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GEO THERMAL

ENERGY

NATIONAL ENERGY STRATEGY

A Compilation of Public Comments

JUNE 6, 1990

**GEO THERMAL DIVISION
U.S. DEPARTMENT OF ENERGY**

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GEOHERMAL ENERGY

NATIONAL ENERGY STRATEGY

A COMPILATION OF PUBLIC COMMENTS

June 6, 1990

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EXECUTIVE SUMMARY

The National Energy Strategy (NES) will serve as a blueprint for Department of Energy policy and program decisions and will contain specific recommendations on how to balance the nation's energy, economic, and environmental requirements. The recommendations will be based on testimony from a series of public hearings conducted around the nation including written testimony sent directly to the Department. The compilation of public input is designed to build consensus on the types of measures that could be implemented to achieve the goals of the NES.

This report summarizes all oral and written testimony related specifically to the development and use of geothermal energy as part of the nation's energy strategy. The report follows the format of the Department's "Interim Report," published in April 1990, which summarized the body of testimony regarding the nation's energy situation and publicly identified goals, obstacles, and options for addressing the situation.

This analysis examines oral testimony delivered in 11 of the 14 hearings held since August 1, 1989, and of written testimony (Q-Files) sent directly to the Department of Energy as of April 1, 1990. Three of the hearings did not address geothermal energy. Table I lists the respective topics at each of the NES hearing sites and denotes those hearings containing material used in this report.

Geothermal's ability to play a significant role in the nation's energy future depends on the achievement of three major goals: (1) to expand geothermal development, both domestically and internationally; (2) to increase the competitiveness of the U.S. geothermal industry; and (3) to enhance public awareness of geothermal energy. Success in achieving these goals depends on how effectively geothermal energy can alleviate some of the nation's major energy-related problems.

As a significant portion of public testimony revealed, geothermal offers several advantages over other forms of energy, and may help to relieve environmental, energy security, and international trade problems. In fact, about 90% of the NES geothermal supporters expressed great concern over environmental degradation and the national energy security problems which accompany the nation's continued reliance on fossil and nuclear fuels. Intensified competition in the international energy market was also cited as a principle concern for the nation's waning lead in geothermal technology.

Many obstacles currently hinder geothermal energy development. The testimony identified numerous impediments to geothermal developments which are categorized into four types of obstacles: policy, market and economic, international trade and competitiveness, and technical.

Much of the testimony offered options designed to direct geothermal development past the obstacles impeding its progress. Each of the options is designed

to increase geothermal's competitiveness in the domestic and the international energy resource market. Tax incentives, R&D subsidies, international trade policy, environmental taxes and incentives, and regulatory measures are the policy instruments recommended to increase geothermal development.

An entire section of this report focuses on geothermal development in Hawaii, because it represents a microcosm of the benefits and risks associated with geothermal development for the nation as a whole. Hawaii, with its abundant geothermal resources and lack of fossil fuels, make it an ideal location for developing this clean and indigenous fuel source. Although the state plans to develop the resource, it must first settle debates concerning the development's cost-effectiveness, its impact on the environment, and other land-use implications. While the concerns about geothermal development will differ from region to region, the outcome of Hawaii's geothermal debate will set examples for many communities seeking to develop clean and indigenous energy resources.

NOTE:

The goals, obstacles, and policy options contained in this report represent a range of public views concerning geothermal energy's role in the National Energy Strategy presented to the Department of Energy. This report is intended as a reference source for the development of a national energy strategy. The Department of Energy does not necessarily support every policy option suggested by the body of oral and written testimony nor does it agree with all of the data presented.

TABLE I
NATIONAL ENERGY STRATEGY HEARINGS
 (* not used in summary of testimony)

	SITE	DATE	TOPIC
SERIES I	Washington, D.C. #1	August 1, 1989	General
	Tulsa, OK	August 8, 1989	General
	Boise, ID	August 23, 1989	General
	Seattle, WA	August 28, 1989	General
	Louisville, KY	Sept. 8, 1989	General
SERIES II	Providence, RI	Dec. 1, 1989	Energy and Productivity, A Northeast Perspective
	Houston, TX	Dec. 4, 1989	Domestic Energy Resource Base
	*Omaha, NE	Dec. 8, 1989	Agriculture as Consumer and Producer of Energy
	*Detroit, MI	Dec. 11, 1989	Energy and Transportation
	*Washington, D.C. #2	Dec. 13, 1989	Energy, Defense, and Security Interests
	Atlanta, GA	Dec. 14, 1989	Energy and the Environment
SERIES III	Honolulu, HI	Jan. 11, 1990	Energy Supply in Hawaii/Pacific Rim Nations and International Competitiveness
	Washington, D.C. #3	Jan. 22, 1990	Energy Regulatory Issues
	New Orleans, LA	Feb. 2, 1990	Energy Taxes

I. INTRODUCTION

The National Energy Strategy has four primary objectives: first, to pinpoint the problems of the nation's current energy situation; second, to set goals aimed at solving those problems; third, to recognize current policy and market obstacles obstructing the success in achieving the new goals; and fourth, to offer policy options to overcome those obstacles. This report is structured in the same pattern. Section II outlines the major energy-related problems discussed most frequently in both the oral and written testimony. The problems addressed here include only those which the development of geothermal energy may possibly help to solve (i.e. environmental damage, energy security, market problems, and international competitiveness). A broader discussion of the nation's energy concerns can be found in the "Interim Report" on the National Energy Strategy issued by the Department of Energy in April 1990.

Section III details the goals provided in the testimony that can potentially solve many of the problems outlined in Section II. Some testimony sets goals specifically for the further development of the geothermal energy industry. Other testimony sets more general goals for the geothermal industry, such as growth of the renewable energy industry to alleviate the problems affecting the environment, U.S. energy security and international technological competitiveness. All the various forms of geothermal energy were represented in the body of written testimony. Section IV presents the policy, market, and technical obstacles to achieving those goals followed by the policy options offered as possible solutions to overcome those obstacles.

Section V analyzes geothermal energy's potential impact in the State of Hawaii. The public hearing held in Honolulu, Hawaii, on January 11, 1990, represents a microcosm of the benefits and risks which geothermal energy can present to a community. The section presents all perspectives and arguments raised at the hearing, both as oral and written testimony, concerning the possible development of a proposed 500 MWe geothermal energy project in the Puna rain forest on the island of Hawaii. While certainly not typical, the project demonstrates how a relatively benign technology, such as geothermal, may be subject to intense local opposition.

LIMITATIONS OF THE TESTIMONY

While geothermal energy was mentioned in many accounts by witnesses testifying before the National Energy Strategy panels, only two addressed geothermal energy in significant detail (except for the Hawaii hearing which

focused primarily on geothermal energy). Charles T. Condy of the California Energy Company at the New Orleans, Louisiana, hearing, and Stephen C. Lipman of Unocal Corporation at the Houston, Texas, hearing provided the only in-depth analysis of geothermal's potential role in the National Energy Strategy. All other verbal testimony mentioning geothermal energy usually addressed broad aspects of energy policy and included geothermal as an important ingredient in the nation's development of a renewable energy market. Most references to geothermal energy in the body of oral testimony must be applied to the various broad energy strategy directions suggested by many witnesses.

A much larger portion of the body of written testimony (123 letters) addresses geothermal energy in more detail than does the oral testimony. Not all of the letters, however, provide detailed appeals for the National Energy Strategy to achieve specific goals and implement specific policy options to further develop geothermal energy. A number of letters simply urge the Department of Energy to consider geothermal in the formulation of the National Energy Strategy. The actual pool to draw conclusions concerning goals, and policy options and obstacles for geothermal energy is smaller than the this reports's "List of Testimonies" suggests.

II. PUBLICLY IDENTIFIED GOALS

A significant portion of the testimony encourages the inclusion of geothermal energy as an important ingredient of the National Energy Strategy to solve several major energy-related problems affecting the nation and the world. Concern over the harmful effects of fossil and nuclear fuels on the environment appeared in well over half of the testimony. U.S. reliance on imported fossil fuel has also prompted the concern expressed in much of the testimony that the nation's energy security is in a precarious and weakening position. Some concern addressed the ability of the U.S. to compete in the international energy technology arena.

This section begins by outlining the major energy-related problems provided in the testimony supporting geothermal energy, followed by a list of the advantages of using geothermal. These advantages may be solutions to some of the major problems cited below. A list of specific goals offers ways and directions in which policymakers can help the nation exploit some of geothermal's advantages.

CURRENT ENERGY PROBLEMS

● Environment

- 1) *Global Warming:* The build up of greenhouse gases caused by the combustion of fossil fuels for electric power generation is the primary concern of most of the testimony addressing energy and environmental problems.

References: (3,4,5,6,8,11,14,18,19,20,21,27,28,29,34,36,37,39,42,45,46,52,58,59,60,67,68,70,74,79,90,91,92,100,4*,7*,8*,10*,12*,13*,14*,17*)

- 2) *Acid Rain:* The continued use of fossil fuels spreads and intensifies acid rain's damage to the environment. Thomas Flynn, Deputy Director of the Division of Earth Sciences Environmental Research Center at the University of Nevada, Las Vegas, asks: "If coal-fired power plants continue to proliferate in the West, ... how will you [we] justify the sudden outbreak of acid rain and snow in the Wasatch Range, the Rocky Mountains, the Grand Tetons, and Yellowstone National Park to the Governors and residents of Utah, Wyoming and Colorado?" (79)
- References: (18,19,28,29,42,45,68,74,79,92,2*,6*,7*,14*)

3) **Toxic Gases:** Gaseous emissions from fossil-fuel generating facilities, such as NO_x, SO₂, CO, O₃, and other effluents contributing to urban and industrial air pollution have been deemed a public health hazard. Many urban areas which do not meet state and federal air quality standards are particularly concerned about solving their air pollution problems. References: (19,52,54,67,2*,4*,6*,7*,8*,13*,14*)

4) **Nuclear Waste Disposal:** Many problems surround nuclear waste disposal because no method of disposal deemed absolutely safe has been developed, nor has the politically contentious issue of choosing waste disposal sites been settled. Possible solutions to these problems pose great expense to ratepayers. References: (5,33,92,7*)

5) **Fossil and Nuclear Fuel Transportation and Storage Hazards:** The oil spill in Valdez, Alaska, sparked great concern for the hazards of transporting fuel supplies not only through sensitive, pristine environments, but through major ports and pipeline systems. Many communities also object to the storage of hazardous materials "in their backyard." References: (45,61,67)

● Energy Supply/Security

1) **Weakening Energy Security (general):** Reliance on imported fossil fuels threatens the nation's economic and international political security. U.S. ability to compete with its industrial rivals weakens as the nation steadily loses control over the price of imported oil, which is the life-blood of industry. References: (4,10,11,12,18,20,22,28,31,33,36,37,39,47,58,59,60,61,64,69,71,81,82,84,92,93,98,3*,6*,7*,8*,9*,10*,14*,15*,17*,19*)

2) **Trade Deficit:** Oil imports account for the largest portion of the nation's trade deficit. Oil imports for the year 1989 cost the U.S. 45 percent of the nation's \$109 billion trade deficit for that year. (Interim Report pp. 42-43) References: (20,28,36,47,58,62,67,69,72,81,84,91,92,2*,3*,6*,9*,14*,19*)

3) **Decreasing Domestic Reserves of Oil and Gas:** Domestic oil and gas reserves are in decline making it continually more difficult to recover fossil fuels economically. References: (12,33,50,59,3*,6*,9*,13*,14*,15*,19*)

- 4) *Military Expenditure (as social cost)*: Some testimony questioned the large expense of military presence in foreign lands and seas which is possibly designed to protect the nation's oil and gas interests.
References: (21,61,64,69)

- **International Competitiveness**

- 1) *Weakening Ability to Compete on the International Geothermal Energy Technology Market*: The U.S. is the world's leader in geothermal energy technology, but is losing its lead because of reductions in federal R&D funding and problems in financing technology export projects.
References: (31,75,81)
- 2) *Tied Aid Credit Practices*: Through the use of tied aid grants, some of the U.S.'s strongest international competitors are able to offer developing countries attractive low-cost loans to install geothermal projects, often underbidding U.S. companies.
References: (75)

GEOTHERMAL ENERGY ADVANTAGES

Many letters and several pieces of oral testimony addressed the various advantages which geothermal energy has over conventional fossil fuel and nuclear generating facilities. These advantages present possible solutions to some of the energy-related problems outlined above.

- **Geothermal is the third largest reserve and largest resource base in the U.S.**
 - Resource Base = 256,992 BBOE (billion barrels of oil equivalent)
 - Accessible Resources = 3,897 BBOE
 - Energy Reserves = 42.5 BBOE

Reference: (75)

- Geothermal is an indigenous resource which can help to reduce the nation's dependence on imported fossil fuel. (37)
- Geothermal is an environmentally benign energy resource.
 - Geothermal emits only 5% of the greenhouse gases that conventional fossil fuel-fired power plants produce. (27,40,46,59,75)
 - Modern geothermal plants emit extremely low levels of gases associated with acid rain. Such plants emit only about 1% of the sulfur emitted by fossil fuel alternatives. Nitrogen oxide emissions are also negligible. (75)
 - Geothermal emits no particulates which create urban smog . (75)
 - No refining of fuel is required. (67)
 - The entire operation of geothermal energy production occurs on site. The problem of transporting fuels and hazardous waste products over long distances is eliminated. (67)
 - All wastewater is typically reinjected back into the reservoir, effectively disposing of hazardous constituents and replenishing the resource. (67)
- Geothermal energy is at a commercial stage today. (37)
- Geothermal has demonstrated extremely high reliability and capacity factors. (37)
- Geothermal energy is well-suited to accommodate small-scale, or incremental power generating additions. This gives utilities flexibility to minimize energy production social costs in the long-term, instead of focusing only on near-term cost considerations to ratepayers. (4,9,18,71,9*)
- Plant construction costs are comparatively low and can be constructed and brought on-line quickly. (18,37,9*)

GOALS

The following is a list of specific goals aimed either at solving one or more of the energy-related problems mentioned above or expressed simply for the intention of further developing geothermal energy. These goals are divided into three sections: (1) expand geothermal development; (2) increase geothermal's competitiveness; and (3) increase public awareness of geothermal energy.

EXPAND GEOTHERMAL DEVELOPMENT

Geothermal energy from hydrothermal resources currently provides the Western U.S. with 2,780 MW of electricity. (75) Direct use applications currently provide the nation with 18,000 billion Btu of energy per year, which is only a small fraction of the total potential. (91) Various letters and hearing witnesses suggested that the National Energy Strategy encourage the expansion of commercial energy production and direct use applications from geothermal sources to relieve environmental and energy security problems. Some testimony cited foreign trade and development opportunities for the geothermal industry.

- ***Environmental Protection:*** A very large portion of the testimony supports the further development of geothermal energy to reduce the impact of energy production and use on the environment. (Same references as those under environmental problems, pp.5-6)

Policy Goals: Renew America and the Environmental Action Foundation suggests that the reduction of carbon dioxide emissions should be the bottom-line goal of U.S. energy policy. The measures should accomplish a 20% reduction by the year 2000. Improved energy efficiency and the promotion of renewable energy resources and technology are the only means to accomplish this goal. (58,2*)

- ***Energy Security:*** Much of the testimony also supports geothermal's inclusion in the NES for its ability to reduce the nation's dependence on imported fossil fuels. (Same references as those under energy security problems, pp.6-7)

Policy Goals: The National Energy Strategy should promote the use of indigenous energy resources for electrical power generation in order to save scarce fossil fuel reserves for high priority needs, such as transportation fuels, petrochemicals, and fertilizers. Replacing fossil-fuel-fired electric power generation with geothermal power will reduce the need for imported oil and natural gas to improve the nation's balance of payments and increase energy security. (18,20,36,37,9*)

- ***Expand Geothermal to More Regions of the U.S.:*** Expand geothermal energy production to the Cascade Range. Resource estimates by the Bonneville Power Administration, the U.S. Geological Survey, and the Oregon Department of Geology and Mineral Industries range between a conservative 3,600 MW to over 400,000 MW sustainable for a 30-year life. (30) Increase federal funding for the resource assessment programs for determining Alaska's geothermal energy potential to \$2 million per year. (46) Many witnesses at the Honolulu, Hawaii, hearing expressed hope that the Department of Energy will help private industry successfully implement a plan to develop 500 MW of geothermal energy on the island of Hawaii. (1,2,3,4,11,12,13)
- ***Foreign Trade and Development Opportunities:*** Over the next 20 to 30 years, developing countries are going to expend several trillion dollars expanding their energy services. (14*) Geothermal energy is the only indigenous resource in many developing countries. Small-scale geothermal developments are the best possible solution to the energy problems of isolated Southwest Pacific islands. (7) Central America is rich in geothermal resources, with a minimum potential of 1,100 MW producing up to 8 TWh per year. (73) Geothermal energy is actively sought by both developing and developed countries. (75) Many of these countries will look to the U.S. since it is the world's leader in geothermal technology.

INCREASE COMPETITIVENESS

Domestic Competitiveness

Geothermal energy has continually struggled to remain economically competitive with other resources in the domestic energy market. The major task of geothermal producers must be to meet the challenge of developing and implementing improved technology to increase geothermal's competitiveness in the energy resource market. The following goals aim to hasten the pace of geothermal's technical advancement.

- ***Improve Technology Transfer:*** Cooperative research between government and industry depends on the smooth transfer of technology to ensure that geothermal energy production remains competitive with other energy resources. (21,32,39,48,14*)

- **Technical Goals:** Several letters addressed the need for the National Energy Strategy to help the geothermal industry achieve some specific technical goals to improve the production capability of geothermal energy. (21,34,42)

- 1) Bob Greider, Energy Consultant, suggests the increase of research on ...
 - a) basic rock physics and chemistry for extending the recovery of geothermal energy.
 - b) rock and fluid reactions at elevated temperatures.
 - c) measuring and mapping the distribution of permeability in potential reservoir rocks.
 - d) economically creating and enhancing incipient permeability in hot rock reservoirs.

Reference: (21)

- 2) J.L. Iovenitti, Consulting Geologist, suggests that efforts be made to develop ...
 - a) new and improved methods to locate, analyze and/or characterize existing and new geothermal fields.
 - b) new and improved methods to site production wells to reduce the number of dry wells and increase the productivity of existing ones.
 - c) new and improved models to predict the long-term behavior of reservoirs under both production and injection conditions.
 - d) enhanced drilling technology to reduce the cost per foot drilled.
 - e) reduction of power plant capital cost, and operation and maintenance costs. Improve power plant steam utilization to improve reservoir-plant system efficiency.
 - f) improved scale and corrosion controls.
 - * g) methods to solve the reservoir pressure problems at The Geysers.

Reference: (34)

- 3) Dr. Tsvi Meidav, President, Trans-Pacific Geothermal Corporation, envisions geothermal energy providing 20,000 MWe by the year 2000 if R&D requirements were sufficiently met. R&D should be directed to...
 - a) reduce drilling costs.
 - b) increase well productivity.
 - c) reduce binary technology costs.
 - d) overcome scaling and corrosion in wells.
 - e) identify promising reservoirs.
 - f) improve reservoir management technology.
 - g) develop hot dry rock technology.
 - h) develop geopressed technology.
 - i) develop magma technology.

Reference: (42)

International Competitiveness

U.S. geothermal developers must meet the growing challenge from foreign competitors to win technology export bids and secure investments in geothermal developments abroad.

- ***Maintain U.S. Lead in Geothermal Technology:*** The U.S. geothermal industry must increase its competitive bidding strength to capture a larger share of future demand for geothermal energy in developing countries. (73,75,23*24*) Low-cost financing mechanisms must accompany the achievement of technical goals in order to compete on the international energy market. (75)

INCREASE PUBLIC AWARENESS OF GEOTHERMAL

Much of the public has little, if any, knowledge of geothermal energy primarily because it is a relatively new energy technology and is a regional resource. Increased public awareness of geothermal's advantages over other energy resources and technologies will be a very important ingredient in assuring geothermal a role to play in the nation's energy future.

- ***Increase Public Awareness of the Benefits of Geothermally Produced Electricity.***
- ***Increase Public Awareness of Direct Uses of Geothermal.***

III. PUBLICLY IDENTIFIED OBSTACLES

Much of the oral and written testimony expressed concern for the many policy, economic, market, and technological obstacles which impede the development of renewable energy resources and technology. The following is a list of obstacles which affect the development of geothermal energy in the U.S. and abroad. This list is divided into four sections: (1) current public policy obstructing geothermal development; (2) market and other economic factors inhibiting geothermal; (3) international trade and competitiveness obstacles; and (4) technical obstacles.

Policy Obstacles

- The geothermal industry suffers from an uneven playing field in the policy arena. Other energy industries have traditionally received larger tax benefits, R&D subsidies, clean-up incentives, and marketing program assistance, placing geothermal at an unfair disadvantage. (36)
- The elimination of tax incentives for renewable energy programs erased much of the technical and economic success gained in those technologies. (18)
- Leasing regulations are too restrictive regarding the maximum amount of land a geothermal field developer may have under lease, particularly in light of the small number of geothermal operators in existence. (26)
- Limitations in usage, vis-a-vis the alternative minimum tax, are a hindrance in that they limit the amount of credit that a company can use. These rules should be relaxed. (3*)
- FERC functions regulating transmission access and competitive bidding programs and policies need to be restructured. (3*)
- Large budget cuts have left the Bureau of Land Management (BLM) unable to effectively assist in the continued development of geothermal resources on state and federal land. (23)

- R&D for new and cleaner methods to burn coal is drawing too much funding away from other energy technologies, such as geothermal. (18)
- The Geothermal Steam Act of 1970 allows for the production of electricity from geothermal resources on federal land, but discourages direct use of those geothermal resources. (66)
- The 80 MW limit placed on renewable energy qualifying facilities under PURPA hinders economic performance by preventing generating facilities from achieving the proper economy of scale. (6*) W. Harrison Wellford, General Counsel of the National Independent Energy Producers, stated: "...qualifying facilities will not be able to fully satisfy the demand for new capacity in wholesale power markets in the 1990's, because of steam hosts and other regulatory requirements. Modification of PUHCA (Public Utility Holding Company Act), therefore, is needed to assure that wholesale generating facilities, in addition to qualifying facilities and traditional rate-based plants, will be able to compete to meet this demand. (19*)

Market/Economic Obstacles

- The price of conventional energy sources has dropped to such a low level that the incentives to invest in alternative resources no longer exists. (9*)
- The market for geothermal power generation is primarily in the Western states which currently have an oversupply of generating capacity. (9*)
- Although electricity can be produced economically from geothermal systems, development is hindered by technical unknowns which increase the risk of exploration and development. (47)
- Direct use development is inhibited by the high risk associated with finding productive geothermal sources and the unfamiliarity with geothermal energy on the part of end-use industries that could take advantage of the availability of direct use energy. (92)

- Ground source heat pump manufacturers are usually small companies which have problems overcoming three obstacles.
 - 1) Small companies cannot afford the television, radio and consumer advertising needed to make consumers and builders aware of the system and its benefits. (99) The geothermal heat pump industry suffers from a lack of consumer education about this technology. (97)
 - 2) Environmentalists may express concern for the underground piping circulating water and antifreeze. (99)
 - 3) Ground source heat pumps have a high installed cost penalty compared to that for some less efficient systems. (99)

International Trade and Competitiveness Obstacles

- There is a lack of funds at acceptable rates in most developing countries. Keeping pace with the growing demand for energy in developing countries will require an estimated \$70 billion per year, which exceeds the expected supply of international lending agencies by \$300 billion. (75)
- DOE's efforts, through ECRE and the CORECT program, to promote the export of U.S. energy goods and services are often thwarted by competition from foreign geothermal developers, especially Japanese and Italian, who offer tied aid grants to their foreign customers. (75)
- Pacific Rim nations are far less able to shoulder the burden of the high investment risks associated with geothermal energy development than is the U.S. (7)
- Developing geothermal resources within a politically diverse and developing region is difficult because such a region may strive to be energy independent and consequently be reluctant to become dependent on U.S. energy supplies. (73)

Technical Obstacles

- **Current data used to locate and define geothermal resources is inadequate. (13,18,59,74) Current technology used to gather this data is not cost-effective making initial drilling costs very high. (91) The lack of resource data and technology to generate data raises the risk for geothermal developers.**
- **Current technology prevents the accurate prediction of the performance of hydrothermal reservoirs. (74)**
- **A lack of technology impedes the management of production/injection well fields. (74)**
- **Inadequate energy conversion technology hinders efficiency and the use of many low-temperature hydrothermal reservoirs. (74)**
- **Hot dry rock, magma, and geopressed geothermal resources cannot be fully developed with current technology. (74)**

IV. PUBLICLY IDENTIFIED OPTIONS

Each of the suggested options call for adopted policy measures to increase the effectiveness of geothermal energy's role in the National Energy Strategy. The body of testimony offered suggestions for policymakers to use several types of policy instruments to increase geothermal energy's competitiveness in the domestic and international energy market. These policy options are divided into the following types: (1) tax incentives; (2) environmental taxes; (3) R&D subsidies; (4) international trade policy; and (5) regulatory policy.

Tax Incentives

- Favorable tax treatment (incentives) to encourage geothermal investment. (4,7,13,16,46,63,92,99,3*,15*,17*,30*,32*,10)
- Tax subsidies should meet or exceed the incentives of the mid 1980's. Energy tax credits should equal 20% of the capital invested and depreciation should extend for only four years for all equipment used to produce and transmit the electricity to the utility. (49)
- Make the 10% energy tax credit for geothermal permanent. (42)
- Congress and the Administration should eliminate "double taxation" of corporate profits and lower the tax rate on capital gains. (3*)
- Geothermal resource users in California and Nevada should receive an extension of the energy tax credit. (7)

Environmental Taxes/Incentives

- A uniform carbon tax (CO₂ emissions tax) may be an effective way to reduce the utility sector's CO₂ emissions to specific target levels. (6*)

- Institute price mechanisms to encourage the use of preferred-source power (e.g., a fossil fuel tax). (4)
- Environmentally preferable energy sources should receive credits for offsetting the pollution that fossil fuel plants emit. (16,43,58,75,3*) Institute the Clean Air Trust Fund of the proposed Clean Air Act Amendments to promote geothermal development. (52,54,13*)
- Recognize social costs, such as pollution, as a routine part of policymaking. (17)
- Promote the adoption of building standards and retrofit programs to encourage the use of clean energy technology. (58)

R&D Subsidies

- Increase federal funding/shared cost for resource assessment: Numerous letters and hearing witnesses expressed the need for the geothermal industry to receive federal funding in order to enhance its ability to assess and analyze potential geothermal fields in the Western and Central states. Geothermal fields now in production were the easiest to locate and to develop, but further expansion to new areas requires more intense and expensive efforts to locate productive fields. (1,6,11,15,20,21,22,26,27,34,35,37,40,42,46,47,60,68,77,78,83,85,86,87,91,3*,6*,9*)
- Correctly balance federal R&D funding programs for all energy technologies. (4)
- Rank the cost-effectiveness of each energy resource: The federal government should accurately rank energy resource options in their order of cost-effectiveness. An accurate comparison of the cost-effectiveness between all available energy resources would decrease federal subsidies for fossil and nuclear fuels and direct more funding to renewable energy resource development by virtue of its higher cost-effectiveness. (14*) Geothermal is one of the most cost-effective of the renewable energy sources. (63)
- Increase federal funding for small R&D firms: Small research institutes may expand the geothermal energy industry's chances to create new and innovative technologies. Small R&D firms need a better opportunity to receive federal funding to carry out innovative R&D programs. (35)

- Increase R&D funding for Hot Dry Rock technology development. (79,80,81) Edward L. Kaufman suggests that DOE drop its funding for geopressed geothermal and divert it to Hot Dry Rock and Magma development.
- The appeals to further develop Magma geothermal resources and technology called strictly for more federal R&D assistance. (83,84,85,86,87) Four separate letters suggest that the National Energy Strategy allocate \$4 million a year to the Department of Energy's Magma geothermal program. (83,85,86,87)
- Increase federal R&D funding for Geopressed geothermal. (77,78) Specifically, increase the Department of Energy's Geopressed geothermal annual operating budget to \$10 million. (78)
- Many regions of the country can use low to moderate temperature geothermal resources by applying Direct Use technology. (88,89,90,91,92) The full development of direct use geothermal can provide the nation with 15% to 20% of its energy needs. (89) The National Energy Strategy could help the nation to begin achieving this goal by supporting:
 - 1) experimental drilling in new and little known areas to overcome the initial risk. (91)
 - 2) evaluate low and moderate temperature resources near hundreds of population centers that have potential for district heating. (91)
 - 3) resolve technical problems of injection wells, production pumps, piping systems, etc. (91)
- Institute a shared cost program between DOE and the ground source heat pump industry to reduce the cost of drilling vertical well bores. (91)
- Develop energy efficiency ratings for geothermal heat pumps. (91)
- DOE should identify and support those technologies which have proven records, such as ground source heat pumps. (96)
- Evaluate those technologies that have the thermodynamic basis for success. (96)

- Create federal recognition publicly endorsing the merits of ground source heat pumps to help overcome the natural apprehension of a consumer to try a "strange" new concept. (99)
- Institute federal support for the ground source heat pump industry by defining criteria or limitations which, if met, would formally qualify ground source heat pumps as meeting federal guidelines as an environmentally safe and acceptable system, guaranteed free from EPA prosecution. (99)

International Trade Policy

- Federal policies should be altered to provide more assistance to U.S. industry engaged in efforts to sell and market geothermal energy technology abroad. (75)
- Increase federal R&D assistance to the domestic geothermal industry and implement measures to provide low-cost loans to companies seeking geothermal developments in foreign countries. (75)
- More federal R&D funding is needed to assure the success of the Pacific Area Cooperative Renewable Energy Development Program (PACRED) which offers the U.S. a good opportunity to assume leadership in developing renewable energy projects in the Pacific and Asia. (23*)
- The State Energy Conservation Program (SECP), Energy Extension Services (EES), and the Institutional Conservation Program (ICP) should receive more attention and funding in the future to assure the energy security of the U.S. Samoan Territories, and other Pacific island nations. (26*)
- Support U.S. firms seeking to open export markets through tax or financing mechanisms. (4)

Regulatory Policy

- Allow small producers of power access to electric transmission facilities. (2,3,75)
- Create a national energy policy which allows the federal government to participate in power generation regulatory policy. This will provide the states with a better opportunity to develop long-range energy plans and employ the best mix of power generating technologies. (9*)
- Geothermal developers in California and Nevada should receive an extension in obtaining wheeling arrangements to reach the markets. (7)
- Allow federal power authorities to offer power swaps as an alternative to transmission for geothermal energy producers. (49)
- Expand State and Federal Land Leasing: Many geothermal resource areas are located on state or federal lands. A low-cost expansion of geothermal energy requires that some of that land with the best geothermal resources be leased for energy production. (23,28,9*) It was also noted that the power production from these lands can provide the state and federal government with attractive royalty payments. (1,28,57)
- Department of Interior/Mineral Management Service should proceed with its geothermal royalty rulemaking procedure and settle industry objections to proposed rules which place inappropriately high value on reservoir resources as opposed to capital intensive production, generation, reinjection and transmission facilities which are not subject to royalties. (16)
- Develop a regulatory strategy to allow utilities to profit more from investments in energy efficiency than simply increased capacity. (91)
- The federal government should exercise favorable royalty and land lease treatment. (92)
- Let the market place determine how to reduce installation costs of those systems that have a basis for saving energy. (95,98)

- Amend the Public Utilities Regulation Policies Act (PURPA) as follows: (6*)
 - Permit energy efficiency investments to compete as qualifying facilities under PURPA with environmental and social costs internalized to the extent possible.
 - Encourage state utility regulatory commissions to adopt least-cost electricity plans and to remove disincentives to utility investment in end-use energy efficiency.
 - Encourage utilities to offer standard long-term contracts to qualifying cogeneration and renewable energy facilities and permit commissions to set buy back rates as a part of avoided cost to capture environmental and social benefits.
 - Eliminate the limit on the size of renewable energy facilities that qualify under PURPA.

V. HAWAII: A MICROCOSM OF THE BENEFITS AND RISKS OF GEOTHERMAL DEVELOPMENT

SUMMARY OF ORAL AND WRITTEN TESTIMONY

DATE: January 11, 1990

PLACE: Honolulu, Hawaii

TOPIC: Energy Supply in Hawaii and Pacific Rim Nations and International Competitiveness.

GENERAL NATURE OF THE HEARING

The hearing provided a sweeping concurrence in the testimony addressing the energy problems of Hawaii and the southwest Pacific region. The lack of indigenous fossil fuel reserves coupled with its geographic isolation has made this region extremely vulnerable to energy interruptions. Most of the testimony, therefore, focused on the development and use of alternative sources of energy (renewable energy). Geothermal energy was the source predominately referred to as the solution to overcoming Hawaii's and the southwest Pacific's current energy vulnerability. Most of this testimony strongly favored developing geothermal resources for commercial energy production.

Opponents to geothermal energy development, however, expressed concern over the potential environmental, religious, and land rights problems which geothermal development may create in Hawaii. While the topic of international competitiveness was slated as a major part of the hearing, only a small portion of the testimony addressed the international competitiveness of the U.S. geothermal energy industry.

HAWAII'S ENERGY NEEDS

Background

The unique energy situation of Hawaii and the Pacific Rim nations prompted a special National Energy Strategy hearing in Honolulu, Hawaii. The lack of fossil fuel reserves has left this region extremely vulnerable to an energy interruption. (17*,20*,3,6,7,8) Hawaii's energy security, in particular, is becoming increasingly threatened as steady population growth has increased its dependence on imported fossil fuel. Hawaii's energy infrastructure was not designed to accommodate long-term growth. Power requirements are met piecemeal by adding steam units or gas turbines as the need arises. Hawaiian Electric, Inc., (HEI) and its subsidiaries constitute the only utility in the state. Electricity is produced almost entirely from fossil fuels due to the demise of the sugar industry which forced the closure of many of the sugar plants. HEI made some preliminary attempts to diversify the energy resource base by developing wind, solar, and a geothermal project, but these alternatives are still at the pilot stage without proven economic success. (4)

Hawaii and the Pacific Island nations are well-suited to sufficiently develop renewable energy to create a stable mix of energy resource supplies. The islands receive plenty of strong sunlight for solar energy. Wind energy potential is strong on most of the islands. Most important, the island of Hawaii is volcanically active which provides their most abundant resource base -- geothermal energy. (24*,4,6,7,8,9)

Current Status of Geothermal Development in Hawaii

Volcanic activity on The Big Island of Hawaii drew the attention of geothermal energy developers 15 years ago. Since 1976, six wells have been drilled, and a 2.5 MWe plant at Puna has been operated by the University of Hawaii since 1982. The well providing steam to the plant has since collapsed, shutting down energy production at Puna, but the plant did prove that energy can be produced at that location. (4)

Hawaiian Electric Company (HELCO), a subsidiary of HEI, plans to add 25 MWe of baseload capacity from geothermal resources in the Puna district. In 1988, Ormat Energy Systems, Inc., (OESI) executed a 25 MWe purchase agreement with HELCO on a 35-year contract. The 10,000 acres of land leased by OESI has a power production potential of approximately 2,000 MWe. (4,13) Of this potential geothermal energy production capacity, 500 MWe may be developed to serve the Hawaiian Deep Water Cable (HDWC) program which would link the islands together by a deep underwater transmission cable. The project, which is still in the feasibility study stage, seeks to provide energy generated from The Big Island's geothermal fields to the island of Oahu by 1995. (13) The HDWC project was initiated in 1980 and is jointly funded by

the State of Hawaii and the federal government in the \$28 million effort. (13) The Puna geothermal development has been funded \$3.25 million by the State of Hawaii under the supervision of the Department of Business and Economic Development.

Private geothermal developers (OESI and True/Mid-Pacific Geothermal Company) are providing an additional \$5 million for reservoir analysis and the drilling of two geothermal production wells. (7) True/Mid-Pacific Geothermal Company has a permit to produce up to 100 MWe of the proposed 500 MWe geothermal energy project.

PUBLICLY IDENTIFIED GOALS

The three major goals expressed by the body of testimony are: (1) to secure Hawaii's and the Pacific Rim Nations' energy future; (2) to mitigate the harmful impact of energy use on the environment; and (3) to enhance U.S. international competitiveness in the energy technology arena.

Energy Security

Many witnesses support the further development of geothermal energy to a commercial stage to lessen the region's vulnerability to energy interruptions. (2*,15*,17*,20*,22*,23*,24*,26*,28*,30*,32*,9,10) John Waihee, Governor of Hawaii, stated: "The commercial development of Hawaii's geothermal energy resource is my top priority as Hawaii's most significant indigenous resource for the production of energy, which has the potential to reduce the dependence on imported fossil fuels." (17*) Hawaii State Senator Mary George, and Director of Business and Economic Development for the State of Hawaii, Roger Ulveling, have placed the development of geothermal resources as the most important step in their proposed three-point energy strategy for the State of Hawaii. The other two elements in the plan are energy conservation programs and developing Hawaii's own strategic reserve of petroleum. (23*,30*)

Leigh-Wai Doo, a member of the Honolulu City Council, hopes that Hawaii's 98.6% reliance on fossil fuels for electric generation be slashed to only 29% by the year 2010. He suggests that Hawaii displace this reliance on fossil fuels with the development of alternative sources of energy. If Oahu's energy could be provided by geothermal energy, then 41% of Hawaii's energy needs could rely on geothermal energy in 20 years. Dan Williamson of HELCO expressed hope that The Big Island's large geothermal energy potential be developed to produce up to 500 MWe to serve Hawaii's rapidly growing population. HECO issued a request for proposals in May of 1989 for the delivery to Oahu of up to 500 MWe of geothermal produced electricity. (25*)

U.S. Senator Daniel Inouye of Hawaii expressed a major goal of the state to be "... attracting the private sector to economic opportunity in the area of renewable energy...." in the important effort in reducing Hawaii's energy vulnerability. (3)

Environmental Protection

Nearly all of the witnesses addressed the need to reduce the harmful impact of energy use on the environment. Global warming and urban air pollution from utility and auto emissions are the largest energy-related environmental concerns for the region. These concerns lent further support to the development of renewable energy projects such as geothermal, wind, solar, photovoltaic, and biomass. (17*,24*,26*,30*,32*,1,2) Governor Waihee stated:

Hawaii's geothermal energy has the best near-term potential to supply our baseload energy needs and do it in an environmentally sound manner. With national and international attention on the "greenhouse effect," geothermal power is more desirable than either coal or oil, which emit many times more CO₂ -- a major contributor to this global warming -- than does geothermal. (17*)

Dr. Victor D. Phillips, Manager of Bioresources and Environmental Research of the Hawaii Natural Resources Institute asserted that promoting conservation programs and a "fast-track" development of renewable energy technologies are the most cost-effective and environmentally sound actions available for Hawaii. (9) Lucien Y. Bronicki of Ormat Energy Systems, Inc., detailed some of the cost and environmental benefits of developing Hawaii's geothermal resources. The first 25 MWe geothermal plant, which will either be in the form of new capacity or will be replacing aging fossil fuel plants, will reduce annual emissions by the following amounts:

- CO₂ -- reductions of 140,000 tons/year
- SO₂ -- reductions of 500,000 lbs/year
- NO_x -- reductions of 175,000 lbs/year

Reductions in emissions will abate the problems of global warming and local acid rain and air pollution.

Bronicki argued that the introduction of a 25 MWe geothermal plant will reduce the social cost of energy consumption in Hawaii. The plant would reduce Hawaii's annual electricity production costs by approximately \$5 million by reducing the emissions of CO₂, SO₂, and NO_x. This translates into the reduction of an equivalent social value of 2.50 cents per kWh. (1)

Roger A. Ulveling cited the strong support for geothermal energy development given by a consortium of 18 environmental groups in its 1988 "Blueprint for the Environment." The consortium stated that geothermal energy is an effective measure to reduce the utility industry's contribution to the buildup of greenhouse gases in the atmosphere. (30*)

PUBLICLY IDENTIFIED OBSTACLES

The success of the Hawaiian Deep Underwater Cable Program relies too heavily on the accuracy of the assessment of the geothermal resource base at The Big Island. The program is based on the assumption that the reservoir projections are correct, and that 500 MWe will be produced and available for transmission to Oahu. (7) Therefore, the more accurate the resource projections, the less risky the HDWC program will be.

Dr. Donald M. Thomas of the Hawaiian Institute for Geophysics, University of Hawaii, who worked closely with the development of the HGP-A program, stated: "Through the course of our operation of the HGP-A Generator Project, we have also found that the barriers imposed by community acceptance of a project can be at least as difficult to overcome as the technical barriers encountered." (10)

The costs and risks of geothermal development, especially at the scale needed to supply the HDWC program, are very high. The successful development of the Puna Geothermal Venture's 25 MWe and the remaining 475 MWe proposed for future development, and the HDWC program are interdependent on each other. If one of these two projects is unfundable, unpopular, or not technically feasible, the success of the other is jeopardized. (13)

Specific Opposition to Geothermal Development in Hawaii

Opponents to geothermal development in Hawaii expressed concern that the Puna Project would destroy the Wao Kele O Puna rain forest, create other harmful effects on the environment, and violate land rights and religious beliefs. Specific opposition to geothermal energy development in Hawaii is summarized from each individual witness' testimony.

Wayne K. Nishiki, a Council Member of the County of Maui, questioned the fairness of DOE's witness selection in addressing the energy needs of Hawaii and the southwest Pacific. He charged that the hearing was dominated by the interests of the geothermal industry and paid too little attention to the community faction opposing geothermal development in Hawaii. He cited a previous public hearing on Maui addressing Hawaii's energy concerns at which 100 attendees voiced their opposition to

geothermal energy development. Many of those who attended objected to the geothermal proponent's neglect in consulting the native Hawaiians who have deep concerns regarding the use of the land needed for the geothermal project. Mr. Nishiki focused on geothermal's potentially harmful effects on the environment of Hawaii. Air and groundwater contamination, and increased seismic activity represent several major points of opposition for the residents of The Big Island. He claimed that the State is threatening the local environment for the sake of Hawaii's energy needs while the proposed geothermal project may reduce the State's fossil fuel consumption by only 10%. (26*,27*) M.S. Merwin expressed similar objections, citing bias in the hearing's witness selection and unfair consideration of the native Hawaiian's land rights. (16)

Nelson Ho, representing the Sierra Club, urged DOE to stop funding geothermal research and development projects until the federal government and the State of Hawaii does "some proper energy planning." A proper energy plan would not include geothermal power in the energy mix for the State of Hawaii because it is not a clean enough energy source. He argued that it will not only introduce toxins to the air and the water, but that it is not a renewable energy resource and may create similar problems to those being experienced at The Geysers in California. He suggested that the proposed geothermal project is to be located at a very risky site which makes the economic risk in developing the project too high. "...the 1983 Kilauea eruption inundated the proposed power plant site with 60 feet of lava. Today, their well feeds are under 300 feet of lava." (25*)

Impropriety in land and religious rights, and the possible injury to the Wao Kele O Puna rain forest represent the Pele Defense Fund's major objections to geothermal development in Hawaii. The proposed geothermal project threatens the religious rights of native Hawaiians who worship the traditions of Pele (the Volcano God). The Pele Defense Fund filed suit against the State of Hawaii for violating the First Amendment rights of the Pele practitioners by permitting the development of the Puna geothermal project. The Hawaii State Supreme Court decided against the Pele Defense Fund and was not granted certiorri review by the U.S. Supreme Court. Geothermal energy production in the rain forest threatens the well-being of what is considered not only a delicate environment, but a religiously sacred place. The Pele Defense Fund also questions the legality of the land transfer which occurred in 1985 between the Campbell Estate (leased by the True/ Mid-Pacific Geothermal Company and subleased by Ormat) and the Department of Land and Natural Resources. Their testimony states:

In 1985, the Department of Land and Natural Resources gave 27,000 acres of the Wao Kele O Puna to the Campbell Estate in exchange for 25,000 acres at Kahauale'a. However, 15,000 acres at Kahauale'a are covered with freshly erupted lava, 1,200 are wood chipped, and 5,600 acres are promised to the Volcano National Park. This leaves our public land trust with only 3,200 acres of good forest land.

Campbell Estate needed the land exchange after Pele began to erupt right at the center of their Kahauale'a lands where they had planned to go dig

geothermal wells. The developer of the geothermal electricity project is True/Mid-Pacific Geothermal Company out of Wyoming.

The group also charges that the Department of Health was negligent in authorizing Ormat Energy Systems, Inc., to construct a geothermal plant in the Puna District without first establishing air quality control standards and noise pollution standards. Finally, they claim that geothermal energy is economically unsound and therefore a bad investment for the State of Hawaii. (14)

Russell E. Ruderman asserts that geothermal energy development is a poor investment because it poses too great a risk to the Wao Kele O Puna rain forest and is foolish to institute when other alternative energy sources are cleaner and are just as available or more available in the near-term. He suggests that Hawaii's baseload energy needs can be met with renewable energy technologies, such as wind, solar, and biomass at less cost to the economy and the environment than can geothermal energy. Threatening a domestic national rain forest while trying to save rain forests in other nations will send a confusing signal to the rest of the world. (19)

Hampton L. Carson, a scientist at the John A. Burns School of Medicine at the University of Hawaii, strongly opposes geothermal energy development in the Puna Forest because of the threat to local environmental quality, to the forest's quality as a scientific research area, and to the survival of the rain forest itself. His research of the weather patterns that sweep across Mauna Loa and the underlying Puna Forest, in which the geothermal development lies, led him to conclude that thermal inversions are highly likely to trap geothermal plant emissions in a confined environment. This would threaten the environmental quality of the village of Volcano and the Hawaii Volcanoes National Park. The project also threatens the survival of many unique plants and animals within what he terms a "dynamic ecosystem" because of its unique geologic and biological properties. (15)

The Rainforest Action-Network asserts that the state-planned 500 MWe geothermal project is unnecessary and economically unsound. It claims that a state-wide energy efficiency program could save two times more electricity than the 500 MWe geothermal development could provide and at five times less cost. New capacity should be added by implementing solar and wind technologies because they are cleaner and cheaper. Finally, the U.S. will be making a grave mistake by forsaking one of its own rain forest while attempting to halt their destruction in other countries. (18)

PUBLICLY IDENTIFIED OPTIONS

Continuing federal tax incentive policies and research and development programs are the most popular means of encouraging the growth of alternative energy technologies. (15*,30*,32*,3,10) Dan Williamson of HELCO recommends that federal funding for research and development for renewable energy technology be increased dramatically to attempt to solve some of the problems of technical risk associated with renewable energy development. He also recommends that risk abatement measures such as a mix of tax incentives, favorable depreciation rates, and direct forms of assistance including loans and loan guarantees be implemented to encourage private investment in alternative energy development. (32*)

The continuation of state-funded efforts to assess the geothermal resource base and to develop "co-product" options for future industrial success needs federal assistance. (15*) Progress in verifying the resource could lessen the risk associated with geothermal development. (32*) The State of Hawaii has spent \$6 million for assessing and proving the geothermal resource base. Governor Waihee is asking the state for an additional \$3 million, and Hawaii is asking the U.S. Congress for \$15 million in matching funds to conclude the financially risky stage of assessing the resource base. (30*)

Ormat Energy Systems, the co-developer of the Puna Geothermal Venture (HEI will purchase the power) suggests the implementation of three important measures to develop geothermal in Hawaii:

- 1) The permitting process should be streamlined to allow geothermal projects to move forward expeditiously (a view shared by HELCO). (1)
- 2) The societal benefits of geothermal development should be quantified so that the true total value of geothermal produced electricity can be assessed -- both by price values and non-price values. (1)
- 3) Further geothermal development needs continued DOE support. (1)

NATIONAL ENERGY STRATEGY LETTERS FOR GEOTHERMAL

(Letters received by DOE before April 1, 1990)

WITNESS	Q#	ORGANIZATION	COMMENTS/ISSUES
GENERAL			
1 Allison, M. Lee	Q-566	Utah Geological & Mineral Survey	Renewables hearing; balanced R&D
2 Anderson, Dr. John A.	Q-852	Electricity Consumers Resource Council	Regulatory Options
3 Barham, Bill	Q-663	2347 Oak Park, Glendora, CA 91740	Utilization of Geothermal
4 Barker, Benjamin J.	Q-724	Unocal Geothermal Division	Promote expansion of geothermal in NES
5 Barham, W. A.	Q-719	Johnston Pump Company	Promote expansion of geothermal in NES
6 Baza, John R.	Q-650	684 W. Porter Ln, W. Bountiful, UT	Need for more Geothermal research
7 Bingham, Hiram A.	Q-624	Southern California Edison System	Importance of natural gas & geothermal
8 Chapman, Gordon A.	Q-606	Chapman Consulting Services	Development of geothermal
9 Chappell, Ronald E.	Q-764	P.O. Box 6854, Santa Rosa, CA 95409	Reassessment of geothermal energy
10 Colahan, Kent	Q-659	Geothermal Advisory Committee	Geothermal's role in future energy needs
11 Council, John R.	Q-701	John R. Council, Engineering Consultant	Role of geothermal in NE
12 DiPippo, Ronald	Q-561	SMU	Geothermal heat pumps
13 Falcone, Domenic J.	Q-625	Domenic J. Falcone Associates, Inc.	Positive tax benefits to geothermal
14 Fantozzi, Craig A.	Q-722	Hood Corporation	Role of geothermal in NES
15 Feuer, Jack	Q-760	Private Citizen	R&D and funding for geothermal projects
16 Finn, Donald F.X.	Q-394	Geothermal Energy Institute	Incentives; R&D; 1st cost; royalty
17 Fish, John	Q-723	Magma Power Company	Advantages and potential of geothermal
18 Flynn, Thomas	Q-497	Environmental Research Center	Issues impeding development
19 Goddard, Wilson B.	Q-512	Goddard & Goddard Engineering Co.	Air quality; greenhouse effects
20 Goldsmith, Aviv	Q-661	U.S. Energy Corporation	Role of renewables in NES
21 Greider, Bob	Q-643	Energy Consultant	Location and utilization of energy
22 Guymer, Peter	Q-571	Yearly and Associates, Inc.	Government support of geothermal
23 Hagerty, Sean E.	Q-668	Private citizen	BLM budget
24 Halter, E.J.	Q-553	Vibration & Noise Eng. Corp.	Role of geothermal in NES
25 Halter, E.J.	Q-563	Private Citizen	Expansion of geothermal in NES
26 Harrison, Malcolm	Q-658	Yearly and Associates	Government support of geothermal
27 Heasler, Henry P.	Q-567	University of Wyoming	Direct heat; tech needs
28 Heuberger, Jurg	Q-620	Planning Department Imperial County	Geothermal/Transmission plan
29 Hock, Andrew W.	Q-614	Magma Power Company	Direct uses of Geothermal
30 Hook, John W.	Q-721	Geothermal and Mineral Exploration	Cascade range, production of electricity
31 Hooper, Charles I.	Q-767	Honey Lake Industries, Inc.	Priority of geothermal development
32 Howell, John R.	Q-1075	U of Texas, Austin	Technology Transfer
33 Hutter, Gerald W.	Q-490	Geothermal Management Co., Inc.	Renewable/Alternative/Geothermal
34 Iovenitti, J.L.	Q-647	J.L. Iovenitti Consulting Geoscientist	R&D Recommendations; Public input
35 Jung, Douglas	Q-655	Two-Phase Engineering & Research Inc.	Support of small organizations research
36 Koening, James B.	Q-729	Geothermal Resources Council	Statement on growing role of geothermal
37 Lacy, Robert G.	Q-703	San Diego Gas and Electric	Role of geothermal in NES
38 Lippman, Marcelo	Q-679	Private Citizen	Role of geothermal in NES
39 Lykos, Peter	Q-1083	Illinois Inst. of Technology	Technology Transfer
40 Majer, Dr. Ernest L.	Q-628	Private Citizen	Greenhouse gas emissions
41 McCarthy, Robert E.	Q-621	Hill Cassas deLipkau and Erwin	Equitable consideration
42 Meidav, Tsvi (12/22)	Q-664	Trans-Pacific Geothermal Corporation	Hearings topics
43 Meidav, Tsvi (1/24)	Q-816	Trans-Pacific Geothermal Corporation	Clean Air Tax
44 Miller, Douglas M.	Q-470	ORMAT	Clean, indigenous fuels
45 Moore, Michael	Q-716	Michael Moore, PE, Mechanical Engineer	Equitable consideration
46 Motyka, Dr. Roman J.	Q-653	State of AL, Dept. of Natural Resources	Assessment and Analysis of geothermal
47 Nielson, Dr. Dennis L.	Q-680	Private Citizen	R&D funding
48 Olsen, Douglas E.	Q-910	Battelle	Technology Transfer
49 Pearce, David R.	Q-752	Private Citizen	Geothermal energy development
50 Peele, Jon R.	Q-704	Magma Power Company	Geothermal electric power generation
51 Pigott, Jack A.	Q-651	Trans-Pacific Geothermal Corp.	Geothermal energy development
52 Pilcher, Paul I.	Q-747	H&H Oil Tool Co., Inc.	Continued Research & Development
53 Prigge, Paul E.	Q-623	Private Citizen	Reassessment of Geothermal energy
54 Quick, Cecil V.	Q-739	Cooper Industries	Greenhouse gases
55 Reedy, Robert D.	Q-613	Rio Delta Resources, Inc.	Exploration and development
56 Reid, Fred	Q-702	Northern California Power Agency	Geothermal power production support
57 Renken, Paul B.	Q-660	American National Insurance Company	Access of geothermal resources
58 Flavin, Christopher, Piltz, Rick	Q-484	Renew America	Sustainable Energy (publication)
59 Ross, Howard P.	Q-766	Private Citizen	Resource assessment
60 Ross, Steven D.	Q-574	Urban Planning	Assessment/Analysis of geo resources
61 Russell, Stuart	Q-648	Russell Associates	Role of geothermal in NES
62 Schechet, Daniel N.	Q-649	Ormat Energy Systems, Inc.	Hearings
63 Schroeder, R.C.	Q-622	Berkeley Group Incorporated	Tax incentives for development
64 Stingley, Douglas H.	Q-455	Private Citizen	Far west energy provision
65 Stingley, Douglas H.	Q-707	Private Citizen	Private Sector development of geothermal
66 Suter, Roger	Q-785	M-I Air Drilling	Public/government support of geothermal
67 Tait-Robertson, Ann	Q-715	Private Citizen	Role of geothermal in NES
68 Thomas, Doanld M.	Q-713	Univeristy of Hawaii at Manoa	Research and Development

69	Thompson, C. Ray	Q-681	University of California, Riverside	DOE role in geothermal
70	Turk, Joe	Q-725	H&H Oil Tool Co., Inc.	Direct use/generating electricity
71	White, Lynn G.	Q-699	GEO Operator Corporation	Role of Geothermal in NES
72	Wiley, Robert A.	Q-654	Geothermal Technical Services	Role of Geothermal in NES
73	World Bank Energy Dept.	Q-1127	World Bank Energy Department	International Trade
74	Wright, Phillip M.	Q-457	University of Utah Research Inst.	Role of Geothermal in NES
75	Wright, Phillip M.	Q-507	Private Citizen	100 page report
	Nielson, Dennis L.			
	Ross, Howard P.			
	Moore, Joseph N.			
	Adams, Michael C.			
	Ward, Stanley H.			
76	White, Hershel	Q-560	Pacific Inspection	Role of geothermal in NES

GEOPRESSURED-GEOTHERMAL

77	Capuano, R.M.	Q-619	University of Houston	Geopressured-Geothermal
78	Eaton, B.A.	Q-626	Eaton Operating Company, Inc.	Research and funding

HOT DRY ROCK-GEOTHERMAL

79	Curtis, Dan L.	Q-663	The Geysers, Inc.	Thermonuclear fracturing
80	Kaufman, Edward L.	Q-831	Private Citizen	Comments on use of geothermal
81	Smith, Morton C.	Q-652	Private Citizen	Identify existing & potential resources
82	Tester, Jefferson W.	Q-683	Private Citizen	100+ page report on Hot dry rock

MAGMA-GEOTHERMAL

83	Candela, Philip A.	Q-610	The University of Maryland	Research to develop magma energy
84	Kaufman, Edward L.	Q-831	Private Citizen	DOE leadership is important
85	Lee, Barbara	Q-607	Private Citizen	Allocation of money
86	Piccoli, Philip M.	Q-608	The University of Maryland	Research & drilling phase
87	Williams, Thomas J.	Q-609	The University of Maryland	Research & drilling

DIRECT USE-GEOTHERMAL

88	Hengel, Raymond	Q-662	Hengel Associates, P.C.	Heating systems
89	Hermann, Walter E.	Q-611	Private Citizen	Application of direct-use
90	Gordon, Bruce A.	Q-615	NOVA Group Inc.	Planning of direct-use
91	Lienau, Paul J.	Q-627	Geo-Heat Center	Role of Direct-use in NES
92	Schmidt, Richard R.	Q-720	State of New Mexico	Research and Development

GROUND SOURCE HEAT PUMPS

93	Assoc. Electric Cooperative	Q-1099	Associated Electric Cooperative, Inc.	Environmental Benefits
94	Braud, Harry J.	Q-xxx	Dept. of Agricultural Engr.	Geothermal heat pumps/refrigeration
95	Braud, Harry J.	Q-xxx	Dept. of Agricultural Engr.	Statement of support
96	Bose, James E.	Q-120	Oklahoma State University	Written testimony/GHP
97	Bourn, Van C.	Q-904	Water Furnace	Market Obstacles
98	Harrell, James E.	Q-795	Jacobsen Energy Industries, Inc.	Educate public/industry on geothermal
99	Harris, Jeffrey J.	Q-751	WaterFurnace International Inc.	Written testimony on NES
100	Lienau, Paul J.	Q-627	Geo-Heat Center	Development of adequate resource base
101	PacifiCorp.	Q-1114	Pacific Power, Utah Power	Technical Obstacles
102	Trelease, S.W.	Q-830	Command-Aire Corporation	Federal recognition/support/consideration
103	Myers, John	Q-969	Congress of the United States	Supporting geothermal heat pumps
104	Rogers, James E.	Q-1000	Public Service Indiana	Promotion of geothermal heat pumps

NATIONAL ENERGY STRATEGY ORAL TESTIMONY

(References to Oral Testimony have *)

	WITNESS	SITE	ORGANIZATION	COMMENTS/ISSUES
1	Bowen, W.J.	KY-300	Transco Energy Company	R&D Funding
2	Bronicki, Lucien Y.	HI-05	ORMAT Energy Systems, Inc.	Environment
3	Condy, Charles T.	NO	California Energy Company, Inc.	Policy Options
4	Cooke, Jerry	ID-302	Snake River Alliance	Environment
5	Eam, Dr. George C.	KY-028	General Motors Corp.	R&D Funding
6	Fedoruk, Nicholas A.	AT	Environmental Action Foundation	Energy/Environment Policy
7	Greenpeace	WA,401	Greenpeace	Environment
8	Harris, Louis	OK-214	Harris Poll	Environment
9	Lipman, Stephen C.	HT	UNOCAL Corporation	Obstacles and Options
10	Manne, Alan S. and	AT	Stanford University	Carbon Dioxide Tax
11	Richels, Richard G.	AT	EPRI	Regulatory
12	McCullough, Vicki	OK-199	Native Americans For a Clean Environment and SECC	Environment
13	Rickert, Allan	WA,418	Solar Utilities Network	Environment
14	Schneider, Honorable Claudine	RI	U.S. House of Representative	Environment/Policy Options
15	Takahashi, Patrick K.	HI	Hawaii National Energy Institute, U of Hawaii	Tax Incentives
16	Trulove, Tom	WA,190	NW Power Planning Council	R&D Funding
17	Waihee, Honorable John	HI	Governor, State of Hawaii	Environment
18	Watson, Richard H.	WA,041	Washington State Energy Office	R&D Funding
19	Wellford, W. Harrison	DC-#3	Natl. Independent Energy Producers	QF Power Limitations

NES HONOLULU SUMMARY REFERENCE LIST ORAL TESTIMONY

	WITNESS	ORGANIZATION
20	Akaka, Daniel	Rep. US House of Representatives
21	Bronicki, Lucien Y.	ORMAT Energy Systems
22	Doo, Leigh-Wai	Councilmember, Honolulu City Council
23	George, Honorable Mary	State of Hawaii
24	Hays, Admiral Ronald J.	Pacific Intl. Ctr for High Tech. & Research
25	Ho, Nelson	Sierra Club
26	Le'I, Matt	American Samoa U.S. Territory Energy Office
27	Nishiki, Wayne K.	Councilmember, County of Maui
28	Saiki, Patrick	Rep. US House of Representatives
29	Takahashi, Patrick K.	Hawaii Natural Energy Institute
30	Ulveling, Roger	State of Hawaii
31	Waihee, Honorable John	Governor State of Hawaii
32	Williamson, Harwood D.	Hawaiian Electric Company

SECTION VI REFERENCES
WRITTEN TESTIMONY: PRO GEOTHERMAL
 (Reference numbers for Written Testimony
 for Honolulu, Hawaii are underlined>)

	WITNESS	n#	ORGANIZATION
1	Bronicki, Lucien Y.	HI-05	ORMAT Energy Systems
2	George, Honorable Mary	HI-17	State of Hawaii
3	Inouye, Senator Daniel	HI-27	State of Hawaii
4	Krieger, H. Ram	HI-xx	ORMAT
5	Le'I, Matt	HI-01	American Samoa U.S. Territory Energy Office
6	Olson, Harry J.	HI-25	University of Hawaii at Manoa
7	Olson, Harry J.	HI-25	University of Hawaii at Manoa
8	Olson, Harry J.	HI-25	University of Hawaii at Manoa
9	Phillips, Dr. Victor	HI-31	Hawaii Natural Energy Institute, U of Hawaii at Manoa
10	Thomas, Dr. Doanld M.	HI-29	State of Hawaii
11	Ulveling, Roger	HI-08	State of Hawaii
12	Waihee, Honorable John	HI-07	Governor State of Hawaii
13	Williamson, Harwood D.	HI-02	Hawaiian Electric Company, Inc.

WRITTEN TESTIMONY: CON GEOTHERMAL

	WITNESS	n#	ORGANIZATION
14	Aluli, Noa Emmett	HI-33	The Pele Defense Fund
	Dedman, P		
15	Carson, Hampton L.	HI-26	University of Hawaii
16	Merwin, W.S.	HI-23	State Capital Building
17	Nishiki, Wayne K.	HI-20	County of Maui
18	Rainforest Action-network	HI-32	Rainforest Action-Network
19	Ruderman, Russell E.	HI-22	Private Citizen