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U.S. DEPARTMENT OF ENERGY

Before the

SUBCOMMITTEE ON ENERGY AND MINERAL RESOURCES

COMMITTEE ON RESOURCES

U.S. HOUSE OF REPRESENTATIVES

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Mr. Chairman and Members of the Committee:

Thank you for the opportunity to appear before you today to discuss the contribution of the Department of Energy (DOE) geothermal energy activities with respect to Federal lands and fueling renewable and alternative energy in America.

I will briefly describe the geothermal energy source, the DOE Geothermal Technology Program, including our GeoPowering the West activity, and how we are working with our sister agencies, the Bureau of Land Management, the U.S. Forest Service, the U.S. Navy, and the U.S. Geological Survey, to better understand the resource and how to facilitate application by the private sector. I will also summarize provisions in the Energy Policy Act of 2005 which led the Administration to determine that Federal support for DOE's Geothermal Technology Program is no longer necessary.

What is the Geothermal Energy Resource?

Geothermal energy is the flow of heat from the earth, coming from natural cooling and natural radioactive decay within the core. This heat flux results in significant temperatures at depths commonly reached by deeper geothermal and oil and gas wells. In areas with appropriate geology, heat traps are formed and there are hotter spots much nearer to the surface. Tapping this energy source requires drilling to reach appropriate temperatures, fractures within the earth to allow flow of a fluid such as water, and circulation of that working fluid to capture the heat energy. That heat can then be used for electricity generation, for direct heating, for driving indirect heating and cooling cycles, and for driving fuels production cycles.

Geothermal resources can be categorized as:

- <u>Hydrothermal:</u> either hot water under pressure or as steam, that is currently being used commercially to power upwards of 2800 MWe of electricity generation capacity within the U.S. and about 8000 MWe of generation capacity worldwide. This hot water is also used directly for its heating value, displacing the use of fossil fuels. A special case that is awaiting application for electricity generation is the hot water that issues from many oil and gas wells, and represents a current environmental liability that commonly is re-injected back to the producing formations. The technology exists to cost-effectively capture and convert a significant portion of the hydrothermal resource today into electrical power and direct use applications. Additional exploration by industry could allow the capture of a much larger portion of the resource base. *This application represents the current use of geothermal energy with significant potential for near-term expansion.*
- <u>Geopressured:</u> along much of U.S. gulf coast, there exists a massive resource consisting of hot water under significant pressure (typically 3000-5000 psi) and saturated with natural gas. The DOE has demonstrated that this resource can be captured and converted, using the thermal energy, the mechanical energy and the chemical energy components. This technology should be cost-competitive in the near future, as the costs of fossil fuels escalate. *This application represents a*

mid-term opportunity for geothermal energy development if industry can further reduce costs.

- Enhanced geothermal systems: anywhere in the U.S., given sufficiently inexpensive drilling to appropriate depth and the ability to create a suitable "fracture cloud," a working fluid such as water can be injected to "mine" the heat and to form a geothermal system suitable for generation of electricity. This potential application is currently in the R&D stage, but represents a very large domestic energy source that is cleaner than current fossil fuel energy generation technologies as there is essentially no release of pollutants or greenhouse gases. Because these engineered geothermal systems can be located anywhere, they are distributed electric generation systems and can minimize transmission losses. *This application represents a long-range opportunity to capture and use geothermal energy.*
- Magmatic: the ultimate geothermal energy source is direct extraction of heat from the molten rock or magma found at depth. The magma also represents a potential chemical environment for direct reduction of water to form hydrogen, especially enhanced by the presence of natural catalysts from the minerals within the magma. *This application would not be economic or technically feasible until well into the future.*
- Direct Use: involves using lower temperature geothermal resources for non-electric activities. The potential for direct uses ranges from application of geothermal water for process heat, district heating, greenhouse heating, and other aquiculture activities. Presently there are approximately 600 MW of energy being used for direct use projects in the U.S. Geothermal or ground source heat pumps for heating and cooling of buildings offer another application that is commercially available today and that should have significant energy impacts in the future. There is a balance of geothermal heat from the earth plus radiant heat from the sun against losses to the atmosphere, resulting in essentially constant temperature at very shallow depths below the surface. This thermal reservoir within the earth is suitable for pumping heat from the earth to heat buildings in the winter, and for pumping heat from the buildings down into the earth in the summer to cool the buildings. This technology has higher first costs than using fossil driven heating and cooling cycles, but has much lower operating costs, with typically much lower life-cycle costs. *This is an "up and coming" application.*

Geothermal energy, however, is often viewed as a regional resource, found mainly in the western U.S. and especially in states such as California and Nevada. This is a misconception as people are mainly aware only of the hydrothermal resource where temperature at depth is a function of the "age" of the geology, and much of the geologic action in the western U.S. is much younger than that of the East, with fewer surface manifestations in the eastern U.S. With the use of engineered geothermal systems, it is feasible to capture geothermal energy anywhere within the U.S. – the challenge is economic viability as the depth of the system (deeper in the East) is a dominant factor.

What's the Potential of Geothermal Energy?
An estimate by a task force appointed by the Western Governor's Association of the near-term potential for additional geothermal application to generate electricity shows a strong dependence on market factors, with upwards of an additional 13,000 MWe potential generation capacity within the next 10-20 years, given sufficient cost reductions and sufficiently high prices for conventional sources of electricity. This estimate considered only hydrothermal from "known" sources under a current policy scenario. Other sources, such as direct heating and the hot water from oil and gas wells, were also not considered.

The long-term potential for geothermal energy will depend on the success of engineered geothermal systems. A prime question is the fraction of energy recoverable from the geothermal source. Even in the most pessimistic case, the amount of geothermic energy that could be recovered annually from a depth of less than 6 km is thousands of times greater than the total amount of energy we consume in a given year.

The DOE Geothermal Technology Program
DOE's Geothermal Technology Program (GTP) is operated within the Office of Energy Efficiency and Renewable Energy. It works in partnership with the private sector to develop the technology base that will enable private sector investment in geothermal energy in the future. The GTP is focused on partnerships with industry, universities and other Federal entities to:

- Understand the potential of the geothermal resource
- Define technology to access and capture geothermal energy
- Cost-effectively convert the energy to end products, and
- Facilitate implementation and deployment of the technology by the private sector.

Resource assessment is an important activity, as the current success rate for discovering new geothermal (hydrothermal) fields is about 20 percent. Most new fields are "blind" in that there are no surface manifestations of the existence of hot water at depth. Much of the risk is up front, requiring investment in exploration, exploratory drilling, and resource assessment.

The basic assessment of the U.S. geothermal resource is Circular 790, issued by the United States Geologic Survey (USGS) in 1978 for only hydrothermal sources greater than 150°C. That assessment estimated about 23,000 MWe of "known" hydrothermal resources and upwards of about 120,000 MWe of "undiscovered and unidentified" hydrothermal resources. Given that our current domestic electric generating capacity is about 900,000 MWe, hydrothermal geothermal is a significant resource. Because there are new data since 1979, this resource assessment must be updated. The DOE is working with the USGS to facilitate this update.

DOE is working on developing new exploration tools with national laboratories such as Idaho National Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, Sandia National Laboratory, and the National

Renewable Energy Laboratory (NREL). Universities such as the University of Nevada at Reno and the University of Utah are also involved in understanding the fundamental geology of the resource and in developing new exploration tools. DOE has also sponsored cost-shared exploratory drilling projects with industry with discovery of significant new hydrothermal fields for development by the private sector.

DOE activities in accessing and capturing geothermal energy have included innovative drilling techniques led by Sandia National Laboratory with strong interactions with industry and other Federal entities such as the National Energy Technology Laboratory. Emphasis is on reducing costs of rotary drilling by better real time control of the drilling parameters via very rapid data transmission from the bit to the control systems, with portions of the envisioned control systems being passive and portions active. The very hot geothermal environment requires electronic elements that can survive high temperatures for long periods, with much of the technology enjoying synergy with developments from weapons, aerospace and engine technologies.

The geothermal environment is not only hot, but also consists of very hard rock, resulting in special requirements for drill bits. There is research on special drag bits that will allow extended life in the geothermal environment. As oil and gas wells are routinely being drilled to greater depths, they require the same advances, so this is a fertile area for collaboration with the oil and gas industry.

Another area of R&D is fracturing and subsurface imaging to maximize the extent and amount of energy that can be recovered from a geothermal reservoir. Again, this is an area for collaboration with the oil and gas industry. DOE is also in the early stages of considering potential use of working fluids other than water, with emphasis on supercritical carbon dioxide. This also provides the potential for increased energy efficiency and possible sequestration of the carbon dioxide based on reactions between the carbon dioxide and the minerals within the geologic strata.

DOE activities are also focused in power plants, with emphasis on validation of low temperature cycles that will become even more important with the eventual development of enhanced geothermal systems by the private sector. One project that uses a mass-produced chiller system runs in reverse to generate electricity at temperatures below the boiling point. Another project uses the ammonia-water Kalina conversion system which promises to be a more efficient binary generating system for geothermal.

Other work includes the development of innovations to reduce the cost of the components used in conversion systems. Examples include better air-cooled heat transfer surfaces for more efficient heat rejection, development of a now-commercial plastic coating that allows inexpensive carbon steel to be used in corrosive environments that normally require higher alloys, and better instruments to enhance power plant performance.

The Geothermal Program is also cooperating with industry in researching the potential of mineral extraction from geothermal brines with pilot-scale testing being done for removal of silica. Conversion activities have been de-emphasized as GTP activities have been sufficiently successful that the private sector is expected to continue development in most areas, with exception being some continued involvement in the low-temperature conversion projects

Collaboration with Other Federal Entities
The barriers to accelerated application of geothermal energy are real, but in some cases deal with misperceptions. In all cases, DOE has partnered with other Federal entities, and progress has been made. These activities directly respond to the President's *National Energy Policy* (NEP). A summary of barriers and recommended actions to overcome those barriers can be found in the study entitled *Opportunities for Near-Term Geothermal Development on Public Lands in the Western United States*, by Barbara C. Farhar and Donna M. Heimiller, April 2003, DOE/GO-10200301707 (downloadable from the NREL web site NREL.gov).

Access to the geothermal resource is critical, especially in Western states where much of the land is Federal, with oversight responsibility by the Bureau of Land Management (BLM) and in the case of National Forests by the United States Forest Service (USFS). Leasing and permitting are critical aspects, with the BLM working to streamline leasing. Resource management plans are being updated. Remaining challenges include:

- Streamlining environmental reviews. While the environment must be protected, there are significant opportunities to accelerate the process, especially through broad Environmental Impact Statement and Environmental Assessment actions, with updating of categorical exclusion lists. In some cases, the processes should be uniform across agencies such as BLM and USFS.
- Updating the Resource Management Plans (RMPs) to ensure inclusion of geothermal energy. If RMPs are updated to specifically address and provide for geothermal development, this will facilitate future processing of geothermal lease applications.
- Accelerating agency concurrence regarding forest lands. The BLM can not issue leases on forest lands without USFS concurrence. The USFS mission mandates that it consider threatened and endangered species, protect surface resources, and prevent conflict with other activities specified in long-term land-use plans. As agencies carry out their respective missions, sometimes permitting processes are delayed.

The GTP has facilitated involvement of various Federal agencies in renewable energy development. For example, the program is working with the USGS to facilitate the update of the national geothermal resource assessment. This is critical, especially for overcoming misperceptions that the geothermal resource is small and is limited to just the Western U.S.

The GTP is working with the Department of Defense to facilitate the use of geothermal resources. GTP investments at Coso, within the Navy's China Lake Naval Weapons Center, are aimed at improving the energy capture potential of a promising on-base energy resource.

The DOE GTP has promoted implementation of a National Geothermal Collaborative to facilitate geothermal development by a mutual effort of Federal entities, private industry and universities. This is an appropriate forum for identification of barriers and development of plans for actions to overcome those barriers.

The DOE GTP, through its GeoPowering the West (GPW) outreach activities, has facilitated education and promoted a grass-roots movement for application of geothermal energy. All western states now have state working groups, typically working with state energy offices. The working groups exist to provide information on geothermal energy and the opportunities for an enhanced domestic energy supply. GPW activities include interactions with industry consortia such as the Geothermal Energy Association and the Geothermal Resources Council (GRC), and educational entities such as the Geothermal Education Office to promote technical outreach at all levels ranging from K-12 through industrial professionals. GPW is also active in working with state and local governments in addressing institutional issues relating to geothermal development.

An important interaction with electric utilities across the U.S. is fostered through a partnership with Western Area Power Administration, through the Utility Geothermal Working Group (UGWG), a group of utilities and ancillary associations formed under the GPW Initiative. The UGWG mission is to accelerate the appropriate integration of geothermal technologies into mainstream applications, and is supported by the GRC, Western Area Power Administration (WAPA), the Bonneville Power Administration (BPA), and other western utility groups.

The Energy Policy Act of 2005

The 2005 Energy Policy Act (EPAct) amended the Geothermal Steam Act of 1970 in ways that should spur development of geothermal resources without the need for subsidized Federal research to further reduce costs. EPAct streamlined leasing requirements, which lowers costs for potential developers. In addition, EPAct mandated that the U.S. Geologic Survey conduct a detailed resource assessment, since the last assessment was conducted in 1978. Resource mapping technology has greatly improved and should enable developers to more accurately identify areas for potential geothermal resource development. This should lower geothermal power costs because exploration is a major cost factor. Finally, EPAct extended from 2006 to 2008 the production tax credit (1.5 cents per kilowatt-hour, indexed for inflation) for electricity produced from geothermal resources. Geothermal power facilities in place before January 1, 2008, may claim the credit for 10 years thereafter.

As discussed earlier, hydrothermal geothermal energy is now a mature energy technology. New geothermal projects in the United States are planned for California, Nevada, Idaho, Alaska, Hawaii, Utah, and Arizona. There are 483 megawatts of new power purchase agreements signed in California, Nevada, Idaho and Arizona. Projects under construction, or which have both Power Purchase Agreements and are undergoing production drilling, amount to 547 megawatts in the seven western states. The Western

Governors Association geothermal task force recently identified over 100 sites with an estimated 13,000 MWe of power with near-term development potential.

Summary

In summary, I would emphasize the following points:

- Geothermal energy is a developing and sometimes overlooked domestic energy source.
- The potential of geothermal energy is vast and could contribute to increased energy independence.
- Many geothermal energy technologies are commercial today, and others offer significant promise for the future.
- Enhanced interagency collaboration continues to help promote the use of this renewable energy source.
- Provisions in the Energy Policy Act of 2005 are already promoting increased development of geothermal resources, obviating the need for Federal support for DOE’s Geothermal Technology Program.