

**An Assessment of Geothermal Resource Development Needs in  
the Western United States**

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*Raft River Groundbreaking. Photo by Daniel J. Fleischmann*

**Prepared for the U.S. Department of Energy**

**EXECUTIVE SUMMARY**

## **A Report by the Geothermal Energy Association to the US Department of Energy.**

*Any opinions expressed in this report are those of the author, and do not necessarily reflect the views of the Department of Energy, the many individuals who contributed to this report, the Geothermal Energy Association or the members of GEA's Board of Directors.*

### **Preface**

The purpose of this report is to combine an analysis of relevant literature and interviews with industry stakeholders in the United States who have different perspectives, in order to understand what types of policies and actions public institutions can take to encourage greater development of America's geothermal resources. Because every state with geothermal resources faces different challenges to development, GEA released five separate research reports in 2006 evaluating geothermal needs in five individual states (Arizona, Idaho, Nevada, New Mexico, and Utah). These five states and an additional nine states were researched for this report (Alaska, Colorado, California, Hawaii, Montana, Oregon, Texas, Washington State, and Wyoming). This report combines general research with state-based research, evaluating the overall needs of the geothermal industry along with similarities and differences across states.

This document also builds upon GEA reports in several related areas. In December 2006, GEA issued a report entitled "California's Geothermal Resource Base" that examines the state's geothermal potential and barriers to its development—the report was presented to the California Energy Commission. Also, GEA produced recent reports examining environmental issues, socio-economic considerations and the factors that influence the cost of geothermal energy. These reports are, respectively, entitled: "A Guide to Geothermal Energy and the Environment," "Handbook on the Externalities, Employment, and Economics of Geothermal Energy," and "Factors Affecting Costs of Geothermal Power Development." Each of these reports is available, free of charge, from the GEA website at: <http://www.geo-energy.org/publications/reports.asp>.

Over the course of the research over 150 individuals involved with the geothermal field in the United States were interviewed to obtain a wide range of views from industry, government, utility, environmental and others. Travel was done in five states to attend conferences, visit facilities, and meet with industry stakeholders and the members of the GeoPowering the West state working groups. During the course of the interview process, opinions differed from issue to issue. Ultimately, after taking into consideration the broad spectrum of opinions, this report represents the general consensus (defined as the majority viewpoint) of what a diverse group of industry stakeholders believe are the overall needs to unlocking greater geothermal development in these five states and the in the U.S. overall. The help received, whether informative, critical, or "filling in a gap" of information, was indispensable to the final product. The individual reports upon which this work was based were each reviewed in draft form by a broad spectrum of the contributors, and the draft of this cross-cutting report was also distributed for comment and review to a broad cross section of individuals. Thank you to all who contributed time and effort to help bring this report to final publication.

## Executive Summary

Geothermal is an underestimated, under-reported, under-explored, and under-studied natural resource that could have a large impact on America's future energy supply. Geothermal has not been developed to its full potential primarily because fossil fuel technologies have been less expensive and less risky to pursue. This report documents twelve months of research, travel, and interviews designed to determine how geothermal fits into energy planning at the state and local level.

The following is a brief snapshot of the current status of geothermal development in the major western states, and the priority needs expressed by those working on geothermal development in that state:

### **Alaska**

Alaska's first geothermal power plant came online in 2006 at Chena Hot Springs, 60 miles north of Fairbanks. This power unit is unique because it produces power from a low-temperature geothermal aquifer (162.5°F (72.5°C)). The plant was built by the United Technologies Corporation (UTC) under the title of PureCycle®. Research indicates that Alaska has an abundant geothermal resource that can be extracted to serve local populations in a number of communities in the state. Initial exploration efforts during the 1970s and 1980s helped to define where these resources are, but inadequate funding stalled more substantive exploration and development. Several communities have considered geothermal projects, but lacked the financing to take advantage of their proximity to the resource. Instead, these communities have continued to rely on increasingly expensive conventional fossil fuel sources. State and federal support is needed to reduce the financial burden on communities before these projects can take shape.

### **Arizona**

Currently only a few geothermal facilities exist in Arizona providing heat for several spas and resorts and three aquaculture facilities. However, based on the research, there is compelling evidence that Arizona has ample opportunity to use its geothermal resource for direct use and electric power applications. Arizona's first geothermal electric power project has been in the works for several years at Clifton Hot Springs in Greenlee County, but confirmation drilling is required before developers can move on to construction. Northern Arizona University has received U.S. Department of Energy (USDOE) funding to perform geophysical and geochemical testing at previously unexplored areas in the San Francisco Volcanic Field north of Flagstaff. While these projects need continued federal and state support to succeed, in the near-term it appears that direct use applications using low-temperature geothermal resources are most likely to be developed. To date, geothermal direct use heating has not been a priority due to the warm climate in Arizona. However, researchers contend that these geothermal resources can greatly contribute to agricultural applications. Geothermal water is used for irrigation in several locations, and enables farmers and ranchers to produce citrus and table grapes for longer growing seasons. Geothermal heat is also used to produce 1 million pounds of shrimp in the Hyder Valley. Neither state nor federal policies have encouraged these applications, and it is clear that more could be achieved if state or federal policies were enacted to help these projects.

### **California**

California is the largest producer of geothermal electric power in the United States. Geothermal power plants represented 5% of California's energy production in 2005. However, based on

analysis performed by GEA, this development is only a fraction of what is possible. While development has stalled since 1992, new capacity is coming online over the next few years. Despite a strong state Renewable Portfolio Standard (RPS) and federal tax incentives for geothermal power plants, much of the new development is limited by transmission issues and delays caused by federal and state permitting regulations. While efforts are being made to prepare a Programmatic Environmental Impact Statement (PEIS) that would allow new leasing in certain areas of the state for the first time in two decades, other areas of the state, beyond those specifically identified in the PEIS, should be considered. The PEIS is a joint effort by the Bureau of Land Management (BLM) and the U.S. Forest Service (USFS) in conjunction with the California Energy Commission (CEC). At the time of this writing, the PEIS has not been finalized, and the BLM encourages input about additional sites that should be included.

### **Colorado**

Interviews with experts suggest that Colorado has a large geothermal resource base. The state has plenty of direct use installations, and hot springs are a major tourist attraction. There are a number of promising areas in Colorado where geothermal resources can likely support electric power projects. However, geothermal electric power has generally not been considered a competitive energy source given the history of low energy prices in the state. Federal and state efforts are needed to analyze Colorado's known geothermal prospects and determine what would be required for their development. Some resources may require deep drilling, while small power units (like those used in Alaska) may be applicable at several locations where deep exploration wells are not needed. As for direct use, there is also an effort to expand use of the resource; however there is not an understanding of where to begin.

### **Hawaii**

Because Hawaii is series of volcanic islands, there is no question that a geothermal resource exists. Much of the resource is volcanic and it is undetermined to what extent the available resource is accessible through hydrothermal resources, as opposed to volcanic systems. Thus far, the largest resource identified in the Hawaiian Islands is on the Big Island of Hawaii. There is currently one project on the Big Island of Hawaii serving just under 1/5<sup>th</sup> of the region's energy needs. That project is being expanded, and is currently permitted to double capacity to 60 MW. The state government is seeking other potential uses for available geothermal power and heat that can benefit agriculture and reduce Hawaii's dependence on energy imports – the state has one of the highest average power rates in the country. The state of Hawaii is also interested in examining the feasibility of using geothermal resources for hydrogen production. Overall, the major barrier to geothermal development in Hawaii has been transmission and siting. There has been resistance to development on the local level through a variety of land use conflicts. Much of the land in Hawaii is on National Parks or on expensive private land where there are competing priorities. The project on the Big Island of Hawaii was very controversial when initially developed. However, despite initial opposition, the plant's successful operation has assuaged many of the concerns voiced by its original opponents. Industry stakeholders suggest that future development will not be limited by resource availability, but will be contingent upon working out local concerns.

### **Idaho**

Geothermal development in Idaho is almost as old as the state itself. Admitted into the Union in 1890, residents of its capital city of Boise began using geothermal resources for district heating in 1892. Since then, the use of the Boise Front geothermal aquifer has expanded to include four separate systems that heat hundreds of buildings, including the State Capitol. Besides Boise, geothermal activity has been identified throughout Idaho; however, to date no commercial

geothermal power plants have been developed in the state. The first commercial geothermal power plant is currently under construction at Raft River, and several other areas are under consideration. Past exploration and development efforts have been limited because power rates in Idaho were among the lowest in the country for many years and the state's small population did not necessitate new sources of electric power. Therefore, there is a great need for exploration and resource characterization to better define resource potential. Currently the best guess by even the most knowledgeable researchers in the state is that Idaho could sustain anywhere from a handful of geothermal power plants to rivaling Nevada or even Southern California in recoverable resource. A number of promising geothermal prospects are on BLM and USFS land which further complicates development. Further, both geothermal direct use and electric power projects may conflict with water allocation issues that can also limit development. For these reasons, federal and state support is needed to mitigate barriers and to help researchers understand the resource potential so that they may plan accordingly for future development.

### **Montana**

Industry stakeholders assert that Montana's geothermal resource has been overlooked due to the state's low fossil fuel energy prices, low population and lack of transmission access to remote locations. Also, some past geothermal projects were proposed for areas just outside Yellowstone National Park, which created local controversy and concerns. There are several direct use facilities currently in operation in Montana, mostly in western parts of the state, where geothermal heating is used for aquaculture, greenhouses, and spas and resorts. The USDOE and the Montana state government have joined together to organize a database of locations where geothermal resources have been identified. According to their records, Montana has at least 15 high-temperature sites, a few of them with estimated deep-reservoir temperatures exceeding 350°F (176.7°C). Among these 15 sites are locations in the vicinity of Helena, Bozeman, Ennis, Butte, Boulder and White Sulphur Springs. There is also interest in oil and gas fields in Eastern Montana, including Poplar Dome, where oil wells co-produce hot fluid at boiling temperatures that may be sufficient to support a small geothermal power plant for use at the site. In the near term, oil and gas co-production and geothermal space heating is considered the greatest potential for using geothermal resources in Montana. State and federal support would help these projects come to fruition and encourage further investment in geothermal projects.

### **Nevada**

From 1984 through 1992, 14 geothermal power plants were developed in Nevada. 15 years later, Nevada is seeing a resurgence in development: 24 new plants under development have a combined capacity of up to 751 MW; nine projects with power contracts already secure have a combined capacity of up to 204 MW. Nevada is the one state that has put together federal and state efforts to develop geothermal in an effective way. While some of the recent success in Nevada is owed to prior exploration and research, progress could not have been accomplished without the coordinated effort of state and federal agencies, the state RPS, the federal Production Tax Credit (PTC), the BLM efforts to reduce leasing backlogs, the USDOE's support for cost-shared drilling and technical assistance, and the work of the Great Basin Center for Geothermal Energy at the University of Nevada Reno. These efforts can serve as a model for other states, but they must continue to maintain industry momentum.

### **New Mexico**

Geothermal resources have an opportunity to be a large contributor to the energy needs of New Mexico. To date, however, New Mexico only uses its geothermal resources for thermal heating applications in about a dozen locations. The greatest use of geothermal resources in New Mexico has been its greenhouses, which provide a few hundred jobs and \$30 million in annual revenues. During the 1970s and 1980s a large geothermal power project was under development in the

Valles Caldera in north-central New Mexico. Resource and regulatory issues led to the cancellation of the project. At the time, it was believed that Valles Caldera was the only geothermal resource area in the state capable of producing a large electric power plant. However, when traveling throughout the state, it became clear that there are a number of attractive resource prospects outside of this conflict area. Unfortunately, limited work has been done in these areas, and most of them are blind (i.e. without apparent surface manifestations). These areas are high-risk and developers in the state need federal or state funding to aid with early exploration and to reduce the high investment risk associated with their development. There is also a need to explore the Rio Grande Rift area in greater detail for both geothermal power prospects and for large-scale geothermal heating potential specifically in Las Cruces and its surrounding areas. In the near term, development is likely for direct use and small-scale power. Drilling has occurred at two locations where small geothermal power units will be installed for an aquaculture facility to produce 10 million pounds of fish annually and a greenhouse that would expand to 40 acres. The resource has been proven at these sites and these projects need continued financial support to ensure project completion.

### **Oregon**

Oregon's geothermal resource base has been well-documented. Numerous geothermal direct use projects have been constructed and a small-scale geothermal power project ran in south-central Oregon in the mid-1980s. Conventional wisdom had been that Oregon's geothermal resources sufficient for power production were only available near the Cascade volcanoes and in remote regions in the eastern part of the state. The problems with these projects have been a lack of transmission access and regulatory hurdles (similar to those experienced in California) associated with development on federal land, USFS land in particular. While several large-scale geothermal power projects are currently under development in the state, their success is contingent upon coordinated efforts by federal and state land agencies to conduct environmental impact statements. In the near-term, however, it is clear that small power and direct use projects can be developed without much conflict. Researchers in Oregon are currently experimenting with geothermal heat and power technologies for alternative fuel production and expansions are planned for several direct use facilities in the state. Most agree that these projects can succeed as long as they continue to receive federal and state support.

### **Texas**

In 1990, Texas became the first and only U.S. state east of the Rocky Mountains with an operating geothermal power plant. The demonstration plant was built in Pleasant Bayou and used a geopressured reservoir of high-temperature fluid and natural gas to produce 982 kW of electric energy. The power produced was not cost-competitive at the time with conventional fossil-fuel sources and the plant was shut down five months later. 16 years later, there is a strong consensus that both the geopressured resource as well as hot wastewater co-produced from oil and gas wells can be used to build several hundred plants statewide just like the one built in Pleasant Bayou.

Developers can do this in Texas because of the abundance of oil and gas wells in the state. The effort to revive these types of plants has been largely encouraged by research efforts at Southern Methodist University and the University of Texas-Permian Basin. As a result of their efforts, Texas has become a major area of interest for geothermal development. Researchers have estimated that electric power production potential from Texas oil and gas wells range from 400 MW in the near term to over 2,000 MW. While a small grant has been provided by USDOE to examine potential areas where these projects can be successful, most agree there is a need to fund demonstration projects using the geopressured and oil and gas co-production resources. Further, these projects must continue operating, unlike the original plant, which could still be in operation today if not shut down. Beyond oil and gas wells there is potential for geothermal heating from low-temperature hydrothermal resources that underlie much of central Texas, including several

identified resource areas within Austin city limits. Researchers indicate that these areas need greater exploration as well.

### **Utah**

Utah is the only state in the continental U.S. outside of California and Nevada with an operating geothermal power plant. The first plant came online at Roosevelt Hot Springs in 1984. Two more facilities were built in 1990 that operated at Cove Fort-Sulphurdale until 2003 and 2004 when those facilities were decommissioned. The Blundell geothermal facility at Roosevelt Hot Springs is still operating, and is being expanded. The Cove Fort resource is also being expanded to three times more capacity, with new larger facilities expected to replace the old facilities. Utah also has great potential for direct use applications. A large-scale geothermal heating project was completed in 2005 at the Utah State Prison, 30 miles south of Salt Lake City. Researchers indicate that geothermal resources underlie much of the Wasatch Front, where the vast majority of Utah's population resides. It is clear from the research that the potential extent of Utah's geothermal resource (both for direct use and electric power) is not well understood, and the geology of these resources is complicated in some areas. A lack of state-level funding support and the short extension of the PTC have caused geothermal power projects to be cancelled or delayed. Most agree that federal and state support needs to be expanded for further development to be successful.

### **Washington State**

The geothermal resource in Washington State has been virtually undeveloped. Only a few spas and resorts use geothermal for direct uses. Despite the state's cold climate, which makes it perfectly suited for geothermal heating systems, there are no district heating systems or large buildings using the resource. There are no commercial developments like aquaculture or greenhouses, and no power plants. Based on the research it is clear that low energy prices and only rudimentary knowledge about the resource have contributed to this lack of geothermal use in the state. Geothermal power development has been limited because the best prospects are located in scenic areas near major Cascade volcanoes. With rising energy costs and an RPS passed in November 2006, most agree that a reconnaissance is needed to examine geothermal resources in the state. There is particular potential for geothermal heating systems in the Columbia River Basin area, where several hundred thermal wells are available to serve the several hundred thousand residents of the region.

### **Wyoming**

As the home of Yellowstone National Park, Wyoming is a state known for its geothermal energy. Outside of the Park, however, researchers indicate that Wyoming has a substantial geothermal resource base. They just haven't found many ways to use it. As one of the most rural states in the U.S., population is sparse in active geothermal regions. However, based on the research it is clear that spas, resorts, and agricultural facilities can utilize the resource at a number of locations. In addition, like Montana, deep oil and gas wells in the state have co-produced hot fluid from deep depths. A demonstration project at the Teapot Dome oil field (operated by the USDOE) is under consideration. The project would install a binary unit to capture the heat energy from the oil-field fluid and use it for electric generation on-site. There is additional interest elsewhere in the state to install similar units in the near future. If successful, these projects could rekindle interest about geothermal potential in Wyoming, and spark new investment. It is critical that federal and state support is given so that these initial projects can be completed.

### **Other parts of the country**

The use of geothermal resources does not end at the Rocky Mountains. As much as a dozen states east of the Rockies use geothermal resources for geothermal direct use applications. Indeed

there are opportunities to develop geothermal resources in the Great Plains, the Gulf Coast, and in several locations in the Eastern United States. Furthermore, as deeper drilling becomes more economical, there may be opportunities for geothermal electric power production throughout the country.

From this research several key conclusions have been reached:

**1) Geothermal resources appears to be more extensive than most people believe**

The geothermal industry has grown throughout the world, now with power plants in 24 countries and growing. As of year-end 2005, no country had more geothermal electric power installed than the United States—although the electric power produced from these plants only make up less than one-half of one percent of annual energy consumption. In the United States, hundreds of locations have been identified in at least 15 states with potential to support geothermal electric power production within the next ten years. To date, however, only 61 geothermal power plants are operating in 23 separate geothermal resource areas in 5 states.

There are currently just over 2,000 Megawatts (MW) of electric power from new geothermal power plants under development in nine states; enough to provide electricity for nearly two million households. Estimates for near-term production potential (by 2015) are enough to meet just under one-seventh (~14%) of new U.S. energy demand and over 50% of new energy demand for the 13 states that make up the western United States (including Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington State, and Wyoming).

**2) The unknowns appear to be more significant**

In 1978, the U.S. Geological Survey (USGS) released USGS Circular 790, a reconnaissance of geothermal resources across the country. The authors of the report estimated a combined identified/undiscovered geothermal resource base in the United States of up to 150,000 MW. While this number may appear high, it was calculated using several limiting assumptions. At the time, only resources with temperatures greater than 302°F (150°C) were considered. However, geothermal electric power is currently being produced at temperatures as low as 162.5°F (72.5°C). At the time only depths shallower than 9,843 feet (3,000 meters) were considered. However, since the release of the report, geothermal electric power production has been achieved at greater depths in other parts of the world. In fact, when considering depths between 9,843 feet (3,000 meters) and 19,685 feet (6,000 meters), every single U.S. state has locations with potential to extract geothermal electric power.

In addition, Circular 790 considers only conventional hydrothermal reservoirs. However, today new applications have expanded the range of potential. One such application is extracting geothermal electric power from geopressured reservoirs of hot water and natural gas or hot wastewater from oil and gas fields. Researchers contend this application is feasible in most of the oil and gas producing states of the central and western U.S., and the Gulf Coast. Geothermal resources can also be used to produce power and cascaded heating for alternative fuel production, aquaculture facilities, greenhouses, mineral and vegetable processing facilities, among other uses. In addition, geothermal direct use applications are expected to have huge potential across the country for thermal heating.

**3) There needs to be a clear path towards developing geothermal projects**

In the United States prior to 1984, no utility-scale geothermal power plants had been constructed outside of California. Many of those plants, and the plants built in Nevada and Utah between

1984 and 1992, were the result of contracts through the Public Utility Regulatory Policies Act of 1978 (PURPA). PURPA, combined with government studies, cost-shared drilling, exploration support, and other incentives, helped these projects to come to fruition. However, during this time a mature industry never formed, and when energy prices took a nosedive in the late 1980s and 1990s, the industry became dormant. Developers today claim they face the same obstacles they did thirty years ago. It is difficult to secure the financing to get a first well drilled; it is difficult to secure a power contract with a utility; and it is difficult to maneuver through regulatory issues involving the leasing of property and environmental reviews.

From 1979 to 1992, over 50 geothermal power plants were installed in the United States in three states. At the same time, many of the largest geothermal heating (or geothermal direct use) facilities were built, serving tens of thousands of households and businesses with thermal energy needs. Like geothermal electric power, these installations barely grew after 1992. Mirroring the previous boom period, over 50 new geothermal power projects are currently under development, and a multitude of direct use projects are under development or have been proposed. However, this time it is apparent that these new projects can be completed with a ten year time frame (by 2015). Further, development has expanded into nine states. The question is whether policymakers will work to keep industry momentum going, or let the same problems throw mud under the tires to slow industry growth once again.

#### **4) Programs and incentives appear to make more of a difference today than ever**

During the late-1970s and 1980s, government programs and incentives helped create a market for geothermal energy at a time when the technology was relatively new. In 2006, the technology has improved, energy prices are back up, there is considerable pressure to reduce greenhouse gas emissions, and private investment in clean energy technology is reaching all-time highs.

Public policy has clearly been affected. Climate change legislation was passed in California, and 23 state governments (and the District of Columbia) have passed renewable portfolio standards (RPS)—including eight of the 13 western states listed above—requiring utilities to generate a certain percentage of electric power sold in the state from renewable resources within specified timelines. In addition, state and federal incentives have been created to benefit renewable technologies like geothermal. The most significant of these is the federal production tax credit (PTC). The PTC provides a subsidy of 1.9¢ per kilowatt-hour (kWh) for ten years eligible to renewable power sources, including geothermal power plants, constructed by December 31<sup>st</sup>, 2008. The PTC has been a large reason developers have been able to finance new geothermal projects.

Despite the resurgence of new geothermal development, and the fact that energy independence is considered one of the top policy priorities of the 21<sup>st</sup> Century, geothermal research programs continue to operate with scant funding. State-funded geothermal research programs are almost non-existent outside of California, and the level of federal funding for geothermal research and development has continued to decline over the past several years. The total budget for the Geothermal Technologies program at the U.S. Department of Energy (USDOE) was just over \$23 million in FY 2006, 16% lower than the average budget from 1990-1999, even without accounting for inflation. Not only was the FY 2006 appropriation the lowest appropriation of the decade, at the time of this writing the FY 2007 budget remains uncertain, operating at a monthly rate equivalent to a \$5 million annual appropriation.

For several years at the start of the previous boom in geothermal development in the late-1970s and early 1980s, the annual budget appropriation for this program was over \$100 million. However, despite the lack of comparative funding the current program has found ways to

accomplish a great deal. It has supported the efforts of university programs that are helping to train the next generation of researchers, geologists, engineers, and project developers. The program has initiated research and development efforts for advanced extraction methods. It established the GeoPowering the West (GPW) program in 2000, which has since initiated state geothermal working groups in 11 states (all outside California and Nevada), held conferences and events, and brought together investors, small businesses, utilities, and state and local governments to learn about opportunities for geothermal development.

In addition to GPW, the Geothermal Resource Exploration and Development (GRED) program initiated by USDOE in 1999 provided funding support and technical assistance for exploration and development efforts at 22 geothermal prospects in seven states (Alaska, Arizona, California, Idaho, Nevada, New Mexico, and Utah). Spending a total of only \$12.5 million from 1999 through 2004, 17 of these prospects currently have a project under development, which, when completed could generate several billion dollars combined over the life of these projects.

#### **5) To develop a state's geothermal resources, the specific needs of the state must be met**

The opportunities for geothermal development vary from state to state. California and Nevada have a large queue of projects under development. These projects benefit directly from the PTC and from each state's RPS, which includes geothermal as an eligible resource in both cases. Projects benefit from funding for state and federal regulatory efforts to process leases and permits in a timely manner. They benefit from an experienced group of established industry players able to raise sufficient capital to take advantage of these policies.

Other western states are only beginning to incorporate geothermal power into their energy mix. States like Idaho, Oregon, and Utah require a great deal of exploration and study to characterize potential resource areas for future development. These and other states have a number of attractive geothermal prospects, but lack adequate financing to complete the projects prior to the current expiration date of the PTC.

Some states stand to benefit more in the near-term from geothermal direct use installations, particularly states with colder climates in the Pacific Northwest and the Rocky Mountains. States like Arizona and New Mexico can benefit from agricultural applications for geothermal direct use. Geothermal greenhouses are already a \$30 million business in New Mexico, and expansions are planned that would more than double the existing production.

#### **In summation**

The geothermal industry is now in a position to progress, take advantage of the ongoing momentum, and invest in new technologies. With high energy prices, growing populations requiring additional energy supply, and new technological advancements and applications, the industry is heading towards a tipping point where what was theoretical will become standard.

Several aspects related to the process of developing this report should be considered. First, the report is a snapshot of the industry growth and the state of development by year-end 2006. Second, due to time constraints, its development did not have the benefit of a long review process like individual state reports written earlier in 2006 by GEA. Additional information, beyond what is included in this report, is needed to truly understand where the industry needs the most help to overcome the obstacles ahead.

Policy recommendations are provided throughout the body of the paper based on the suggestions of the interviewees and the conclusions of the overall analyses. However, a smaller number of key recommendations are critical to point out upfront. These key recommendations, chosen from

a larger number of recommendations included in the body of the report, have been determined based on feedback from a number of experts. Among these experts are consultants, engineers, and project developers who work tirelessly on a daily basis to build geothermal projects and to maneuver through the financial, regulatory, and political morass that is the American retail energy market. Others who were consulted include utilities that purchase electric power from these projects; regulators who process leases and permits for geothermal drilling; clean energy advocates who lobby, testify, and write reports; and the researchers and geologists who have studied geothermal systems and helped lay the groundwork for future discovery.

### **Key Recommendations**

The individual state-level reports released by GEA from June through December of 2006 each focused on needs rather than barriers. The geothermal industry is experiencing some measure of success as a result of needs being met for projects to reach their completion. If policymakers are serious about energy independence and reducing the emission of greenhouse gases and toxic pollutants, they must develop a comprehensive approach supporting geothermal development as one of several resources that can help meet these goals.

For incentives, the PTC should be extended for at least five years to create some degree of certainty for investors to support geothermal electric power projects. Incentives should also be introduced for geothermal distributed generation projects, in particular alternative fuel facilities that use geothermal resources for both electric energy and thermal energy.

For the USDOE Geothermal Technologies Program, funding should be diversified. There is no silver bullet technology that will increase geothermal resource potential. Activities like outreach from GPW, GRED, and demonstration projects for new applications should continue to be part of the program. The program should continue to expand into as many states as possible and should fully support university programs in all states with near-term geothermal electric power potential. Because geothermal development efforts have increased significantly since the 1990s, the level of funding for the USDOE Geothermal Technologies program should be commensurate in order to contend with greater demand for information and technical support. This includes fully funding the efforts of the Intermountain West Geothermal Consortium (IWGC) to conduct exploration and resource characterization for resource areas lacking substantive subsurface drilling. The IWGC, currently focused on under-explored areas in Idaho, Oregon, Nevada, and Utah, should be expanded to cover areas like the Rio Grande Rift in New Mexico and the Arkansas River and San Juan Basins in Colorado.

Because the process of exploring, developing a project, and transmitting the electricity requires a great deal of regulatory oversight, there needs to be strong interagency coordination on transmission issues, environmental reviews, leasing, and permitting for geothermal development on federal lands. First and foremost, there needs to be adequate funding for regulatory processing. Delays from the regulatory process have been a primary reason geothermal developers have not been able to finance projects to their completion. As for transmission, BLM and the USFS should designate transmission corridors as part of the Programmatic Environmental Impact Statement (PEIS) where geothermal resources in scenic areas could cross. In addition, due to transmission lines at or near capacity, there should be a focus on the use of next-generation transmission lines, including superconductors and improved transformers, as part of demonstration projects for geothermal power plants.

For geothermal direct use, there needs to be continued USDOE support for residential, commercial, and industrial projects to help foster an industry catering to geothermal direct use developments. There should be updated reconnaissance performed for potential geothermal

direct use projects in cold climate locations experiencing significant population growth such as the Wasatch Front, Utah; Reno-Lake Tahoe, California/Nevada; Boise-Treasure Valley, Idaho; and the Columbia River Basin in northern Oregon and Washington State. This has already begun at the state level, and should remain a state-level activity.

Direct use facility operators who expand their installations or construct new facilities should be able to apply for state and federal incentives. In addition, there should be loan guarantees or some type of incentive offered to facilitate the drilling of re-injection wells which prevent resource degradation. In addition, agricultural extension programs should include geothermal development staff in every western state, and land-grant universities should offer “business incubator” programs like the one created by New Mexico State University (NMSU) in the 1990s.

Finally, there is a need for organized curriculum for K-12 students about geothermal resources (and other renewable resources). Also, because geothermal projects use clean renewable resources, there should be a coordinated effort between environmentalists, clean energy advocates, community and civic groups to coordinate on projects so as to limit opposition through communication and shared goals.