<10%) is needed to lower the ultimate cost for the consumer. They mentioned that western U.S. states and AK were looking at a reduced royalty structure (AK royalty is tiered 1.75% first 10 years; 3% thereafter) in order to stimulate development
- The views of state agencies regarding use of their land (e.g., OHA) are not well known
- The ability to either directly negotiate with state agencies regarding land use, or a mechanism to account for money spent and work done on geothermal resource in the state's competitive bidding process for land rights, would facilitate fair and efficient land allocation

16. Marco Power

TEAM AND APPROACH: Principals of Marco Power were involved with Hawaii geothermal project development two decades ago. Marco Power has an alliance-based platform; the philosophy is to build strategic partnerships for key areas, such as technology and finance. For example, in Indonesia Marco Power worked with a Japanese company to help finance a geothermal project.

Marco Power's approach is informed by the principal's experience in Hawaii in the 1980s and 1990s related to Puna Geothermal Venture. PGV was formed by an alliance of three companies, so the new development could use a similar model.

STATE POLICIES AFFECT FINANCING: One of the key messages conveyed by Marco Power was to ensure that the state understands that there is a globally competitive marketplace for financing. Even large players with substantial balance sheets need to make the case to Wall Street to invest in Hawaii. This relates to planning and permitting. If the regulations are too cumbersome / unclear / in flux, financiers may go somewhere else where it is easier to plan and execute projects. This will impact the competitive landscape and the ability to see low-cost projects proposed in Hawaii

Simpler regulations are better, and it is helpful to have a lead agency for permitting, and a coordinated permitting process.

The size of the project and the size of investment need to be attractive. Larger projects and larger venues for business opportunity will lead to more interest. Future opportunities will also weigh on any development team's appetite for a Hawaii project.

From a Wall Street perspective, the overall plan must be clear. It is easier to get development capital for larger, integrated, aggregated energy projects that are part of a clear public policy effort. For example, Indonesia has an economic development group that has the responsibility to assist, then regulate geothermal. They are also facilitating funding for exploration, which is a major barrier for development.

An overall plan for energy is needed, with geothermal as one element. The plan could describe that DBEDT will do X, DLNR will do Y, DOH will do Z, etc. The state could also include a timetable that can help make projects happen. A comprehensive state energy plan would serve to manage the time uncertainty by simplifying processes and articulating deadlines for decisions by the utility, agencies, and others.

Developers want to follow the state plan, not lead it. A policy statement at the Hawaii Governor level to support geothermal and the energy plan could help. But, there is recognition that the state/county/community relationships are also complicated. Hawaii has some potential to clarify the overall game plan in the IRP effort.

ENABLING EXPLORATION: The state needs to recognize that a different set of regulations for exploration might be needed, and have a better comprehension of what exploration actually means. Banks expect a great deal more exploration and proof of the resource before coming in with debt financing for a specific project. In the past, developers could drill to confirm 25% of a resource to obtain project financing. Now, they need more exploration or at least to split it into two phases: 1) discovery (25%) and 2) confirmation (50-75%) before lenders will provide debt. Lenders have had bad experiences where they provided debt and the resource is not there (e.g., Nevada project DOE was involved in).

How could the state encourage or enable exploration? Following the examples from Indonesia and the Philippines, 1) the state could fund some exploration, and 2) the PUC could provide a mechanism for exploratory costs to be recovered if the resource is developed. The state needs to decide and articulate what exploration costs could be covered if the project moves forward.

The state would benefit from greater transparency about where the royalty money goes. One option is for royalty money to co-fund or underwrite slim holes or other exploration.

SECURING LAND: Marco Power has spoken to major landowners on Hawaii Island. These landowners are looking for developers to show them where and how to look for geothermal resources. Landowners are also waiting for the state to declare its game plan and overall policy on geothermal.

The state should “raise the bar” on local geothermal companies, and should not be locked into past patterns of resource development and technology.

COMMUNITY EDUCATION: Marco Power met with DOH, and found them friendly and receptive. However, there are concerns about the health questions emerging at the community level around development plans. The question was raised: who is in the best position to articulate facts? State attention is needed to address information and education needs.

17. Innovations Development Group (IDG)

IDG is a Native Hawaiian-owned and -operated geothermal development company. Our interview with IDG covered topics ranging from state policy to the history of geothermal to international geothermal development models.

ENGAGING WITH STATE PLANNING EFFORTS: In terms of state policy, IDG noted the absence of a "geothermal framework" or any working groups devoted to the process. They expressed a sense of frustration that the broader energy planning efforts are not open to a wide range of stakeholders, and that geothermal is always represented by incumbent players, rather than a broader cross-section of potential industry entrants. IDG suggested a broad Hawaii Energy Policy Conference to hear and integrate input from stakeholders from across the state.

NEW ZEALAND MODEL OF NATIVE BENEFIT: IDG has been active in geothermal development in New Zealand since 2007, and shared some lessons learned and different models from that experience. For example, in NZ each generator has a right to distribute electricity and there is a spot market for small producers. The government is the grid operator. In contrast, in Hawaii access to market is a huge problem.

Regarding responsible development of geothermal, IDG stressed that the resources in Hawaii, like in NZ, are connected to the host culture. In NZ the Maori own the resource, and this has been established by treaty. The issue with previous geothermal development was a lack of consultation with the community and lack of protocols to ensure buy-in and distribution of benefits. The Maori experience in NZ has shown a path forward that addresses these challenges.

IDG was involved in two geothermal projects in New Zealand, both of which are currently underway. In one, IDG has significant equity. This project will start at 15-20 MW, then expand to 50 MW, and possibly to 100 MW. In the other, IDG serves the role of cultural and developer consultants.

The key paradigm shift that they see is the change from a lease model to taking equity positions, which provides more value to host communities. The country of New Zealand was set up based on a native treaty in both English and Maori. According to the treaty, Maori own surface, subsurface, and development rights to the land. IDG's business model is to expose the native partner to the least amount of risk, and extract the true "Wall Street" value of the project, not a discounted lease value. In terms of cost, IDG wants comparable rates to the rate that PGV is paid for geothermal under the existing regulatory scheme. With a 50 MW project, they envision a majority of the revenues going to operating expenses, debt service, tax, and developer's equity, a small percentage going directly to the landowner, and a couple of percentage points being devoted to a community trust. Under the current rules, 10% of revenues would also go to pay the royalty.

IDG envisions selling the project equity to the community at a discounted price some years after the project is completed. The company would transfer its equity interest to the native partner at cost (rather than at its true value, which is greater than cost). Thus, they will return native lands to native hands rather than having the lands controlled by multinational companies. In this way, IDG aims to find a balance between advocacy and a commercial business model. In Hawaii, the land situation is similar because the land is in a public trust owned jointly by Native Hawaiians and the State of Hawaii, with the State as trustee. Why should the community benefit? Because geothermal is a public trust resource. IDG's stated goal is to have two projects in all Pacific Rim locations with significant native populations operating within a generation.

DEFINING COMMUNITY BENEFIT: IDG values are PONO (**P**olicies for energy, **O**pen and transparent, **N**o violation of culture, **O**pportunity for community to participate and benefit). Their development model follows the United Nations Declaration of Indigenous Rights Model. There should be metrics — in writing, enforceable — associated with each of these values: culturally appropriate, environmentally sustainable, socially responsible, and economically sensible. IDG would like to see these values included in the RFP and in the utility evaluation process.

The financial structure for IDG's development would allow for a community trust, separate from the native equity, funded by a couple of percentage points of gross revenue. IDG would not mind seeing the royalties go away, since royalty payments are just a business expense that add to the cost of the project. Getting rid of the state royalty would actually encourage competition.

Benefits of a project should include:

- Fair, reasonable cost
- Energy jobs to natives, with onsite job training to ensure it can happen
- Scholarships and educational opportunities
- Public-private partnership. At the end of the lease term, turn the plant over to the state because the state owns (is the Trustee of) the resource
- Complementary uses and economic benefits should also be explored; geothermal could be at the center of an industrial park and/or co-located with other renewable energy facilities
- Steam and energy would be provided for local agriculture and other small businesses
- "Cascading" steam uses to create additional value-added products: dry timber (170 degrees), food-drying (80 degrees), then hothouses

DEVELOPMENT APPROACH: IDG's strategy is to partner with major developers. In the big picture, Hawaii needs affordable electricity to drive the economy. Food security is also a very important long-term concern. Energy security should be looked at together with food security.

IDG observed that HECO's view on geothermal to date has been that a "Hawaiian consensus" is required, but IDG takes issue with the rationalization that one group would need to be in a consensus position in order for the utility to move forward.

IDG is gearing up for the HELCO RFP by working on the business plan and talking to labor unions, policymakers, community members, and others about their plan. The IDG consortium for responding to the RFP would include Eastland (started as a state-owned enterprise), and leading technical consultants such as SKM.

TECHNOLOGY APPROACH: Regarding technology, there are two ways to develop geothermal:

1. Bring in the technology first, get a good deal on the technology components (Ormat does this, as they are married to the technology, though it might be the wrong technology)
2. Science first, assess the resource, then bring the technology that's most appropriate (this would be the IDG approach)

Another important consideration is bringing in a technology that does not damage the resource. In Hawaii, a steam system would likely be the best technical approach. [*Note: Ormat manufactures mainly binary turbo-expander turbines, and owns 89% of the binary market. Projects developed by Ormat generally use this binary technology. The alternative technology – "steam turbines" – now serves the vast majority of geothermal projects. Fuji, Toshiba, and Mitsubishi are the top three steam turbine suppliers.*]

ADDRESSING THE LAND QUESTION: IDG shared their views regarding public access to lands. There is legal precedent in Hawaii, where the courts have confirmed that Hawaiians have gathering rights across Hawaii on lands that they traditionally had access to. To qualify for these rights, the person must be a Native Hawaiian practicing Native customs.

The state has some 1.2 million acres of ceded lands. Certain state legislators have been pushing a ceded land inventory bill. The bill would require the state to inventory its ceded lands, starting by looking at acres with potential for energy assets such as geothermal, OTEC, tide, wave — and also perhaps wind and sun. IDG supports such an inventory.

Regarding public land management, IDG recommends utilizing the PLDC. IDG would like to see energy included in the PLDC charter. In terms of access to public land, IDG recommends that the law be changed so when a company invests money for resource assessment, that group gets the right of first refusal on developing that resource. Right now there is confusion in the rules, but clarity is needed from PLDC and also DLNR rules.

ENVIRONMENTAL APPROVALS: IDG would also like the environmental council (OEQC) to be more informed about geothermal exploration and development. There are technologies and international standards (e.g., 5000 lbs/sq. in. steel casing to protect aquifers) that can be adopted to protect environmental resources.

An EIS exemption for geothermal exploration can be a significant factor to encourage competition. This is a big deal for investors, because why and how would you do an EIS when you do not know if there is a resource or how large it might be? This is a significant barrier for new market entrants and for overall resource characterization in the state. As it currently stands, you would need an EIS to even do geothermal heat pumps on Hawaiian homestead lands in Waimanalo, for example. Also, the current environmental regulations say that holes have to be filled with concrete after they are drilled, but it would be good to leave the holes there to provide scientific information and inquiry.

ROLE OF THE UTILITY AND THE STATE: As for HECO, IDG would want them to be able to invest as an equity partner, but they believe that they are currently limited to a 10% stake per state law. They would prefer that HECO have significant skin in the game – there should be an "affiliated interest test." There is still significant concern that HECO just wants to move toward burning biofuel in existing utility assets. Regarding "dispatchable" energy, IDG and their technical consultants are of the view that dispatchable is the wrong word. It would be better to have geothermal as baseload, and the intermittent resources as dispatchable.

DBEDT, DLNR, and UH could be a good team to help support the geothermal industry. But there is a question as to whether DBEDT has sufficient capacity to help out, especially since the energy program is not its own department.

18. Kuokoa

TEAM AND APPROACH: Before starting discussions in earnest we were advised that the company is currently in a communications "blackout mode" because of SEC regulations. Kuokoa has made numerous management changes in the last year or so.

The overall Kuokoa plan remains heavily dependent on geothermal and smart grid, but they will be taking a phased approach and doing different pieces in increments. The phasing depends on existing identified resources; Hawaii Island would first power itself and perhaps have enough additional geothermal resources to help finance a cable. Kuokoa would likely not develop the geothermal itself (at least at first) but continue the IPP model for geothermal development. Kuokoa sees itself playing a more active role in overall resource characterization than development, at least initially. The company's current focus is to concentrate on the financial model for the business as that is what is needed to secure investment funding.

THE ROLE OF THE STATE IN OUTREACH AND EDUCATION: Active community discussions around the current PGV plant prompted Kuokoa to suggest posting monitoring results online so that the public could easily access and track the happenings at the plant. They suggested that DOH could step in to do more education on health issues. DOH or perhaps the University could be generating unbiased information about health impacts, as well as demonstrating permitting requirements address potential impacts, and providing this information to the public.

Regarding DBEDT, it is unclear within the agency who has the lead for certain things, and the overall energy plan is unclear. This would include, for example, information on the sequencing of geothermal development.

For DLNR, the geothermal working group report recommended using half the royalty money that goes to DLNR to help identify further geothermal resources. They suggested DLNR leadership is supportive of this idea.

The exploratory work being done by the University of Hawaii will be very helpful to better define location, which can help to alleviate fears in the community.

A key area needing clarity is the DLNR/DHHL disagreement over mineral rights. Does DHHL control the mineral rights of its lands, or would it need to go back to DLNR for mineral permits?

One way the state could help would be to bring subject matter experts on health, disaster preparedness, etc., out to the community to directly answer questions about specific concerns. A cabinet-level coordinated effort to work out the health, royalty, and permitting issues could be effective.

Finally, there is a critical need for coordination between the state agencies and counties; a collaborative approach is important to reduce redundancy and delays.

ROYALTIES: OHA, County, and DLNR royalty collections need to show a real benefit to Hawaii Island. Where is the money going? How is it improving the lives of people on Hawaii Island? There is a need for transparency and showing clear benefit to the community.

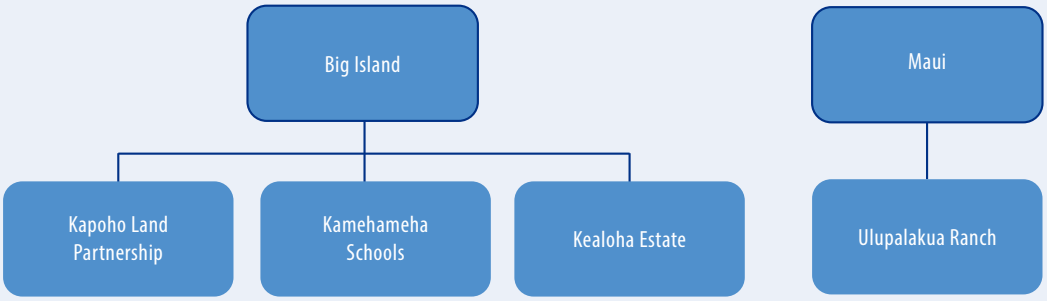
COMMUNICATING BENEFITS: To build public support for geothermal, Kuokoa believes that benefits have to be clearly demonstrated and communicated. First, one must prove that geothermal is safe, reliable, and reasonably priced — accruing benefits to Hawaii Island in terms of rates. Second, the state needs to lay out the preferred sequencing and plans from a policy perspective. Sequencing is important (e.g., serve Hawaii Island needs first). Then, you would need to show exporting power to other Hawaiian Islands would economically benefit Hawaii Island.

Some folks in the community are forming a non-profit to educate the community and encourage thoughtful discussion of various possibilities or scenarios. The money to support activities would likely come from landowners and other stakeholders.

Time is important, because the faster we move, the less oil we buy and burn.

B. Interviews: Landowners

Figure 9. Landowners Involved in Geothermal on the Big Island and Maui.



19. Kapoho Land Partnership

BACKGROUND AND CONTEXT: Kapoho Land Partnership (KLP), a Hawaii Limited Partnership (Kapoho Management Company, Inc.), holds the subsurface and occupier rights to, and the surface lease for, the land on which the current Puna Geothermal Venture (PGV) plant is located. KLP offered a brief history of their landholdings, of which 815 acres is leased to PGV, as well as perspectives on the future of geothermal development.

There has been interest in geothermal development since the 1960's. Various developers have been associated with development on their lands: Constellation Energy, then HEI investigated purchasing the project, and finally Ormat. At one point, HEI wanted to acquire the capital asset but did not.

KLP is very satisfied with the current developer, Ormat. Ormat has undergone a recent transition, from a tightly controlled family entity to one where a significant ownership portion has been sold to an Israeli technology firm. KLP feels that Ormat takes a "lean" approach to development, which is to their liking, contrasted with other developers who have invested heavily in situating executives in the state.

KLP felt that it was better to have development proceed with the landowner and developer as a team, rather than landowners opting to wait for qualified bidders to emerge from an RFP. There is too much uncertainty associated with the latter, and raising risk capital is likely to be difficult without a firm agreement with the landowner beforehand.

As a landowner, they want to see the community succeed, including the use of geothermal funding for community benefit.

GEOTHERMAL KEEPING LAND IN AGRICULTURE: KLP feels that geothermal development will return many benefits derived from revenues to the state, county, and OHA. Revenues from geothermal development help to keep their land in agriculture (papaya and cattle operations) that could not otherwise be sustained without the energy revenue. Thus, the land is kept in open space contrasted to other large agriculture lands formerly in sugar that were subdivided and sold as private lots.

Today KLP has 50% of their designated agricultural lands in an active lease status. KLP is actively looking for other types of agriculture ventures on their lands; the aquaculture operation is an example. PGV provides hot water from one of its wells, which mostly produces water for PGV operations, to the aquaculture venture. It is a relatively shallow well, with temperatures of approximately 100 degrees F. The water is pumped into a reservoir where it can be used for aquaculture; the water cools before being used by the aquaculture operation.

Efforts to identify secondary uses have focused on using surplus heat, and to date there have not been any strong feasible candidates. Alternatively, the secondary use efforts should concentrate on using surplus energy that is not used by HELCO. Such uses could include, but are not limited to, hydrogen production, production of ammonium nitrate fertilizer, cold storage, and aquaculture and hydroponic uses. Battery storage could also be utilized to store the surplus energy for use by HELCO during peak demand periods, or use by secondary users 24/7.

FUTURE DEVELOPMENT: KLP would like to see more geothermal. They noted that historically it has taken a long time for commercial geothermal development to come to fruition. The first commercial project at PGV took from 1978 to 1991: 13 years from idea to commercial production. KLP has additional resource that can be developed on their lands, and is very supportive of new development by PGV on their leases on KLP land.

KLP did mention that ownership of the resource is still an unresolved issue from a legal perspective. In the state's Resource Lease No. 2, which governs rights for the PGV project, this unresolved legal issue was acknowledged under the heading "No Warranty of Title." The section reads, "The Lessor does not warrant title to the leased lands or the geothermal resources and geothermal by-products which may be discovered thereon; this Lease is issued only under such title as the State of Hawaii may have as of the effective date of this Lease or may thereafter acquire." While some of the attorneys with the State may postulate that the Trust Doctrine applies to geothermal resources, the courts have not yet reviewed this theory. The State does not claim ownership of cold water, nor does it claim ownership of the heat from the sun or the energy that is associated with the winds.

For developers the bottom line is they need to be able to get a contract. There needs to be a greater stimulus from the state. For example, the PUC is underfunded and is unable to exert greater influence on resource acquisition direction in the greater interest of the state. It would help to get more direction from the PUC, for them to look at the greater public benefit to reduce dependence on oil, and lead to a more favorable financial treatment for geothermal and renewable energy.

WORKING WITH THE UTILITY: PGV was required to build a redundant transmission line along the highway for the initial project. Transmission for expansion may be a further constraint that needs clarification. The HELCO transmission lines are not energized at levels comparable to HECO (69kv compared to 138kv), which may be a constraint that can be addressed. A bigger issue is over HECO's position on increased acquisition of generation. KLP expressed some concern that past practice and the current HECO business model skews their preference to preserve utility-owned assets, which can discourage acquisition of non-utility-owned generation.

If the Mayor and Governor really want to see geothermal development accelerated, they need to address this constraint.

KLP suggests a clearer articulation of any path forward for geothermal by addressing three key issues:

1. Should development proceed as part of the next increment of demand
2. Should development proceed with less regard to meeting additional projected demand and instead proceed to replace oil based generation
3. Should development proceed with the inter-island cable (could be "game changer")

20. Kamehameha Schools

ORGANIZATIONAL PHILOSOPHY AND THE ROLE OF GEOTHERMAL: The productive discussion with multiple members of Kamehameha Schools' (KS) team covered their plans and philosophy related to geothermal. The philosophy that underpins the KS decision-making process is also informing the geothermal work at KS. These are summarized as:

- **Cultural identity** – connection to the land, history, culture, and stewardship
- **Financial sustainability** – uses that can sustain KS operations and educational mission from a financial perspective

Thus, KS is looking at holistic landscapes achieved through development, and balancing considerations, such as ecosystem restoration (ecosystem services), culture, and income.

Regarding geothermal, KS has the view that geothermal done well, and with the proper regulatory scheme, can be a good thing to support the organization's mission. However, geothermal development needs to be balanced against multiple value sets (e.g., sustainable food, renewable energy, water and cultural resources). KS acknowledged that this outlook makes their organization more complicated to deal with than other traditional landowners. They see the cultural issues of whether and how to move forward as independent of "social issues" and financial structures, such as project royalties and equity arrangements.

TEAM AND APPROACH: Consistent with their philosophy, KS is investigating geothermal through team leads in the following areas: renewable energy, natural and cultural land use, and analysis and modeling. KS has retained a consultant on their overall renewable energy plan.

KS measures impacts of any potential development against the status quo—not against a blank slate. When assessing future projects, they'll look at current land use patterns, existing challenges, and future likely challenges. In order to help with the evaluation of geothermal in particular and its appropriateness for KS, KS has retained three consulting groups:

A. Technical – GeothermEx

B. Cultural – Edith Kanakaʻole Foundation

C. Process, regulatory, social perspective – Honua Consulting

A. Technical Investigation: On the technical side, KS understands resource assessment and exploration have significant expense, and larger projects may be needed to justify the upfront investment. They believe that at least 20 MW are needed to justify the costs, but could possibly start at 10 MW and expand in a modular fashion. HELCO requirements are also important, and now there are two major unknowns: 1) can electricity costs be reduced with geothermal, and 2) can HELCO dispatch geothermal. They believe that the cable may be a long-term (>10 year development window) proposition.

B. Cultural Investigation: For cultural resources, Edith Kanakaʻole Foundation is looking at the understandings and traditions around volcanoes. This will result in research to inform KS's decision-making process, not actual recommendations.

C. Process Investigation: Honua Consulting is looking at what can be learned from other experiences with renewable energy, resorts, and other big projects to provide process-oriented best practices. The scope would not be limited to just energy, but would also look at other integrated issues (on West Hawaii these could include jobs, water, land use, etc.). This is part of KS's focus on master planning for each area and addressing multiple needs, rather than being geothermal or energy project-specific. KS is really looking at West Hawaii, since it is a large landowner in that area.

The inputs from the three studies should be ready in mid-2012. This would just be the beginning of the "process train" if the decision is made to take the next step forward. Right now the decision is between "no-go" or "take the next step, slowly, carefully." In all of these steps, the community would need to be brought along as well. KS anticipates needing 12-24 months to complete their development plan, working with stakeholders and communities along the way.

ROLE OF THE STATE: Some recommendations for the state included:

- Articulate a plan, and provide clarity on a greater vision
- Reduce uncertainty surrounding geothermal by increasing transparency
- Show the value proposition consisting of stronger communities through integrated solutions coming from clean energy
- If the state plans top-down, it will be met with cynicism from many groups
- Similarly, projects that are "fast-tracked" also raise community concern

21. Kealoha Estate

BACKGROUND AND CONTEXT: The Kealoha Estate has 510 acres in the Kilauea East Rift Zone near the present geothermal plant. The land is designated Ag 10, and the ocean-side parcel is Ag 1. The Trust is very open to geothermal development, and is in the process of doing due diligence with the various geothermal developers. At present they expressed a preference to not sign non-disclosure agreements with the seven or so developers that are talking to them.

Kealoha Estate would like to do an exploratory drill on the property. This could possibly be done by the University of Hawaii. They are very open to working with the ongoing University exploration work, and it could also be done by a developer once the Estate selects someone to work with on geothermal development on their land-holdings.

DEVELOPING THE RESOURCE FOR COMMUNITY BENEFIT: One of their main priorities is that any development benefits the host community – to include Puna, Native Hawaiians, but also the broader County of Hawaii. Community benefit is more important to the Trust than other considerations. IDG has presented a very interesting idea because of the strong emphasis on direct community benefit and because of the company's Native Hawaiian roots.

They expressed a view that the existing PGV project needs to better comply with current oversights (monitoring, evacuation routes, etc.) before developing additional capacity.

Another important motivator for them is geothermal helps bring down the cost per electricity customer on the Big Island. Cost of electricity has become a crisis on Hawaii Island, and Kealoha Estate would like to be part of the solution. In general, they believe a community-owned or other alternative utility model could provide lower cost energy, along with greater benefit for people in the county and the state.

Geothermal development would be part of a larger plan for the Estate that would also help them pay high property taxes on their lands. This vision would also include, besides agriculture:

- Kupuna housing
- A Hawaiian cultural center, supported by and drawing upon the kupuna
- Herbal gardens (already under development by UH students)
- A full-time wellness center
- Possibly solar in addition to geothermal, since the solar resource is very good there

ROYALTIES: Currently, half of the geothermal royalties are going to the state, but it is not clear what has been done with that money. This is a huge problem, because it is difficult for the community to see direct benefit. There is little confidence in the benefits fund controlled by the state.

ADDRESSING COMMUNITY CONCERNS: Regarding opposition to geothermal in the community, they are of the view that more validation and real facts are needed, and that the lawsuits are often not based on solid information.

However, there are real concerns around health impacts and more information is needed, along with communication from the state and Department of Health. State agencies need to follow up on health issues and communicate their findings and information to the community. In general, state agencies need to be more visible and available to the community.

In contrast, the County is largely not needed in these discussions, as they have limited expertise to add in the health and monitoring arena, and County actions tend to be more politically motivated.

LISTENING TO KUPUNA FOR GEOTHERMAL AND UNDERSEA CABLE: Regarding the cable, geothermal should take care of the Big Island first, then look at the rest of the state. However, there is the recognition that all islands may need to benefit to make the investments work. The Kealoha Estate land actually has the potential to be a landing site for an inter-island cable, and in fact this was part of (former Hawaii County Mayor and Lieutenant Governor) James Kealoha's vision from decades ago. The Estate reinforced their support for the future cable project as consistent with the early vision of their lineage. They further advised that any cable project must be well thought out, and done transparently.

In an interesting anecdote the family considers kupuna Iolani Lauhine to be part of their lineage. Kupuna Lauhine took their family to Halemaumau fire pit to visit with Pele. Their grandmother's name is Pelekumu, as the family traces their lineage to Pele. There is a direct family lineage to Pele, contrasted with others who claim to be Pele worshipers, but may have no ancestral ties to Pele.

In summary, the Kealoha Estate sees geothermal as a very attractive resource that could help improve the community as a whole. For their lands, this type of development can produce the resources needed for much more productive community gain.

22. Ulupalakua Ranch

Ulupalakua Ranch is a 20,000-acre working ranch on Maui, of which 11,000 acres are in an agricultural easement with the Hawaiian Islands Land Trust (formerly the Maui Coastal Lands Trust).

BARRIERS TO RENEWABLE ENERGY AND THE ROLE OF THE STATE: In the Ranch's view, the biggest need from the state is education. Based on their experience with wind development, they have seen that the majority of elected officials and the public do not understand electricity. Clean energy is good, and as a state we need it but people also have to recognize that 1) clean energy has a cost (it is not "free") and 2) we cannot be all solar, or all wind — because electricity grids do not work like that.

A project, like Sempra, on their lands cost $140 M and requires commercial financing. Just as water is "free" — it's the cost of delivery that is expensive. Wind and sun are free, but the delivered energy is not.

Many members of the public also do not understand that the energy projects on Ulupalakua Ranch (e.g., Sempra wind) are providing electricity for the whole island, not just for the ranch. Basic education should not be part of the developer's role, but developers are often thrust into this because of the needs that arise during project development and approvals.

A greater understanding of energy resources among public agencies and policymakers would make the permitting process easier.

Also, education is needed about how the PUC works, especially about setting rates. Developers have little to do with setting future electricity rates. In the Ranch's view, the permitting/EIS process is not the place to address and argue rate issues. These processes should be solely about the environmental and community effects of projects, and yet they are often dominated by discussions of electricity rates.

In general, the state needs to be clear about what we want to do. Theory is okay for a while, but we need to get serious to attract real developers and investors.

GEOTHERMAL AS A TECHNOLOGY CHOICE: Many members of the public do not understand geothermal is a well-developed resource, it is not unique to Hawaii and our active volcanoes, and the U.S. actually produces more geothermal energy than any other country in the world.

Geothermal was something that was considered decades ago, but Ulupalakua Ranch backed away from it in the 1980s because the technology presented technical challenges on the Big Island (referring mainly to the HGP-A experience).

RENEWABLE ENERGY KEEPS LAND IN OPEN SPACE: Renewable energy provides an important income opportunity for the ranch. Hosting cell towers and renewable energy projects allow Ulupalakua Ranch to maintain ranching operations, agriculture enterprise, and open space.

Geothermal and wind are particularly good because they provide steady income streams while occupying a small footprint. Cattle can graze around the Auwahi (Sempra) Project wind turbines, which take up only 12-13 acres including roads, turbines, and buildings. Solar uses a lot of land, so it may not be as compatible with other agricultural uses and may be a difficult fit for the Ranch. Solar with hydro would be more attractive to increase access to water, which would then increase the productivity of the land and make up for lost acres.

AGRICULTURAL EASEMENTS AND RENEWABLE ENERGY: Ulupalakua Ranch can use its land for renewable energy projects because it worked with federal agencies to allow renewable energy development on land that has agricultural easements. They were one of the first agricultural conservation easements to allow renewable energy. But the next ranch that attempted this strategy (on the Big Island), did not receive approval from the IRS and USFWS, so this may not be a precedent that can be replicated across the state. This is very unfortunate because it is a strategy that enables the preservation of open space for the long term.

COMMUNITY ENGAGEMENT: In general, Ulupalakua Ranch's preference is to engage with the community and have public meetings beyond what is required by the permitting rules. Ulupalakua Ranch works with renewable energy developers to get them to buy in to this approach. At the same time, they believe the current permitting process allows too much opportunity to weigh-in by people from other islands or even other states that are not directly involved with the project. Input from immediately impacted communities should carry the most weight.

PROSPECTS FOR THE UNDERSEA CABLE: On the topic of the undersea cable, the Ranch believes that it makes all the sense in the world to interconnect the islands, but stopping a cable at Maui wouldn't be ideal. The state's first emphasis should be to get the biggest firm power source – geothermal on the Big Island. They expressed some concern over whether the state can successfully execute such a huge project. In particular, the state needs a well-articulated plan to pay for it.

Ulupalakua Ranch is not currently entertaining projects dependent on the cable because of the significant uncertainty. It would help to have greater definition, greater public education, and more specifics about why it is good for the state.

FUTURE PLANS: Ulupalakua Ranch is open to many different possibilities. Sempra can expand at their site, eucalyptus may be able to supplement HC&S, and possibilities exist for biofuels, solar, and geothermal. One common grass on the property is very high in citronella and seems to be an interesting research subject for UH.

23. U.S. Department of Energy, Geothermal Program Office (DOE)

ORGANIZATION AND GOALS: The U.S DOE geothermal program's primary focus is to reduce the risk and cost of developing geothermal resources through resource assessments and new discovery techniques. The agency estimates that there is 30 GW of undiscovered resources in the U.S.

EXPLORING NEW TECHNOLOGY: The U.S. DOE Enhanced Geothermal System (EGS) program opens up new opportunities to extract geothermal energy from non-hydrothermal resources, i.e. locations where there is heat but not water and permeability in the ground. They have programs to develop engineered systems that flow more fluid in areas that have hot, dry rock. [*Present geothermal technology utilizes traditional hydrothermal resources, not EGS. The State has not yet characterized enough of the resource areas to know what fraction of them will be amenable to conventional development and what fraction may require EGS technology; one of the characteristics of Hawaii's resource is that it is generally less permeable than many of the already-developed systems in the world and EGS technology might add measurably to the production potential of resource areas in the State.*]

U.S. DOE is also developing new surface exploration techniques that will improve resource characterization without the need for some drilling for exploration. Their work with the Bureau of Land Management and the Marine Minerals Service could be applied to Hawaii.

REMOVING REGULATORY BARRIERS: U.S. DOE is working to reduce transaction costs related to complex permitting regimes. They are undertaking a project called "regulatory roadmapping" to characterize the regulatory process, obtain stakeholder agreement, find inefficiencies, and get parties to remove those inefficiencies. Their efforts are aimed at federal processes, but could also be applied to states and regions. U.S. DOE is funding NREL to take the lead on this effort, which surveys eight western states, including Hawaii. Talking to developers tied to exploration activities can help DOE prepare a geothermal development roadmap for the U.S.

This work is tied to the U.S. Geological Survey (USGS) 50 state effort on updated resource characterization and inventory that will take two more years. The NREL effort will be completed sooner; NREL rolled out a draft template in September 2012 at the Geothermal Resources Council annual meeting in Reno.

As part of this work, U.S, DOE would also like to develop a finer baseline for anticipated exploration costs. U.S. DOE believes that their regulatory roadmapping effort can help the industry achieve a 20-50% cost reduction.

Much of this work was funded by the Recovery Act, and will be completed by 2013. The Geothermal Program's FY13 budget request was for $65 M.

DEVELOPING GEOTHERMAL IN HAWAII: Out-of-date resource assessment and community education were identified as two challenges for Hawaii. For resource assessment, they were aware of the limitations of the 2005 GeothermEx study, and indicated they can help Hawaii address that. The current University of Hawaii effort is an example. The NREL activity discussed above will reach out to organizations that have their own resource databases to compile known information and identify gaps that need to be addressed. However, it is unlikely there is any good resource information, besides propriety data, beyond what was included in the GeothermEx study. A link to the results of NREL work is included in the appendix of this assessment Section VIII: Resources.

U.S. DOE has assisted with public education. An example cited was the recent Geysers, CA experience where developers were having community acceptance issues. U.S. DOE, in collaboration with the California Energy Commission, funded a community center that includes an information kiosk and serves as a community-gathering place. We discussed the possibility of doing something similar at the NELHA Puna Research Center, where there used to be an educational display many years ago, and U.S. DOE expressed interest.

U.S, DOE is also interested in what happens with geothermal in Hawaii because their NEPA team is assisting with the programmatic EIS for Hawaii's energy future.

PRESERVING THE RESOURCE: The state must recognize its responsibility to manage not only the development of resources, but also the sustainability of the well fields after they are developed. The latter is critical, and can be impacted by efforts to obtain a "dispatchable" instead of a baseload resource. Other states, such as California, have experience that Hawaii can benefit from in this area. California has had extensive experience managing geothermal resources, with a range of outcomes.

IDENTIFYING FIRMS WITH THE RIGHT EXPERTISE: U.S. DOE has knowledge of the competent firms that can help the state answer questions around geothermal. Consulting firms in the financial sector could be very helpful (e.g., IHS Global Insight). The state could also consult with the California Energy Commission (CEC), who has used various firms including GeothermEx.

U.S. DOE suggested that we look at the Iceland development experience. Iceland's grid is comprised of 99% renewable energy, 30% from geothermal. Iceland is seriously looking at a cable connection to Scotland to export energy.

24. U.S. Army, Members of the Army Energy Initiatives Task Force

PEOPLE AND APPROACH: PICHTR interviewed members of the Army Energy Initiatives Task Force (EITF) (**http://armyeitf.com/**) from Washington D.C., Texas, and California. The EITF is housed under the Assistant Secretary for Energy and the Environment, and under the Deputy Assistant Secretary for Sustainability. There are three aspects to the EITF: Planning, Execution, and Outreach. Essentially, the EITF transfers responsibility from the individual commands to Army HQ to meet its energy goals.

The DOD is currently focused on the goal of 1 GW by 2016, meaning 1 GW of large-scale renewable energy p rojects developed with private money on Army land. The power would be provided to civilian grids, not just Army operations. This goal is a subset of a larger goal (about 7 GW) needed to meet DOD mandates, such as reducing greenhouse gas emissions. There are also important Army goals to reduce service energy consumption across the board.

INVESTIGATING GEOTHERMAL: DOD is exploring a couple of different areas for geothermal, include Hawthorne and White Sands. The Navy is exploring Falcon Navy Air Station and Chocolate Mountains – using China Lake funding. [*Note: China Lake Naval Weapons Center is the site of a long-standing Navy geothermal project, the revenues of which are reinvested by the Navy team in new geothermal opportunities and renewable energy opportunities*.] The geothermal projects EITF has been investigating are in NV and UT at very low prices of $0.05-0.06/kwh.

In general, the group seemed relatively new to the idea of developing geothermal in Hawaii, but there was significant interest. We were able to walk through some scenarios of how such development could possibly occur.

Based on their understanding of the market conditions and how much more electricity demand there is on Oahu than on other islands, the group was very interested in characterizing Oahu's resource. In the longer term, they were interested in the market opportunity presented by a cable to the Big Island. The Army is also interested in low temperature geothermal, perhaps combined with solar.

STRATEGIES FOR RESOURCE EXPLORATION: They suggested the UH partnership with PACOM (a MOU has been signed between these parties) as one avenue to direct resources to the Army's high priority interest areas — e.g., looking at Oahu for a resource base.

We also discussed the process for how the Army might want to proceed with geothermal investigation once the results of UH water drilling at the Army's Pohakuloa Training Area (PTA) is known (in mid to late 2013). The Army, at this point, is unlikely to use its own money to do additional exploration. If promising geothermal conditions are found, the Army EITF would likely coordinate with the installation to determine next steps.

> **Step 1:** The garrison would likely assess the land assets and might exclude certain areas from interest because of training needs or other uses, and would then move forward.
>
> **Step 2:** Putting approved parcels of land out for lease. Companies who want to take the risk to put holes in the ground would be invited to bid on the opportunity.
>
> Proposal evaluations are not based entirely on economics; technical capability to perform is actually the most important consideration. A proven track record and ability to execute are paramount.
>
> The lease would likely have provisions that require certain activity and/or progress. The Army would not allow a lease where the land becomes tied up without being explored or developed.
>
> Another consideration would be working with Native Hawaiian Organizations. A joint venture with a Section 8A organization could reduce the competitive requirements on the process. The Army can also execute non-competitive arrangements with state organizations for activities that are part of the state's responsibility. This could be relevant because much of PTA adjoins state land or is actually leased from the state.

WATER AND GEOTHERMAL: The geothermal activities are closely linked to water supply. They anticipate that PTA will get increasing joint training efforts, which will exacerbate current issues with water supply. There is a very large cost and safety issue associated with the current practice of hauling trucks of water up narrow mountain roads to service PTA. The same problem is present for sewage disposal.

Fully developing the water resource at PTA, if one were found, would require additional funding for the well, pumps, and other infrastructure. There is a placeholder for this funding but funding is not yet committed. One possibility, in addition to bringing in private developers, is leveraging some of the Navy China Lake funding for shallow drilling for geothermal exploration and water retrieval.

25. Geothermal Energy Association

The Geothermal Energy Association (GEA) is the trade organization that represents the geothermal industry.

THE HAWAII OPPORTUNITY IS NOT TOO SMALL: GEA noted that many in the industry view Hawaii as almost a "foreign country". It is remote, land use laws are complex, and projects are generally difficult to get started. However, a project of 25 to 50 MW in Hawaii would not be too small to attract industry interest if market leaders were aware of the opportunity.

MARKET DYNAMICS ARE CHANGING: There has been an evolution of the geothermal industry in the last 20 years. In the past, geothermal was pursued by the big oil companies like Unocal and Chevron. In the last couple of decades, project development has scaled down to smaller companies, and consortia have been formed, such as Ormat, U.S. Geothermal, and Nevada Geothermal. The industry is now more complex, and project development takes a more flexible approach. Given this new model, industry should be very interested in Hawaii projects.

Developers now typically bring partners to explore the resource, and provide technology, and some of these partners have good ties to capital markets for financing projects (e.g., Lockheed Martin).

ENCOURAGING COMPETITION AMONG MARKET LEADERS IN HAWAII: Hawaii would benefit from robust competition from more geothermal firms who could offer the most options in terms of technology, approach, and price. The discussion turned to firms that are not known to be looking at the Hawaii opportunity, but that have executed successful projects elsewhere. The state can and should take an active approach in making industry leaders aware of the state's development plans.

ENEL, formerly the Italian electricity company, has diversified and is an example of an innovative geothermal company. Their Nevada project in Reno was combined with PV that allows them to "dispatch" load. This feature is increasingly important because projects want to sell into wholesale markets and want to time sales to gain the best financial return. ENEL may have up to $6 B to invest in America because the U.S. presents safe returns compared to other countries. The Hawaii opportunity could pique ENEL's interest.

Star Energy could also be interested in Hawaii; this is another innovative firm that has strong leadership and has seen significant success — in Indonesia and elsewhere. [*Note: as of October 2012, Mitsubishi acquired 20% of the company's shares, so future development may also look toward Japan*].

One way for Hawaii to attract additional developer interest is to get engaged by participating in industry meetings. GEA hosts a summit every summer focused on the U.S. industry and a very large trade show every fall, in combination with the Geothermal Resource Council's annual conference, for global participants. State governments have been exhibitors in the past, and GEA is willing to help Hawaii organize a break out session focusing on the Hawaii opportunity to share new exploration activity, discuss the market potential, and explain the regulatory requirements.

UTILIZING PUBLIC LAND FOR MAXIMUM BENEFIT: The state needs more sophisticated knowledge of how to put state lands in play. Currently, most developers prefer private lands because it is simpler to consummate a deal and it offers them a superior competitive position. In California, revenue from geothermal development on state lands goes into the teacher's pension fund – which is a significant political driver. Idaho is trying to do the same. The state land commission must be very favorable toward use of the land to encourage developers, which can be very beneficial for residents.

Federal lands are generally more difficult to develop. In the Philippines, the government (Philippine National Oil Company) did the drilling, and then auctioned off the rights for development. This results in very competitive pricing for geothermal because the risk for exploration is mainly taken by the public sector.

The World Bank is interested in geothermal, specifically on the reduction of drilling risk. They believe drilling risk can be covered by insurance; the risk management is not different from that of oil and gas. The bigger problem is defining the return on investment, i.e. when can income be expected from the resource developed, which is less defined in geothermal than in oil and gas.

USING GEOTHERMAL AS A DISPATCHABLE RESOURCE: Hawaii's attempts to seek dispatchable geothermal must be handled carefully. Requirements may pose a problem if the project must throttle back on the well field. California is trying to get geothermal to "cover" for solar and wind, but this can be challenging. Developers must exercise great care with the well field; there are issues of potential well damage, scaling, and casing failure. Some approaches have addressed this problem by using down-hole pumps, so there can be technical or engineering solutions. In some cases two contracts have been offered, one portion based on providing baseload energy, and another based on meeting dispatch requirements. This may be a good approach for Hawaii, at least to explore the cost difference between dispatchable and geothermal, and inform the most prudent investment from a system perspective.

The Geysers project in CA now sells to the market, but in the past it operated and sold as baseload power. The Geysers is now able to vary their sales output up and down 40 to 60% based on the market prices; all of this is new.

Utility initiated bid projects do not often result in the best technical outcome. For example, some California requests for proposals were overly restrictive, resulting from a lack of communication within the utility company and desire to adhere to the status quo. This can be managed by very active participation by regulators.

TECHNOLOGY ADVANCEMENTS: There are promising advancements in low heat geothermal, particularly in Germany, which is not known for its geothermal resources. Use of low and medium grade resources can be a game changer. Low is defined as starting from 160 degrees F; the optimal is 190 to 200 degrees F. It is most effective if you can have a good heat sink (cool temperature sink), so Hawaii could have a challenge there. It may be good to learn more from some equipment manufacturers, e.g., Turbine Systems, TAS Energy, and others with binary equipment.

26. Bloomberg New Energy Finance (BNEF)

U.S. MARKET: The U.S. has the most existing geothermal capacity, but is not currently the hub of activity for exploration and development.

Land availability is one of the main constraints that affects the U.S. market for geothermal. In 2007, there were a significant number of leases on federal land made available for geothermal in the western states. With the financial crisis and generally slow pace of geothermal development, sponsors had too many projects on the books or other financial challenges, and so they had a limited ability to develop projects where they had land position.

The federal government offers incentives for geothermal energy that include accelerated depreciation, production tax credits (PTC), and investment tax credits (ITC). The investment tax credit could be claimed as a cash grant until recently because of the federal stimulus policies. To qualify for the Section 1603 grants, drilling had to be started by the end of 2011 and the plant has to be done by the end of 2013. Geothermal plants also benefit from accelerated depreciation (a.k.a. Modified Accelerated Cost Recovery System, or MACRS) that also reduces down the cost of the plant. The sunset of federal production incentives and uncertainty over future incentives is impacting geothermal investment. Overall, these incentives have the potential to reduce levelized cost of electricity (LCOE) up to approximately 30% ($30/MWh, or $0.03/kWh).

In the U.S. mainland, the USGS estimates that California has the best developable resource. There has been significant geothermal activity, largely because of California's aggressive RPS and other regulatory measures.

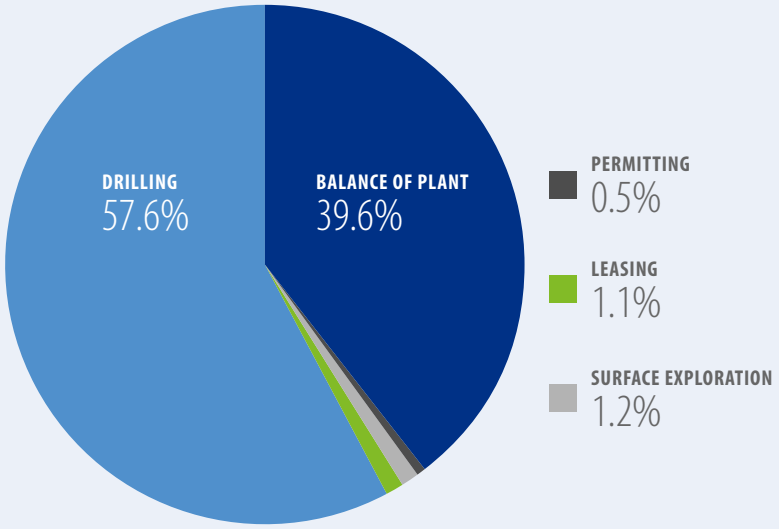
In California, geothermal has historically been an attractive resource because of its baseload characteristics. Utilities would pay about $0.10/kwh, which is more than the going PPA price for wind, for geothermal because it is baseload. Now, a new rule that may allow utilities to bank their Renewable Energy Credits (RECs) could reduce the utility demand for geothermal because it will make the stable, baseload kWh less important to meeting regulatory requirements.

COST OF GEOTHERMAL: The question of cost is central to the discussion of whether and how to pursue geothermal development. From PICHTR's experience interviewing geothermal experts for this assessment, BNEF was found to have some of the most complete and detailed cost information for geothermal plants and development. While some of their findings are summarized in the section below, further detail on the technical and financial drivers of cost is available to subscribers of their information service.[6]

BNEF has built a detailed project finance model that estimates LCOE for geothermal. This cost model identifies the main drivers of geothermal cost as drilling and the return on investment required (i.e. debt to equity ratio). The model indicates that in terms of resource, the number of failed exploration wells has the greatest impact on LCOE since each well costs $4-7 M, whether it results in resource or not. Surface exploration is a lot less expensive (often under $1 M for a site), but does not provide sufficient proof of the resource that is required for drilling of production wells, or for securing financing for full commercial development.

The LCOE for geothermal, which takes into account the capital cost and ongoing operations of the plant over its lifetime, depends mainly on two factors — drilling and balance of plant — each comprising about 50% of total costs. Figure 10 presents a scenario from the BNEF model in which drilling accounts for nearly 60% of the capital expenditure. Labor, land, permitting, and early surface exploration account for less than 5% of LCOE on average for plants in the U.S. (*Figure 10*).

Figure 10. Breakdown of Overall Development Costs – from Bloomberg New Energy Finance.



Source: Bloomberg New Energy Finance. Note: Does not include royalty payments or operating expenses

6 Mark Taylor, Head of Geothermal Research. Subscription information is available online **http://about.bnef.com/** or by email **sales@newenergyfinance.com**.

The actual cost of drilling depends on a number of factors, such as resource depth; rate of penetration (ROP) — the rate at which the drill bit penetrates the rock, which depends largely on rock type, equipment used and any problems encountered during drilling; and day rate – the daily cost to rent the rig and crew (*Figure 11*).

Figure 11. Factors Affecting Cost of Drilling – from Bloomberg New Energy Finance.

Source: Bloomberg New Energy Finance
Note: Rate of penetration (ROP) is the rate at which the drill bit processes through the rock: it is measured in m/day.

LCOE is also very sensitive to the financial structuring of investments at each development stage. Project equity and other high risk capital is generally used in early stages of the project for resource exploration and drilling, whereas debt comes in much later once the resource has been confirmed and the project risk reduced. Depending on the return sought by the investor, LCOE can range from $40–160/MWh ($0.04–0.16/kWh) on the basis of financing alone. This is one reason that larger companies with significant financial resources (e.g., Enel, Ormat, Calpine) can often develop geothermal for lower prices than small development companies.

Another key finding is that returns from commissioned geothermal projects can be strong, and attractive to project equity investors requiring returns up to 30%, as long as the investors have a long-term view — ie, are willing to make most of the return on the second half of the project lifetime. Venture returns of 20-40% are possible in the high-risk, early stages of a project, but can also raise LCOE by $25-30 / MWh depending on the structure of the financing, which is significant and can make geothermal less competitive with other renewable energy resources. In terms of financing, the required return on investment has the biggest impact on LCOE. After this, the capital structure is the most important variable; equity investment should be less than a quarter of total capital expenditures for the project to be financially competitive.

Because of these capital structure considerations, geothermal projects can benefit from segmenting the development stages and the returns of various players at each development stage. For example, a resource developer could start with the high risk exploration activities, and then sell the project to a private equity backed developer to finance and build the plant, who could then sell it to a utility or operator with a long investment horizon.

PLANT PERFORMANCE: Global plant performance has been quite different from expected. In a recent study, Bloomberg New Energy Finance looked at global performance data and determined the average capacity factors as 73% for the world, and 63% for the U.S. All reservoirs have a natural rate of decline — typically in the range of 3% annually — but there are multiple explanations for this further underproduction, some of which include:

1. Insufficient characterization of the resource, resulting in developers buying more plant than they can handle (e.g., 50 MW turbine for 30 MW resource), which increases per unit cost of the project
2. Mismanagement of the resource, which leads to faster-than-anticipated decline

RESOURCE EXPLORATION: Resource exploration is one of the best ways to interest developers. State assessment of the resource, with some auction or reimbursement mechanism, is likely the best way to facilitate competition and open up the Hawaii market. Hawaii would likely need surface work, slim holes, and full-scale exploration wells to spark serious industry interest. There is sufficient idle rig capacity in the U.S. that could be put to work in Hawaii.

For example, in Indonesia, there is a well exploration program in place to promote exploration and development. The government takes the risk to drill the well, and then the company that develops the resource reimburses the government for the cost, plus a premium for the data and to cover the losses for failed wells.

INTERNATIONAL DEVELOPERS AND CONSULTANTS: It would benefit the state to have multiple companies and techniques involved in the market, as well as technical advisors/consultants. In a market that already has a strong incumbent, new players will need to be those with big balance sheets in order to compete.

International developers are currently the most active in the industry and are among the most highly regarded. These may also be a good fit because Hawaii's resource is more similar to New Zealand, Indonesia, and Philippines than Nevada. Hawaii may want to reach out to some of the more active global companies in this space, some of which include:

- **Energy Development Corp. (EDC)** — of the Philippines. Is the privatized geothermal development arm of the Philippine National Oil Company (PNOC). It is the biggest and most active geothermal developer in the world, and has very strong leadership
- **Origin Energy** — of Australia. Is in a joint venture with Indian giant Tata for development in Indonesia. It is actively expanding its geothermal portfolio. Subsidiary Contact Energy has developed 400 MW in New Zealand
- **Chevron** – has a goal to develop 1.3 GW of geothermal
- **Ormat Industries** – of Israel. Ormat Industries manufactures and supplies geothermal equipment, including binary systems. Subsidiary Ormat Technologies is a Reno-based project developer
- **Sinclair Knight Merz (SKM)** – experienced technical consultants

Ormat develops projects that employ its own binary technology, but the majority of geothermal projects are moving to flash technology because it is generally less expensive. The leading manufacturers of flash turbines for geothermal are Toshiba, Fuji, and Mitsubishi.

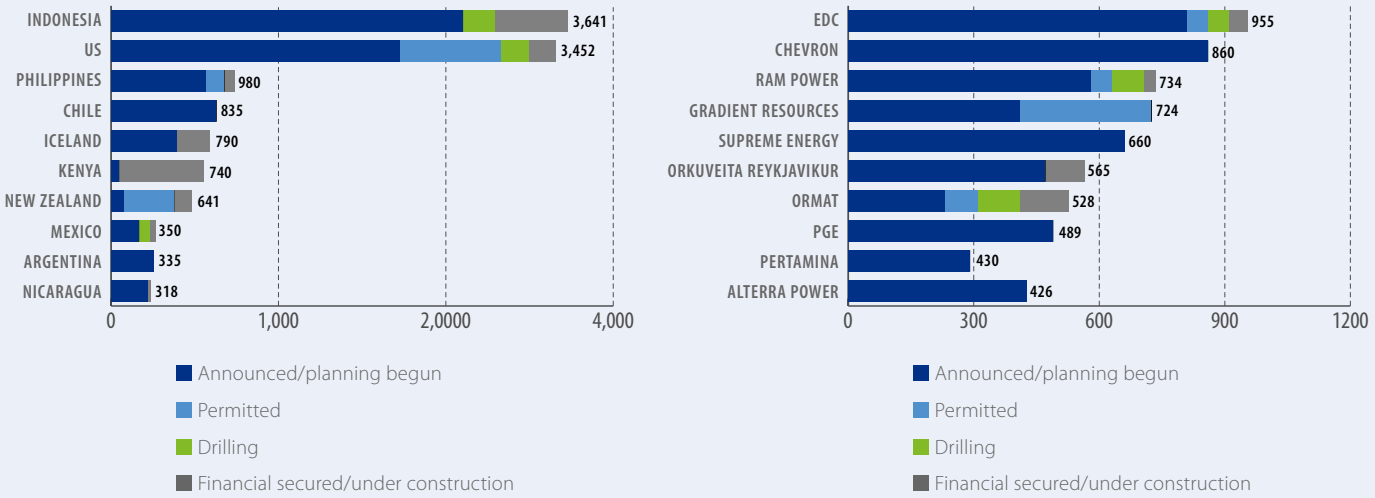
INDONESIA AS MARKET-LEADER: Indonesia is shaping up to be the world's fastest-growing geothermal market in the coming decade, with a goal to develop an additional 9.5 GW over its current installed capacity of 1.2 GW. In early 2012 the government has 51 projects in its fast-track 'Crash' program representing approximately 5 GW of capacity. Chevron, state-owned Pertamina Geothermal Energy, and Star Energy lead new development in Indonesia.

As part of the regulatory framework established with the Crash program, the government requires the state utility to buy all power produced from geothermal, and outlines pricing rules, including a fixed ceiling price of $97/MWh ($0.097/kWh).

OTHER INTERNATIONAL LEADERS: Besides Indonesia's growing capacity, New Zealand, Kenya, the Philippines, and Mexico are the most active geothermal developers. Together with the U.S., these six countries represent over 75% of development expected over the next 5-15 years.

Japan, Ethiopia, Turkey, and Latin America (e.g., Chile) also have ambitious plans to expand their geothermal project pipelines. Japan currently has the world's strongest feed-in tariff, begun on July 1, 2012, of $330-$500/MWh depending on project size and technology.

Figure 12. Top 10 Country Pipeline and Top 10 Developer Pipeline, Q2 2012 – from Bloomberg New Energy Finance.



Source: Bloomberg New Energy Finance

Note: The pipelines include all declared development; we expect approximately 0.5GW of this to come online after 2021. EDC is Manila-based Energy Development Corp. PGE is Jakarta-based Pertamina Geothermal Energi.

Favorable feed-in tariff rates in European countries, ranging from $175-375/MWh in France, Italy, and Germany, may lead to future development in Europe as well.

While the U.S. still leads in installed geothermal capacity, international players are growing quickly in this arena and U.S. projects, including Hawaii projects, are competing for developer interest and dollars in an increasingly global marketplace.

V. FINDINGS AND CONCLUSIONS

After conducting extensive interviews with government, industry, and other stakeholders in Hawaii and beyond, PICHTR concludes that it would be prudent for the state to pursue additional geothermal development in Hawaii.

Government agencies and others, including members of the Native Hawaiian community, expressed the opinion that geothermal can be developed safely and economically in Hawaii, and can return significant benefit to the state.

Chief among those benefits would be reducing and stabilizing electricity prices, reducing the state's dependence on oil, and increasing economic security through local, renewable energy sources. Additional benefits would derive from enabling land to stay in agriculture and open space, supporting local enterprises that can utilize direct use heat, reducing pollution from oil-burning power plants, and providing non-tax revenue for state and county services.

A. Industry and Government Momentum

We conclude that momentum is building for geothermal energy in the public and private sectors. New activity related to geothermal in Hawaii is summarized in *Figure 13*.

Figure 13. New Geothermal Activity in Hawaii.

ORGANIZATION	ACTIVITY
County Government	Enacted rules for the geothermal resource permit in Maui County
	County of Hawaii representatives visited the Philippines and are researching models for geothermal development
State Government	Addressing regulatory barriers, e.g., removing subzone requirement for geothermal
	Approved EIS exemption for non-invasive exploration activities
	Establishing permitting wizard and expanding permit facilitation activities
	Recruiting and hiring geothermal expertise within agencies
	Co-funding geothermal exploration activities through UH
University of Hawaii	Conducting surface exploration and planning slim hole drilling to obtain geothermal resource data for the public domain
	Digitizing and publishing geothermal documents and well data
Federal Government	Funding geothermal exploration work in Hawaii
	Supporting development of new exploration techniques in U.S.
	Supporting industry development of new power production technologies in U.S.
Utilities	Released draft 50 MW geothermal RFP for Hawaii Island
	Plan to release 30 MW firm renewable RFP for which geothermal can bid in on Maui
Geothermal Developers	Conducting community outreach
	Securing land position for geothermal exploration
	Working with agencies to understand permitting requirements
	Exploring the resource using non-invasive technologies and planning slim holes
	Expansion of PGV plant from 30 to 38 MW
Landowners	Entering into lease agreements or assessing agreements with geothermal development companies
	Hiring consultants to conduct due diligence and provide cultural and technical guidance
	Assessing direct use and other complementary enterprises

B. Cost of Geothermal

Since cost is such an important driver for geothermal development, a section here is devoted to the examination of cost. For more comprehensive cost data and modeling, Bloomberg New Energy Finance (BNEF) is the best information source discovered in the course of this assessment. Definitive cost information for the Hawaii resource is highly dependent on detailed knowledge of the resource (and therefore risk involved in exploration), its overall quality, the ratio of debt to equity, and regulatory and permitting risk — but some general conclusions can be made about cost drivers and factors.

The levelized cost of energy (LCOE) of geothermal, which takes into account the capital cost and ongoing operations of the plant over its lifetime, depends mainly on two factors — drilling and balance of plant — each comprising about 50% of total costs. Permitting, leasing, and surface exploration activities account for less than 5% of total costs.

Therefore, policies to reduce drilling cost, which is broken down in the Bloomberg New Energy Finance section above, and drilling risk should be the focus for policymakers concerned about the price of electricity.

The capital cost for drilling can be very large for geothermal plants. Cost experience in Hawaii for geothermal production wells is limited to PGV's commercial plant. From that experience it appears that a good ballpark estimate is that each geothermal production well can produce about 5 MW (PGV has six production wells to produce 38 MW of energy, or about 6.3MW/well). Global averages, based on BNEF information, show that new development efforts can expect to have several failed wells, and depending on the production and energy conversion technology employed, may need a few injection wells as well. PGV has three injection wells. BNEF research indicates that, on average, production wells cost more than failed wells and injection wells because of the casing and infrastructure required. On a conservative basis, if we assume that each failed, production, and injection well costs in the neighborhood of $5 M, the total cost for *just drilling* for a new 50 MW plant may be in the ballpark of $100 M.

These kinds of tradeoffs are important for policymakers to understand, as government actions can directly impact these critical cost components. Well into the course of this assessment, PICHTR learned that in fall 2012 Hawaii County enacted a drilling prohibition during evening hours from 7:00 pm to 7:00 am if the location of drilling is within one mile of any existing residence. This type of action has the potential to significantly increase the cost to produce geothermal electricity. In an October 12, 2012 memorandum to DLNR, GeothermEx estimated that the rule would result in drilling taking three times as long by reducing productive drilling hours from 24 to 8 (because of needed safety precautions, the equipment would take a few hours to set up and take down each day). See Appendix I and Appendix J for the relevant memos. Based on the information from BNEF model, this could impact LCOE more than 10%; a more accurate estimate would require detailed analysis.

PICHTR learned from representatives of the geothermal industry that geothermal project costs are driven primarily by two elements: 1) drilling and, 2) rate of return required by the project. The former is that portion of project development cost that carries the highest capital cost and highest degree of risk. The latter is directly related to project risk, with investors and lenders requiring higher rates of return to accommodate increased project risk. Further, the debt to equity ratio of a project has a very large impact on project LCOE. The debt to equity ratio is determined by the level of risk a project faces, including resource risk and regulatory risk, as well as by the characteristics of the developer and the developer's own capital or access to capital markets.

C. Technology

Cost also depends on the technology deployed. For example, flash (or steam turbine) technology appears to have a lower capital cost and lower LCOE — by about a third — than binary turbo-expander technology. The technology approach depends on the developer as well as the characteristics of the geothermal resource and regulatory requirements, and increasingly, water availability at the site.

Technology can be driven by the developer's approach. One geothermal developer, Ormat, is vertically integrated and uses its own technology, while others specialize in specific segments of the market, such as drilling and exploration. Ormat is the market leader in binary technology, and sells approximately 89% of the binary turbines in the geothermal market. The majority of new geothermal projects uses flash technology, and will continue to for the foreseeable future. Fuji, Toshiba, and Mitsubishi are the world's leading flash turbine suppliers for geothermal, representing almost 70% of the market in 2012.

A deeper understanding of technology among Hawaii policymakers, regulatory agencies, and utilities will help the utility choose a developer or a set of developers that present the most cost-effective and appropriate solution for utilizing Hawaii's geothermal resources.

D. Community Acceptance

The interviews conducted revealed a clear preference among stakeholders to first proceed with geothermal development at a local scale that meets Hawaii Island and Maui energy needs, and then investigate and pursue the potential of geothermal for an undersea cable to other islands. This suggests a two-stage approach would be the preferred development scenario, and we elaborate on this approach in the Roadmap section towards the end of the report.

Geothermal development in Hawaii could proceed in one of several ways. Based on our interviews, we conclude that certain elements are important to successfully re-starting the geothermal industry in Hawaii:

- Community acceptance and benefit
- Clear and predictable policies and rules
- Shared plan and vision among state and county policymakers
- Proactive public outreach and education
- Environmental procedures that are comprehensive while not overly restrictive for exploratory activities
- Sustainable use of the geothermal resource
- Widespread industry interest and competition
- Utilization of advanced techniques and new technologies
- Cost-effective and efficient development of the resource

State and county agencies can facilitate and enable these elements in a number of important ways, such as funding and facilitating comprehensive resource assessment, serving as an information clearinghouse and data repository, facilitating permitting for geothermal developers, streamlining and publishing the regulations regarding geothermal exploration and power production, establishing clear rules for developing geothermal on state lands while reducing risk for developers, and pursuing strategies that reduce development risk and cost. In order to facilitate investment and support industry in a complex undertaking, state agencies will need to recruit and hire resident technical expertise in geothermal.

Finally, education and outreach to policymakers, communities, and the public will be important in gaining public acceptance and support. Projects that result in reduced electricity rates and demonstrable benefit beginning at a local scale would likely result in broader public support of and demand for additional geothermal development.

Specific recommendations on each of these topics are outlined in the following section.

VI. RECOMMENDATIONS FOR AGENCY CONSIDERATION

Based on the extensive interviews with government, industry, and other stakeholders, PICHTR has formulated recommendations for agencies that reflect common themes and needs expressed by the stakeholders and community interviewed. In some instances, the agencies concerned are already moving forward with efforts in these areas, and the recommendations below should serve to reinforce their efforts. In other instances, the community may have raised new issues, ideas, or needs that can be informative for the organizations concerned. The recommendations focus on lead state agencies, but are not limited to these agencies. Stakeholders shared many perspectives that relate to the counties and other agencies, so those are also reflected below — with the recognition that decisions about how to support or facilitate geothermal development would lie at the individual agency or county level.

At the same time, because of the complexity of undertaking geothermal planning, development, regulation, outreach, and communications, a significant amount of coordination among these agencies is needed. This type of coordination might best be provided by a "lead organization" that has the requisite authority to capably perform the coordination function.

If the state decides to move forward with increased geothermal development in Hawaii, as supported by the findings from this assessment, public agencies can choose to implement these recommendations to support the efficient and effective development of geothermal.

A. Resource Assessment and Information Clearinghouse

SECTOR CLEARINGHOUSE (DBEDT). DBEDT should assume the role to be the central access point for developers needing assistance to pursue geothermal, and serve a facilitating function for development.

ORGANIZE AND PUBLISH RESOURCE INFORMATION (DBEDT, UH). DBEDT should organize and maintain data related to geothermal resource information. This will require working with UH to provide access to the resource information and studies they have online, and supporting UH efforts to create and maintain a geothermal information portal. (This would be similar to how the Office of Planning maintains a repository of GIS and zoning information for the state.) In industry outreach and marketing efforts, include activities to make industry aware of the information available online.

OUTREACH TO INDUSTRY (DBEDT). Develop marketing plan to let the industry know of Hawaii's interest and commitment to develop geothermal resources. Potential elements may include **1)** Organizing "Hawaii geothermal market development" briefings in conjunction with major industry trade shows like the GRC Annual Meeting in conjunction with Geothermal Energy Association, **2)** Working with geothermal trade organizations to host a future GRC annual meeting in Honolulu to help promote Hawaii as a place for new geothermal project opportunities, **3)** Organizing industry tours of geothermal assets in Hawaii, **4)** Hosting roundtable discussions with top global geothermal development companies and high level Hawaii government officials, **5)** Hosting webinars in conjunction with UH showing how to access and utilize the newly digitized documents, and **6)** Hosting webinars or sessions with state geothermal permitting agencies to explain regulatory requirements and processes, perhaps in coordination with DOE/NREL permit mapping activities.

CHARACTERIZE RESOURCE (UH, DLNR, WITH ADDITIONAL STATE FUNDING). Expand UH efforts to update geothermal characterization studies, possibly with funding from royalties, the Food and Energy Security Fund, or other sources. Focus particularly on resource potential on public lands. When commissioning resource assessments, explore the capabilities of various analysis and/or resource assessment firms to have the best chance of developing high-quality, trusted information. While there was a diversity of viewpoints expressed on whether the state should do resource assessment or leave this activity to private industry, we believe that state resource exploration could facilitate more cost-effective, near-term geothermal development if done prudently.

REDUCE RISK (DBEDT, UH, OTHERS). Encourage private exploration by considering programs to reduce investment risk in exploratory slim holes via cost-share through royalty collections or cost recovery in subsequent power purchase contracts as a "prudent" investment. U.S. and international models exist for different ways to structure such programs, and have been successful in attracting industry interest — as well as returning value to the government.

B. Permitting And Regulatory Process

INTERAGENCY COORDINATION (GOVERNOR/LT. GOVERNOR/DESIGNEE, IN COORDINATION WITH COUNTY MAYORS). Convene and maintain high level working group, to include relevant department heads and key agency staff, to clarify roles and responsibilities, identify gaps, and track progress toward geothermal development. Coordinate with county mayors and agencies, set the policy direction and articulate vision for resource development.

CLARIFY ACT 97, AND CLARIFY COUNTY GRP RESPONSIBILITIES (DLNR). Address the ambiguity created with enactment of Act 97, as it relates to county Geothermal Resources Permits. Recommend that the GRP process for the counties be maintained, and validate that the counties have the authority needed to issue the GRP, in order to reduce uncertainty for developers.

PERMITTING GUIDANCE AND INFORMATION (DOH). Work with DBEDT and NREL to ensure that state and federal geothermal permit guides both adequately describe regulatory permits overseen by DOH. Clarify permits that remain within EPA purview. **(DBEDT).** Update state permitting guide and online permitting wizard to reflect information gathered from this assessment. Ensure that the state permitting guide complements DOE-funded NREL permit facilitation tool for Hawaii.

PERMIT COORDINATION (DLNR, DBEDT). Consider whether legislative action is needed to clarify the responsibility for geothermal permit coordination. Currently, general renewable energy permit coordination and facilitation lies with DBEDT per Act 208 of 2009, but DLNR has some legacy responsibilities to coordinate geothermal permitting related to an undersea cable still on the books. This could create confusion if not addressed. Since the most recent responsibility for renewable energy permit facilitation was given to DBEDT, the state could consider removing these responsibilities from DLNR.

C. Developing Geothermal on State Lands

AGENCY ROLES AND RESPONSIBILITIES (GOVERNOR/LT. GOVERNOR/DESIGNEE, DLNR, DHHL, OHA). Clarify roles and responsibilities to permit future geothermal development on state lands among DLNR, OHA, and DHHL.

SIMPLIFY RULES FOR PUBLIC LAND (DLNR). Pursue amendments to HRS that will permit geothermal to be treated like other renewable energies insofar as direct negotiation of leases if at-risk exploration work confirms development potential on public land.

STATE LAND UTILIZATION (DLNR, DBEDT). Concurrent with identification of "probable" resources on state lands, initiate development scheme(s) to offer the inherent value of those lands to developers willing to undertake exploration and development in exchange for novel approaches that return the maximum community benefit from development.

INTEGRATED PLANNING PROCESSES FOR STATE LANDS (DBEDT). In any future inventory of state lands for resource development, ensure that geothermal energy is included among renewable energy assessments. In county general plans and other planning efforts, ensure that geothermal is included in areas where exploration and development may be likely to occur.

D. Expertise and Capacity in State Agencies

INDUSTRY DEVELOPMENT AND ADVOCACY (DBEDT). If the state decides to move forward with a plan to advance additional geothermal development in the state, the energy office would benefit from building capacity within the state energy office. Specifically, we suggest that a senior program manager be assigned to liaise with industry, landowners, and other public agencies, and function as a sector development manager. This person would also serve as the state's authoritative, objective "spokesperson" for geothermal going forward. Consider industry suggestion to convene a geothermal working group or workshop specifically to hear industry input and share information about current research, resource assessment, permitting, and market development activities. Develop a proactive marketing plan to foster competition.

SUBJECT MATTER EXPERT ON GEOTHERMAL (DBEDT). Provide technical support to DLNR, PUC, DOH, and other organizations as needed. Monitor utility geothermal and firm dispatchable renewable procurements, in the context of the overall energy system, and provide technical assistance when appropriate. Monitor advancements in geothermal technology (e.g., binary turbo-expander and flash turbine technology) and approaches to ensure that the state attracts a variety of proven technical approaches, resulting in project designs that work well with the state's geothermal resource.

CONSISTENT TREATMENT OF GEOTHERMAL IN ENERGY PLANS (DBEDT). Ensure that geothermal plans are consistent across state energy plan, utility planning processes and integrated resource plans, county general plans, community development plans, and other plans that relate to energy development in Hawaii.

TECHNICAL EXPERTISE TO SUPPORT PERMITTING (DLNR). PICHTR believes that DLNR is in a strong position to carry out its oversight and regulation responsibilities with the positions they have (some of which have yet to be filled), but there must be investment in training and personnel development to ensure that the capacity is developed.

OBTAIN EXPERTISE NEEDED FOR GEOTHERMAL PROCUREMENTS (PUC). Consult with other state agencies, especially DLNR, DBEDT, and DOH, as geothermal-related issues and procurements come before the PUC. If additional technical expertise is needed, seek and dedicate resources to hiring technical consultants to investigate and/or re-work specific questions. For example, review provisions requiring dispatchable geothermal energy that could create long term stresses in the well field and may harm long-term sustainability of the well fields.

E. Reducing Cost

REDUCE DEVELOPMENT COST (PUC, DLNR, DBEDT, OEQC). Since cost reduction is a serious concern and major driver to developing geothermal, explore strategies that reduce cost across the board. Many of these recommendations suggest ways to reduce uncertainty and therefore reduce transaction costs for geothermal developers.

RECONSIDER ENVIRONMENTAL REQUIREMENTS FOR EXPLORATION (OEQC). Consider strategies for reducing transaction costs for slim holes and other geothermal exploration activities, such as allowing exploration activities to proceed without a full environmental impact statement. This would reduce barriers to entry for geothermal development companies, potentially leading to reduced ratepayer cost. A full EIS could be required if geothermal resource were confirmed and commercial development activities were pursued.

CONSIDER ROYALTY WAIVERS TO PROVIDE IMMEDIATE COST RELIEF (BLNR, DLNR). Similar to the PGV project in the 1990s, consider waiving royalties for the first few years of geothermal project operation to help jump start more industry investment. Ensure that the savings are passed along to the ratepayers (rather than remaining with the developer or the utility), for example in the form of a reduced cost PPA in the first few years.

F. Communications, Education, and Outreach

COMMUNICATE OVERALL ENERGY PLAN (DBEDT). Develop and communicate the state's plan regarding stages (timeline and levels) of geothermal development in context of other resources in order to help attract serious developers. Clarify distinction between levels of development — island scale vs. statewide cable — with recognition that near-term geothermal development must first satisfy the needs of the island where the resource is located.

RESOURCE INFORMATION (DBEDT). Provide objective, timely, and credible information to the public regarding the potential of geothermal to reduce long-term electricity costs.

ROYALTY EXPENDITURES (DLNR, OHA, AND COUNTY). Move to a better awareness and understanding of geothermal royalty expenditures to communicate direct community- or island-scale benefit from the royalties. Consider differentiating or highlighting those funds directed to resource management and direct community benefit. Possible strategies for communicating to the public might include signage on funded projects, appendix to the annual report to the legislature, article in the County publications, and/or other outlets.

HEALTH INFORMATION (DOH). Provide objective and credible health information on effects of geothermal, including current plant monitoring activities for noise and air emissions, to inform community discussions and policymakers. This would supplement what is currently being provided by developers and UH in reaction to community concerns. Develop content for proactive outreach program possibly in conjunction with U.S. DOE based on their efforts with the California Energy Commission.

COMMUNITY DIALOGUE (DBEDT, SUPPORTED BY DLNR, COUNTY, COMMUNITY ORGANIZATIONS). Create opportunities for proactive community dialogue on the benefits that accrue to communities from geothermal: electricity cost control, direct community improvement projects, direct use benefit for co-located enterprises such as agriculture or visitor attractions, local living-wage jobs, preservation of open space, and community scale agriculture.

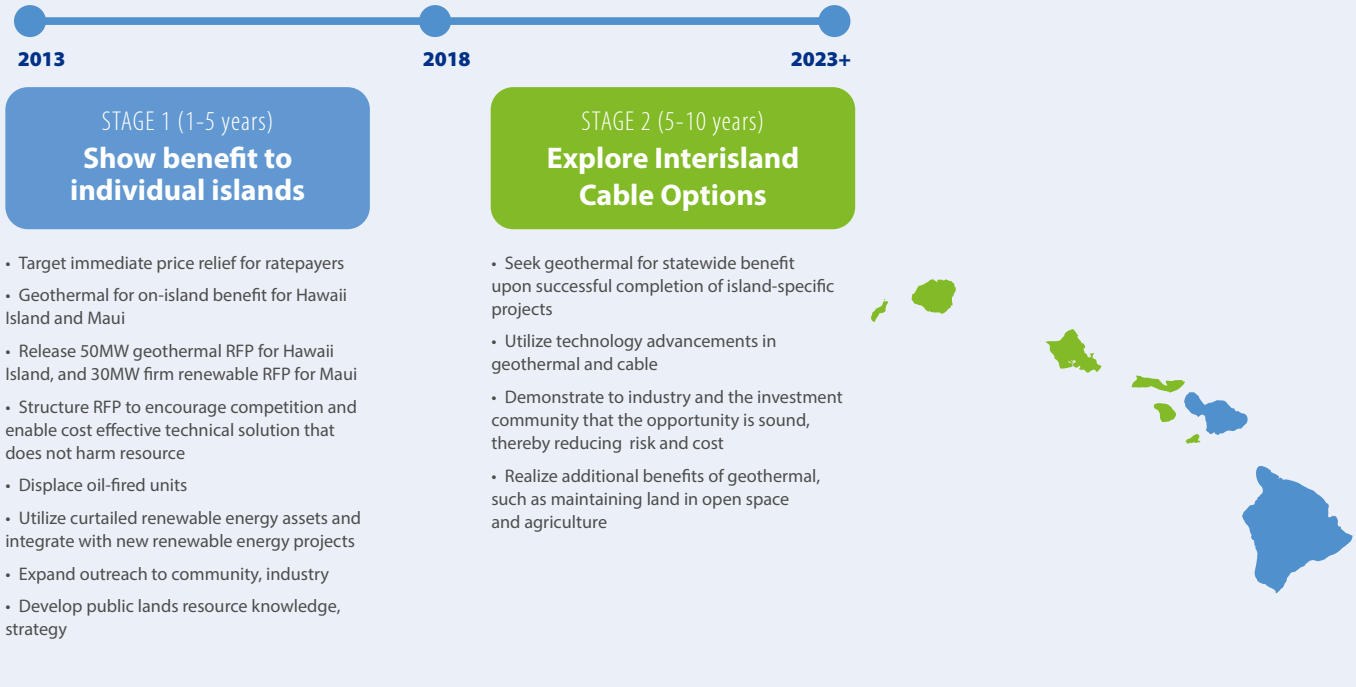
VII. SUGGESTED ROADMAP FOR GEOTHERMAL DEVELOPMENT

A roadmap is a useful tool to guide geothermal development direction for the state. If the state elects to follow a plan of pro-active geothermal development for the near- and long-term, we suggest following a two-phase geothermal resource development roadmap (*Figure 14*). This type of a roadmap could go a long way toward addressing uncertainties about state plans for geothermal heard from stakeholders, and aid the state in attracting serious industry participants who see the potential for a long-term investment in the State of Hawaii.

The following development plan, carefully implemented, offers a two-stage approach that:

1. Achieves near-term pricing benefits of geothermal as a lower cost renewable resource compared to oil
2. Ensures that development is focused first on island-specific electricity needs, in response to desire expressed by many members of the community
3. Demonstrates the ability to develop and manage the resource competently
4. Enables the state to plan when and how to ramp up internal capacity within the Hawaii government
5. Promotes opportunities for future competition as well as geothermal technology advancements
6. Provides for greater utilization of state land assets for future development
7. Provides concrete input to the Integrated Resource Planning process in which the utility and stakeholders are tasked to map timelines and priorities for resource deployment, as well as other county and community planning efforts
8. Envisions geothermal as part of a system that integrates various clean energy technologies
9. Enables future geothermal development for statewide benefit upon demonstration of initial success

Figure 14. Geothermal Development Roadmap - Two Stages.



A. Near-Term (1-5 years): New Geothermal Capacity For On-Island Benefit

- Seek immediate electricity price relief on Hawaii Island and Maui by releasing competitive RFPs: **RFP for geothermal expansion for the Big Island (50 MW)** and **RFP for firm renewable on Maui (30 MW)**, for which geothermal could also "bid in"
- Emphasize the focus of this phase is to **develop geothermal for the benefit of Hawaii Island and Maui**
- Require existing petroleum-fueled HELCO and MECO units to be displaced or retired
- Demonstrate how geothermal can reduce and stabilize electricity costs. **Reduced and stabilized rates would be the principal community benefit**
  - Target a highly competitive pricing scheme and determine the levelized cost of electricity (LCOE) range likely for geothermal development in order to drive significant cost savings for ratepayers, i.e. $0.10 to 0.15/kwh[7]
  - Investigate how the state can help achieve lower project cost for the first one or two projects that come online, thus reducing electricity costs on Hawaii Island and Maui (e.g., consider one-time reduction or forgiveness of all or a portion of royalty collections in an effort to restart the geothermal industry)
- Determine the technical nature or characteristics needed from geothermal to displace oil-fueled units, baseload and any load following capability, without ultimately causing harm to the geothermal investment or the resource. Work this requirement into the project specification
- Encourage strong industry participation and competition, and expand proactive outreach to industry, to ensure that each island has a range of expertise and technology options available
- Work with PUC and the utilities to define appropriate approaches for expanded geothermal that address risk-management, (e.g., geographic dispersal of projects, reasonable criteria to obtain ancillary services for geothermal energy), while ensuring that such criteria do not jeopardize the investment or geothermal resource, and are not so restrictive that they discourage participation by potential industry players
- Consider how to utilize 22 MW of capacity remaining on the PGV permit to achieve near-term development and achieve lower electricity prices from geothermal; this development could be completed on an accelerated schedule since permits are already in hand. The PGV permit allows 60 MW, 38 MW have come online thus far
- Together with the permit facilitation tool for geothermal, expand online information and establish a user-friendly public interface for geothermal resources
- Gain a better understanding of potentially developable geothermal resource as the efforts of the University of Hawaii are completed and sources are better understood outside of the Kilauea East Rift Zone
- Make significant upfront investments in resource characterization, and rule reform and clarification, to prepare public lands for inclusion in this phase of development. Develop a strategy and processes to auction or otherwise allocate rights on public lands to enable cost-effective geothermal development

7 During several of our interviews PICHTR heard somewhat unsubstantiated comments that PGV's 8 MW expansion cost $0.08 to $0.10/kwh. Interview with a major industry trade organization revealed that the geothermal industry has been able to deliver projects at a $0.06 to $0.09/kwh with more difficult projects costing as much as $0.15/kwh. Thus a useful starting point for a project development target owing to Hawaii's traditional higher costs of development, discounted for much less permitting uncertainty falls into the range suggested.

- Develop and manage a complementary advocacy, public education, and outreach strategy
- Contribute this potential development scenario into the PUC's integrated resource planning process for HECO/HELCO/MECO
- Complement the effort to develop geothermal to reduce electricity cost by concurrently seeking to utilize zero or very low marginal cost curtailed variable renewable generation (e.g., wind, hydro), and seeking to integrate new renewable energy additions (e.g., utility scale solar, waste to energy)

B. Longer-Term (5-10 years): Several Hundred New Megawatts Of Capacity For Statewide Benefit

- Upon successful completion of island-specific projects and demonstration of benefits of geothermal, **embark on possible expansion of geothermal for statewide benefit**
- More information will be available about resource potential, as well as technology advancements including electricity production from lower temperature geothermal resources
- More information should become available about the feasibility of an undersea electricity cable extending to Hawaii Island
- Deploy strategy to utilize public lands for geothermal energy development to include resource assessment, as well as auction or other land allocation mechanisms to achieve cost effective development proposals
- Build upon the successes of the initial Hawaii Island and Maui projects, demonstrating to industry and the investment community that the opportunity for further expansion is sound
- Realize additional benefits of geothermal, such as providing revenue streams that enable landowners to keep their lands in open space and agricultural production

VII. RESOURCES AND APPENDICES

A. **DBEDT Geothermal Permitting Guidebook 2011**
http://energy.hawaii.gov/wp-content/uploads/2011/11/geothermal_guidebook.pdfSummary

B. **DBEDT Permitting Wizard 2012**
http://demo1.pbid.com/

C. **NREL Geothermal Permitting Checklist 2012**
http://www.nrel.gov/geothermal/developer_checklist/

D. **Geothermal Working Group Report 2011**
http://www.hawaiicounty.gov/research-and-development

E. **GeothermEx Assessment 2005**
http://energy.hawaii.gov/wp-content/uploads/2011/10/AssessmentOfEnergyReservesAndCostsOfGeothermalResourcesInHawaii.pdf

F. **HELCO Draft RFP Released November 9, 2012**
http://www.helcohi.com/vcmcontent/StaticFiles/pdf/DraftGeothermalRFP_11-09-2012.pdf

G. **Geothermal Royalty Dispositions Report 2012**
http://hawaii.gov/dlnr/reports-to-the-legislature/2013/EN13-Geothermal-Rpts-FY12-Secs182-18-196D-FY12.pdf

H. **Letter from State of Hawaii DOH to Hawaii County Council June 29, 2012**
(included on page 67)

I. **GeothermEx Letter to DLNR Regarding Potential Effects of Restrictions on Night-Time Drilling of Geothermal Wells October 12, 2012**
(included on page 71)

J. **GeothermEx Letter to DLNR Regarding Safety Aspects of Restrictions on Night-Time Drilling of Geothermal Wells October 31, 2012**
(included on page 80)

Letter from State of Hawaii DOH to Hawaii County Council June 29, 2012

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

LORETTA J. FUDDY, A.C.S.W., M.P.H.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HI 96801-3378

In reply, please refer to:
File:
EPO-0689
PGV 7-2-12 Mtg

June 29, 2012

Mr. J Yoshimoto, Chair
Agriculture, Water and Energy
Sustainability Committee
Hawai`i County Council
County of Hawai`i
25 Aupuni Street, Suite 1402
Hilo, Hawaii 96720

Dear Mr. Yoshimoto:

I am sorry I will be unable to attend the Agriculture, Water and Energy Sustainability Committee meeting on July 2, 2012. On June 26, you emailed a list of questions that may be asked during the meeting. Below are my responses:

1. **What permits is PGV required to have in order to operate its facility, for exploratory drilling, production or for re-injection?**

   The PGV Project Environmental Impact Statement completed in November 1987 provides extensive information on this project. The EIS can be viewed on the OEQC website by going to: http://oeqc.doh.hawaii.gov/Shared%20Documents/EA_and_EIS_Online_Library/Hawaii/1980s/1987-11-23-EIS-Puna-Geothermal-Venture-Project.pdf

   Table 13-1 in the EIS details the applicable permits, legislation, and regulations.

   Department of Health related permits and regulation includes the following:

   a. Clean Air Permit – The authority to construct or modify a facility and the permit to operate is based on Clean Air Amendments of 1977, Title I Section 165, 40 CFR 52.21 PSD regulations, HRS Chapter 342, and Administrative Rules of the DOH, Title 11, Chapters 59 and 60.

      PGV must comply with Non-covered Source Permit (NSP) No. 0008-02-N which regulates the air emissions from the 41 Megawatt (nominal) geothermal power plant, well-field, and geothermal exploratory/developmental wells. The permit incorporates operational limitations and monitoring, recordkeeping, reporting and testing requirements including a requirement that PGV maintain three ambient air quality monitoring stations.

b. Underground Injection Control (UIC) Permit – Approval to construct and approval to operate is based on 40 CFR 122 and 146, Regulations and Technical Criteria Standards; State Underground Injection Control Programs, HRS Chapter 340E, and Administrative Rules of the DOH, Title 11, Chapter 23.

The construction, operation, and abandonment of PGV's injection wells are covered under the UIC permit and its permitting process. Exploratory drilling and production well drilling are regulated by the Department of Land and Natural Resources.

c. Noise Permit: At this time no noise permits are required for drilling, production or re-injection. Because the facility is located on land zoned as a Class C zoning district that includes agriculture, country and industrial lands, all of the activities have been within the maximum permissible sound levels as set forth in Hawaii Administrative Rules (HAR), "Community Noise Control", Section 11-46-4. Class C zoning districts allow 70 dBA at any time of the day or night as measured at the property line.

2. What standards must PGV comply with in its drilling activities, for production wells, and for injection wells?

Clean Air: In addition to the requirements of the Non-covered Source Permit, PGV must comply with Hawaii Administrative Rules (HAR) Chapter 11-59, Ambient Air Quality Standards and Chapter 11-60.1, Air Pollution Control.

Hazardous Waste: PGV is a generator of hazardous waste from the maintenance and activities of the plant. Waste drilling mud may require testing and may be regulated by the Solid and Hazardous Waste Branch of DOH.

Noise: All activities must comply with the maximum permissible sound levels as set forth in HAR 11-46-4. If activities are expected to exceed the allowable levels, then a noise permit must be procured pursuant to HAR 11-46-7. Class C zoning districts allow 70 dBA as measured at the property line.

3. What air quality standards must PGV comply with? What are these standards based on? Is there a relationship between these standards and public health?

The Hawaii State air standard for hydrogen sulfide is 25 parts per billion on an hourly averaging basis. The standard has been set to protect public health and is also designed to minimize nuisance odors, although many people can smell hydrogen sulfide at lower levels. There is no EPA standard for hydrogen sulfide.

4. What water quality standards must PGV comply with? What are these standards based on?

PGV has no permit with the Clean Water Branch as there is no discharge to surface waters. Any project that disturbs an acre or more of land will first require a construction storm water permit from the Clean Water Branch of DOH.

5. **What noise standards must PGV comply with? What are these standards based on?**

   PGV activities must comply with all applicable parts of HAR, Chapter 11-46. These standards were based substantially on the now repealed HAR 11-43, "Community Noise Control for Oahu". Another significant source of scientific information is the "Noise Effects Handbook" authored by the EPA. Class C zoning districts allow 70 dBA as measured at the property line.

6. **What is the relationship between these standards and EPA standards?**

   Air: There is no EPA standard for hydrogen sulfide.

   Noise: EPA currently has no regulations with regards to noise and enforcement was delegated down to the local level.

7. **How would you describe PGV's compliance with the above standards and permit conditions?**

   Air: PGV has generally been in compliance with the air permit conditions and standards. There have been six (6) formal Notices of Violation (NFVO) for H2S exceedances over the last 20 plus years with the last NFVO occurring in 2005. Two (2) informal notice of violations (NOV) were issued more recently for various reporting infractions.

   Hazardous Waste: PGV has been inspected annually and the Solid and Hazardous Waste Branch has sent warning letters. However, PGV has corrected its violations.

   Noise: Since implementation of the noise rules in 1996, PGV has never been found to be out of compliance.

8. **When was the last determination made that PGV had exceeded permissible standards or was in violation of any permit condition?**

   Air: The most recent CAB violation was an informal NOV issued on June 23, 2010 for failing to submit a test plan in the required time.

   Noise: None since implementation of the statewide noise rules in 1996.

9. **Has there been any need to issue any cease and desist orders based on the failure of PGV to operate in compliance with its permits which implicate health and safety standards?**

   No.

10. Can members of the public access air or noise monitor and permit information?

Air: The public can access the DOH Puna E air monitoring data at DOH's public website for current data: **http://emdweb.doh.hawaii.gov/air-quality**. Members of the public that do not have internet access can call the CAB Honolulu office at (808) 586-4200. To request a hard copy of the data or the air permit, a request for information form will need to be submitted.

Members of the public can access PGV's current air monitoring station data at PGV's website: **http://www.punageothermalventure.com**. Those that do not have internet access can call the PGV Information Line at 934-9072 for recorded general information. Calls may be made to the PGV Response Line at 965-8843. A messenger service will forward the messages to PGV to respond.

Noise: While there is no online access to noise monitoring data, members of the public can request information either verbally or in writing.

11. Who maintains and calibrates the monitors?

Air: The DOH Puna E station monitor is calibrated and maintained by the State Laboratory Division/Air Surveillance and Analysis Section. The three PGV air monitoring stations are maintained by an independent third party contractor hired by PGV.

Noise: Sound level measuring devices are calibrated by a third party on an annual basis.

If you have further questions, please feel free to contact me at 808-586-4424. Thank you for this opportunity to allow the Department of Health to respond to these questions.

GARY GILL
DEPUTY DIRECTOR FOR ENVIRONMENTAL HEALTH

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MEMORANDUM

To: Carty Chang
Chief Engineer
Department of Land and Natural Resources
State of Hawaii
carty.s.chang@hawaii.gov

Date: 12 October 2012

cc: Cameron Black
Hawaii State Energy Office
Department of Business, Economic Development & Tourism
State of Hawaii
Cameron.B.Black@dbedt.hawaii.gov

From: James Lovekin and Eduardo Granados

Subject: Potential Effects of Restrictions on Night-Time Drilling of Geothermal Wells

Per your request, GeothermEx has investigated questions posed by the Department of Business, Economic, Development and Tourism (DBEDT) regarding the potential effects of restrictions on night-time drilling of geothermal wells. We have considered this topic from the point of view of the additional time and costs that restrictions on night-time drilling would incur. We have also conducted a brief literature search to locate references related to this topic.

GeothermEx estimates that a well drilled with 12-hour restrictions at night will take about three times as long to drill as a well without such restrictions. The reason is that, when drilling operations are shut down, safety requires that the drilling bit be pulled out of the hole. This process can take several hours, depending on the depth of the hole. At the start of drilling operations the next day, the bit must be run back into the hole, which can also take several hours. The net effect is that the nominal 12-hour drilling day would get reduced to only about 8 hours of effective drilling. Furthermore, hole stability would likely be jeopardized during the shut-down period due to the additional exposure time of the formation to drilling mud, which can result in de-stabilization of the wellbore wall, especially in hydrothermally altered geothermal zones. Thus, the estimate of 8 hours of effective drilling out or a nominal 12-hour drilling day is probably optimistic, since it doesn't account for extra time to recover from hole stability problems.

The tables and diagrams in Appendix A show a breakdown of drilling time and cost for a typical

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6,000-foot geothermal well drilled in the mainland US, both as it would normally be drilled (without time restrictions) and for a hypothetical case with 12-hour drilling restrictions at night. The ratio of drilling duration for restricted vs unrestricted wells is estimated at three-to-one, for the reasons discussed above. The illustrative drilling costs for these two cases are not necessarily indicative of actual drilling costs in Hawaii – actual drilling costs depend on a variety of factors, including geologic conditions and rig availability – but the cost ratio of the two cases can be considered representative to a first approximation for a range of drilling conditions, including those typical of Hawaii. This example shows that a well drilled with 12-hour night-time restrictions can be expected to cost roughly twice as much as a well without such restrictions.

Appendix B includes an Excel worksheet of references GeothermEx has located in our brief literature search. We are unaware of any jurisdiction worldwide that has placed a blanket prohibition on drilling at night. There are instances of oil fields in urban areas (such as Long Beach, California) where extensive sound-proofing and camouflage have been employed to allow drilling and well-maintenance activities to continue in close proximity to human habitation. In the Long Beach example, there are night-time restrictions on certain drilling-related activities (such as hammering on pipe or the racking of pipe). However, even at Long Beach, the regulations allow for "on-bottom" drilling to continue around the clock. Sound-proofing and light-shielding technologies exist that allow drilling activities to be compatible with rural and touristic environments as well - for example, in the Lardarello area of Italy (Lazzarotto and Sabatelli, 2005). The need for such technologies should be assessed based on site-specific conditions, because noise-proofing and light shielding equipment also add to the cost of drilling. However, they may be appropriate in some settings in Hawaii, and they would have much less cost impact than a prohibition on night-time drilling.

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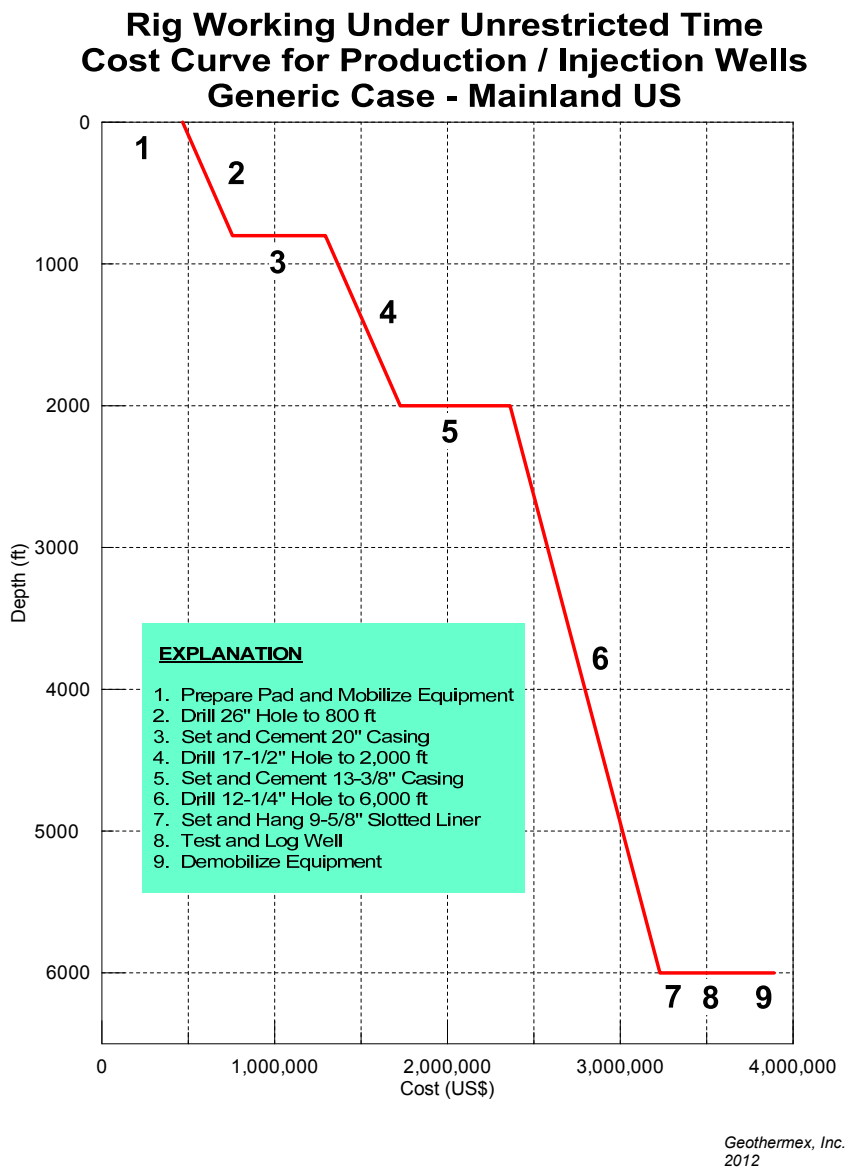
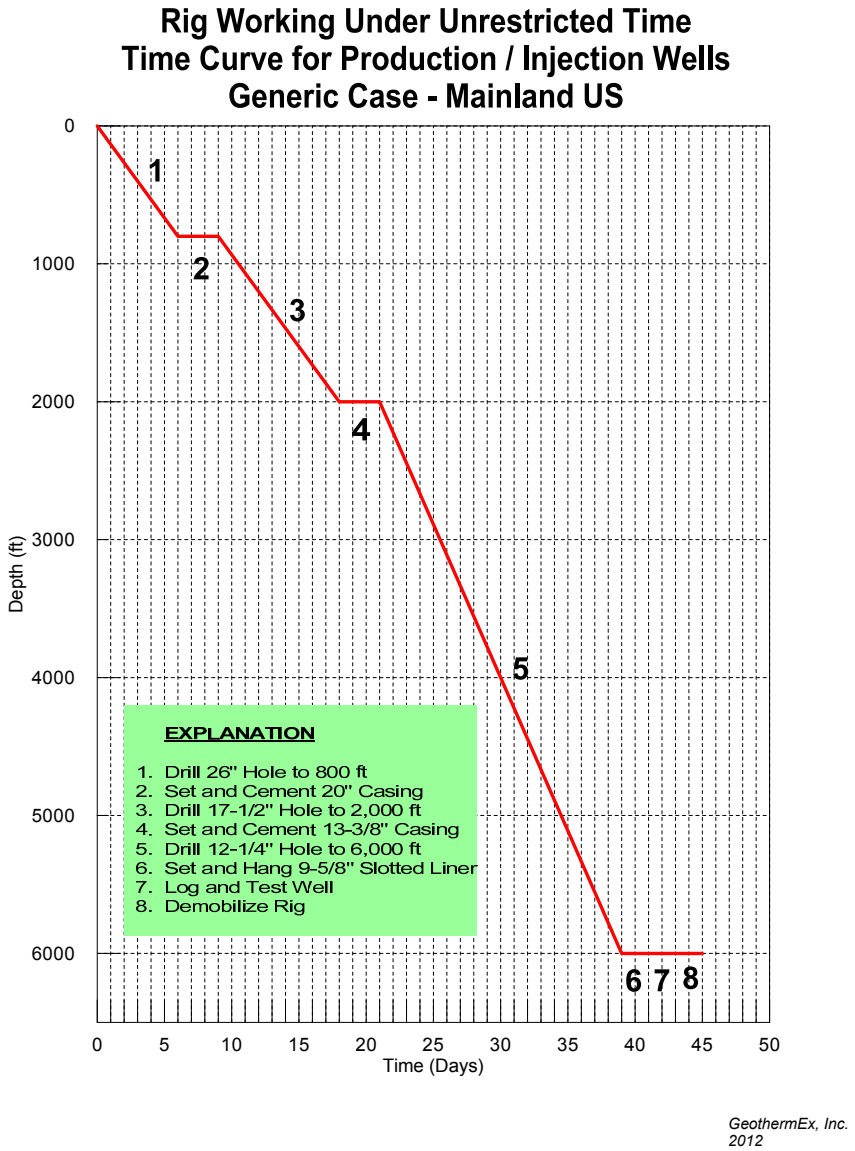
APPENDIX A

Drilling Costs With and Without Night-Time Restrictions

Generic Case - Mainland US - Drilling Rig Working Under Unrestricted Time
Time and Cost Breakdown for Drilling a Production / Injection Well

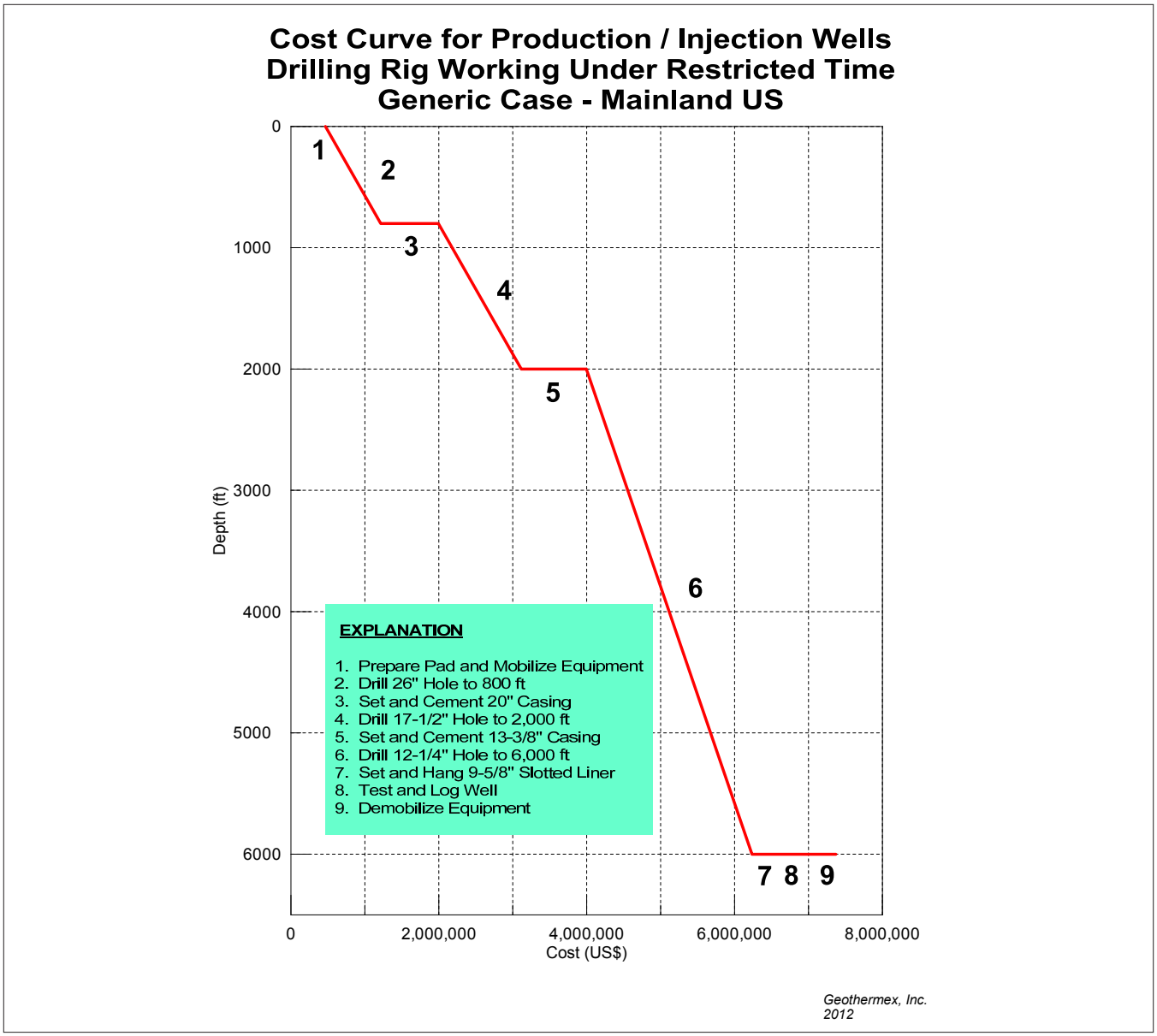
No.	Activity	Days	Cum. Days	Depth	Cost	Cumulative Cost
1	Pad preparation, conductor and mobilization	0	0	0	$467,500.00	$467,500.00
2	Drill 26" to 800 ft.	6	6	800	$289,000.00	$756,500.00
3	Set and cement 20" casing	2	8	800	$488,666.67	$1,245,166.67
4	Install BOP's	1	9	800	$48,166.67	$1,293,333.33
5	Drill 17-1/2" to 2,000 ft	9	18	2000	$433,500.00	$1,726,833.33
6	Set and cement 13-3/8" liner	2	20	2000	$512,466.67	$2,239,300.00
7	Install BOP's and Wellhead	1	21	2000	$123,166.67	$2,362,466.67
8	Drill 12-1/4" to 6,000 ft	18	39	6000	$867,000.00	$3,229,466.67
9	Set 9-5/8" slotted liner	2	41	6000	$261,804.87	$3,491,271.53
10	Survey & test well	4	45	6000	$372,666.67	$3,863,938.20
11	Demobilize	0	45	6000	$26,000.00	$3,889,938.20

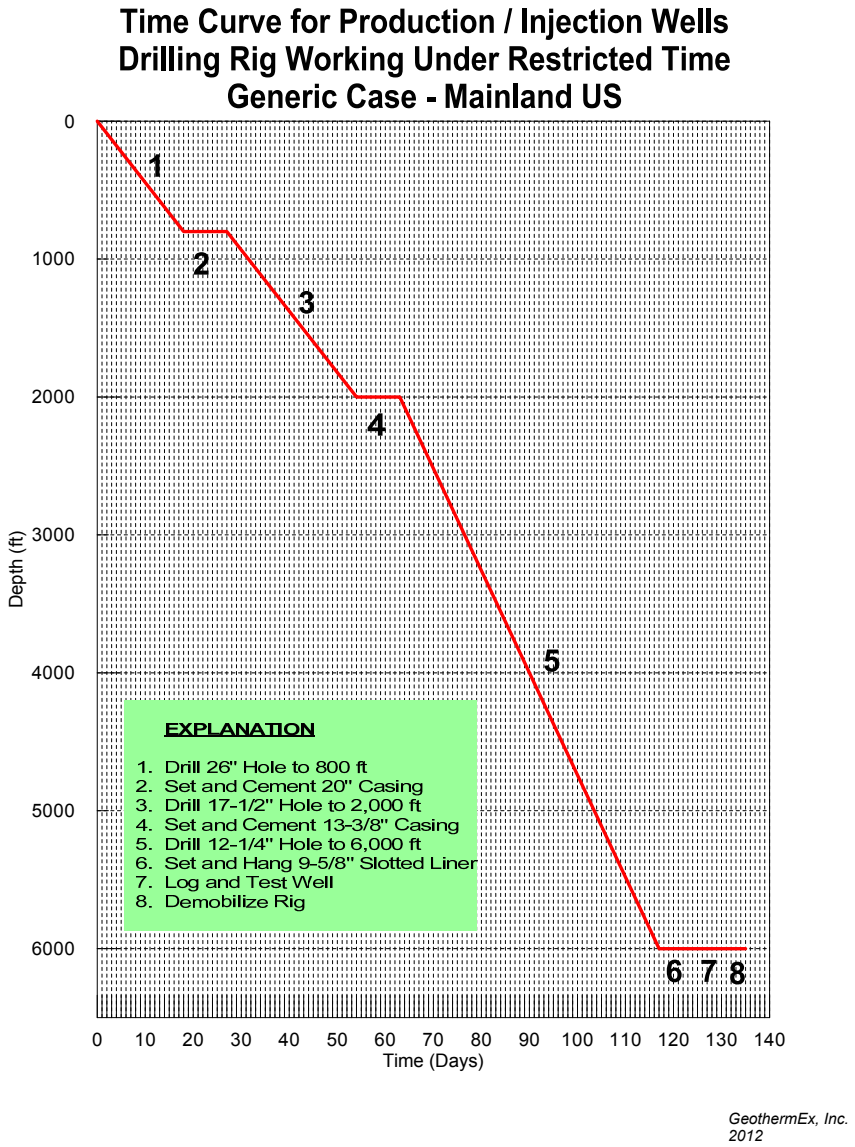




Generic Case - Mainland US - Rig Working Under Restricted Time
Time and Cost Breakdown for Drilling a Production / Injection Well

No.	Activity	Days	Cum. Days	Depth	Cost	Cumulative Cost
1	Pad preparation, conductor and mobilization	0	0	0	$467,500.00	$467,500.00
2	Drill 26" to 800 ft.	18	18	800	$747,000.00	$1,214,500.00
3	Set and cement 20" casing	6	24	800	$656,333.33	$1,870,833.33
4	Install BOP's	3	27	800	$124,500.00	$1,995,333.33
5	Drill 17-1/2" to 2,000 ft	27	54	2000	$1,120,500.00	$3,115,833.33
6	Set and cement 13-3/8" liner	6	60	2000	$680,133.33	$3,795,966.67
7	Install BOP's and Wellhead	3	63	2000	$199,500.00	$3,995,466.67
8	Drill 12-1/4" to 6,000 ft	54	117	6000	$2,241,000.00	$6,236,466.67
9	Set 9-5/8" slotted liner	6	123	6000	$429,471.53	$6,665,938.20
10	Survey & test well	12	135	6000	$678,000.00	$7,343,938.20
11	Demobilize	0	135	6000	$26,000.00	$7,369,938.20


Cost Curve for Production / Injection Wells
Drilling Rig Working Under Restricted Time
Generic Case - Mainland US
Depth (ft)
0
1000
2000
3000
4000
5000
6000
1
2
3
4
5
6
7 8 9
EXPLANATION
1. Prepare Pad and Mobilize Equipment
2. Drill 26" Hole to 800 ft
3. Set and Cement 20" Casing
4. Drill 17-1/2" Hole to 2,000 ft
5. Set and Cement 13-3/8" Casing
6. Drill 12-1/4" Hole to 6,000 ft
7. Set and Hang 9-5/8" Slotted Liner
8. Test and Log Well
9. Demobilize Equipment
0
2,000,000
4,000,000
6,000,000
8,000,000
Cost (US$)
Geothermex, Inc.
2012


Time Curve for Production / Injection Wells
Drilling Rig Working Under Restricted Time
Generic Case - Mainland US
Depth (ft)
0
1000
2000
3000
4000
5000
6000
Time (Days)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
1
2
3
4
5
6 7 8
EXPLANATION
1. Drill 26" Hole to 800 ft
2. Set and Cement 20" Casing
3. Drill 17-1/2" Hole to 2,000 ft
4. Set and Cement 13-3/8" Casing
5. Drill 12-1/4" Hole to 6,000 ft
6. Set and Hang 9-5/8" Slotted Liner
7. Log and Test Well
8. Demobilize Rig
GeothermEx, Inc.
2012

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APPENDIX B

Preliminary Literature Review of Night-Time Drilling Restrictions

Website	File	Summary
ftp://ftp.consrv.ca.gov/pub/oil/publications/prc03.pdf	CADOGGR_1976Recap_Regulations on Drilling-O&M-Abandonment.pdf	A 1976 legislative opinion reprinted in 2002 on Regulations on Drilling, Operation, Maintenance, Abandonment Of Oil, Gas, and Geothermal Wells
http://www.cracked.com/article_18717_6-massive-secret-operations-that-are-hidden-all-around-you.html http://en.wikipedia.org/wiki/Beverly_Hills_Oil_Field http://los-angeles.travora.com/articles/urban-oil-wells-in-los-angeles		All sites about the LA region - Beverly Hill Oil Field and its development in an urban area
http://a123.g.akamai.net/7/123/11558/abc123/forestservic.download.akamai.com/11558/www/nepa/87713_FSPLT2_123428.pdf	USDAFS_2010_RODMtBaker_P4.pdf	Lists limited drilling hours during the nesting season of the marbled murrelet by USDA Forest Service
http://www.energy.ca.gov/sitingcases/saltonsea_amendment/documents/applicant/afc/5-8%20Noise.pdf	ENERGY.CA.GOV-5-8 Noise.pdf	Details federal regulations on noise & role of state/local authority.
http://wellservicingmagazine.com/drilling-and-producing-city	WSmagazine_Drilling in a City_Article.pdf	Highlights cities with active production & methods used to screen facilities
http://www.colleyville.com/titanupdate012612.html		Time restrictions on fracking operations (hi-P injection & resultant flows) only. Not for drilling ops
http://www.cityofwhittier.org/civicax/filebank/blobdload.aspx?blobid=3578	Long Beach, CA.pdf	Lists details on noise abatement, specific restrictions on noise levels and times for Long Beach specifically, also states that on bottom drilling can go 24hrs as long as a list of specific activities do not occur.
http://www.dallascityhall.com/pdf/GasDrilling/GasDrillingandProductionOrdinanceComparisonDallasItemstoIncludeandStrawmanDraft1-19-12.pdf	GasDrillingandProductionOrdinanceComparisonDallasItemstoIncludeandStrawmanDraft1-19-12.pdf	Lists rules on use of noise blankets for any type of operations, and a daylight time restriction for fracking only.
http://www.contactenergy.co.nz/web/pdf/environmental/A2Noise_Assessment.pdf	A2Noise_Assessment.pdf	Noise restrictions for testing only
http://www.geothermal-energy.org/pdf/IGAstandard/WGC/2005/1018.pdf	Lazzarotto_2005_Tech Developments Larderello.pdf	Paper describes rig soundproofing for drilling in a sensitive area.
http://www.noisecontrol.com/drilling-2/		A company website dealing with noise blankets & specializing in all types of drilling construction including geothermal
http://www.drillingnoisecontrol.com/blanketpanels.html		A company website dealing with rig acoustics & control (there are others)

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MEMORANDUM

To: Carty Chang
Chief Engineer
Department of Land and Natural Resources
State of Hawaii
carty.s.chang@hawaii.gov

Date: 31 October 2012

cc: Cameron Black
Hawaii State Energy Office
Department of Business, Economic Development & Tourism
State of Hawaii
Cameron.B.Black@dbedt.hawaii.gov

From: James Lovekin and Eduardo Granados

Subject: Safety Aspects of Restrictions on Night-Time Drilling of Geothermal Wells

Introduction

GeothermEx has prepared this memo to summarize the ways in which restrictions on night-time geothermal drilling could affect the safety of drilling operations. Fundamentally, shutting down drilling operations at night would cause repeated interruptions in the circulation of drilling fluids, and it would extend the period of time in which the wellbore is exposed to drilling fluids without having casing installed. There are three consequences of this that could create adverse conditions for safety: (1) thermal cycling of the well casing; (2) a build-up of gas pressures in the wellhead; and (3) loss of integrity of the wellbore wall. These three topics will be discussed in greater detail below.

Thermal Cycling

As a geothermal well is drilled, a sequence of pipes (casing strings) are cemented at successively greater depths to help keep the shallow underground aquifers from being contaminated, seal up the upper parts of the well and protect the formation from pressures that could lead to fracturing. By the time a well is completed, there are several concentric strings of casing at the surface, with cement in between each string and in the annulus between the outer casing and the formation. Each casing string is susceptible to thermal expansion when it gets hot, and thermal contraction as it cools. The cement around the pipes helps control this expansion and contraction by binding the concentric casing strings to each other and to the surrounding formation. The cement also prevents the unwanted migration of fluids from the geothermal

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reservoir to shallower formations through annular spaces outside the casing strings. In the normal operation of a geothermal well, casings are exposed to periodic cycles of heating and cooling (for example, when a production well is put on line and when it is shut in). These cycles are relatively infrequent, and well-cemented casing strings are designed to accommodate this. However, repeated thermal cycling of a well during drilling can lead to cracking of the cement sheaths around the casing strings. This renders the cement less effective in controlling expansion and contraction. It can also make the cement sheaths prone to leakage of geothermal fluids to zones nearer the surface. Once pathways for fluid flow through the broken cement sheath outside the casing strings are established, they can become progressively worse over time. This can lead to contamination of shallow groundwater aquifers, and in extreme cases, can lead to discharges of geothermal fluids to the atmosphere around the wellhead and from areas at some distance from the well. The odds of this happening are difficult to predict, and the incidence of such leakages is low - in large part because geothermal drilling operations put a premium on keeping circulation going (even when the bits are not penetrating new formation), in order to keep thermal cycling to a minimum. However, an enforced regimen of shutting down drilling operations at night would increase the frequency of thermal cycling and correspondingly increase the safety risk of groundwater contamination and blow-outs.

Build-up of Gas Pressures

In normal drilling operations, gases that are present in the formation (either in solution or as gas pockets) will typically enter the wellbore in small amounts and be continuously circulated out of the hole by the drilling fluids. Once circulation stops for a period of several hours, these gases can migrate to the top of the wellbore and accumulate in the wellhead. Because they originate in high-pressure zones at depth, these gases actually remain at high pressures as they rise in the well, resulting in an increase in pressure at the wellhead. The higher wellhead pressure, in combination with the hydrostatic pressure of drilling fluids and natural liquid-phase fluids in the well, can exert pressures at the bottom-most casing string that are much higher than just the weight of the liquid-phase column alone. This can lead to fracturing of the formation and flow of drilling fluids or geothermal fluids into unintended zones. Depending on natural zones of weakness, these fluids can break through to shallower intervals, and again there is some risk of a breach to the surface, even at some distance from the wellbore. This is a separate phenomenon from leakages induced by thermal cycling, but the safety consequences of groundwater contamination and well blowout are much the same.

Loss of Integrity of Wellbore Wall

Drilling fluids (often referred to as drilling mud) are designed to coat the wall of freshly drilled hole with a “mud-cake” that seals off small fractures and pore spaces to prevent seepage of drilling fluids into the formation. The formation typically contains certain amounts of clay

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minerals (all the more common in rocks that have been altered by high-temperature geothermal fluids), that can swell on exposure to waters of different chemistry than natural formation fluids. It is commonly recognized that the longer the formation is exposed to drilling fluids (even in conditions where circulation is maintained), the more susceptible the formation is to sloughing. To the extent that night-time drilling restrictions increase the overall duration of drilling, this loss of formation integrity can lead to a higher incidence of getting drilling tubulars stuck in the hole. This not only increases the duration and cost of the drilling operation, it also increases the likelihood that some form of uncontrolled flow to the surface will occur, due to the intense use of pressure containment equipment such as blow-out preventers ("BOPs") at the wellhead. The loss of wellbore integrity at depth also contributes in some degree to the possibility that geothermal fluids will channel and break through to shallower horizons, thereby compounding the risks of groundwater contamination and blowouts from thermal cycling and gas-pressure build-up.