Committee on Resources,

Subcommittee on Energy & Mineral Resources

energy - - Rep. Barbara Cubin, Chairman
U.S. House of Representatives, Washington, D.C. 20515-6208 - - (202) 225-9297

Witness Statement

STATEMENT OF
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BEFORE THE
SUBCOMMITTEE ON ENERGY AND MINERAL RESOURCES
COMMITTEE ON RESOURCES
U.S. HOUSE OF REPRESENTATIVES

May 3, 2001

Madam Chairman and distinguished Members of the Subcommittee, thank you for this opportunity to present, on behalf of the U.S. Geological Survey, this statement regarding our assessment of the location, extent and nature of geothermal resources in the United States.

Background

The Geothermal Energy Research, Development and Demonstration Act of 1974

(P.L. 93-410) assigned responsibility for the evaluation and assessment of geothermal resources to the USGS through the U.S. Department of the Interior (DOI). The assessment efforts initiated under this Act led to the publication of USGS Circular 726, *Assessment of Geothermal Resources of the United States - 1975* and USGS Circular 790, *Assessment of Geothermal Resources of the United States - 1978*. These reports established the methodology for geothermal resource assessments and provided estimates of potential electric power generation that have guided geothermal energy research and development for the past 22 years.

In this statement I will summarize the current state of geothermal energy in the United States and provide information on the evolution of geothermal science and technology as it relates to the resource assessments of the 1970s.

The Current State

Today, the United States has an installed capacity of approximately 2,860 Megawatts (MW) of electrical power production from geothermal plants located in California, Hawaii, Nevada, and Utah. This constitutes 0.4% of our total electricity generation capacity and is the Nation's largest source of non-hydroelectric renewable electrical power.

Classification, Location and Development of Geothermal Resources

The Earth’s internal heat drives many geologic processes and, where it is locally concentrated, this heat can be manifested as volcanoes, hot springs, and other thermal features. Large portions of the western U.S. are characterized by abnormally high heat flow as a result of active faulting and volcanism. All of the existing geothermal power plants fall within these regions. The Earth’s heat can be exploited at various temperatures to provide a source of geothermal energy.

Geothermal reservoirs are classified according to their temperature and whether the reservoir fluid occurs as liquid water or as steam. Geothermal power is obtained from steam produced directly from the ground, from steam flashed and separated from hot water, or from binary systems involving closed-loop heat exchange between hot water and organic fluids with low boiling temperatures.

High temperature geothermal systems have temperatures greater than 150 ^{o}C (302 ^{o}F) with the reservoir fluid comprising hot water and/or steam. These systems are typically the best candidates for electricity generation and power plants exploiting these systems typically flash the hot water to drive steam turbines.

Intermediate temperature systems have temperatures between 90 and 150 ^{o}C (194 and 302 ^{o}F) and generally require the use of binary power plants with closed-loop heat exchange technology that allows transfer of the heat in the geothermal fluid to a second fluid that vaporizes at lower temperature.

Low temperature systems are those with temperatures less than 90 ^{o}C (194 ^{o}F) and are generally considered appropriate for direct use applications (space heating, agricultural process heat, spas). In this statement I will concentrate on the nature and abundance of intermediate and high temperature geothermal systems in the United States. A general overview of all aspects of geothermal energy can be found in USGS Circular 1125, *Tapping the Earth's Natural Heat*.

The last nationwide geothermal resource assessment (USGS Circular 790) was published in 1978, and a comparison of its findings with the current state of knowledge and development highlights some important points.

- Circular 790 identified nine western states (Alaska, Arizona, California, Hawaii, Idaho, Nevada, New Mexico, Oregon and Utah) with the potential for at least 100 MW of electrical power generation per state from identified geothermal systems.
- The total identified high temperature geothermal resource in these nine states was estimated at approximately 22,000 MW. On a state-by-state basis, only California has realized a significant fraction (22%) of this potential (2,600 out of 12,000 MW). Estimates of undiscovered resources ranged from 72,000 to 127,000 MW.
- The Great Basin region, which lies mostly in Nevada and Utah but also encompasses parts of California, Oregon, and Idaho, has the lowest percentage of developed power with respect to the Circular 790 estimates. Only about 500 MW are produced in the Great Basin compared with an estimated high-temperature resource of about 7,500 MW.

The following table summarizes the results of the state-by-state comparison for the nine states highlighted in the 1978 resource assessment and the installed electrical power generating capacity as of 1998 (Source - Energy Information Administration (EIA) – Department of Energy).

- State	Estimated Geothermal Resource - 1978 (MW)	Installed Capacity - Geothermal (MW)	Installed Capacity -All Sources (MW)	Percentage of Geothermal Power
Alaska	250	0	2093	0
Arizona	1,000	0	15,254	0
California	12,000	2,600	52,349	4.9%
Hawaii	250	30	2,353	1.3%
Idaho	540	0	3,001	0
Nevada	2,000	200	6,389	3.1%
New Mexico	2,700	0	5,531	0
Oregon	2,200	0	11,344	0
Utah	1,350	33	5,206	0.6%
TOTAL	22,290	2,863	103,520	2.8%

If the entire estimated resource for these nine states could be exploited as electrical power, it would equal 21.5% of the electrical power generated from all other sources. The possible reasons for the large difference between the estimated geothermal resource and installed capacity are varied and, in the absence of another systematic resource assessment, difficult to quantify.

Among the factors limiting geothermal resource development are the following.

- Economics – Until recently, the 5- to 8-cent per kilowatt-hour (kwh) cost of geothermal energy was not competitive with fossil fuel-generated power costing as little as 3 cents/kwh.
- Water – Reservoirs exploited with flash-steam power plants lose a significant fraction of the produced water from their cooling towers. In many western states water for reinjection into geothermal reservoirs is either unavailable or in short supply.
- Remote Locations – Many geothermal systems, particularly those in the Great Basin, are dispersed in relatively remote locations with limited access to electric power transmission lines and other facilities.
- Validation of the Resource – Because geothermal reservoir development requires drilling, it has often proven difficult for power companies to obtain financing in the absence of up to date resource

assessments.

- Uncertainties in the Circular 790 Assessment – The state of knowledge about geothermal resources has advanced dramatically in the past 20 years, and there is evidence that Circular 790 may have overstated the abundance of undiscovered high temperature resources in the western U.S.

There are also a number of technical reasons why geothermal resource development could approximate some of the estimates contained in Circular 790.

- Binary Power Plants - The maturation of binary power plant technology has provided a means of exploiting geothermal reservoirs with little or no loss of water. In addition, binary power plants have enabled the development of intermediate temperature systems not included in the Circular 790 estimate.

- Reclaimed Water – Effluent pipelines carrying reclaimed water from urban areas have become a cost-effective and environmentally sound means of providing water for reinjection into declining or depleted geothermal reservoirs. For example, reclaimed water is now being used to replenish The Geysers geothermal field in California, which produces approximately 1,200 MW of electricity.

- Enhanced Geothermal Systems – With DOE support, scientists and engineers have been developing a geothermal reservoir stimulation technique known as Enhanced Geothermal Systems (EGS). Through the hydraulic fracturing of the hot but impermeable rock surrounding geothermal reservoirs, power companies will be able to increase the amount of hot rock available to heat geothermal fluid, increasing the capacity and extending the lifetime of existing geothermal systems.

- Exploration Technology – Improved geochemical and geophysical tools for geothermal exploration, together with targeted test drilling, have allowed power companies to more accurately predict the productivity of a specific geothermal resource before embarking on an expensive program of production drilling.

Recent efforts to incorporate some or all of these developments in updated assessments have led to widely varying results. According to a 1999 report prepared by the Geothermal Energy Association (GEA) and the DOE (*Geothermal Energy, The Potential for Clean Power from the Earth*), the domestic geothermal energy potential ranges from 6,520 MW with existing technology to 18,880 MW with enhanced technology. A geothermal industry consultant's re-examination of the Circular 790 assessment with the addition of potential Enhanced Geothermal System sources gives a range of values between 6,300 and 27,400 MW (J. Sass, unpublished report). The Strategic Plan for the DOE Office of Power Technologies has a goal for geothermal energy to provide 10% of the electric power requirements of western states by the year 2020. This would require more than 10,000 MW of additional geothermal power, and a review by the National Research Council (NRC) suggests this goal is unlikely to be met (*Renewable Power Pathways: A Review of the U.S. Department of Energy's Renewable Energy Programs,* NRC, 2000). By contrast, the Energy Information Administration of DOE estimates an installed geothermal power capacity of 4,140 MW by 2011 (*EIA Annual Energy Outlook 2001* - http://www.eia.doe.gov/oiaf/aeo/aeotab_17.htm).

<u>Future Directions for Research and Development</u>

Along with the need to reduce the uncertainties in the assessment of domestic geothermal resources, there are many active research efforts in geothermal science and technology that could benefit the geothermal power industry in the near term.

- Exploration and Drilling - Although the technology of power generation is well advanced, new geothermal systems can be hard to locate and expensive to develop. Advances in exploration and drilling technology can cut costs and increase the probability of success.
- Enhanced Geothermal Systems - Techniques for expanding and sustaining geothermal reservoirs are in their infancy, and EGS experiments proposed for the next few years could greatly expand the existing resource base.
- Integrated Geological Studies - In order to accurately assess the geothermal resources of the western U.S., significant progress needs to be made on understanding the processes responsible for the formation of geothermal systems, particularly in the Great Basin. Recent investigations of the interrelationships among heat flow, ground-water circulation, active faulting, volcanism, and geochemical fluid-rock interactions suggest that the Earth Science community is on the verge of developing a new, comprehensive understanding of geothermal systems. The resulting models for the nature and extent of geothermal systems would not only improve the accuracy of any new assessment but also enable the development of more economical exploration and development strategies for geothermal energy.

Madam Chairman, this concludes my remarks. I would be happy to respond to questions Members of the Committee may have.

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