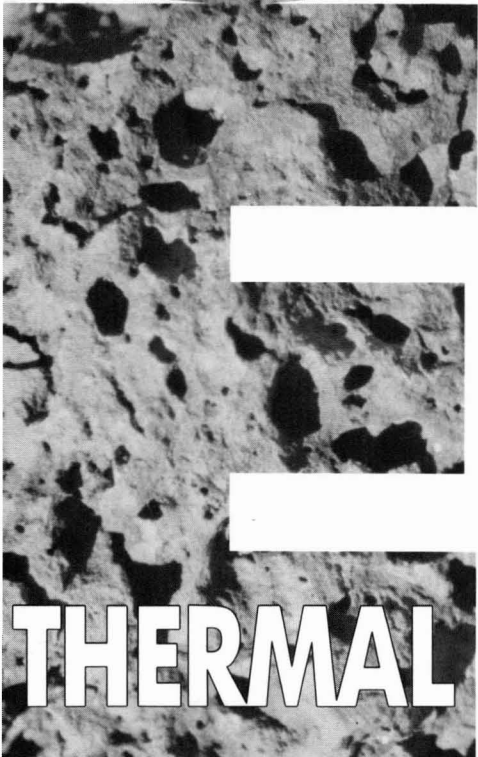
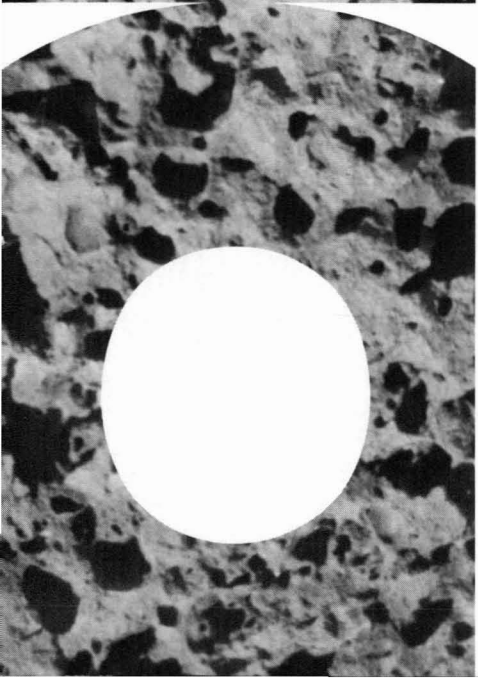




*Envision Hawaii!*



**Geothermal Energy**  
*Harnessing Hawaii's Energy Future*





## The Importance of Geothermal Energy

Hawaii has long recognized the importance of developing its geothermal energy resource. Tapping the heat energy stored deep underground has been an integral part of the state's planning for more than a decade, and generating electricity from geothermal resources is a keystone of Hawaii's Energy Functional Plan.

Alone among the 50 States, Hawaii is 90 percent dependent upon imported oil for producing electricity; more than any other state, we are subject to the instability of the world oil market. Fortunately, we are blessed with a large geothermal energy resource which may eventually supply half of Hawaii's electricity needs, and provide jobs to numerous small businesses who can use the heat directly.

Geothermal has proven beneficial in decades of use around the world. Because emissions from geothermal power facilities are far lower than from comparable oil- or coal-fueled power plants, geothermal is particularly appealing for Hawaii's unique environment. Oil-generating facilities emit 13 times as many gasses and particulates by weight as geothermal plants and coal plants emit 40 times as many as geothermal.

This pamphlet looks at many facets of Hawaii's promising geothermal future and shows how we are working to develop it now. Thank you for your interest and support.

Sincerely,

Roger A. Uveling  
Director

# Geothermal Energy

## What is Geothermal Energy?

"Geo," meaning "earth," and "thermal," referring to "heat," geothermal energy is heat stored deep below the earth's surface. By drilling wells, this heat can be brought to the earth's surface in the form of steam or hot fluids. Like the heat created by burning fuel oil or coal, geothermal heat can be converted into electricity to serve the everyday needs of home and office. Used directly, the heat can also be used in a variety of agricultural and industrial processes, such as drying fruit or sterilizing.

## Why is Geothermal Energy Important to Hawaii?

Approximately 90 percent of Hawaii's electricity is produced by oil-burning power plants, making the state almost completely dependent upon imported oil. Isolated from its nearest state by 2,500 miles of ocean and possessing no fossil fuel resources of its own, Hawaii is energy-dependent on overseas oil.

But Hawaii has an abundant supply of geothermal energy stored deep underground. According to some estimates, this energy could supply as much as one-half the state's electricity needs. Using the geothermal resource to produce electricity would:

- Free Hawaii from its critical dependence upon imported oil;
- Improve Hawaii's air quality by limiting the burning of oil or coal for energy; and
- Add as much as \$300 million to the local economy each year which presently goes out of state to pay for the imported oil.

## Is Geothermal Energy a new technology?

Because the commercial development of geothermal energy is just getting underway in Hawaii, some people think it is a new technology. Actually, geothermal energy is a commonly used resource around the world.

For as long as humans have lived in geothermal regions, this energy has been used for cooking, bathing and other similar purposes.

The earliest use of geothermal energy to produce electricity was in Italy in 1904. Today, the largest geothermal electric field in the world is at The Geysers, in Northern California.

The first commercial geothermal power plant at the Geysers began providing electricity in 1960. Today the

# for Hawaii

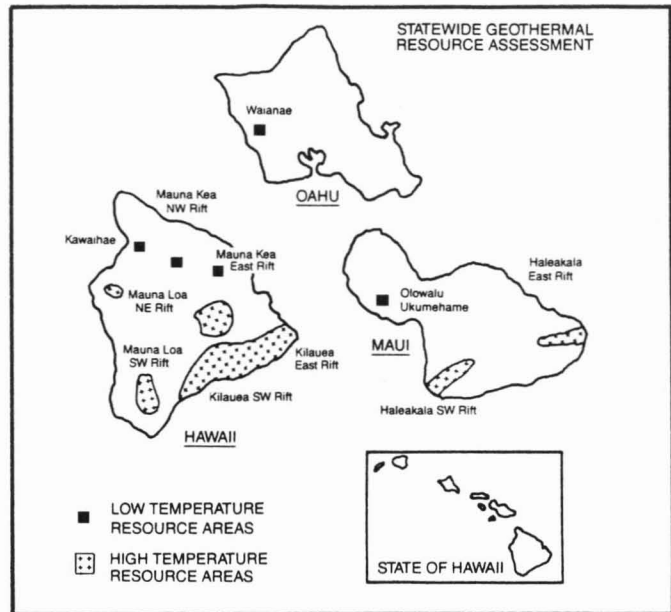
Geysers provide approximately 2,000 Megawatts of geothermal produced electricity — four times the eventual total production envisioned for Hawaii.

From the Philippines to Iceland, New Zealand to Japan and California, geothermal resources generate electricity, heat homes and swimming pools, and serve many other uses as well.

In Hawaii, geothermal energy was first used by ancient Hawaiians who used the steam vents near the active volcanoes of the Big Island to cook food. While geothermal exploration has been going on in Hawaii since 1955, the use of the resource to generate electricity was actually first proposed by King David Kalakaua more than 100 years ago.

## What are the Environmental Impacts of Geothermal?

Decades of experience in producing electricity from geothermal energy have shown that the process is one of the most environmentally acceptable methods of generating power on a large scale.



Hawaii geothermal resource subzones.

Both the U.S. Department of Energy and the California Energy Commission consider the production of electricity from geothermal resources to be environmentally safer, especially concerning the critical issue of air quality, than production from oil or other fossil fuel resources.

The most significant emissions from geothermal power plants are small amounts of sulfur dioxide, and

## HGP-A: A Hawaii Geothermal Success Story

A half-hour's drive from Hilo through the lush green Puna rain forest at a place called Pohoiki, a small geothermal power plant has been steadily providing electricity for more than six years.

Properly known as the Hawaii Geothermal Project-Abbott and commonly known as HGP-A, this facility began operating in 1981 as a two-year project to demonstrate geothermal energy's potential for Hawaii. Although designed as a 24-month demonstration facility, HGP-A continues to produce electricity 24 hours a day as part of the island's electrical system.



Peter Allen of Papaya Products Hawaii uses geothermal brine to provide heat to produce green papaya powder.

HGP-A produces more than 18 million kilowatt-hours of electricity each year — enough to provide

power to 2,500 or 3,000 homes. This electricity is sold to Hawaii Electric Light Company, which saves more than 30,650 barrels of oil each year by using this small geothermal facility.

HGP-A will be used for long-term testing on another well drilled nearby for Puna Geothermal Venture. That company has an agreement to supply 25 Megawatts of electricity to the Big Island utility before 1994; another company, True/Mid-Pacific Geothermal Venture, has secured its permit to explore for up to 100 Megawatts and develop 25 Megawatts from geothermal resources.

large amounts of harmless water vapor. The facilities are designed to minimize emissions. For example, even if 500 Megawatts of electricity were developed from geothermal on the Big Island, total sulfur dioxide emissions from generating plants would be just over one-half metric ton per day. By comparison, the natural emission of hydrogen sulfide from fissures and volcanic activity in the area ranges from 1,200 to 1,600 metric tons per day, according to the U.S. Geological Survey.

***Both oil and coal generating facilities send greater amounts of emissions into the air than comparable geothermal facilities.***

For brief periods when geothermal wells are first completed, they produce a loud noise when steam is released — or “flashed” — into the air. After the installation of mufflers, no further noise of any significance is produced beyond the generator building. (However, the wells do have to be flashed every so often to be cleaned.)

The visual impact of geothermal development is minimal, and decentralized. Generating plants and wells are generally scattered, low-rise facilities, not concentrated into large industrial facilities. The electric transmission lines and poles associated with such facilities are generally similar to power lines already common in Hawaii.

### ***Do the people of Hawaii support Geothermal Development?***

Several surveys have shown that the people of Hawaii overwhelmingly support geothermal energy development. In the most recent (1987) poll, 84 percent of the State's residents said they favored geothermal energy development. On the Big Island, where most of the development is anticipated, fully 77 percent of the residents said they were in favor of geothermal development.

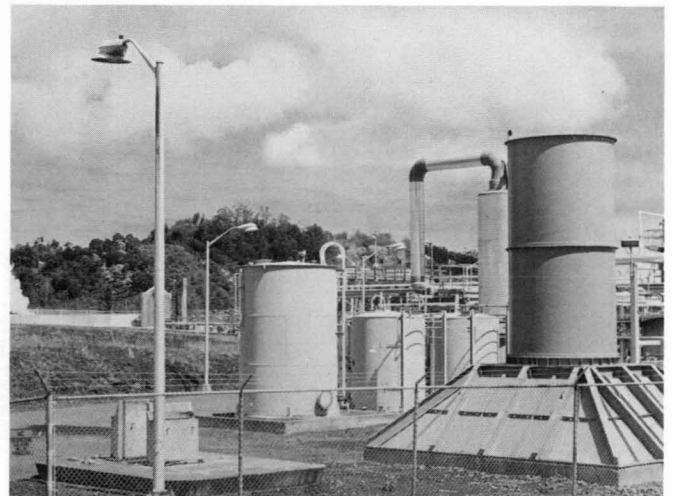
### ***What is the scope of geothermal development envisioned?***

Hawaii's first geothermal power plant has been contributing electricity to the Big Island's power system for about six years. Over the next several years more wells and power plants are expected to come on line, first providing 25 Megawatts to residents of the Big Island, and eventually perhaps providing as much as 500 Megawatts. This electricity, which far exceeds the electricity needs of the Big Island, may then be transported to Maui and Oahu via an underwater cable.

# September 25, 1881 proposes geothermal

Although modern geothermal exploration in Hawaii began in 1955, the first proposal to turn the Big Island's geothermal energy into electricity — and to share it with others via undersea cable — was actually made more than 100 years ago. The occasion was a meeting between Hawaiian monarch King David Kalakaua and the inventor of the light bulb, Thomas Edison.

A Monday, September 26, 1881 report in the New York newspaper *The Sun*, was headlined “Kalakaua Visits Edison, The King in Search of a Means to Light Up Honolulu. The Hawaiian Attorney-General's Proposal to Provide Edison with Power from a Volcano.”



*Part of the HGPA Well now producing electricity in Puna on the Big Island.*

The following account is taken from *The Sun*:

“King Kalakaua was introduced to Mr. Thomas A. Edison at the latter's headquarters in Fifth Avenue, at 9 o'clock last night.

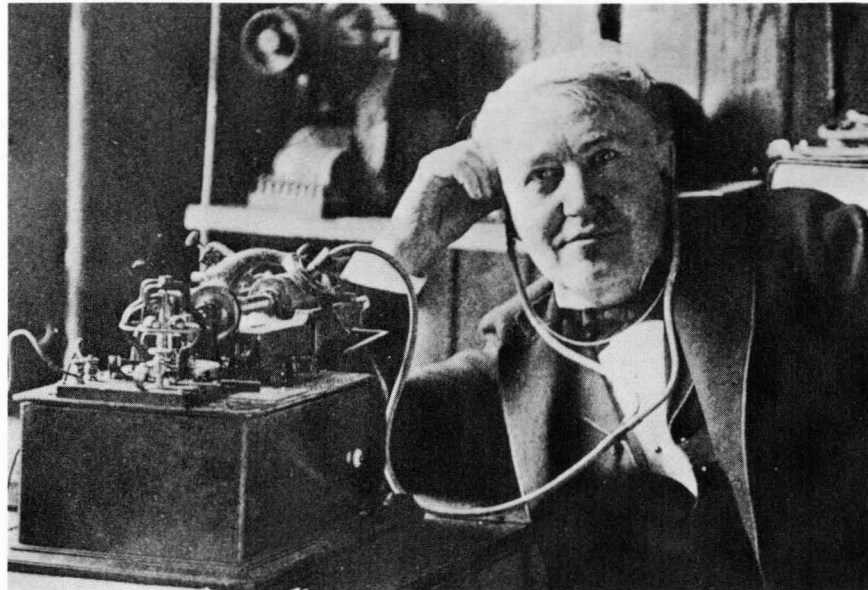
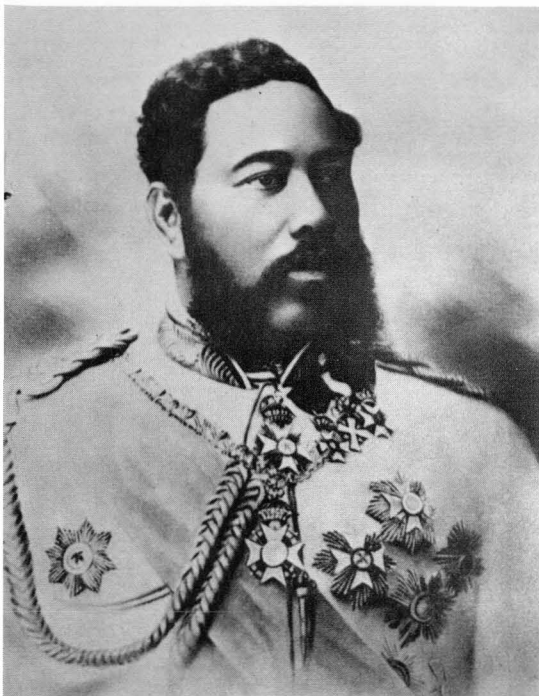
“‘I have heard about you, Mr. Edison,’ said his Majesty, ‘and I have wished to see you and your wonderful inventions.’

“Edison exhibited his light..The King was interested. Attorney-General Armstrong says that his Majesty is especially interested in the electric light, because his capital, Honolulu, must be lighted soon by something superior to the kerosene now employed there.

“‘Can you lay your wires in submarine cables?’ Attorney-General Armstrong asked. ‘Because you might come over to the Sandwich Islands,’ the King's advisor said, ‘where we have a volcano that burns a thousand million tons of coal a day, and you could put your boilers on top of the volcano and get power enough to supply this country.’

“‘...we build great hopes on that volcano.’”

# 81: Kalakaua Thermal electricity, undersea cable



*King David Kalakaua and inventor Thomas Edison...progressive men who lit Honolulu with hopes of geothermal energy in Hawaii's future.*

## The Geysers: California's Geothermal Success Story

The world's largest and most successful geothermal development is The Geysers, located about 90 miles north of San Francisco.

More than 250 geothermal wells drilled there produce 2,000 Megawatts, enough to meet the needs of a city of more than two million people.

Situated in Lake and Sonoma counties, The Geysers area has been known for geothermal activity since the mid-1800's.

Geothermal steam was initially discovered in commercial quantities in The Geysers in 1955, and the first electrical generating plant was built by Pacific Gas and Electric Company in 1960. Initial progress at The Geysers was slow, but in the late 1960s and early 1970s additional development made it the largest



geothermal project in the world.

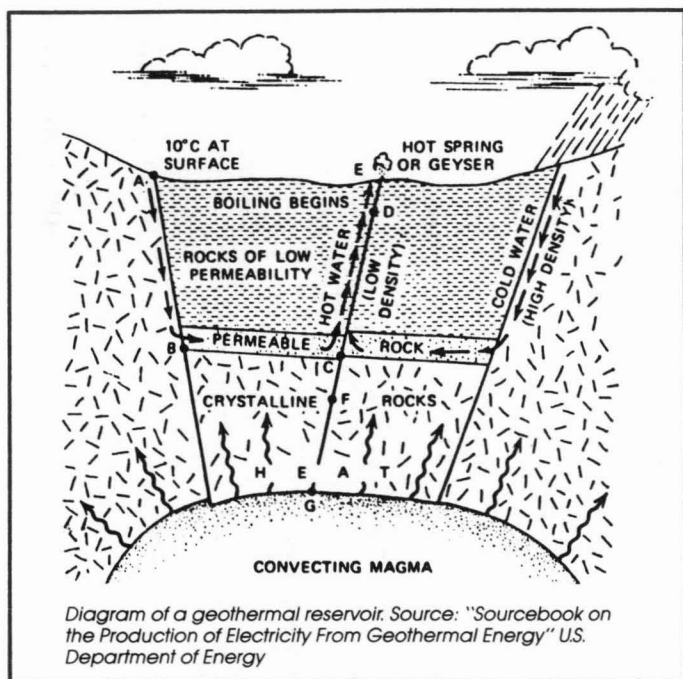
While geothermal wells and specially insulated pipelines which carry the steam to electrical generating plants dot the Geysers, special attention has been paid to protect the environment.

The geothermal production area is located near many of the fine vineyards of Northern California, and

the atmosphere-sensitive grapes and geothermal wells co-exist without any complications.

In addition, The Geysers is responsible for a sizeable contribution to the economy of Lake and Sonoma counties, through property taxes, purchases by the various geothermal companies and employee payrolls.

# Geothermal Energy: A proven resource used around the world



The geothermal power story started in 1904 in Lardarello, Italy, with the first power generation from a geothermal field. Today, from Greece to California, from the Philippines to Kenya, geothermal energy is reducing man's dependence on fossil fuel.

Geothermal projects are actively producing electricity in use in more than 15 countries around the world, and exploration for geothermal energy is under way in many other locations.

As technology has advanced during the past decade, the amount of power generated worldwide through geothermal projects has tripled.

Island countries such as the Azores, Iceland, Guadeloupe, New Zealand and Japan, generate electricity from geothermal fields, as do continental countries such as the Soviet Union, China, Mexico and El Salvador. Within the United States, geothermal wells are producing electricity in California, Idaho, Nevada, Oregon, and Utah, as well as in Hawaii.

## The Hawaii Deep Water Cable Program

### *Connecting Oahu and Maui to the Big Island's geothermal resource*

Two extensive undersea surveys were made — in October/November 1985 and July 1986. This represents the most detailed mapping of the ocean floor ever done in Hawaii. As a result, the HDWC program has been able to identify a preferred path for the undersea cable which appears feasible even through the 1,200-meter depths of the Alenuihaha Channel.

The conceptual layout for the proposed cable-laying vessel has been developed. At-sea testing of the techniques proposed for laying and retrieving the cable will be conducted in the Alenuihaha Channel with a five mile-long surrogate cable in late 1989.

The first beneficiary of the technology and techniques developed by the HDWC program will be the State of Hawaii, which will be able to realize its goal of greater energy self-sufficiency. But many others will benefit from the project. Cable manufacturers, research laboratories, oceanographers, the scientific community, the U.S.

Geological Survey — all will benefit from the transfer of HDWC-related technology. The project has already drawn the attention of:

- Southern California Edison, which is planning an undersea transmission cable from the Pacific Northwest to California.
- The Nova Scotia Power Corporation, which hopes to transmit up to 1,200 Megawatts to Plymouth, Massachusetts via undersea cable.
- Icelandic power authorities hoping to export hydro-power electricity to Great Britain via an undersea cable linking Iceland, Scotland and Great Britain.

The work of the Hawaii Deep Water Cable program promises to connect the electrical power systems of Hawaii's major islands together for the first time. This will not only permit the transmission of geothermal-produced

electricity from the Big Island to Maui and Oahu, but will also mark the first time that shortages or outages on one island could be helped by power generated on another island. In the process, Hawaii will be taking a position of world leadership in this important technology.

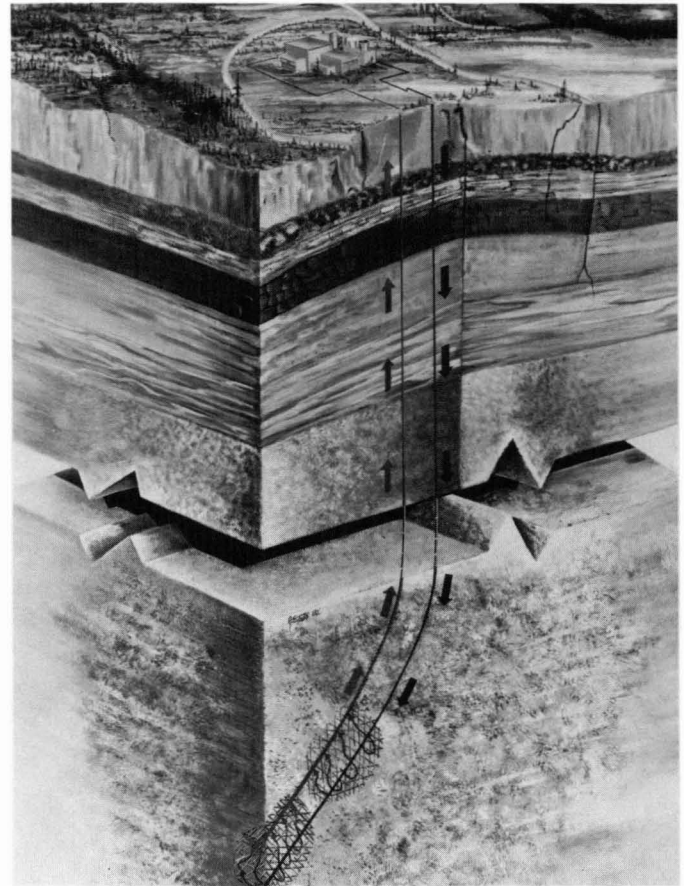
The largest demand for electrical power in Hawaii is on Oahu, which accounts for over 80 percent of the State's total electrical consumption. But the geothermal resources of the Puna area of the Big Island are separated from the islands' major market for electrical power by 130 miles of ocean. For the geothermal resources of the Big Island to be developed to their potential, and for the State to take its single most important step toward energy self-sufficiency, the Big Island resource and its Oahu market must be brought together.

This is the goal of the Hawaii Deep Water Cable (HDWC) program. HDWC is a federal and State of Hawaii funded research and development project aimed at developing and providing the technology needed to lay, operate and maintain a submarine cable power transmission system between Kohala on the Big Island and Makapuu on Oahu. The system will be designed to perform for at least 30 years.

The HDWC research project is a significant one. Sending geothermal-produced power to Oahu from the Big Island will require a submarine cable that travels four times as deep and twice as long as the current state-of-the-art deepwater cable. The successful completion of this research effort, expected in 1990, will place Hawaii on the world forefront of undersea cable technology.

The HDWC program has two major challenges:

- First, to design and develop a cable that will withstand the depth, pressure and stresses of ocean currents necessary to operate between the Big Island and Oahu.
- Second, to find a preferred route for the cable and develop the techniques necessary to



System for extracting energy from a dry geothermal reservoir.  
Source: Los Alamos National Laboratory

deploy and retrieve the cable.

The HDWC program has already been successful in several important ways.

The cable design and fabrication are well under way. From a field of 251 possible designs, HDWC selected the most promising cable design and has had a prototype built by Pirelli Cable Corporation of Italy (there are no major American deep sea cable manufacturers). A laboratory testing program began in the Spring of 1988 with 6,000 feet of cable.

## The Governor's Advisory Committee

On August 7, 1987, Governor John Waihee established the Governor's Advisory Board on the Underwater Cable Transmission Project. Members of the board include William F. Quinn (Chairman), Roger A. Ulveling (Vice Chairman), John D. Bellinger, Mayor Dante K. Carpenter, Paul Finazzo, Sheridan C.F. Ing, Fujio Matsuda, Russell K. Okata, William W. Paty, Jr. and Howard Tasaka.

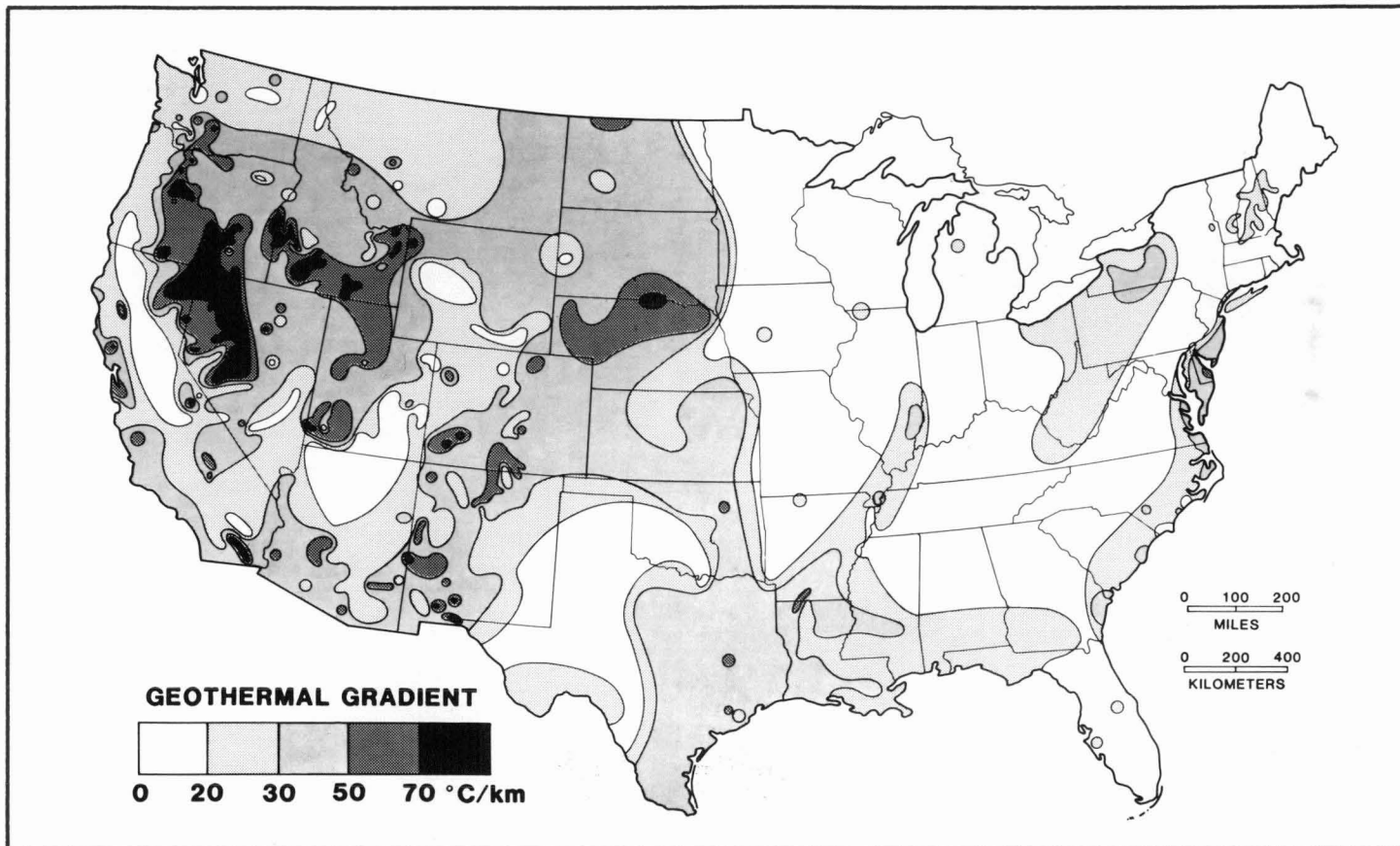
The purpose of the board is to advise the Governor on the technical, economic, financial and social feasibility of the construction of geothermal power facilities and an underwater cable transmission system to transmit electricity from geothermal energy on the Big Island to

Maui and Oahu. The board also advises on the appropriate role of State government in the project.

The board has concluded that the overall project is technically, socially, economically, and financially feasible. The board has recommended that the State take a strong leadership role in providing for and facilitating the coordinated development of geothermal resources and the submarine cable system.

The board has recommended that the State establish a goal of providing at least fifty percent of its electricity needs through geothermal or other indigenous and renewable energy sources by the year 2010.

# Geothermal Energy



For further information contact:

*Geothermal gradient map of the United States based on gradients measured where the terrestrial heat flow is by conduction through the rock.  
Source: Los Alamos National Laboratory*

● **Energy Division**

State of Hawaii Department of  
Business & Economic Development  
335 Merchant Street, Room 110  
Honolulu, HI 96813

or call the Energy Hotline: (808) 548-4080  
(neighbor islands ask Operator for Enterprise 8016)

● **Hawaii Energy Extension Service**

Hilo Lagoon Centre Annex Building, #214  
101 Aupuni Street  
Hilo, HI 96720

or call: (808) 961-7558



250 South King Street, 7th Floor, Honolulu, HI 96813