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

Raft River Groundbreaking. Photo by Daniel J. Fleischmann

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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 1/5th 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 five 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. This number, while high 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 31st, 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 21st 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.

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Masson, Inc.), Ken Miller (NW Energy Coalition – Idaho office), Roy Mink (U.S. Department of Energy), Garnette Monnie (Edwards Greenhouse), Kathi Montgomery (Montana Department of Environmental Quality), Joe Moore (Energy and Sciences Institute at the University of Utah), Christy Morris (Nevada Division of Minerals), Steve Munson (Vulcan Power Company), Greg Nash (Energy and Sciences Institute at the University of Utah), Ken Neely (Idaho Department of Water Resources), Robert Neilson (Idaho National Laboratory), Gerry Nix (National Renewable Energy Lab), Amanda Ormond (The Ormond Group), John Pease (Bonneville Power Administration), Jack Peterson (Bureau of Land Management – Idaho), Susan Petty (Black Mountain Technology), Steve Ponder (Sierra Pacific Power), Jim Powers (Raft River Rural Electric Cooperative), Phil Powlick (Utah Geological Survey), John Pritchett (Science Applications International Corporation – SAIC), Nicholas Rahn (PacifiCorp), Leo Ray (Fish Breeders of Idaho, Inc.), Marshall Reed (U.S. Geological Survey), Joel Renner (Idaho National Laboratory), Maria Richards (Southern Methodist University), Subir Sanyal (GeothermEx, Inc), Claude Sapp (Geothermal Rail Industrial Development, LLC), Allan Sattler (Sandia National Laboratory), Julie Scanlin (Idaho Water Resources Research Institute), Allen Scherbinske (College of Southern Idaho), Dan Schochet (Ormat Technologies, Inc.), Damon Seawright (AmeriCulture), Gary Seawright (AmeriCulture), F. Mack Shelor (Consultant), Lisa Shevenell (University of Nevada-Reno), John Snow (Amp Resources), Walt Snyder (Intermountain West Geothermal Consortium), Ross Spackman (College of Southern Idaho), Rick Sterling (Idaho Public Utilities Commission), Kip Sykes (Idaho Power), Jeff Tester (Massachusetts Institute of Technology), Priscilla C. Thompson (Hawaii DBEDT), Paul Thomsen (Ormat Technologies, Inc.), Dennis Trexler (Nevada Geothermal Utility Co.), Doug Ward (Ward's Greenhouse), Charlene Wardlow (Calpine), Ed Werner (Converse Area New Development Organization), Ernie Wessman (PacifiCorp), Colin Williams (U.S. Geological Survey), Ryan Wiser (Lawrence Berkeley National Laboratory), Jim Witcher (Witcher & Associates), Kermit Witherbee (Bureau of Land Management), Frank Wright (Amp Resources), Sarah Wright (Utah Clean Energy), Tim Young (Sierra Capital Services).

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Acronyms and abbreviations

AMA – Active Management Area
BHT – Bottom-hole temperature
BLM – Bureau of Land Management
BPA – Bonneville Power Administration
CEC – California Energy Commission
CDEAC – Clean and Diversified Energy Advisory Committee
CREB – Clean Renewable Energy Bonds
EA – Environmental assessment (EA)
EGS – Enhanced Geothermal Systems
EIA – Energy Information Agency
EPAct – Energy Policy Act of 2005
GAO – Government Accountability Office
GEA – Geothermal Energy Association
GHG – Greenhouse Gases
GPM – gallons per-minute
GPW – GeoPowering the West program
GRDA – Geothermal Resources Development Account
GRED – Geothermal Resource Exploration and Development
GWh – Gigawatt-hour
IDWR – Idaho Department of Water Resources
IOU – Investor-owned utility
IRP – Integrated Resource Plan
IWGC – Intermountain West Geothermal Consortium
KGRA – Known Geothermal Resource Area
kWh – Kilowatt-hour
MOU – Memorandum of Understanding
MW – Megawatt
MWh – Megawatt-hour
NEPA – National Environmental Policy Act of 1969
NMSU – New Mexico State University
NREL – National Renewable Energy Lab
OIT – Oregon Institute of Technology
ORC – Organic Rankine Cycle
PEIS – Programmatic Environmental Impact Statement
PPA – Power Purchase Agreement
PTC – Production Tax Credit
PURPA – Public Utility Regulatory Policies Act of 1978
REC – Renewable Energy Certificate
RFP – Request for Proposal
RPS – Renewable Portfolio Standard
RTO – Regional Transmission Organization
UNR – University of Nevada-Reno
USDOE – United States Department of Energy
USFS – United States Forest Service
USGS – United States Geological Survey
WGA – Western Governors' Association

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 the 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 120 individuals involved with the geothermal field in the United States were interviewed. 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. Thank you to all who contributed time and effort to help bring this report to final publication.

Introduction

Landscapes in the western U.S. are far different than those in the eastern U.S. Much of the West is comprised of wide open land with little development. Lofty mountains with small trickles of snow rise above the dry cracked ground. Some say what lies beneath this ground is similar to the immense oil fields of the Middle Eastern desert -- a gigantic source of the earth's heat, available for energy uses. Unlike fossil fuel sources, geothermal resources provide natural heat that does not require burning like oil, coal or natural gas. Thus far, only a fraction of the available resource in the U.S. has been tapped for use.

Direct uses for geothermal heating have existed for thousands of years before the U.S. was formed. The first commercial facilities for geothermal direct uses began in the late-1800s and the first U.S. geothermal power plants began operation in the early 1960s. Over this time, geothermal resources have been looked to as a clean, renewable alternative to fossil fuels.

Two consistent themes emerged over the course of interviews and research for this report. First, geothermal development has been limited by the volatility of energy prices, and second, a lot remains to be learned about where geothermal resources are located. Federal and state policies promote geothermal development when conventional energy prices are high and, usually, this means that there is an energy crisis. But, when prices decline, supporting policies disappear and geothermal prices are not cost competitive at least in the short-run. Once again, today, the urgency to use geothermal and other alternative energy resources has reached a fever pitch. As gasoline and natural gas prices reach historic highs, it is increasingly evident that the U.S. needs alternative forms of energy. As we burn more fossil fuels at home, import more energy from overseas, and face an ever-growing energy demand, we jeopardize our environment, our economy, and our national security. The aftermath of Hurricane Katrina in 2005 demonstrated just how vulnerable our energy supply has become. This was not the first time the U.S. faced an energy crisis, and it will not be the last.

According to estimates by the U.S. Census, there are 50 million more Americans today than there were in 1990. Further, according to the Energy Information Agency (EIA), U.S. electric energy net-generation is projected to grow by another 8.4% by 2015[1]. It is unclear whether or not the U.S. will be prepared in the event of a prolonged energy crisis. It is likewise unclear whether or not the U.S. will be able to develop a diversity of domestic energy resources while preventing further damage to the environment.

In the electric energy sector, we consume 2% of our electric energy from a diversity of non-hydro renewable energy sources, including wind, solar, biomass, and geothermal. Geothermal electric power today makes up roughly 18% of that total. While this percentage is poised for an increase as new geothermal developments become more cost-competitive with traditional fossil fuel

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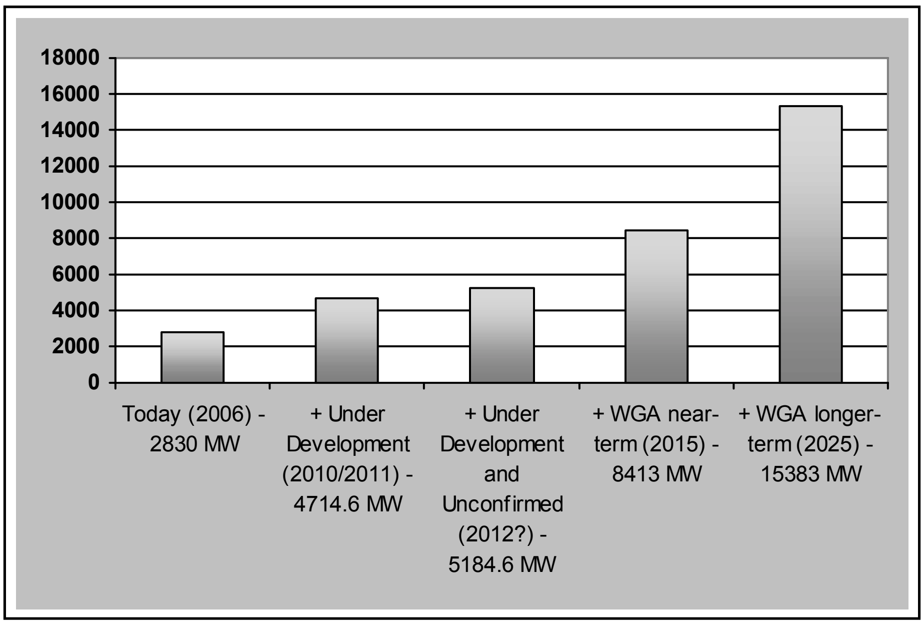
[1]The 8.4% is based on calculations by the Energy Information Agency (EIA) using a base year of 2004 for electric energy usage. See: http://www.eia.doe.gov/oiaf/aeo/pdf/aeotab_8.pdf & http://www.eia.doe.gov/cneaf/electricity/epa/epat1p1.html
The 50 million is based on estimates from the U.S. Census: http://www.census.gov/.
The estimated population in 1990 was 248.7 million and crossed 300 million in 2006.

sources, there is an urgency to do more, and to find innovative ways to use the resource and to extract more in the future.

There is a general consensus that geothermal energy has the potential to become a major contributor to our future energy needs, particularly in the western states (see Figure 1). This report examines the present and future of geothermal development in the U.S. and what it will take for this potential to be realized. Part I examines current development and potential to produce power using geothermal resources through a variety of applications. Part II examines individual states, with long summaries for the five states covered in GEA's state-level reports released from June through December of 2006. Part III examines key issues affecting development and the similarities and differences between states and regions of the country.

Figure 1: Geothermal Production and Development (Source: GEA – 11/14/2006)



Part I: Geothermal development and potential in the U.S.

Photo: Soda Lake binary power plant. Fallon, Nevada. Photo by Daniel Fleischmann

By December of 2006, there were 61 power plants operating in the U.S. in five states (Alaska, California, Hawaii, Nevada, and Utah) with a total power capacity from existing facilities of 2,830.65 megawatts (MW) (although not all of that capacity is online). In 2005, geothermal power produced 16,010 gigawatt-hours (GWh), equal to 0.36% of total U.S. consumption. Estimates for geothermal direct use facilities by year-end 2004 are 617 MWt (MW of thermal energy or electric energy saved) from facilities in 25 states[2].

Of the 2,830.65 MW of geothermal power plant capacity and the 617 MWt of geothermal direct use capacity currently installed in the U.S., the vast majority of it was developed in the late-1970s and the 1980s after the two previous energy crises. There is a general consensus that more could have been developed during this previous boom period, but economics and political will prevented further investment, especially as energy prices dropped in the late-1980s and early 1990s.

Developing projects and geothermal potential

Geothermal resource development is clearly making a comeback. In November of 2006, the Geothermal Energy Association (GEA) took a survey of new power projects and found 51 new projects in various stages of development (See Table 1). Together, these projects have the potential to produce up to 1,924.7 MW of new geothermal power plant capacity in the next 3-5 years in nine different states. If you consider projects that are unconfirmed or in the early planning stages, there are 61 projects with the potential to produce up to 2,376.7 MW of new capacity. The 1924.7 MW by itself is enough to boost total U.S. geothermal electric power capacity by over 2/3rds. Further, these projects are expected to be far more efficient than earlier

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[2]Sources:
Electric Power capacity – Geothermal Energy Association (GEA) – November 2006 Geothermal Power Production and Development Survey: http://www.geo-energy.org/publications/reports.asp
Direct use heating capacity – Geo-Heat Center at the Oregon Institute of Technology (OIT): http://geoheat.oit.edu/pdf/tp121.pdf
A thorough description of these plants is online at the GEA website: http://www.geo-energy.org/information/plants.asp

models. While the GEA survey did not cover geothermal direct use projects under development, these installations are expected to experience a similar increase.

Table 1: Developing Projects by State and Status as of 11/10/2006*

State	Unconfirmed	PHASE 1	PHASE 2	PHASE 3	PHASE 4	TOTAL* (PHASE 1to PHASE 4)
	Number of sites and MW-range					
AK	1 project 15 MW	1 project 20 MW			1 project 0.6 MW	2 projects 20.6 MW
AZ		1 project 2-20 MW				1 project 2-20 MW
CA		5 projects 320-330 MW	3 projects 326.8 MW	5 projects 139.5 MW	2 projects 35-73 MW	15 projects 821.3-869.3 MW
HI		1 project 30 MW		1 project 8 MW		2 projects 38 MW
ID	2 projects 200 MW		1 project 26 MW		1 project 10 MW	2 projects 36 MW
NM			2 projects 21 MW			2 projects 21 MW
NV	5 projects 72-102 MW	7 projects 304-393 MW	3 projects 49-64 MW	6 projects 157-167 MW	3 projects 37 MW	19 projects 547-661 MW
OR		3 projects 86-91 MW	1 project 40-60 MW	2 projects 60.2 MW		6 projects 186.2-211.2 MW
UT	2 projects 135 MW		1 project 36.6 MW		1 project 11 MW	2 projects 47.6 MW
Total	**10 projects 422-452 MW**	**18 projects 762-884 MW**	**11 projects 499.4-534.4 MW**	**14 projects 364.7-374.7 MW**	**8 projects 93.6-131.6 MW**	**51 projects 1719.7-1924.7 MW**

Key

- **Phase 1:** Identifying site, secured rights to resource, initial exploration drilling
- **Phase 2:** Drilling and confirmation being done; PPA not secured
- **Phase 3:** Securing PPA and final permits
- **Phase 4:** Under Construction
- **Unconfirmed:** Proposed projects that may or may not have secured the rights to the resource, but some exploration has been done on the site

**Unconfirmed projects are not counted in the state or final total. For more information on these projects, see the GEA website: http://www.geo-energy.org/information/developing.asp & the November 2006 Geothermal Power Production and Development Survey on the publications page: http://www.geo-energy.org/publications/reports.asp*

Based on these numbers, an important question is whether or not these installations will make any impact on our growing energy demand. For instance, if electricity demand grows by EIA's projected 8.4% by 2015, the U.S. would be consuming another 335,000 GWh of electricity[3]. In 2005, just considering electric power production, geothermal power plants produced a net

[3]The 335,000 GWh is based on calculations using a base year of 2004 for electric energy usage, but we use those numbers as a conservative baseline. The source is the Energy Information Agency (EIA).
Current figures: http://www.eia.doe.gov/oiaf/aeo/pdf/aeotab_8.pdf
Projections: http://www.eia.doe.gov/cneaf/electricity/epa/epat1p1.html

generation of roughly 16,010 GWh[4]. If we calculate 90% availability and an additional 2,376.7 MW of projects currently being considered, geothermal power could generate an additional 18,737.9 GWh in nine western states, which is 5% of the total needed by 2015 for the entire country. However, this is enough to provide over 20% of the new energy generation needed in those nine states (with the assumption that all these projects would expect to be completed prior to 2015 given the 3-5 years average time for development of a geothermal project)[5]. This would assume that no geothermal projects not included in the figures on Table 1 would be developed by 2015, but it is likely other projects will be proposed over the next few years that will be completed by that time.

Resource estimates

The most comprehensive estimates for the total U.S. recoverable resource were produced by U.S. Geological Survey (USGS) in the late-1970s. In 1978, USGS Circular 790 suggested that the total recoverable resource from identified geothermal prospects is roughly 23,000 MW and the total combined identified/unidentified resource base is as high as 150,000 MW[6]. Taking into consideration all the data compiled up to that point, the report listed specific locations where resource temperatures had been estimated or subsurface exploration had recorded. For those resources with more extensive data, information was given on resource conditions such as fluid discharge and permeability. However, overall estimates were based specifically on temperature.

The findings in USGS Circular 790 have been subject to a variety of opinions on the reliability of the estimates. For example, when it was released most power plants existing today had yet to be constructed. After new geothermal sites were established and resources identified in the report were explored in greater detail, drilled, and power plants were constructed, the accuracy of the USGS data was able to be compared to reality. According to a 2004 report by GeothermEx, Inc., new data showed that a majority of identified resources cited by USGS which were developed or explored in detail after the USGS Circular 790 report was released, were overestimated[7]. However, other reports and studies have indicated that in other ways, USGS Circular 790 underestimated available resources. For example, USGS was only considering hydrothermal resources at depths shallower than 9,843 feet (3,000 meters). However, geothermal wells have been drilled to greater depths and geothermal power production has been achieved at greater depths in other parts of the world. Researchers contend that in addition to deep convective

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[4]California: 14,379 GWh – California Energy Commission (CEC):
http://www.energy.ca.gov/electricity/gross_system_power.html
Nevada: 1,268.8 GWh – State of Nevada Commission on Mineral Resources, Division of Minerals:
http://minerals.state.nv.us/forms/ogg/ogg_NGU/NVGeothermalUpdate2006.04.pdf
Utah: 184.4 GWh based on 2002 generation from the Blundell plant, the only one in operation today. Source: Blackett, R.E., and Wakefield, Sharon, 2004: Geothermal resources of Utah – 2004: Utah Geological Survey Open-File Report 431DM (page 14):
http://geology.utah.gov/emp/geothermal/pdf/utah_high_temp6.pdf
Hawaii: 178.2 GWh based on 2003 numbers from EIA:
http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/trends.pdf (page 30)
The total is 16,010.4 GWh; however, generation changes from year to year, so the number is roughly 16,000 GWh considering we do not have exact numbers for Utah and Hawaii in 2005.

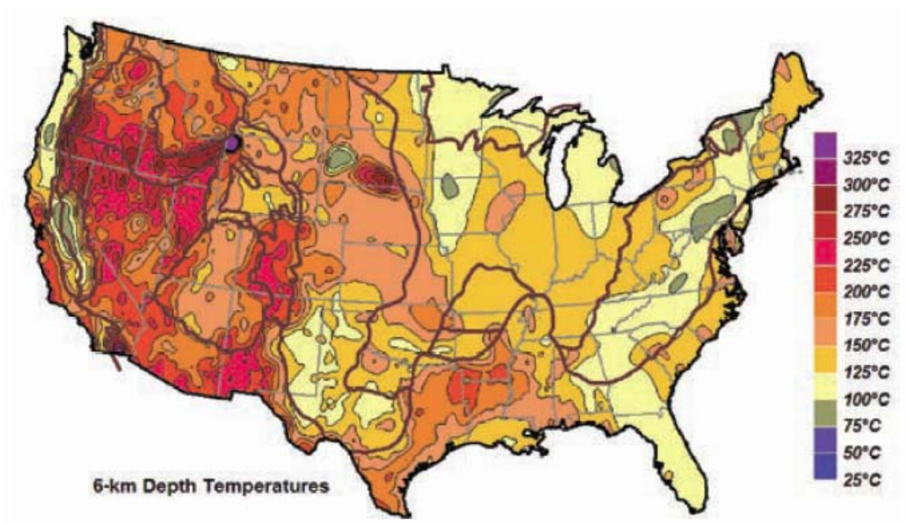
[5]These states represent roughly 20% of the U.S. population, so statistics would reason that 25% or 1/4th of new power could be met by geothermal resources by 2015. However, these states are also the fastest growing states, so 1/5th is more realistic for these numbers.

[6]Source – Geothermal Energy Association, "All about geothermal energy – Potential Use":
http://www.geo-energy.org/aboutGE/potentialUse.asp

[7]Source: Henneberger, Roger C., Klein, Christopher W., Lovekin, James W., and Sanyal, Subir, K. *"National Assessment of U.S. Geothermal Resources – A Perspective"*. GeothermEx, Inc., September 2004.

resources, conductively heated hydrothermal resources may be available for production at deep depths throughout the state, depending on fluid, permeability, and the economics associated with development. In fact, a U.S. map was released measuring heat flow to 19,685 feet (6,000 meters) that showed geothermal electric power potential exists in all 50 U.S. states. The challenge is the cost (and financial risk) of drilling deep wells to this depth are not considered economical at this time, although oil and gas wells in the U.S. currently produce at depths greater than 30,000 feet (9,144 meters) (see figure 2)

Figure 2: Estimated Earth temperature at 6-km (3.7-mile) depth. Southern Methodist University (SMU) Geothermal Laboratory. Source – National Renewable Energy Lab (NREL) – *"Geothermal—The Energy Under Our Feet: Geothermal Resource Estimates for the United States."* November, 2006: **http://www1.eere.energy.gov/geothermal/pdfs/40665.pdf**



Another limitation associated with USGS Circular 790 is that its authors only considered resources with temperatures that exceeded 302°F (150°C)—due to then existing engineering and technological limitations to generate electricity from below these temperatures. However, binary geothermal power facilities have since been able to produce electric power using temperatures below 302°F (150°C). In fact, less than a decade after USGS Circular 790 was released, binary technology enabled electric power production from temperatures as low as the boiling point of water (equivalent to 212°F (100°C) at sea level and lower at higher altitudes). More recently, a power plant installed in Alaska in 2006 is producing electricity using temperatures of 162.5°F (72.5°C) (this project is discussed in more detail in the next section).

There are several sites not identified as sufficient for power production in USGS Circular 790 that subsequently produced electric power. The most significant of these is at Raft River in Idaho. USGS Circular 790 estimated the reservoir temperature at Raft River to be just below 300°F (149°C) and as a result, it was not given an estimate for electric power potential in the report. However, three years later, in 1981, when binary technology tested at Raft River produced electricity, it demonstrated how quickly technological change can occur. Developers of a new geothermal power project at Raft River plan to develop additional power units that may result in as much as 90 MW of installed capacity once the property is fully developed. The Raft River area, extending beyond existing leases, has been estimated to contain even more electric power potential, with the most recent "high" estimates at 515 MW[8].

Since 1978, additional resource assessments have been completed. For example, a 1992 report by John Geyer, William P. Long, B.J. Livesay, and Susan Petty, entitled *Supply of Geothermal Power from Hydrothermal Sources: A Study of the Cost of Power in 20 and 40 Years* provided power potential estimates for 51 sites in five states corresponding to two different development timeframes (20 and 40 years). In addition, in 2004, a report by GeothermEx, Inc. entitled *National Assessment of U.S. Geothermal Resources – A Perspective* analyzed the likely power potential at 37 specific resource areas in three states.

In January of 2006, a more comprehensive assessment was released by the Western Governors' Association (WGA) in its 2006 Geothermal Task Force Report. The assessment was performed as part of the WGA's Clean and Diversified Energy Advisory Committee (CDEAC) (described in more detail in Part III). The report covered 11 western states (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Nevada, New Mexico, Oregon, Utah, and Washington State) and estimates that there is up to 12,558 MW of recoverable geothermal power by 2025 from identified locations available at a future market cost of up to 20 cents per kilowatt-hour (¢/kWh). In the near-term, WGA estimated 5,588 MW of economically developable capacity (5.3 to 7.9¢/kWh [with the federal production tax credit (PTC) included] by 2015 in these 11 western states (see Table 2)[9]. In contrast to the statistics above describing the power generation from projects currently proposed or under development, the development of 5,588 MW of geothermal power could generate an additional 44,056 GWh by 2015, enough to meet 13.9% of new U.S. demand and over 50% of new demand in those 11 states alone. If you take California out of the equation (both its energy demand and its potential new capacity) the remaining ten states could meet nearly 75.6% of their new electric energy consumption from geothermal power plants. Furthermore, these estimates predict that the states of Nevada and Idaho have the potential to meet over 1/4th of their **total** energy consumption from geothermal sources by 2015[10]. Keep in mind that these numbers do not reflect the potential for direct use applications, which experts say could have an appreciable impact on energy savings by that time in these states.

The prospects listed by the WGA Geothermal Taskforce report in California and Nevada, builds upon the findings of the April 2004 Public Interest Energy Research Program (PIER) report on *New Geothermal Site Identification and Qualification*, prepared for the California Energy Commission (CEC) by GeothermEx, Inc. While the volume of potential prospects for these states exceeded 80 locations in both these reports, there have already been areas leased in Nevada not

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[8]See Excel file from the Geothermal Energy Association webpage on "Potential Use": http://www.geo-energy.org/aboutGE/potentialUse.asp

[9]Western Governors Association (WGA) Geothermal Task Force Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf

[10]These 11 Western states currently contain 22.5% of the U.S. Population (based on 2004 estimates). This means that for those 11 states (if we assume they use the same electricity use as other Americans), could possibly get over 1/2 of new electric power from geothermal power projects by 2015. Remove California, and you have a WGA estimate of 3,213 MW for a population less than 10% of the U.S. population. That is enough power for 75.6% of new demand, based on 10% of 335,000 GWh.
These numbers were calculated based on estimates from these sources:
Census data: http://quickfacts.census.gov/qfd/index.html
EIA state profiles: http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html
WGA Geothermal Task Force Report (January 2006):
http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf

covered in either of them. The explanation for this is that some discoveries had been held in propriety, and there are likely sites in multiple states not evaluated in previous reports that have been explored and studied, but the data was not released publicly. An effort to evaluate the full quantity of the work performed on geothermal resources (both from identified areas and from areas where exploration was not available publicly) was funded by the U.S. Department of Energy (USDOE) and released in 2005 by Geo Hills Associates. In their final report, they cited 4,617 thermal gradient boreholes and 1,924 slim holes or exploration and/or production wells in California and Nevada—most drilled in the 1970s and 1980s. Also for these states, they cited 148 separate geothermal prospects (including those that now have power generation projects). This is well above the number of total prospects included in the WGA and PIER reports. In total, they covered 13 states, including all the states west of the Rocky Mountains, Texas, and Hawaii. For these states they cited 2,906 thermal gradient boreholes (38.6% of the total), but only 154 slim holes or exploration and/or production wells (7.4% of the total)[11]. Unlike the WGA report, they did not list the names of all the prospects included in the study.

Researchers say that this volume of geothermal exploration is not overestimated. Oil and gas exploration companies came to the western U.S. in the 1970s to perform exploration drilling for geothermal resources throughout the western U.S. At the time, however, they were generally looking for big hits, similar to The Geysers in California. When no resource areas even approaching this potential were found, many viable projects did not move ahead.

In November of 2006, the National Renewable Energy Lab (NREL) released a report entitled "Geothermal—The Energy Under Our Feet Geothermal Resource Estimates for the United States." This report, unlike the reports mentioned above, includes estimates of geothermal power potential from various methods of recovery, including electric power estimates from geopressured and co-production from oil and gas wells (discussed in the following section), estimates from hydrothermal resources at temperatures above 194°F (90°C), estimates from low-temperature thermal uses of geothermal resources (based on avoided electric power use from these technologies) and estimates from deep geothermal resources accessible beyond three kilometers and through alternative recovery methods such as enhanced geothermal systems (EGS) and Hot Dry Rock (also discussed in the following section)[12].

While the NREL study shows that significant untapped geothermal development potential likely exists across the country given new applications, most agree that California remains the state with the greatest near-term development potential for development. In September of 2006, GEA released a report entitled *California's Geothermal Resource Base: Its contribution, future potential, and a plan for enhancing its ability to meet the states renewable energy and climate goals*. In the report, various estimates of California's total recoverable potential are examined which range from a near-term potential of over 3,000 MW to a longer-term potential of over 24,000 MW. The report notes that "each of these studies made different assumptions about the price at which geothermal resources would or could be developed, often reflecting the market expectations around the time the report was written." Also, these estimates range in their assessment of the kind of technology used to recover the resource. Of note in the report were assessments by the University of Utah's Energy and Geosciences Institute (EGI) that examined

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[11]Source: Combs, Jim. *Historical Exploration and Drilling Data from Geothermal Prospects and Power Generation Projects in the Western United States*. Geo Hills Associates, Reno NV. GRC Transactions, Vol. 30, 2006: Pgs. 387-392.

[12]National Renewable Energy Lab (NREL) – *Geothermal—The Energy Under Our Feet: Geothermal Resource Estimates for the United States*. November, 2006: http://www1.eere.energy.gov/geothermal/pdfs/40665.pdf

the potential of one resource area, the Salton Sea known geothermal resource area (KGRA). For example, in a November 13, 2002 Resource Evaluation for Salton Sea Unit 6, CEC staff compared the applicants estimates of "possible reserves of 2,300 MW" with prior estimates by Union Oil, who had explored the area in the 1970s. As the CEC paper notes, Union Oil's estimate of geothermal potential for the Salton Sea KGRA was "25,000 MW for 30 years." The area EGI examined actually encompasses more than the Salton Sea KGRA. Their study area was called the "Greater Salton Sea Geothermal Cluster" and covered an area of some 615 kilometers (km) (or 146,100 acres), which they contend that with "a combination of advanced technology and aggressive development…could produce a viable geothermal resource [of] 40,000 MW by 2040."[13]

One thing these resource estimates agree upon is that the majority of recoverable geothermal resources in the U.S. have gone unidentified and the majority of identified resource areas have seen little to no subsurface exploration. Recently, the USGS was authorized to conduct a new assessment of geothermal resources to update the 1978 Circular 790 report. Researchers throughout the geothermal energy field have encouraged the new assessment in part because there is a broad spectrum of opinions about the size of the available resource. There is also a need for reliable information to guide new exploration based on advanced information technology and field data not available in 1978.

Table 2: New Hydrothermal Geothermal Resource Potential (MW) and Cost Allocations

State	Near-Market cost up to 8 ¢/kWh online within 10 years (2015)	Longer-Term cost up to 20 ¢/kWh online within 20 years (2025)
Alaska	20	150
Arizona	20	50
Colorado	20	50
California	2375	4703
Hawaii	70	400
Idaho	855	1670
Nevada	1488	2895
New Mexico	80	170
Oregon	380	1250
Utah	230	620
Washington	50	600
Total	**5,588 MW**	**12,558 MW**

Source: WGA Geothermal Task Force Report (January 2006):
http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf – (pages 60-66)

Widening the scope of geothermal potential through new technological applications

Although there is a general consensus that the exploration and development of geothermal resources is still a maturing industry, recent innovations in technology, combined with improving

[13]Source – Gawell, Karl. *California's Geothermal Resource Base: Its contribution, future potential, and a plan for enhancing its ability to meet the states renewable energy and climate goals*. Geothermal Energy Association (GEA), September 30, 2006: http://www.geo-energy.org/publications/reports/CaliforniaGeothermalResourcesSeptember302006.pdf

economics for alternative energy resources, has expanded the range of applications for capturing geothermal energy.

Enhanced geothermal systems (EGS) and Hot Dry Rock

While a numerous deep wells in the U.S. have been recorded which measured intermediate-to high temperatures, many do not encounter adequate fracture permeability to deliver a continuous source of fluid. EGS is a process where geothermal aquifers with low permeability can be stimulated to create a conductive fracture network where the reservoir operates like a conventional hydrothermal reservoir. It was proven feasible by a demonstration project in Soultz-sous-Forêts, France. This process can serve to extend the margins of existing geothermal systems or create entirely new ones[14]. Hot Dry Rock targets a heat source that lacks both permeability and fluid. It was first proven technically feasible through a demonstration project at Fenton Hill (on the western rim of the Valles Caldera in New Mexico), completed in the early 1990s. These methods, while more expensive than those used for conventional geothermal power projects, have potential for future application in the U.S. and abroad[15].

Drilling technologies

Drilling technologies are also considered critical to new development. Drilling is often the greatest barrier to geothermal projects. Just because developers drill a "dry hole" does not mean that the resource is unavailable or extraction methods like EGS or Hot Dry Rock are necessary. Often times, a resource is available, but the drilling was not precise. In this case, researchers assert that other technology can be employed that can decrease the risk of drilling dry holes. The challenge, according to developers, is drilling within a precise vicinity of the targeted resource (say within a quarter of a mile) to be able to reduce the risk of drilling dry holes. Generally, the techniques used for oil and gas drilling, such as seismic surveys, are not as effective for geothermal drilling, because geothermal resources typically form in areas of abrupt changes in geology (such as faults) that may confuse the seismic signal. For this reason, developers need assistance combining traditional methods such as temperature gradient drilling with advanced methods such as remote sensing. Although researchers say that improvements in drilling technology will be made as the industry grows, most agree that research and development funding from the federal government is essential to help solve this dilemma.

Geothermal development at oil and gas wells

As noted above, geothermal electric power can be extracted from geopressured reservoirs and co-produced through hot wastewater from oil and gas wells. Geopressured geothermal resources encompass a significant area of geothermal potential noted in the NREL report, which are largely located in Texas, Louisiana and under the waters of the Gulf of Mexico. Geopressured resources are buried reservoirs of hot brine under abnormally high pressure that contain dissolved methane. The NREL report indicates a significant potential energy contribution from these resources—ranging from 5,000 MW in 2015 to as much as 70,000 MW by 2050. Researchers contend that hot wastewater is also available for co-production in most of the oil and gas producing states of the central and western U.S., and the Gulf Coast. Mature oil and gas fields in many areas in the U.S. produce large amounts of water along with oil and gas, the water being considered a burden to producers. According to the USDOE, "oil and gas deposits are frequently mixed with fluids that get pumped to the surface along with the oil or gas. Because these fluids can come from 4

[14]For more information see the USDOE – "Enhanced Geothermal Systems": http://www.eere.energy.gov/geothermal/pdfs/egs.pdf

[15]Source – Brown, Don & Duchane, Dave. "Hot Dry Rock (HDR) Geothermal Energy Research and Development at Fenton Hill, New Mexico." GHC Bulletin, Geo-heat Center, Oregon Institute of Technology (OIT), December 2002: http://geoheat.oit.edu/bulletin/bull23-4/art4.pdf

km (2.5 miles) to 8 km (5 miles) deep or from areas of unusually hot rock, they often carry substantial heat to the surface." Researchers say that the heat from the wastewater can be captured and the heat energy extracted by running these fluids through a binary power plant. For this application, the NREL report indicates a potential energy contribution ranging from 5,000 MW in 2015 to as much as 40,000 MW by 2050[16].

For both of these applications, researchers suggest that to be considered, water from these sites needs temperatures ranging from a minimum of 200°F to 250°F (93.4 to 121.1°C) with a discharge of at least 500 gallons per minute (gpm). Ideal depths are at 15,000 feet (4,572 meters); however, researchers assert that oil and gas wells over 20,000 feet (6,096 meters) deep may also be likely candidates for geothermal electric power production. This process can be done at either abandoned wells, or at existing wells—with minimal interference with current oil and gas production[17]. While these resources have the potential to contribute significantly to US energy needs, they are not discussed or examined in detail since the focus of this report was on the Western states. The March 2006 Conference at Southern Methodist University provides significant information about both geopressured resources and the co-production potential from oil and gas wells. The papers presented at the SMU conference are available at: http://www.smu.edu/geothermal/Oil&Gas_SMUmeeting.htm

Distributed generation

Ultimately, there is a general consensus that geothermal prospects with resource conditions sufficient to produce fewer than 10 MW of electric power are generally not seen as profitable as a power plant project, particularly if the area is remote and would require substantial investment in new transmission infrastructure to reach the nearest substation. Because geothermal power plants use a localized resource, this raises the opportunity for distributed generation projects. According to the USDOE, distributed generation units are "small, modular electricity generators sited close to customer loads."[18] Further, proponents of these technologies agree with the assessment by USDOE that the advantages of geothermal-powered distributed units are their ability to avoid "transmission and distribution power losses" because the system can be "located inside or immediately adjacent to" the facility receiving the power. The low emissions of geothermal power systems make them more ideal for this type of setting. The plant may be connected to the utility grid, or may be completely off-grid, providing power directly to a facility. In this case, the developer is not required to procure a power purchase agreement (PPA) or go through a lengthy utility regulatory process. Proponents point out that if these units are used to produce a commercial product (rather than just power for the electric grid) they can potentially generate more revenue and more jobs than a dedicated power plant of equivalent size. Furthermore, while small power units might cost more per kWh than a utility would be willing to pay, they might still be lower than the retail power cost the utility would charge.

Proponents of distributed generation projects say these projects might be viable for geothermal aquifers with temperatures at or slightly above 212°F (100°C), which, while sufficient conditions

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[16]Geothermal-The Energy Under our Feet, National Renewable Energy Laboratory, Technical Report NREL/TP-840-40665, November 2006: http://www1.eere.energy.gov/geothermal/pdfs/40665.pdf

[17]For more information see:
Geothermal Technologies Program – Texas: http://www.nrel.gov/docs/fy06osti/38242.pdf & Southern Methodist University (SMU) – "Texas Workshop Opens Discussion of Major New Area for Geothermal Energy Production – Oil and Gas Fields":
http://www.smu.edu/geothermal/Oil&Gas/Oil&Gas_SMUmeeting_summary.htm

[18]Source – U.S. Department of Energy (USDOE) Distributed Energy Program:
http://www.eere.energy.gov/de/power_generation.html

may exist for power production, are incapable of producing large amounts of power. This can make applicable geothermal power development in states where identified geothermal systems are not expected to produce high temperatures suitable for large power plants, and can open up more geothermal resources to development in general.

Alternative fuels

One form of distributed generation is to use geothermal resources to produce alternative fuels. Alternative fuels plants are notoriously energy intensive to develop, and most agree they are ideal for localized power units. For example, according to ongoing research at Iowa State University, since the ethanol boom in the state, early estimates show that Iowa's annual production of more than one billion gallons of ethanol accounts for about 16% of the state's demand for natural gas (although many ethanol producers in the U.S. have been locating plants near coal-fired power facilities)[19]. Geothermal power facilities can provide both power and cascaded heat for alternative fuel production and this affects all aspects of production, including refining and drying. Proponents of these projects say that given the current price of oil an ethanol or bio-fuels plant can use small-scale geothermal electric power (from 1-10 MW) and generate several times more revenue than a power plant of equivalent size. In addition to the revenue, the cost of both natural gas and coal today enable energy savings large enough for an attractive rate of return to pay back the upfront costs of the project. A number of potential geothermal resource areas in the western U.S. are located nearby major highways and rail lines that can grow their own feedstock or move feedstock from other parts of the country and transport alternative fuels to emerging markets in California.

Geothermal energy was first used to produce alternative fuels in the early 1980s in Wabuska, Nevada, 70 miles south of Reno. Using grain as a feedstock, the plant made gasohol for several years until oil prices plummeted and existing federal tax credits expired. This same facility is expecting to open up again in 2007 to produce five million gallons per year of bio-diesel from locally grown oil seed. Additional geothermal-alternative fuel plants are currently under development in Nevada and Oregon.

The grain silo, methanol recovery towers, and the tank farm at the Wabuska bio-diesel facility; under construction. Photo by Claude Sapp, Infinifuel Biodiesel: http://www.infinifuel.com/
Used by permission

Cascaded heat and power

The concept of geothermal resources providing both power and cascaded heat is relevant not only to alternative fuels, but can also be used for greenhouses, aquaculture, mining operations, or industrial applications. In fact, cascaded systems have been proposed or utilized for various uses in several states, including Alaska, California, Hawaii, Nevada, New Mexico, Oregon, and Utah.

According to researchers, facilities like these can also be applied to sites with existing power plants (if technically feasible) to utilize the resource for additional business opportunities and increase revenues; or to sites with existing direct use facilities; if sufficient temperatures are present for small power production. Most agree that the range of possibilities for these technologies have not yet been explored. Several interviewees suggest geothermal resources

[19]Source: "Researchers Helping Take Natural Gas Out Of Ethanol Production" – Iowa State University: http://www.pollutiononline.com/content/news/article.asp?docid={FD009FED-93C2-4CCB-81F5-CD67463C2F19}&VNETCOOKIE=NO (9/27/2006)

could be used for hydrogen production. Others suggest combining geothermal heat with concentrated solar power (CSP) or biomass refining. In some areas, geothermal facilities can be used to recover minerals such as zinc, lithium, manganese, cesium, rubidium and even precious metals such as gold, silver and platinum. This process has been successful at several locations in the world, although most agree that it can be a risky investment, as developers in the U.S. have lost money pursuing it. For this reason, most agree that some government funding for demonstration projects is necessary if this process is to occur more frequently in the U.S.[20]

Demonstration projects

Proponents of distributed generation projects or other geothermal electric power applications agree that what is needed are more demonstrations of these technologies to expand their visibility to attract new investors and establish new markets for the technology. Thus far, there have been several of these projects that have operated over the years, including the first alternative fuel plant at Wabuska, and vegetable dehydration facilities at Brady's Hot Springs and Empire—also in Nevada. However, those facilities benefited from existing power plants on the site. In New Mexico's southwest corner, Dale Burgett installed a small geothermal-powered binary unit to use for his greenhouses at Lightning Dock. The facility was installed in 1995 and ran for two years, capable of producing 750 kW from a 235°F (113°C) resource at depths just below 600 feet (183 meters). Design problems (and the cost of correcting them) forced a shutdown of the facility in 1997, although operators say the system is still viable if those issues are corrected.

Most recently, a potential breakthrough has been demonstrated in geothermal distributed generation through a project installed in Alaska at the Chena Hot Springs resort, 60 miles north of Fairbanks. The power unit is unique because it produces power from a low-temperature geothermal aquifer with temperatures of 162.5°F (72.5°C). Although binary power plants have made use of secondary fluids with a lower boiling point than water, the geothermal resource being extracted still generally required greater than boiling temperatures (212°F (100°C) or slightly lower at altitude), this project is the first to produce from fluid below the boiling temperature. The plant, called a PureCycle® geothermal power plant, uses Organic Rankine Cycle (ORC) technology, using a process similar to existing binary power plants. However, because the geothermal water at Chena Hot Springs never reaches the boiling point of water, a refrigerant, called R-134a, is used which has a much lower boiling point than water. The water is pumped at 480 gpm and passes through a heat exchanger where it transfers heat energy to the refrigerant. When the refrigerant boils, it vaporizes and is then routed to a turbine to generate power. The system runs in a closed loop and most of the water is injected back into the reservoir with the rest of the fluid being used for space heating. At the first plant, cooling water is siphoned from a shallow well close to a nearby creek using the natural gradient, or fall, of the property. A second plant has been installed at the resort using air-cooling during the winter months[21].

Developers of the technology say that this process is feasible throughout the country. However, based on the climate conditions in the continental U.S. these units would likely require temperatures at or above 200°F (93°C) in locations with generally warm climates, and just under 200°F (93°C) in colder areas in the Pacific Northwest in order to operate at the same capacity. These temperatures are present in numerous locations throughout these states in shallow geothermal aquifers and hot springs that have been generally overlooked as a source of power. In

[20]For more information on mineral recovery see: Bloomquist, Gordon. "Economic Benefits of Mineral Extraction from Geothermal Brines." GRC TRANSACTIONS, V. 30, September 2006: Pgs 579-582.
[21]Source – Chena Hot Springs: http://www.yourownpower.com/Power/

fact, orders for PureCycle® units have already been made for several sites outside of Alaska, although the exact locations have not yet been specified at the time of this writing.

Challenges to development of non-conventional geothermal energy applications

Whether geothermal power units are used for alternative fuels, industrial applications, or commercial agricultural facilities, most agree that the challenge to moving projects forwards is in creating a market for them. In order to profitably produce small power units there needs to be enough resource areas and enough willing buyers to enable mass production. One challenge is whether units need to be custom made for each individual site, or whether they can operate (with only small adjustments) anywhere a suitable resource exists.

Developers express concern that geothermal power projects that are not used for on-grid electricity may not qualify for federal incentive programs like the PTC or the federal Clean Renewable Energy Bonds (CREB) program. A new facility might not be covered by a state renewable portfolio standard (RPS), unless it is included in a utility's demand-side management plan and powers an existing facility rather than a new business or industrial facility. For alternative fuels, those working on these projects suggest that alternative fuel credits could be weighted to give an advantage to alternative fuel plants using 100% renewable energy for production. Furthermore, geothermal-powered alternative fuel technology could receive funding from the USDOE ethanol program.

Part II: State descriptions

Part II provides a description of 14 individual states: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, Utah, Washington State, and Wyoming. Each of these states is experiencing new geothermal development and each state has critical needs and barriers affecting future development.

It begins with summaries of five states that were evaluated at length in reports released by GEA earlier this year: Arizona, Idaho, Nevada, New Mexico, and Utah. The reconnaissance performed for these five states was approached from the bottom-up. The process began with a review of available literature on these states, followed by interviews with people in each state about the issues and problems as they saw them. Next, the states were visited to attend conferences, view facilities, and meet in person with industry stakeholders. After returning from these states, final interviews were conducted; a draft was prepared, and sent out for review. Once final comments were received they were incorporated into the final draft which was then completed and released by GEA.

Following the summaries of these five states, the other nine states are described in smaller detail. These states were not subject to a full length report earlier this year, but were evaluated specifically for this report to assess needs, barriers, and the status of projects currently under development. Four of these states were subject to longer descriptions, including Alaska, California, Hawaii, and Oregon, which have all used geothermal resources to produce electric power, and all of which are undergoing near-term geothermal power development. Following the summaries of those four states are brief analyses of geothermal needs, barriers, and activities in states without a history of geothermal power development, including Colorado, Montana, Texas, Washington State, and Wyoming. These descriptions are followed by a brief summary of issues affecting geothermal development in other U.S. states not covered in detail by the report. The process for each of these summaries involved a literature review and several interviews (although far less than in the first five states). Experts in these states (including the GPW state leads) were given an opportunity to review the write-up before it was fully incorporated into the report.

Each of these fourteen states is considered in the analysis prepared in Part III of this report.

New projects in these states have benefited from the recent growth of the industry and state and federal policies that have encouraged geothermal development. Nine of these 14 states have an RPS requiring some or all of its utilities to generate a certain percentage of their retail sales from renewable power sources within a specified timeline. Projects in all of these states are affected by the PTC. In its current form, the PTC provides a subsidy of 1.9¢ per kilowatt-hour (kWh) for ten years eligible to renewable power sources, including geothermal power plants.

In December of 2006, the PTC was extended through December 31st, 2008, a one-year extension. Efforts to extend the provision beyond this date are likely in 2007, although not assured, and this affects projects expected to be completed after that date. The PTC is only eligible for electric power sold to investor-owned utilities (IOUs) and not to municipal utilities or rural cooperatives. Although geothermal power plants developed by municipal utilities or rural cooperatives are not eligible for the PTC (and in some states, the RPS would not apply to them) they are eligible to receive tax incentives through the Federal CREB program. In the Energy Policy Act of 2005 (EPAct), the CREB was created, and was authorized to offer up to $800 million in “tax-credit” bonds for eligible renewable energy projects, including geothermal, initiated by these utilities. Unlike normal bonds that pay interest, these bonds pay the bondholders by providing a credit against their federal income tax. In December of 2006, CREB was extended through December 31st, 2008, and allowed for the provision of an additional $400 million of CREB bonding authority[22].

Each of these states has also been affected by regulations on geothermal resource development within property under jurisdiction of the federal government. In 2005, EPAct authorized changes to the Geothermal Steam Act of 1970 to address concerns affecting developers who wished to build geothermal power projects at these locations. The new regulations address backlogs for existing lease applications and permits, the processing of environmental reviews in accordance with the National Environmental Policy Act of 1969 (NEPA), and issues involving interagency coordination. In addition, the new regulations address royalty calculation methods impacting geothermal direct use projects. Prior to EPAct, the method in which royalties were calculated for these projects had resulted in fees that were large enough to make most of them uneconomical. Although the final regulations authorized by EPAct are still under review, there is an expectation that developers will be charged a small fee—something that will open up more land to this kind of development. These changes are discussed in more detail in Part III.

In the analysis of the first five states below, each state has a summary that includes basic information and past and present development, information on new activity, potential for development, promising resource areas, existing programs, incentives, power market issues, regulatory issues, and an analysis of progress and extenuating issues regarding the development of geothermal direct use applications.

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[22]For more information on the CREB program, see the Environmental Law & Policy Center (ELPC) – "Clean Renewable Energy Bonds": http://www.elpc.org/energy/farm/crebs.php & the U.S. Department of Energy (11/29/2006): http://www.eere.energy.gov/news/news_detail.cfm/news_id=10423

Arizona

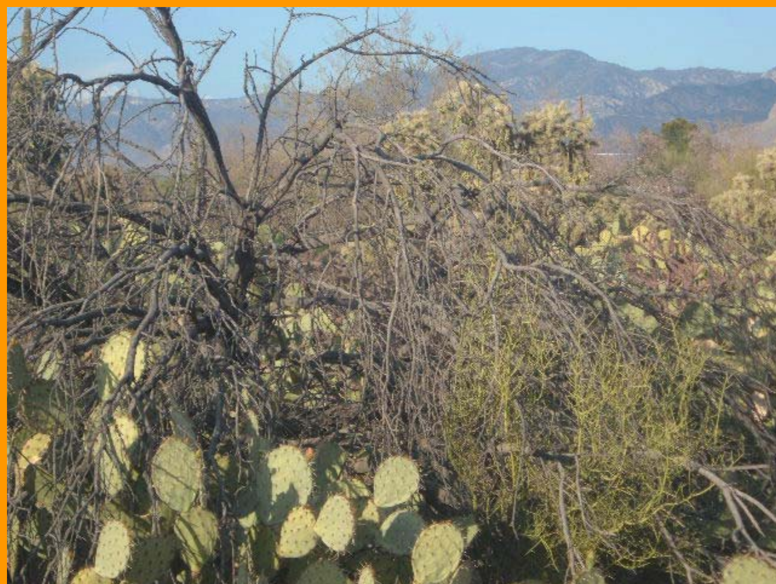

Photo: Mount Lemmon rises above the cactus in Tucson, where direct-use heating projects have been considered. Photo by Daniel J. Fleischmann – Geothermal Energy Association (GEA)

When people think of renewable energy in Arizona, they often think of the sun. However, underneath Arizona's soil rests acres and acres geothermal resource potential. Between 1977 and 1982, the "geothermal assessment" team within the Arizona Bureau of Geology and Mineral Technology -- now known as the Arizona Geological Survey (AZGS) -- conducted a reconnaissance of the state's geothermal resources with attention focused mainly on the southern part of the state. A subsequent database, completed in 1995, cataloged the data compiled by this effort, which included 1251 thermal wells and springs above 68°F (20°C) (See Figure 3) and 215 thermal wells and springs above 100°F (38°C).

A quarter-century later, with its population doubled, and energy demand and energy prices at all time highs, the state has launched renewed efforts to expand its use alternative technologies to exploit its natural renewable resources. While much of the focus has been on solar, researchers say that geothermal resources hold promise for a variety of beneficial applications in the state, and are included in their efforts.

New activity

In September 2006, GEA released a report entitled *Geothermal Development Needs in Arizona* that studied new activity and identified possible areas for further study. To date, Arizona has no power plants and few direct use facilities. However, new activity is likely to change that very soon.

A power plant prospect has been in the works for several years at Clifton, in eastern Arizona in Greenlee County. While the hot springs have a surface temperature of only 159.8°F (71°C), studies of the resource area have estimated reservoir temperatures likely capable of small-scale power production[23]. In 2005, two deep core-holes were drilled near Clifton Hot Springs, which

[23]Temperatures for Clifton and Gillard: http://geothermal.nau.edu/about/resources.shtml

measured promising temperature gradients (with one core-hole indicating sufficient fluid in the underground reservoir). USDOE and Arizona Public Service (APS), the state's largest IOU, have collaborated on the project, and are currently evaluating the next steps. Before a power facility can be constructed, deep exploration drilling is needed to confirm the resource. While drilling at Clifton is planned on private land, several researchers contend that Bureau of Land Management (BLM) lands in the area also have potential, and should be considered for additional exploration drilling.

Northern Arizona University has received federal funding to study geothermal resource potential east of the San Francisco Peaks, north of Flagstaff. Although most of the geothermal potential in Arizona is believed to be in the southern part of the state, the San Francisco Volcanic Field has been considered a favorable geothermal prospect. According to researchers, the San Francisco Peaks are associated with silicic eruptions as recent as 50,000 years ago. Existing geological, geophysical and geochemical data are consistent with that of a high-temperature geothermal resource. Funding is being sought for deep core hole drilling in the area to determine the likely temperatures and whether sufficient fluids exist at depth for electric power production.

A geothermal direct use project is currently under development in Willcox (82 miles east of Tucson) where the USDOE provided FY 2006 funding to study the utilization of a geothermal direct use heating system at a 7½ acre tomato greenhouse complex that is planning to expand operations to 15 acres. Those familiar with the project say that if it is successfully demonstrated, it could raise visibility of the technology and may encourage other greenhouse businesses to consider them for their operation. There are several other greenhouse complexes in the Willcox area that are much larger (several hundred acres) and are heated with natural gas. If natural gas prices continue to climb in coming months, the developers say it might be practical to approach these and other large greenhouse complexes in Arizona about pursuing a feasibility study for installing a geothermal direct use facility. These systems can start small and be expanded over time, so the technology can be tested on several acres, and then, if successful, be expanded to cover a larger part of the operation.

In addition to Willcox, there is interest elsewhere in the state to use geothermal resources. This includes expanding an existing aquaculture facility, and proposed projects for a geothermal greenhouse in Florence, and for a space heating project in Chandler.

Potential

Arizona includes two major physiographic provinces: The Southern Basin and Range Province and the Colorado Plateau. According to researchers, with the exception of the San Francisco Volcanic Field, the most promising resource areas in Arizona lie in the Southern Basin and Range Province, particularly southeastern Arizona. Resources in this area share similar characteristics to resources in southeastern New Mexico, where several intermediate-temperature geothermal resources have been identified, including geothermal resources at Lightning Dock, less than 20 miles from the Arizona border.

According to the WGA Geothermal Taskforce Report, there are 20 MW of near-term power potential in Arizona (compared with 5,568 MW in the ten other western states discussed in the report) with Clifton the only resource area mentioned in the report[24]. Researchers say that this reflects the lack of intermediate-to high temperature resources identified in the state.

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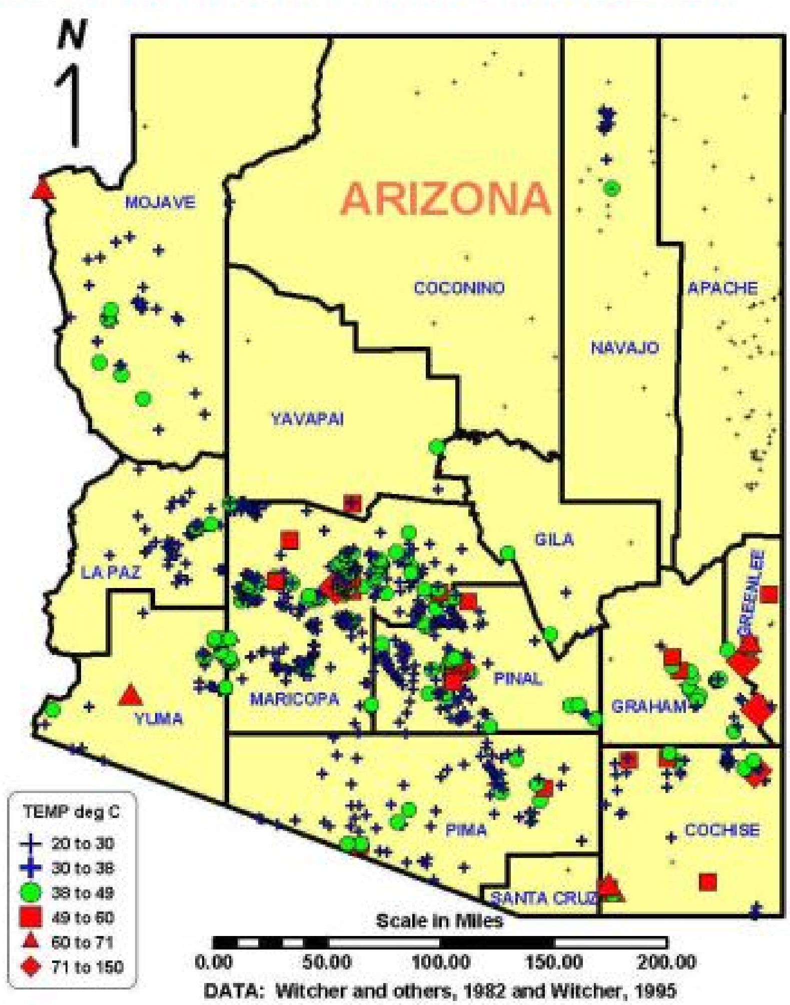
[24]See Western Governors Association (WGA) Geothermal Task Force Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (pages 60-66)

Figure 3: Arizona Thermal Wells and Springs. Map courtesy of James C. Witcher of Witcher & Associates.



Promising resource areas

Outside of Clifton and the San Francisco Volcanic field, only a few other potential resource areas have been suggested as likely prospects. Ten miles south of Clifton, Gillard Hot Springs has measured surface temperatures of 183.2°F (84°C). The area is near transmission lines and there is industrial development located nearby. However, the springs are located on BLM land, and no exploration has been done beneath the surface. Although researchers contend that the area may have potential for small-scale power production, the area has received little interest thus far, partly due to uncertainty over whether sufficient fluid exists in the deep underground aquifer.

Researchers suggest that Arizona may contain extensive resource potential at deep depths, although accessing these resources may not yet be economical. However, technological advancements may be able to access intermediate-temperature geothermal aquifers, exceeding 212°F (100°C), for small-scale power production. These resources may be available at moderate depths in southeastern Arizona. For direct use, Figure 3 clearly shows that geothermal resources are available in a multitude of areas, including in the Phoenix metropolitan area.

Programs

In October of 2006, the minimum requirements for Arizona's RPS were increased from 1.1% by 2007 to 15% by 2025 and eligibility was extended to geothermal technologies (which were not included in the previous standard). While geothermal resources are expected to help meet some of the RPS requirements, there is currently no state funding provided directly for geothermal research work. In January 2002, the GeoPowering the West (GPW) program of the USDOE held its first meeting of the Arizona Geothermal Working Group. At the meeting, participants discussed the steps that would be necessary to help re-evaluate resources and expand use. Soon after the establishment of the Working Group, AZGS began updating the 1995 database. It is likely that the state will provide some general assistance to collaborative work initiated by the USDOE.

The most recent meeting was held in May of 2006 in Tempe, and brought investors, utilities, and developers together to discuss opportunities in the state. Currently, the state working group is in the process of implementing a "strategic plan", similar to ones developed in Idaho in 2002 and New Mexico in 2004, with a purpose of reducing barriers, identifying opportunities, and highlighting the appropriate actions necessary to address these issues. Through the work of GPW, a collaborative effort is being established between the state government and research departments at Northern Arizona University and Arizona State University. In addition to GPW, USDOE has provided assistance for geothermal development through the Geothermal Resource Exploration and Development (GRED) program. GRED projects in Arizona include the study of the San Francisco Volcanic Field and the project at Clifton Hot Springs.

Incentives

Incentives to use geothermal power or direct use have been limited thus far in Arizona because its geothermal resources have barely been exploited. Direct use facility operators in Arizona say they currently receive no financial incentive from the federal or state government for their existing geothermal systems. There is a general consensus that efforts to incentivize renewable energy use in Arizona have leaned towards solar energy, and have targeted primarily residential or small business users. Arizona has several solar energy non-profit organizations and the Arizona Department of Commerce has a Solar Energy Advisory Council. Arizona provides a sales tax exemption for the sale or installation of solar energy devices (although wind electric generators and wind-powered water pumps are also included). There are several other incentives that might apply to geothermal direct use applications, although most agree that the sales tax exemption is the most relevant for geothermal projects.

The new standards for the RPS have opened the door for new investment in geothermal direct use due to the requirement that 30% of the megawatt-hours (MWh) of renewable energy come from distributed resources. The RPS includes thermal geothermal processes such as aquaculture, greenhouses, space heating, and district heating and allows utilities that finance these projects to receive credits towards their RPS requirements. The Arizona Corporation Commission (ACC) has been conducting a set of workshops to create an incentive program for renewable energy resources that would be similar among the regulated utilities since the new standard was proposed. Called the Uniform Credit Purchase Program, the incentives developed would provide direct financial payments to those developing electric production from geothermal or using geothermal resources in direct use applications.

Most agree that while the RPS is the most important state incentive for geothermal power production, the federal PTC is the largest overall incentive. The geothermal power project at Clifton is not on pace to qualify for the PTC before it expires. While developers agree that a two to three year extension would give them a better chance to get that project online, they contend that any other potential geothermal power projects in Arizona would not benefit in that time frame.

Power market

The two largest utilities in Arizona already have geothermal power in their portfolio, although it comes from plants in California. APS was the top provider of retail electricity in Arizona in 2004, providing 38.1%[25]. They are working with USDOE and private developers on the Clifton project. While the PTC and the RPS only affects IOUs like APS, municipal utilities and rural electric cooperatives in Arizona have also made efforts to incorporate renewables into their portfolios. The largest of these utilities in Arizona is the Salt River Project (SRP), one of the largest municipal utilities in the western U.S. In 2004, SRP provided approximately 35.6% of the electricity for Arizona residents (including 870,000 customers in the Phoenix Metropolitan Area). SRP has pursued renewable alternatives, offers incentives for energy-efficiency and solar installations, and is the top purchaser of geothermal power in Arizona; purchasing renewable energy credits (RECs) from a 25 MW geothermal power plant in California's Imperial Valley. Their total capacity from renewable energy is 80 MW (the generation of which makes up about 5% of their retail sales). In February of 2006, SRP set a new target of 15% of its total retail electricity sales coming from renewable resources and energy efficiency by 2025[26]. While both APS and SRP have procured geothermal power from California, most agree this is not a long-term option, given California's need to generate its own baseload renewable power. An issue for generating geothermal power in Arizona may be transmission in the long-term, however at this time transmission is not a major issue for geothermal development in the state, because the only area of interest right now is Clifton where the project would serve local load.

Regulations

The regulations in Arizona define a "geothermal resource" as:

> (a) All products of geothermal processes embracing indigenous steam, hot water and hot brines;
> (b) Steam and other gases, hot water and hot brines resulting from water, other fluids or gas artificially introduced into geothermal formations;
> (c) Heat or other associated energy found in geothermal formations, including any artificial stimulation or introduction thereof; and,
> (d) Any mineral or minerals, exclusive of fossil fuels and helium gas, which may be present in solution or in association with geothermal steam, hot water or brines.

Geothermal wells for the purpose of power production are permitted through the Oil and Gas Conservation Commission (OGCC)[27].

Most thermal wells or springs in the state are put to traditional water resource uses. Water issues will come up for any power or direct use project proposed in the state. State geothermal and water regulations apply to geothermal resources on all lands in Arizona except for tribal lands.

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[25] 38.1% – Source – Energy Information Agency (EIA): http://www.eia.doe.gov/cneaf/electricity/st_profiles/arizona.pdf

[26] Source – Salt River Project, 2/6/06: http://www.srpnet.com/newsroom/releases/020606.aspx & Source of 35.6% – Energy Information Agency (EIA): http://www.eia.doe.gov/cneaf/electricity/st_profiles/arizona.pdf

[27] For more information see Bloomquist, Gordon. "A Regulatory Guide to Geothermal Direct Use Development: Arizona". Washington State University, 2003: http://www.energy.wsu.edu/ftp-ep/pubs/renewables/arizona.pdf

Tribal lands in Arizona make up roughly 27% of Arizona's land. No geothermal direct use facilities are known to be operating on these lands. Those who work with tribes in Arizona assert that continued education and public involvement are essential if tribal leaders will pursue geothermal projects.

Roughly 42% of the total surface acreage in Arizona is federally-managed and approximately 49.2% of the total mineral acreage; half of which is managed by the BLM[28]. Clifton Hot Springs, Gillard Hot Springs, and the San Francisco Volcanic Field involve federal land, with both BLM and U.S. Forest Service (USFS) land in these locations (although drilling for the Clifton project is on private leases). With the limited number of power projects under development in Arizona, there are no lease backlogs. However, because regulators in the state have had a lack of experience with geothermal leasing, they are learning from other states, like Nevada, on how coordinate on geothermal projects in the future.

In the near-term, Arizona regulators are more likely to work on geothermal direct use projects; both on state and federal land. However, they point out that near-term projects will likely be more practical in rural agricultural areas outside major population centers. One reason for this is that most population centers in Arizona are designated as an active management area (AMA)—which includes Phoenix, Pinal, Prescott, Santa Cruz, and Tucson—where water use regulations are more intensive for large installations. For instance, if a user in an AMA plans to use a direct use well where more than 35 gpm is pumped, a well impact study is required[29].

Direct use

Existing direct use facilities in Arizona use geothermal resources for aquaculture, recreation, and space heating and geothermal water from shallow irrigation wells has been used directly by Arizona farmers to lengthen the season for fruit production (including table grapes and citrus plants).

Most agree that the geothermal direct use in Arizona remains poorly developed and is underutilized. Two reasons for this were given by geothermal expert Jim Witcher of Witcher and Associates, in his 1995 Report, *Geothermal Resource Data Base: Arizona* which summarized the 1995 database. The first is that thermal wells in Arizona typically exist in warm climates "where space cooling is generally more desirable than heating." The second is that "Arizona values the thermal waters more for irrigation of field crops, municipal water supply, and industrial uses than for the heat carried by the water". Therefore, according to Witcher and others, the first step to successful development and promotion is to find areas and uses with the most "potential to enhance or create economic opportunities"[30].

The general consensus by industry stakeholders in Arizona is that the most likely near-term geothermal development opportunities are for agricultural industries such as greenhouses and

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[28]Total tribal and federal mineral acreage in Idaho: Bureau of Land Management (BLM) (2002): Mineral and Surface Acres Administered by the Bureau of Land Management: http://www.blm.gov/natacq/pls02/pls1-3_02.pdf

[29]See: Cason, Lori. Arizona Department of Water Resources: "Water Management Support Section Notice of Intent Unit." Presentation given on 5/18/2006 at the Using the Earth's Energy: Arizona Geothermal Direct Use Conference in Tempe, Arizona & Bloomquist, Gordon. "A Regulatory Guide to Geothermal Direct Use Development: Arizona." Washington State University, 2003: http://www.energy.wsu.edu/ftp-ep/pubs/renewables/arizona.pdf

[30]James C. Witcher "Geothermal Resource Data Base: Arizona" Southwest Technology Development Institute, New Mexico State University. September 1995: Page 12

aquaculture. One of the most successful operations in the state today is in the Hyder Valley (about 40 miles east of Wellton) where an aquaculture facility produces shrimp along with various types of fish, depending on the season. The farm is near Aqua Caliente (Spanish for "hot water") where hot springs once existed that have since dried up. There are several fish farmers using hot water, but only one with a geothermal heating system installed. The system is used to pump and pipe geothermal water for heat and then irrigates it for agricultural use. According to the facility's operator, shrimp is produced in this area primarily due to the existence of salty waters; however the use of the geothermal resource extends the shrimp producing season, as well as providing other essential thermal energy needs for the operation throughout the year. Nearly all shrimp consumed in the U.S. today comes from overseas imports, however, the Hyder Valley shrimp farm is planning to expand operations.

Idaho

The geothermal-heated Idaho State Capitol. Photo taken by Daniel Fleischmann, GEA

Idaho has an abundance of geothermal activity, from its mountain hot springs to its volcanic remnants, including its calderas abutting Yellowstone National Park in Wyoming. Geothermal resource 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. Development has occurred in other parts of the state where geothermal resources are used for thermal energy needs to serve homes, public buildings, recreation, and businesses.

However, years of low-cost hydroelectric power have limited efforts towards extensive geothermal development. Geothermal resources provide only a small percentage of Idaho's heating and currently no electricity generation. With its population rising, energy prices soaring, and power markets reliant on out-of-state power facilities for 46% of its energy consumption, a new emphasis has been placed on developing Idaho's abundant geothermal resources.

New activity

In November of 2006, GEA released a report entitled *Geothermal Development Needs in Idaho* that discussed new activity and examined opportunities for further development in the state. Among the advances it reported, included data on the construction of Idaho's first commercial geothermal power facility at Raft River. As noted in Part I, Raft River was the site of the first binary geothermal power project. Funded by USDOE and constructed with the help of the Idaho National Laboratory, the demonstration plant had a nameplate capacity of 7 MW. It ran from the fall of 1981 until June of 1982, achieving a net-output of 4 MW. While the project was declared a success, the plant was shut down because it was not economic for commercial production at the time.

In its first phase, the new plant at Raft River will produce a constant flow of 10 MW of power to the electric grid, after which additional facilities expect to be built on the site. This project is by no means the only new activity in the state. Three more geothermal power plant projects have been proposed since 2004 and as of November of 2006 developers have either leased or submitted lease applications at four other geothermal prospects in the state.

In addition to electric power projects, several geothermal direct use projects have been proposed as well. These include an expansion of the City of Boise district heating system, with several new customers expected to join the system in coming months, and plans to expand the system to heat the campus at Boise State University. Other projects are on a smaller scale, including expansions to existing commercial facilities and expanding geothermal heating to new homes in multiple locations throughout the state.

The most active development of geothermal direct use facilities occurred during the 1970s and 1980s. Over the past 15 years, there has been some growth, including new customers joining the City of Boise district heating system, geothermal space heating installed in new homes built in Crouch in Boise County and near the Givens Hot Springs airstrip in Owyhee County, and expansions of existing facilities and businesses.

Potential

In Idaho, most of the promising areas identified as having near-term electric power production potential are located in the Basin and Range Province and the Snake River Plain. The Snake River Plain is a crescent-shaped rift zone characterized by young volcanism and containing geothermal resources that extends across south-central Idaho (See Figure 4).

Figure 4: Snake River Plain regional aquifer system:

Source – USGS: http://capp.water.usgs.gov/gwa/ch_h/jpeg/H052.jpeg

The Basin and Range Province extends into southern Idaho south of the Snake River with its largest section in the southeast and south-central part of the state. Both the Snake River Plain and the Basin and Range Province reflect a geologic setting with abundant faults, fractures, and inherent high crustal heat flows -- features that are important for the generation of geothermal systems. There is also geothermal electric power potential in the Idaho Batholith region, a large mountainous area covering approximately 15,400 square miles stretching from the Boise National Forest to the Bitterroot Mountains. Thermal springs are common in this region, where researchers assert that anomalous heat results partly from "the decay of radioactive elements contained in many of the minerals which commonly occur in the granitic rocks…" and "are also the result of deep circulation of ground water in fault zones."[31]

According to the WGA Geothermal Taskforce Report, it is estimated that there are 855 MW of near-term power potential in Idaho[32] enough baseload energy to provide nearly 30% of Idaho's current energy needs if sold entirely in-state[33]. However, in the report, there are 305 MW of new electric capacity possible at identified locations and 550 MW at "other Idaho sites". This differs

[31] Source – DeTar, Robert E. "Thermal Waters". Idaho State University: http://imnh.isu.edu/digitalatlas/hydr/thermal/thermal.htm
[32] See Western Governors Association (WGA) Geothermal Task Force Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (page 65)
[33] Source – Energy Information Agency (EIA): http://www.eia.doe.gov/cneaf/electricity/epa/fig7p2.html Take 90% availability for a geothermal power plant and the number is over 30.8 percent based on 2005 numbers for retail sales in Idaho.

from the analysis of other states in the report because so much of the supposed economical resource was not specifically identified. According to researchers, the primary reason for this is that many of Idaho's presumed sites are near hot springs where high heat flow has been recorded at the surface, but little to no subsurface exploration has been performed. However, heat energy at these areas may be able to be captured using the type of plant installed at Chena Hot Springs in Alaska. These units (or a similar type of technology) may be applicable at a multitude of Idaho's shallow geothermal aquifers and hot springs.

Promising resource areas

Besides Raft River, there are at least twenty identified geothermal resource areas in Idaho that can potentially be exploited for electric power. One location that has gotten considerable attention is Crane Creek Hot Springs, near Weiser at the Oregon border. Developers have attempted to establish a power plant project at Crane Creek Hot Springs since the early 1980s; however, none of them have been able to secure the financing necessary to complete the project.

Power plants have been proposed in southeast Idaho at China Cap, Sulphur Springs, and Willow Springs. All three areas are considered part of the Basin and Range Province. Both China Cap and Willow Springs are nearby Gray's Lake and the Blackfoot Reservoir in Bonneville and Caribou Counties where a temperature of 374°F (190°C) was recorded in a 3 km well drilled in 1979. Potential has also been suggested between Banida and Preston near Battle Creek Hot Springs and Squaw Hot Springs.

In the Idaho Batholith region, lease applications were filed in 2005 for Big Creek Hot Springs in Lemhi County, near the Montana border and Boiling Springs in Valley County about 75 miles north of Boise. A feasibility study for a power project at Big Creek Hot Springs was conducted in 1981 which outlined how development of the resource could serve a nearby cobalt mine and small communities to the south. While the study found that the project was technically feasible, economics were not favorable at the time. Boiling Springs is one of several locations in the forests north of Boise where geothermal resource areas have demonstrated potential. Feasibility studies are likely in the near-term.

In the Snake River Plain, several potential areas have been targeted including Barron's Hot Springs and the Magic Reservoir Hot Spring areas in Camas County. Potential areas have also been targeted in a wide area within the Mount Bennett Hills region of Camas and Elmore Counties and the Rexburg Caldera Complex in Madison County.

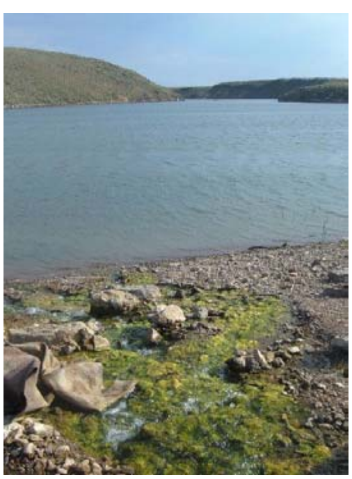

Photo: Hot water pours over the rocks near Magic Reservoir, situated in a valley of rolling hills south of the Smoky Mountains. A hot tub (not in the photo) sits to the side where swimmers still use the geothermal waters for soaking. Photo by Daniel Fleischmann, GEA

Programs

To date, Idaho has provided minimal financial assistance to help explore and develop geothermal resources in the state, and currently provides no funds directly for programs that perform geothermal research or exploration. There is no RPS in Idaho, due in part to its reliance on hydroelectric power and what some have considered a resistance to regulations deemed unnecessary.

Any significant research activity in Idaho has been federally-funded, including geothermal research and outreach efforts by the Idaho Department of Water Resources (IDWR) Energy Division and research at Boise State University, Idaho State University, and the Idaho Water Resources Research Institute (IWRRI) at the University of Idaho

These programs have participated in the Idaho Geothermal Working Group since its creation in 2001, with the help of USDOE and the GPW program. In the summer and fall of 2002, select members of the Working Group drafted a Strategic Plan which reviewed the needs and barriers involved in the continued development of geothermal resources, and composed strategies and an action plan for the future. It was released in October of 2002. Since its release, members of the Working Group have updated databases, held conferences, performed outreach, and created Internet resources. Meetings have been held throughout the state to discuss new developments with investors, businesses, and the general public. The most recent being a series of three meetings held in early November 2006 in Boise, Cascade and Murphy to discuss potential developments and applications, including the use of PureCycle® geothermal power plants.

Additional support has been given by the Idaho National Laboratory, which has geothermal research staff in Idaho Falls and has had a presence in the state for three decades. It is responsible for many of the reports and on-the-ground research that has helped establish a framework for future study. While not everything the Idaho National Laboratory geothermal team does relates to Idaho's resources, most agree they provide critical expertise valuable to development efforts in the state. They collaborated on a GRED project at Raft River for well clean-up and a flow test program completed in 2004 that laid the groundwork for its completion.

There is a general consensus that for Idaho's potential to be realized there needs to be funding for new exploration and resource characterization. Despite its potential resource, Idaho has seen far less activity than states like Nevada. For Idaho's geothermal prospects where there was geochemical and geological work, there has been little follow up exploration. Most of the existing data on areas that were drilled in Idaho dates back to the 1970s and early 1980s, and drilling in these areas was usually limited to one or two wells.

Researchers say that because the geothermal resource in Idaho is not well defined there exists a unique opportunity for new discovery. Efforts are underway to pursue an exploration program through the Intermountain West Geothermal Consortium (IWGC). IWGC is a collaborative effort of researchers in four states to conduct on the ground research for promising areas that have not been well-defined. Participants include several Idaho institutions, including Boise State and the University of Idaho. However, additional funding is needed for the program to begin on-site exploration efforts.

Incentives

On the state level, Idaho has a low-interest loan program (for which geothermal electric power and direct use are eligible) and a sales tax exemption for equipment used in the construction of renewable power facilities—passed in 2005—(for which only geothermal electric power projects are eligible). The legislature passed a sales tax exemption in 2005, including geothermal[34]. However, most agree these incentives are not large enough to make a significant impact. In fact, the low-interest loan program has only provided loans to two geothermal projects—both direct

[34]Source – Database of State Incentives for Renewable Energy (DSIRE): http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=ID08F&state=ID&CurrentPageID=1&RE=1&EE=1

use—in its 20-year existence). A state renewable production tax credit of 0.5¢ per kWh passed through the legislature in 2004, but was vetoed by the governor due to fiscal concerns.

Clean energy advocates working with the state legislature assert that the geothermal industry needs to be more involved in the incentive process (both for power production and direct use). This is critical at present because Idaho is revising its State Energy Plan, which has remained unchanged since 1982. The revised plan is expected to be completed in early 2007, and many of its provisions will assuredly impact future geothermal development.

On the federal level, the PTC has benefited the developers of the Raft River project, who are eligible to use the credit because the plant is expected to be online before the credit expires. However, additional facilities at Raft River will be affected by whether or not the PTC is extended beyond December 31st, 2008 and for how long. Because the cost of power in Idaho remains among the lowest in the country, developers contend that the PTC is critical to the demand for geothermal projects in Idaho. A longer extension will likely enable other projects under development in the state to move forward with confirmation drilling. In addition to the PTC, most agree that funding for exploration work by the IWGC is essential to identifying a queue of projects and reducing the risk and uncertainty for developers interested in Idaho's geothermal prospects. Well data shows no more than a dozen geothermal exploratory wells deeper than 1,000 feet (305 meters) have been drilled in Idaho outside of the Raft River Valley[35].

Power market

In the early 1980s, Idaho customers received nearly ¾ of their power from hydroelectric sources. As energy demand has grown, the supply of hydroelectric power has remained stagnant and now makes up a smaller piece of the pie. Salmon recovery issues in the Pacific Northwest will likely limit future development, and may cause hydroelectric dams on the Snake River to close operation in the near future.

The state's largest utility, Idaho Power, relied on hydroelectric generation for 45% of its power generation in 2004, relying mostly on out-of-state coal-fired generation for the rest[36]. Idaho Power provided 57.7% of retail electricity in the state in 2004, covering areas mostly in southern and central Idaho not served by cooperative and municipal utilities. Its largest customer-base is Boise and Treasure Valley -- both areas experiencing considerable load growth. In 2004, PacifiCorp and Avista provided another 30% of Idaho's retail electricity, with the rest served by municipal utilities and rural cooperatives[37].

There are restrictions on building coal-fired power plants in Idaho, causing utilities to consider out-of-state coal plants for baseload power. This has also led to increased interest in procuring geothermal projects. Idaho Power has committed to purchase electricity from the first phase of the Raft River geothermal project and in 2006 they increased their existing request for proposal (RFP) for geothermal electric power from 100 MW to 150 MW (albeit over a longer time period).

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[35] Additional drilling has been done that has not been documented by state well data. However, that number is likely small. Sources – INL Geothermal Program: Idaho-collocated_Keller_revised.xls; Idaho Deep Wells.xls & Idaho Department of Water Resources, Energy Division: geothermal_snapshot.xls

[36] Source – Dunlop, Michelle. "Senate sends energy plan to governor", the Times-News, Twin Falls, Idaho. 3/29/06: http://powermarketers.netcontentinc.net/newsreader.asp?ppa=8knpp%5E%5Bgkquunr%5BVgb%216%3C%22bfel%5D%21

[37] Source – Energy Information Agency (EIA) – 2004: http://www.eia.doe.gov/cneaf/electricity/st_profiles/idaho.pdf

Geothermal development in some areas of the state is limited by either development restrictions or transmission access. Much of Idaho's transmission infrastructure was built in the past 50 years, and as the state population has grown, some transmission lines have begun to reach capacity limits, (even with subsequent upgrades). The main state grid runs east-west along the Snake River Plain, although large transmission lines run from Hells Canyon near Weiser. Several of the proposed power plant projects have adequate transmission access, including China Cap, Crane-Creek Hot Springs, Magic Reservoir, Raft River, Sulphur Spring, and Willow Springs. However, more remote resources in parts of the Basin and Range Province, and the Idaho Batholith face additional hurdles, especially resource areas on USFS land, where transmission projects require NEPA analysis.

Regulations

The regulations in Idaho define a "geothermal resource" as "the natural heat energy of the earth" further classified as "ground water having a temperature of 212°F (100°C)" or more in the bottom of a well. However, the state regulations further describe geothermal resources to be sui generis, "being neither a mineral resource nor a water resource, but they are also found and hereby declared to be closely related to and possibly affecting and affected by water and mineral resources in many instances." Idaho has separate designations for a "low-temperature geothermal resource" which is defined as "ground water having a temperature of greater than 85°F (29°C) and less than 212°F (100°C) in the bottom of a well". Low-temperature geothermal resources used for purposes such as "greenhouse heating, warm water aquaculture, space heating, irrigation, swimming pools and spas" are administered by the IDWR, which is responsible for the regulation of all water resources (with additional oversight by other state agencies) and regulated "in accordance with the rules and statutes governing groundwater appropriation and well drilling regulations"[38].

Water use issues affect all energy and agricultural development in Idaho. Water is critical for irrigation and the survival of agricultural industries and water rights and appropriations can be contentious, especially in years of drought. State geothermal and water regulations apply to geothermal resources on all lands in Idaho except for tribal lands. Tribal lands in Idaho make up roughly 1.1% of Idaho's land. The largest reservation is the Fort Hall Reservation north of Pocatello where potential for geothermal resource development has been suggested by research in the area.

Many of Idaho's most promising geothermal resources are located on or near federally-managed lands. 64% of Idaho's land is managed by the federal government (69% of the mineral acreage)[39]. While resource areas in the Snake River Plain tend to contain mostly private land (with a small mix of BLM land), areas in the Basin and Range Province contain significant tracts of BLM and USFS land. About 39% of Idaho lands are managed by the USFS. The largest concentration of this land covers the Idaho Batholith region. Because of this, geothermal development in Idaho has been affected by a Memorandum of Understanding (MOU) between the USFS and BLM authorized in EPAct, and officially signed in April of 2006. Efforts by these agencies to encourage renewables development on federal land have increased in recent years. By February of 2002, there were no geothermal leases on federal lands in Idaho and the relationship between

[38]Bloomquist, Gordon: "A Regulatory Guide to Geothermal Direct Use Development: Idaho". Washington State University Extension Energy Program, 2003: http://www.energy.wsu.edu/documents/renewables/idaho.pdf (page 2)

[39]Total tribal and federal mineral acreage in Idaho: Bureau of Land Management (BLM) (2002): Mineral and Surface Acres Administered by the Bureau of Land Management: http://www.blm.gov/natacq/pls02/pls1-3_02.pdf

the BLM and the USFS on this matter was relatively non-existent in the state. However, as of August 2006, there were three federal leases issued and 12 pending lease applications under review in four of Idaho's most promising resource areas. Nine of those lease applications are for geothermal prospects on USFS land.

Direct use

By the mid-1990s, the Geo-Heat Center at the Oregon Institute of Technology (OIT) had identified 73 operating direct use facilities operating in Idaho at over 40 separate resource areas. Among these are greenhouses, aquaculture facilities, schools, hospitals, churches, hotels and resorts, using temperatures ranging from 85 to 200°F (29 to 93°C). OIT suggests there are additional facilities not included in its records[40]. However, despite a history of using geothermal resources for direct uses in Idaho as compared with surrounding states, researchers frequently express exasperation that these resources are vastly under-utilized. Much of Idaho's population resides along the Snake River Plain, which has a number of existing facilities. Due to its northern latitude and the high elevation of many of its towns and communities, Idaho's winters are long and have large heating loads. The presence of geothermal resources throughout the state makes geothermal direct use applications a viable heating alternative to fossil fuels. Besides energy savings, proponents of these technologies tout the contribution to economic development, particularly of geothermal-heated greenhouses, which currently employ several hundred workers in the state.

While the largest installation remains the four district heating systems in Boise, there are also commercial resorts and greenhouses in the Boise area. Customers of City of Boise system currently pay rates priced at 30% below the cost of natural gas, and interest from new customers has increased planning for expanding the system. The most active areas of development outside of Boise include spas, space heating, and commercial greenhouse and aquaculture operations between Hagerman, Buhl, and Twin Falls in south central Idaho along the Snake River Plain, and greenhouses, spas, and residential heating in Boise and Valley Counties. Researchers suggest that new regulations governing royalty collection on federal land will likely open up more resources in Boise and Valley Counties to direct use projects, particularly in the Boise National Forest. Existing direct use facilities in this area are all located on private or state land, and none of numerous hot springs on USFS land has been used for commercial or residential use. In fact, nearly all new commercial developments in the state that have been proposed are for resources on private lands, generally in areas where the developer owns the water rights. This includes a planned greenhouse project in Owyhee County at the Castle Creek KGRA.

Direct use facility operators say that commercial geothermal developments like the Castle Creek KGRA project represent needed economic development for Idaho's agricultural community. According to Leo Ray of the Fish Breeders of Idaho, Inc. in Buhl, there are many opportunities in Idaho to use geothermal resources for agricultural production. Leo Ray currently uses geothermal resources to raise catfish, tilapia, sturgeon, and alligators. However, he had to build his operation from the ground up, and he says that the reason that many available geothermal resources go unused is that many of the developable low-temperature geothermal resources in Idaho are on private land owned by small farmers and ranchers who rarely communicate with the government

[40]This includes both installations that have come online since the mid-1990s and installations already existing that were not recorded at the time. Source – Geo-Heat Center, Oregon Institute of Technology (OIT): PTL idaho-direct.xls

and the research community[41]. Leo Ray suggests that agricultural extension programs operated by land-grant universities, like the University of Idaho, can help expand use of the resource for greenhouses, aquaculture, or other applicable uses.

In addition to commercial uses and agricultural uses there is interest in development in areas such as Grandview, Hailey, Ketchum, Mountain Home, and several locations in the Boise metropolitan area. These communities and numerous others in the state have had direct use projects proposed in the past, but abandoned them because they weren't cost effective at the time.

[41]They are "developable" because they are near agricultural areas with existing developments or populations in the area.

Nevada

Photo: Mount Rose (10,776') looms a vertical mile above the Richard Burdette Plant, Steamboat, Nevada. Taken by Daniel Fleischmann, GEA

Nevada is home to the Great Basin, a large section of the Basin and Range Province that runs throughout the western U.S. The Great Basin covers the entire state, with high-temperature geothermal areas concentrated in northeast and north-central Nevada primarily north of US Route 6 and west of Elko and Eureka[42]. For thousands of years, geothermal resources have been used in Nevada and the Great Basin for cleansing, cooking, and heating. However, it wasn't until 1940 that the state's first commercial geothermal operation was installed to heat residential homes in Reno. Exploration for high-temperature resources began in the 1970s after the first oil crisis. The exploration performed during that period led to the development of every existing geothermal power plant in Nevada today. Nevada's first geothermal power plant came online in 1984 and 13 more geothermal power plants were constructed in the state over the next decade.

Over the past few years, Nevada has garnered an impressive queue of new projects under development. As energy issues have become more prominent in the state, the recent progress made in Nevada in developing its geothermal resources can serve as a model for states wishing to increase geothermal development. Its developers, utilities, universities and state and federal agencies have all worked together to facilitate the development of new projects.

However, this is a recent phenomenon. There was a lull in development between 1993 and 2004. It was also during that time that Nevada experienced a growth spurt. Its population nearly doubled and its retail sales for electric power increased by over 57%[43]. This has made these recent efforts that much more critical.

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[42]The geothermal areas stretch as far south as the Railroad Valley and Silver Peak, making up about 2/3rds of the state, which is roughly 70,000 square miles.

[43]Actual numbers have Nevada's population nearly doubling between 1990 and 2005, and according to the Energy Information Agency (EIA), between 1993 and 2002, retail sales for electric power in Nevada increased by 57.8%, growing at a rate more than 2.7 times faster than the U.S. average during that time. Sources: Energy Information Agency (EIA): http://www.eia.doe.gov/cneaf/electricity/epa/epat7p2.html &

New activity

In December 2006, GEA released a report entitled *Geothermal Resource Development in Nevada – 2006* that examined ongoing efforts to facilitate development in the state and how policymakers can address challenges to developing Nevada's potential and get new projects online. As of November 2006, Nevada had 15 power plants in operation. The most recent installation was in November 2005, when the 25 MW Richard Burdette Plant came online at Steamboat Springs, just outside of Reno.

The well field at Steamboat Springs already has several power facilities, and there are three more facilities expected to come online at the site in the next two to three years. The well field is planned to support a capacity of 100 MW once these projects are fully developed. In addition to projects at Steamboat Springs, there are 21 other power projects under development in Nevada and another five that have been proposed. As of December 12th, 2006, the total queue of new projects under development was up to 751 MW and adding the number under proposal amounts to 853 MW; based on the GEA's Nevada report. The number of projects under development is different from the one listed in Table 1, because of a subsequent update made on December 12th, 2006, which added 90 MW in Phase 1[44].

Nevada is currently the most active state in terms of new exploration and research. As many as 20 projects are under development on "greenfields" -- i.e. locations that have never had a producing well. Nevada is also seeing a broadening of applications for its geothermal resources. As noted in Part I, Nevada will add a geothermal-powered bio-diesel facility in operation at Wabuska in the first quarter of 2007. In addition to that project, drilling began in late-2006 for a large-scale geothermal-powered ethanol plant in Gerlach, 100 miles north of Reno. Developers are also looking to expand geothermal space heating applications in Elko and Reno and feasibility studies are underway for other geothermal direct use projects in the state.

Potential

Nevada has been demonstrated as a hotbed of geothermal activity, from both its hot springs and surface features and through the active exploration that has taken place there. Nevada's geothermal resources are the products of both recent magmatic activity and the deep circulation of high heat flow in underground reservoirs. Both types of geothermal systems can be used for power production, and both are prevalent in the state. Evidence of recent magmatic activity is often identified at the surface by the presence of Pleistocene rhyolite domes -- surface features abundant in northern Nevada. According to the USDOE, deep circulation of high heat flow is caused by the Great Basin pulling apart each year, creating fractures in the earth's crust which allows water to circulate in the hot, primarily volcanic rock formations[45].

The 853 MW of proposed geothermal power capacity in Nevada is more than half of what the WGA Geothermal Task Force report estimates as economically developable by 2015. In the report, up to 1,488 MW of geothermal electric power potential was estimated as economically

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http://www.eia.doe.gov/cneaf/electricity/st_profiles/nevada.pdf & Negative Population Growth – State Population Facts - Nevada: http://www.npg.org/states/nv.htm & U.S. Census: http://quickfacts.census.gov/qfd/states/32000.html

[44] These numbers are not included in the analysis in Part I and are not included in Figure 1, which goes with the numbers from GEA's November 10th survey. However, these projects were added by request of the developer, and are listed in the report, *Geothermal Resource Development in Nevada – 2006*

[45] Source – U.S. Department of Energy (USDOE), Geothermal Today – Geothermal Energy Program Highlights (2001): Page 8.

viable at identified locations in Nevada. The report estimated higher-cost potential by 2025 as high as 2,895 MW from identified resource areas. As noted above, the list of geothermal sites in the WGA report complemented the sites listed in the PIER report. 42 geothermal prospects are given electric power potential estimates in the WGA report (63 total are mentioned – with 21 estimated as "all other NV sites together") and 60 prospects are identified in the PIER report (although the report did not estimate the # of MW) [46].

In 2004, the University of Nevada-Las Vegas released population forecasts which estimated Nevada would contain 3.6 million residents by 2024. This would result in an increase of nearly 60% from the energy needs in 2004 (based on existing consumption figures) representing an additional 17,523 GWh needed by that time. If the 2,895 MW of potential estimated by WGA is developed by that time, 140% of that new demand could be met by geothermal power plants (not factoring in a decline in energy intensity through improvements in energy efficiency)[47].

Promising resource areas

Figure 5 shows the areas with the highest concentration of geothermal activity in Nevada. The most active regions for development are situated along the I-80 corridor near Winnemucca, Steamboat Springs in Reno, in Churchill and Lyon counties just southeast of Reno, in northwest Nevada at Pyramid Lake and just to its north, and several areas in north-central Nevada between I-80 and U.S. Highway 50. Another area with new projects under development is near the California border along the Sierra Nevada mountain range in Esmeralda and Mineral Counties.

In GEA's Nevada report, 24 projects cited as under development were in 20 unique resource areas. In addition, the five proposed projects represent another five unique resource areas. While several of these projects are in areas that already have had producing well fields (including Desert Peak, Steamboat Springs, and Stillwater) most of the new projects are in areas where no development has taken place. Among these, projects at Blue Mountain, Buffalo Valley, Carson Lake, and Salt Wells have already secured PPAs.

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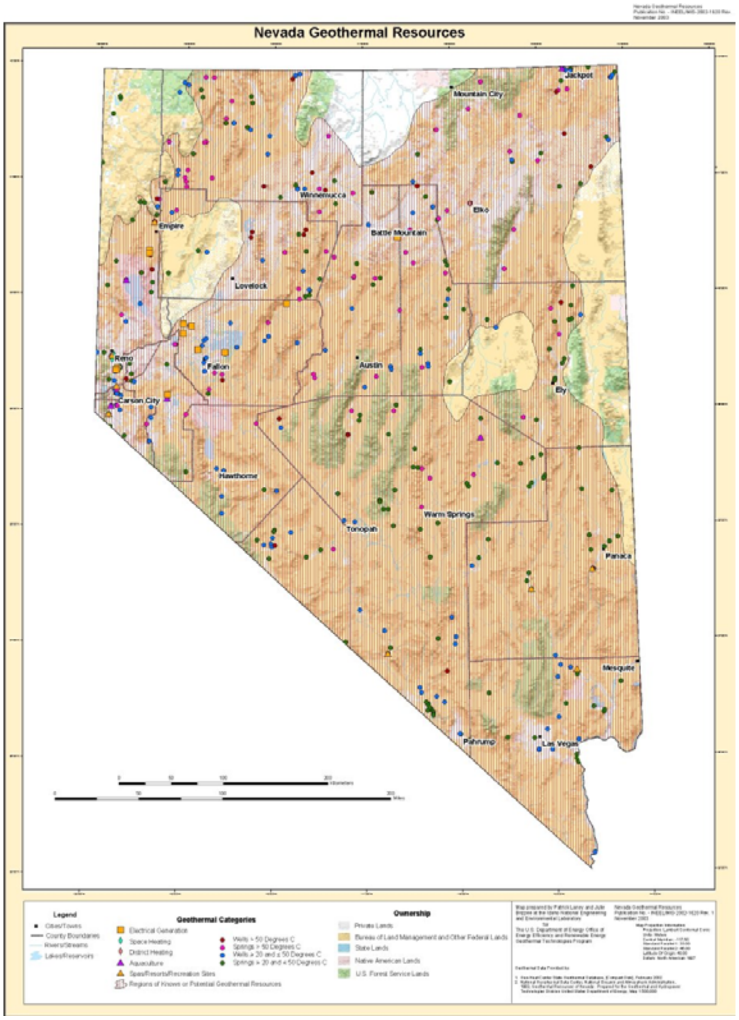
[46]Sources: GeothermEx, Inc. New Geothermal Site Identification and Qualification. Prepared For the California Energy Commission (CEC) Public Interest Energy Research Program (PIER). April 2004: http://www.energy.ca.gov/reports/500-04-051.PDF & Western Governors Association (WGA) Geothermal Taskforce Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (pages 62-64).

[47]While the 2,895 is predicted by 2025, we roughly estimate 2,895 by 2024 for this calculation. Sources: Energy Information Agency (EIA) (2004): http://www.eia.doe.gov/cneaf/electricity/st_profiles/nevada.pdf & University of Nevada Las Vegas, Center for Democratic Culture – Economic Trends and Forecasts for Nevada: http://www.unlv.edu/centers/cdclv/healthnv/economy.html

Figure 5: Nevada geothermal resources – Source: Idaho National Laboratory: http://geothermal.id.doe.gov/maps/id.pdf



Programs

Nevada has several programs and policies that directly affect geothermal development. The Nevada RPS was initially passed in 1997 by the state legislature, and in 2001 was revised to require minimum renewable portfolios to increase by 2% every 2 years, culminating in 15% by 2013. In 2005, the standard was revised again to 20% by 2015, increasing 3% every two years. Nevada's potential for geothermal development will likely enable it to be the largest source of these increases. Although the RPS requires that 5% of the portfolio come from either solar power plants or residential solar energy and utilities are allowed to meet up to ¼ of their RPS requirements (or 5% of their total requirements by 2015) through demand-side management (i.e. energy conservation or energy efficiency), based on the GEA Survey of new projects under development, if 5% of the RPS was met by solar power and 5% through demand-side management, geothermal power plants could meet the other 10% even if only geothermal projects currently in Phases II through IV stages of development (see Table 1) were developed by 2015.

Federal funding has been the largest source for research programs in Nevada. The only major program in the state is at the Great Basin Center for Geothermal Energy at the University of Nevada-Reno (UNR). The Great Basin Center was officially established in May of 2000, and has since become a model research institute for geothermal study in the U.S. Among its recent activities include geophysical and geologic analysis, regional and local structural analysis, resource characterization to understand existing geothermal systems, remote sensing (mapping rocks, minerals, and thermal features from aircraft and satellites), using multi-gas soil gas detectors to find concealed structures, satellite imagery, seismic velocity, short-wave and thermal infrared imagery, geochemistry, and InSAR. Using the Global Positioning System (GPS), methods like InSAR are used to study earth movement over time to determine if geological features are pulling part from one another indicating preferential locations for geothermal systems[48]. Already, the work done at the Great Basin Center has led to new projects that are under lease and are expected to move ahead to exploration drilling.

On the state level, there are no specific geothermal programs funded by state dollars. While the Public Utilities Commission of Nevada (Nevada PUC) regulates the state RPS, and incentives and rate flexibility mechanisms are built into the system, the state has no grant or loan program for geothermal development. The geothermal program at UNR receives some general state funding for staff, but not for specific research projects. Geothermal permitting activities at the Nevada Commission on Mineral Resources-Division of Minerals (NDOM) are funded by fees on oil, gas, and geothermal drilling. Geothermal programs at the State Energy Office are funded partly from royalties from geothermal power plants and partly from the USDOE. Federal funding for state energy offices has been reduced 25% in recent stop-gap funding bills, leaving Nevada's government with less ability to expand renewable energy programs at the state level. While most agree the Nevada state government does not have the capability to fund a large geothermal program like the Geothermal Resources Development Account (GRDA) and PIER in California, the contribution of geothermal resource development to the state energy mix warrants additional support. In fact, the establishment of a state renewable energy office is under consideration, funded by a tax such as a "public benefit" or "system benefit" fund, or through another revenue stream, and Nevada has already implemented a similar type of funding source to help pay for projects that qualify for the RPS (described in the "Needs of the power market" section in Part III).

While the geothermal industry has been active in pursuing projects in Nevada, support has come from the USDOE through the GRED program. Developers of geothermal prospects in ten separate resource areas in Nevada received assistance from the GRED program and six of them now have projects under development. Projects have been proposed at two of the other locations.

Because of the industry presence in Nevada, and the active relationship between the USDOE, the Great Basin Center, the State Energy Office, and the utilities, there is no official "state working group" in Nevada. However, GPW has participated in outreach events and regulatory meetings, they have brought together investors, they have reached out to tribal groups, and they have held an all-states GPW meeting in Reno in 2004. The Great Basin Center also hosts workshops (sponsored by the USDOE Technologies Program) as part of their outreach mission, the most recent of which took place December 4-5, 2006, to discuss the industry's exploration needs.

[48]For more information see the U.S. Geological Survey (USGS) – "What is InSAR?": http://quake.usgs.gov/research/deformation/modeling/InSAR/whatisInSAR.html

Incentives

The PTC and the RPS have been critical policies affecting Nevada's geothermal development. The Richard Burdette plant that came online in 2005 is the first geothermal power plant to take advantage of the PTC and there are at least six more power facilities expected to be built in Nevada by the time the credit expires[49].

Besides the RPS, the only existing incentive for geothermal development at the state level is a property tax exemption which exempts "any value added by a qualified renewable energy system from the assessed value of any residential, commercial or industrial building for property tax purposes" including a geothermal power plant[50]. There are other small tax abatement programs in Nevada, but these affect revenues of county governments and the use of them has been infrequent.

Because geothermal power plants are expected to play a primary role in meeting the state RPS, clean energy advocates suggest that the state can do more to incentivize these projects. That could mean a state tax credit. That could mean a subsidy. It could mean loan guarantees to developers to reduce risks.

Power market

Nevada has two major utilities, Nevada Power Company and Sierra Pacific Power, both IOUs. The parent company, Sierra Pacific Resources, manages both utilities. There are also a number of small rural cooperatives and municipal utilities in the state, although they have not been active in geothermal development.

Nevada Power Company and Sierra Pacific Power plan to spend $2 billion from 2007-2015 to comply with the RPS, but that figure will be a combination of spending by both utilities. The bulk of new renewable projects will be constructed in northern Nevada, the majority of which are geothermal projects (counting existing projects and projects under development that have negotiated contracts). As of December 2006, all geothermal power plants in Nevada deliver electric power to Sierra Pacific Power, except for Dixie Valley which sells its power to Southern California Edison (SCE).

There is a general consensus that transmission access remains a barrier to geothermal development in Nevada. While over 2/3rds of the retail power sales in Nevada serve the southern part of the state, there is no transmission line connecting northern and southern Nevada that would bring geothermal power plants to the Las Vegas power market. However, a north-south intertie connecting the two utility grids has been proposed and is planned for completion by 2010 at the earliest. The line would be 500 kV and connect Las Vegas to Ely, 245 miles to the north where a large-scale next generation coal-fired facility is proposed that will sell power onto the high-voltage line. Until the north-south intertie connects the utility grids, power generated by Sierra Pacific Power in excess of its RPS requirements will be sold as RECs to Nevada Power Company.

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[49] This includes all projects in Phase 3 and 4 from Table 1, except for Blue Mountain, Buffalo Valley, and Carson Lake, which are expected to be online in 2009 at the earliest.

[50] For more information see the Database of State Incentives for Renewable Energy (DSIRE) – Renewable Energy Systems Property Tax Exemption: http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NV02F&state=NV&CurrentPageID=1&RE=1&EE=1

Regulations

Approximately 83% of the surface land and 83.5% of the mineral acreage in Nevada is managed by the federal government. Many of Nevada's best geothermal resources are on federal land, which affects all aspects of development, from leasing to transmission. Projects on federal land must also comply with state regulations which define a "geothermal resource" as "the natural heat of the earth and the energy associated with that natural heat, pressure and all dissolved or entrained minerals that may be obtained from the medium used to transfer that heat, but excluding hydrocarbons and helium." Geothermal resources in Nevada belong to the owner of the surface property (which is the federal government if the resource is on federal land or mineral acreage). Nevada's regulatory definition of a "geothermal resource" does not place a temperature limit, nor provide separate definitions for different temperatures. Rather a "geothermal resource" is defined by how it is used. A well drilled for geothermal power production is considered an industrial well, while most geothermal direct use applications fall under the designation of a "commercial well" which covers applications such as greenhouses, aquaculture, space heating, irrigation, swimming pools, and spas. These wells require drilling permits from the NDOM. Residential geothermal space heating projects often fall under the designation of a "domestic well", although that only includes space heating on a single parcel of land[51].

Private lands in Nevada predominate near cities (like Las Vegas and Reno) or else are scattered in small areas. State lands make up less than 1% of Nevada's total acreage and predominate in state wildlife refuges and in Carson City where the state capital offices reside. Water appropriations apply to all land in Nevada, and involve tribal lands in the process as much as possible. Tribal lands in Nevada make up roughly 1.7% of its land. There are three tribal reservations of particular interest for geothermal development opportunities. One is the Pyramid Lake Paiute Reservation located 50 miles north of Reno where extensive exploration has been performed and development is likely within the next few years. The others are in the Walker River Paiute Reservation and the Fallon Reservation and Colony of the Paiute-Shoshone tribe. Developers have expressed interest in geothermal projects in both reservations, although no projects have yet been proposed. However, the Fallon Reservation and Colony abuts existing geothermal power facilities at Stillwater, and tribal leaders are involved in the process of the new facility currently being developed there.

There a several projects under development on federal lands in Nevada, and new plants are expected to be constructed on federal leases within the next three years. For several years, the volume of federal lease applications in Nevada had created a significant backlog which stifled new development. However, after additional funds were appropriated to BLM to conduct the necessary NEPA documentation, they have been able to significantly reduce the backlog.

Direct use

In Nevada, geothermal resources have been used for a variety of direct use applications, including aquaculture, heap leaching, greenhouses, recreation, vegetable dehydration, and district and space heating. Over the past few years, some of these facilities have gone out of business, especially those in remote areas. However, this decline is expected to cease and new projects are likely to emerge in coming months and years.

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[51]For more information on state regulations see: Bloomquist, Gordon: "A Regulatory Guide to Geothermal Direct Use Development: Nevada". Washington State University Extension Energy Program, 2003: http://www.energy.wsu.edu/documents/renewables/nevada.pdf

Total federal mineral acreage in Nevada: Bureau of Land Management (BLM) (2002): Mineral and Surface Acres Administered by the Bureau of Land Management: http://www.blm.gov/natacq/pls02/pls1-3_02.pdf

An industrial park is under construction in Elko, with the first building already completed, which will utilize an existing geothermal district heating system. Another project under development is at the Redfield Campus in south Reno near the Steamboat geothermal area. The Redfield Campus is a collaborative effort between Ormat Technologies Inc., UNR and the Truckee Meadows Community College. There are plans to heat the buildings with geothermal fluid from the nearby power facilities at Steamboat Springs; which will also provide 100% of the power for the campus. When completed, the campus will have six buildings and will house, among other programs, a "Renewable Energy Center" where students will be able to study geothermal energy, as well as other forms of renewable energy[52]. Space heating systems in the Moana neighborhood in Reno are also expected to increase. More than 250 individual wells currently serve several hundred homes and businesses in the city. No new geothermal systems have been installed in this area since the early 1990s. However, new installations are expected over the next few years as recent increases in heating costs have driven new demand.

Feasibility studies have also been performed at Hawthorne and Fernley (where development is likely in the near-term). Researchers suggest that new regulations governing direct use projects using federal resources can be very effective in Nevada. Every city and town in Nevada is encircled by federal land, with geothermal resources in close proximity to communities. Nevada currently has a direct use facility that has paid royalties to the federal government. This operation is at Brady's Hot Springs, where ConAgra Foods, Inc. operates a vegetable dehydration facility next to an adjacent geothermal power plant.

One other operation in Nevada has paid royalties to the federal government for its geothermal direct use facility. This operation was at the Round Mountain Mine where geothermal heating was used for heap leaching. According to John Lund of the Geo-Heat Center, the reason it went idle is because of "low prices for gold and silver" and "high operating costs" no longer justified paying the "federal royalty charge for the use of the geothermal energy produced from wells on [BLM] land" which amounted to 10% of "the equivalent avoided competing fuel cost" at the time[53]. When in operation, the mine piped geothermal fluid from shallow wells to transfer heat to cyanide heap leach solutions designed to extract additional gold and silver from piles of ore. This process is generally not feasible in cold weather, however when using geothermal heating, the process can continue year-round.

While heap leaching is one potential use for geothermal resources in Nevada that is relatively unique to the state (given the size of its gold reserves) researchers say that there are a number of unique uses for geothermal resources. For example, the developer of the bio-fuels plant in Wabuska is working with the state government on indigenously-produced agricultural feedstock to use for the facility. Nevada is not a major agricultural state, taking in just under $447 million in 2002 from agricultural products and livestock (primarily cattle) -- a small percentage of its total economy[54]. However, researchers assert that geothermal resources create opportunities for agricultural applications in Nevada that wouldn't otherwise be available, such as aquaculture,

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[52]For more information on this project, see the Great Basin Center for Geothermal Energy: UNR Renewable Energy Center (UNR-REC): http://www.unr.edu/Geothermal/UNRREC.htm

[53]Sources:
Lund, John, "Examples of Industrial Uses of Geothermal Energy in the United States." GRC TRANSACTIONS, V. 30, September 2006: Pgs 214-215 & Nevada Bureau of Mines and Geology – Round Mountain Mine http://www.nbmg.unr.edu/geothermal/site.php?sid=Round%20Mountain%20Mine

[54]Source – U.S. Department of Agriculture (USDA) – Nevada State Agricultural Overview – 2005: http://www.nass.usda.gov/Statistics_by_State/Ag_Overview/AgOverview_NV.pdf

greenhouses, milk and cheese processing facilities, and vegetable drying. Furthermore, because Nevada has promising resources nearby major highways and rail lines, some say it is possible to build these types of facilities at these locations. These technologies can provide jobs and tax revenues for communities without requiring additional water use to operate.

For residential space heating, researchers suggest that there remains potential to be studied in populated areas in northern Nevada, including Carson City, Fallon, and Sparks. Potential also exists along the I-80 corridor where populations have been growing over recent years.

New Mexico

Photo: *"Cerro Pedernal from the West."* The Jemez Mountains, New Mexico. The Jemez Mountains have a history of geothermal activity. This photo is of Cerro Pedernal (9,862'); not far from the Valles Caldera. Photograph by Ed Fornataro of http://www.summitpost.org (Used by permission)

New Mexico is a geologically diverse state. It ranges from wide open desert to alpine forests to expansive farmland to dormant volcanoes. Although geothermal hot springs resorts and spas have operated in New Mexico for decades, most agree that the utilization of geothermal resources are rather modest considering New Mexico's overall energy use. Efforts to develop and explore for high-temperature geothermal resources (capable of power production) began in New Mexico in the early 1970s and large amounts of land were leased for geothermal exploration in the state. However, only a few areas were seriously drilled during that time, while many other potential resource areas were left unexplored. In the 2005 Geo Hills Associates report, they cited 443 thermal gradient boreholes in 23 separate prospects in New Mexico. 26 slim holes and/or exploration or production wells were drilled in a few of these, mostly in the 1970s and early 1980s.

To date, the small geothermal binary power facility used by Burgett Greenhouses at Lightning Dock in Hidalgo County has been the only use of geothermal electric power in the state. Nearly a decade after its first geothermal power facility went offline, renewable energy has become a priority in New Mexico's energy policy, with geothermal slowly starting to become a larger part of the conversation. Over 95% of its electric power from fossil fuel sources (primarily from coal), and the state has an RPS and established incentives and government programs designed to support overall renewable energy development.

New activity

In September 2006, GEA released a report entitled *Geothermal Development Needs in New Mexico* that examined the reasons New Mexico had not yet completed a power project, and how its policy initiatives can be enhanced or modified to advance ongoing efforts to develop commercial geothermal power projects in the state and expand the development of geothermal direct use applications.

Two geothermal power projects are currently under development in the Lightning Dock KGRA. The first is a power plant project that would sell power to the utility, and the second is a smaller binary unit that would serve the needs of AmeriCulture, an aquaculture facility adjacent to the

Burgett Greenhouses and the site of the power plant. Both projects received GRED money and had drilling performed in 2003 and 2004. While the power plant project is in the confirmation stage, the feasibility of a 1 MW project has been demonstrated at the site of the AmeriCulture project and they are currently working with potential investors to develop the project. AmeriCulture currently produces roughly 250 thousand pounds of fish per year, and utilizes geothermal resources to heat culture water for tropical fish production. According to their business plan, if they install the geothermal binary power plant to meet their electrical needs, they could save 30% on their total costs and expand production to ten million pounds per year (at about \$1-\$1.50 per pound) generating enough revenue to pay off the cost of the unit in 17 months. Additionally, they report they could hire another 80 workers (in a county with a population of just over 5,000 which had recently seen massive unemployment resulting from the loss of manufacturing jobs)[55].

Power production is being considered at two other sites in the south-central part of the state, including Radium Hot Springs where a small binary unit is being considered to provide power for an already-large geothermal-heated greenhouse complex that is planning major expansions, and Rincon (20 miles to the northwest) where the geothermal resource is under consideration for an alternative fuel plant.

Current efforts to expand direct use include a project near Socorro, where New Mexico Institute of Mining and Technology (New Mexico Tech) is drilling geothermal wells to heat the campus. In addition, two greenhouse projects are under consideration that would more than double the geothermal-heated greenhouse space in the state. New Mexico already leads the country in geothermal greenhouse acreage (at over 50 acres), with the industry employing several hundred workers, and producing over \$30 million in annual sales. Space heating projects are also under consideration for locations in New Mexico's two largest cities: Albuquerque and Las Cruces.

Potential

New Mexico's geology contains a mix of volcanic and tectonically active regions that indicate the presence of geothermal resources with conditions that could support electric power production. According to the Strategic Plan, "hot dry rock represents a mostly deep-seated geothermal resource base that exists across the state and most accessible geothermal resources and reserves in New Mexico are the hydrothermal or water-dominated variety of reservoirs"[56]. Geologists working on geothermal projects in New Mexico say they benefit from the state's history of oil and gas exploration and production. As one of the top oil and gas producing states (In 2005 it was ranked 6th in crude oil production and in 2004 produced over 8% of U.S. dry natural gas)[57] geological studies containing subsurface data in the state are well documented in some areas. According to geological studies of New Mexico, the most promising resource areas for electric power production potential are in the Basin and Range Province and the Rio Grande Rift where temperature gradients are higher than in the rest of the state (See Figure 6). Most of these

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[55]Source: Gary Seawright; President, AmeriCulture, Inc.: gary@americulture.com

[56]See: New Mexico Energy, Minerals and Natural Resources Department (EMNRD). *Strategic Plan for New Mexico Geothermal Resources Development*. Prepared by James C. Witcher 8/31/2004: http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/documents/NMGeothermalStrategicPlan.pdf (page 6 of 28)

[57]New Mexico Natural Gas and Oil production – Energy Information Agency (EIA): http://tonto.eia.doe.gov/oog/info/state/nm.html & http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_057.pdf

resources are in the intermediate-temperature range, below 302°F (150°C), and not expected to support large power plants.

According to the WGA Geothermal Taskforce Report there are 80 MW of near-term power potential in New Mexico (compared with 5,508 MW in the ten other western states discussed in the report)[58]. These resources are located mostly in southwestern New Mexico stretching from the Arizona border to Las Cruces. This leaves out the Valles Caldera in north-central New Mexico where temperatures as high as 647.6°F (342°C) were recorded at its western rim. A 50 MW power plant was proposed there in 1977 after confirmation drilling took place. The proposed plant, a joint venture between the USDOE, PNM Resources, and UNOCAL Geothermal, planned to utilize an air-cooled condenser to avoid the use of ground or surface water. At the time, an air-cooled structure had never been demonstrated on a large-scale geothermal power plant. Drilling continued until January 1982 when the project was terminated due to a myriad of complications. The primary issue with the project was that only 20 MW was able to be proven sustainable using technology available at the time[59]. Although those who have worked in the area believe that advanced plant technology could likely increase that number, there are currently restrictions to development in the area, part of which has been designated the "Valles Caldera National Preserve", unlikely to be changed in the near-term.

Promising resource areas

Outside of the Animas Valley, several areas have been identified throughout the state with electric power potential. These include Hillsboro Warm Springs, Lower Frisco Hot Springs, and Rincon. There are several areas with identified intermediate-temperatures with potential for small-scale power or distributed generation including the McGregor Range (on US Army land operated by Fort Bliss near El Paso, Texas) and Radium Hot Springs.

These areas represent only those studied already for their geothermal potential, and researchers say that New Mexico, in particular, may contain numerous resources that are "blind" (i.e. without apparent surface manifestations). Most agree that despite data from oil and gas drilling, and the favorable geology contained therein, that the state has not been adequately explored, particularly in the Rio Grande Rift area that runs through central New Mexico and southwest New Mexico, as seen on Figure 6.

In addition to areas with electric power potential, extensive low-temperature geothermal systems may be able to serve large populations with thermal heating, including residents of Las Cruces.

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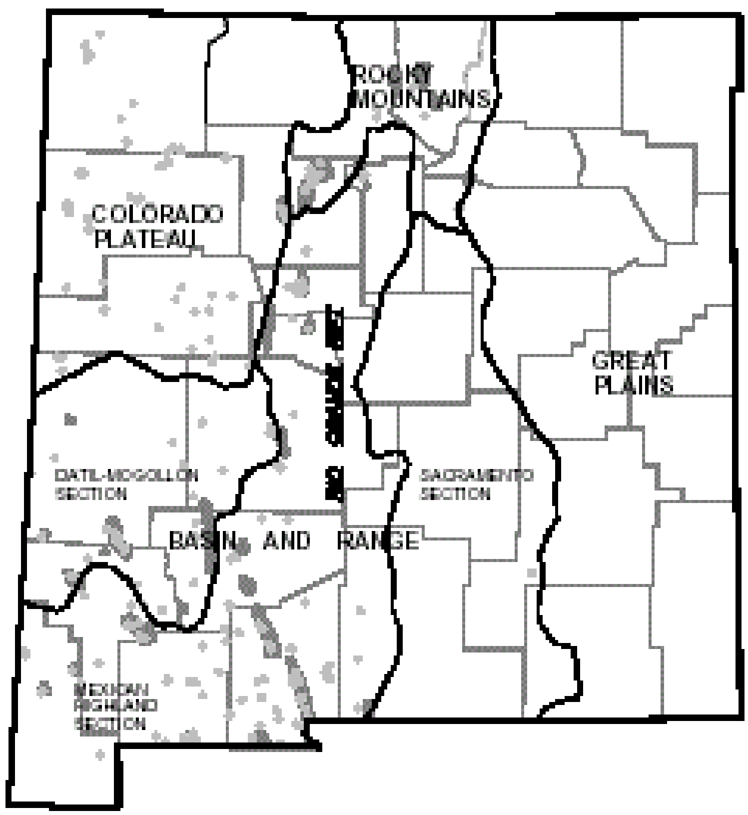
[58] See Western Governors Association (WGA) Geothermal Task Force Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (pages 65-66)

[59] Sources: Goff, Fraser. "Geothermal Potential of Valles Caldera, New Mexico". GHC Bulletin, Geo-heat Center, Oregon Institute of Technology (OIT), December 2002: http://geoheat.oit.edu/bulletin/bull23-4/art3.pdf & New Mexico Energy, Minerals and Natural Resources Department (EMNRD). *Strategic Plan for New Mexico Geothermal Resources Development*. Prepared by James C. Witcher 8/31/2004: http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/documents/NMGeothermalStrategicPlan.pdf (page 6 of 28)

Figure 6: The Rio Grande Rift is seen running from the Mexican border up to the Rocky Mountains. (Witcher, 1995): http://geoheat.oit.edu/bulletin/bull23-4/art2.pdf



Programs

In 2002, the New Mexico Public Regulation Commission (NMPRC) approved an RPS requiring its IOUs to generate 10% of their retail sales from renewable resources by 2011. The RPS encourages geothermal development over other renewables, by giving every kWh of geothermal two RECs as opposed to one REC for wind[60]. There is currently no state funding provided directly for geothermal research work in New Mexico, although state funding was provided during the early 1990s for core hole drilling at Rincon, and some annual funding had been provided for a portion of the work done at the Southwest Technology Development Institute (SWTDI) program at New Mexico State University (NMSU). Today, the NMSU geothermal program is not active.

Support for geothermal exploration efforts in New Mexico has come mostly from the USDOE, including Sandia National Laboratories, which has had a presence in the state for more than three decades, and has received federal funding to study geothermal resources in New Mexico and

[60]This policy also encourages solar, biomass, landfill gas, and fuel cells. One kWh of electricity generated by biomass, geothermal, landfill gas or a fuel cell is worth two kWh toward the RPS and one kWh of electricity generated by solar resources is worth three kWh toward the RPS. Source: The Database of State Incentives for Renewable Energy (DSIRE): http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NM05R&state=NM&CurrentPageID=1&RE=1&EE=1

elsewhere. Together with the GPW, Sandia worked closely with NMSU, before the geothermal program ceased in 2004, on the New Mexico Geothermal Energy Working Group that was formed in April of 2002. Since its initial presence in New Mexico, GPW, and the state working group it helped organize, have held conferences, performed outreach, created internet resources, and released *A Strategic Plan for New Mexico Geothermal Resources Development* in August of 2004.

While no working group meetings were held in New Mexico in 2006, a renewable energy fair was held by Congressman Steve Pearce (NM-02) in August where presentations were made on geothermal development. In addition, New Mexico stakeholders participated in the May 2006 Arizona working group meeting, which brought in primarily experts from both states, and partly covered issues concerning geothermal development in New Mexico. In addition to efforts by the state geothermal working group, USDOE has provided assistance to geothermal exploration through the GRED program for the two projects at Lightning Dock and for the geothermal district heating project at New Mexico Tech.

Incentives

Besides the RPS, the only existing incentive for geothermal development at the state level is an Energy Efficiency & Renewable Energy Bond program. Passed in April of 2005, the program can apply to geothermal power plants, distributed generation, or direct use applications. One policy that could apply to geothermal power development (in particular) is a State Renewable Energy Production Tax Credit of 1 cent per kWh (which can be added to the federal PTC). In its current form, it does not include geothermal power (although it does not specifically exclude it). While the credit is directed towards utility-scale projects, there are no specifications excluding distributed generation. One stipulated restriction is that the power needs to be sold to an "unrelated person" or entity who does not own 50% or more of the generator. Currently the tax credit only applies to facilities larger than 10 MW and there are restrictions that mandate only New Mexico companies can build the power facility; the incentive being that the credit reduces state income tax liability. To date, the credit has not yet been utilized for a producing renewable power facility although there are renewable projects in the pipeline (none of them geothermal)[61].

Most agree that the RPS remains the most important state-level policy for geothermal power production, while the federal PTC is the most important financial incentive. However, there is concern that the geothermal power project at Lightning Dock is not on pace to qualify for the PTC before it expires. Developers agree that a two to three year extension would give them a better chance to get that project online, and may allow other projects to move ahead in the state. However, there are concerns that PTC does not benefit distributed generation projects, which is more likely a development option for geothermal resources in New Mexico.

Power market

There are three IOUs in New Mexico, which combined made up just over 68% of its retail power sales in 2004. Those utilities serving rural cooperatives and municipal utilities made up the other 32% (with much of that power coming from Tri-State Generation & Transmission serving several of New Mexico's largest rural cooperative utilities with large coal and gas-fired power facilities). PNM is the largest IOU in the state, providing approximately 43.1% of the electricity for New

[61]For more information on this tax credit see the Database of State Incentives for Renewable Energy (DSIRE): http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NM02F&state=NM&CurrentPageID=1&RE=1&EE=1

Mexico residents in 2004[62]. To date, none of New Mexico's utilities have purchased geothermal electric power.

Without a long-term extension to the PTC, there is concern that the RPS will not be adequate to compel these utilities to pursue geothermal projects. Part of the reason is because the "reasonable cost" threshold for geothermal in the RPS is 6.3 cents per kWh[63] which developers say is unrealistic for geothermal prospects currently under consideration in New Mexico. While utilities in New Mexico have actively pursued wind projects, most agree that geothermal projects remain under the radar and that the geothermal industry needs to have a greater advocacy presence in the state.

Transmission access is a limitation for some geothermal power prospects in New Mexico, several of which are in remote areas removed from major utility lines. While some of the areas of near-term interest (including Lightning Dock, Radium Hot Springs, and Rincon) are not far from transmission lines, there is concern that because these locations may only support a small amount of power in the near-term the cost of transmission access is more of an issue than it would be for a larger project. Furthermore, the lines that exist may have limited transmission capacity to deliver power without transmission upgrades or new transmission construction. While efforts are being made by the New Mexico State legislature to finance renewable transmission projects (including efforts to pass the Renewable Energy Transmission Authority Act[64], progress has been limited thus far.

Regulations

The regulations in New Mexico define a "geothermal resource" as "the natural heat of the earth or the energy, in whatever form, below the surface of the earth present in, resulting from, created by or which may be extracted from this natural heat and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases and steam, in whatever form, found below the surface of the earth, but excluding oil, hydrocarbon gas and other hydrocarbon substances." To be considered a "geothermal resource" the resource must have a temperature of at least 250°F (121°C). Accessing geothermal fluid at or greater than this temperature require drilling and production permits from the New Mexico Energy, Minerals and Natural Resources Department (EMNRD) Oil Conservation Division (OCD) and the New Mexico State Engineers Office (NMSEO). On state lands, it is subject to leasing and royalties with the State Lands Department. Geothermal fluid below 250°F (121°C) is defined as "naturally heated water" and falls under New Mexico water law, requiring permits from the NMSEO[65]. There are two areas in

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[62]Source – Energy Information Agency (EIA): http://www.eia.doe.gov/cneaf/electricity/st_profiles/new_mexico.pdf

[63]Per Case 04-00253-UT (Page 13 of the recommended decision of the Hearing Examiner (adopted by the Commission in the Final Order.) There is an individual resource threshold of $.049 per kWh for wind and hydro; $.06254 per kWh for biomass and geothermal; and $.10 per kWh for solar units greater than 10 kW ($.15 per kWh for units less than 10 kW). Source – John Curl New Mexico Public Regulation Commission**:** john.curl@state.nm.us

[64]The legislation, introduced in January of 2006, passed the House, but did not make it onto the Senate floor (dying in committee). As of August 2006, the legislation was still being pushed by Governor, and it is expected to be proposed again in the next legislative session. Here is the text: http://legis.state.nm.us/Sessions/06%20Regular/bills/house/HB0111.html

[65]Sources: Bloomquist, Gordon. "A Regulatory Guide to Geothermal Direct Use Development: New Mexico". Washington State University, 2003: http://www.energy.wsu.edu/documents/renewables/NewMexico.pdf & New Mexico Energy, Minerals and Natural Resources Department (EMNRD). *Strategic Plan for New Mexico Geothermal Resources Development*. Prepared by James C. Witcher 8/31/2004:

New Mexico with state leases for geothermal resources considered “naturally heated water”, and both pay small royalties (no more than $10,000) to the State Lands Department

Water is a major issue for both geothermal power and direct use development in the state. The scarcity of water is commonly cited as the reason for New Mexico’s small population. Unlike solar and wind, geothermal production involves the use of water by pumping from underground reservoirs. Thus, the process of drilling into geothermal reservoirs brings up issues concerning water rights and the impacts on local users (including agricultural, municipal, and domestic users, and resources used for irrigation). The regulation of all water resources is under the jurisdiction of the NMSEO and involves all land in New Mexico, regardless of whether it is private, state, or federal. As with other western states, there are exemptions for tribal lands which are subject to federal jurisdiction. Tribal lands in New Mexico make up roughly 8.4% of its total acreage and several locations on tribal reservations have been identified as having potential for geothermal development. This includes tribal lands in the San Juan Basin of northwest New Mexico where considerable oil and gas drilling has occurred and intermediate-temperature fluid has been encountered. Another potential area is in the Jemez Mountains (in the vicinity of Valles Caldera). From 2002-2004, the Pueblo of Jemez worked with USDOE who cost-shared a feasibility study to install a geothermal direct use heating facility. The study concluded that there were business opportunities related to geothermal resources, but further drilling is needed before these applications can be developed on the site[66].

According to the BLM, 34% of the surface acreage in New Mexico is federally-managed, with approximately 16.5% managed by the BLM. However, in terms of mineral acreage, nearly 35% is managed by BLM and 46.3% is managed by the federal government[67]. The U.S. military manages about 4% of the land in New Mexico, while USFS manages large tracts throughout the state (including the Valles Caldera National Preserve). Some of the most promising geothermal resources in New Mexico often are located on or near federally-managed lands. Projects at Lightning Dock and Radium Hot Springs both have a mixture of private and federal land, and federal leases were issued at one time for geothermal exploration at Hillsboro Warm Springs.

While federal regulations have not been a primary impediment to geothermal power development in the state, most agree that federal regulations have affected direct use development. There are two areas in New Mexico where direct use facilities have utilized federal geothermal leases in the past (with the facilities on federal land both currently inactive). In Las Cruces, J&K Growers operated a small greenhouse facility and purchased the hot water from the owner of the well who had the federal geothermal lease. In this case, the royalty was based on the arms length sale of hot water between the well owner and J&K Growers and those familiar with the project say that the royalty determination was simple and straight forward. At Lightning Dock, Burgett Geothermal was required to install expensive metering equipment in order to determine the equivalent energy use needed to calculate a royalty. In addition, the calculated royalty was more than the royalty that an electrical power plant would pay for the equivalent amount of energy use.

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http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/documents/NMGeothermalStrategicPlan.pdf (page 7 of 28)

[66]Source – U.S. Department of Energy Tribal Energy Program (April 2004): http://www.eere.energy.gov/tribalenergy/pdfs/jemezpueblo05final.pdf

[67]Total federal mineral acreage in New Mexico: Bureau of Land Management (BLM) (2002): Mineral and Surface Acres Administered by the Bureau of Land Management: http://www.blm.gov/natacq/pls02/pls1-3_02.pdf

As a result, the owner shut down all facilities that were affected by the federal lease. It is undetermined whether the changes EPAct will lead to these facilities re-opening in the near future.

Direct use

Several geothermal direct use projects are under development in New Mexico that may produce promising results in the near-term. Geothermal direct use operations are already a profitable source of income for the state. Aside from its greenhouses, New Mexico uses geothermal resources for aquaculture, space heating, and recreation at several spas and resorts. However, researchers suggest that these existing facilities represent only a fraction of what is possible. According to resource maps, geothermal resources are available throughout the state for residential heating and can be applied to numerous agricultural industries including milk and cheese processing, process heat for bio-fuels refining, and chili and onion processing as well as expansions to the aquaculture and greenhouse industries. In the fact, the SWTDI created a geothermal direct use "business incubator" in the 1990s as a university program that recruited out-of-state businesses to use aquaculture and greenhouse facilities located on campus. Several businesses operated on the property as a result, and the program is being replicated elsewhere in the country.

Although New Mexico is generally considered an area of the country with a warm climate, the aridity and high elevation of many parts of New Mexico create significant heating loads on cold winter nights[68]. For example, the average low for New Mexico's largest city, Albuquerque (4955 feet above sea level) is below freezing from November through February and the average low for New Mexico's second largest city, Las Cruces (at 3,908 feet) is below freezing from December through February[69].

The space heating projects in these cities include a proposed district heating system for a new development in Mesa Del Sol, located just south of Albuquerque. While there are no existing direct use facilities in Albuquerque, Las Cruces has a history of geothermal development. According to studies and well data for the area, a vast low-temperature geothermal system is located below and around Las Cruces in the Las Cruces East Mesa KGRA (comprising Tortugas Mountain -- also referred to as "A Mountain"). The Las Cruces East Mesa is a blind geothermal system which parallels the east side of I-10/I-25 from the Texas line to Hwy 70 northeast of Las Cruces. Researchers familiar with the area contend that the resource could provide significant heating for Las Cruces if fully developed. A district heating system already exists at the NMSU campus in Las Cruces; however the system is in need of maintenance and much of it is currently idle. The USDOE authorized FY 2006 funding to evaluate the system and further study the resource[70]. At Socorro, drilling began in November of 2006 at New Mexico Tech to find geothermal water sufficient to replace natural gas heating. Infrastructure for the system is partly

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[68]New Mexico's average elevation is 5,700 feet – Netstate:
http://www.netstate.com/states/geography/nm_geography.htm

[69]Weather Statistics
Las Cruces: http://www.weather.com/weather/wxclimatology/monthly/graph/USNM0169?from=search
Albuquerque: http://www.weather.com/weather/wxclimatology/monthly/graph/USNM0004?from=search

[70]I toured part of the Las Cruces East Mesa with Jim Witcher on May 17th, 2006. I also relied on his 1995 report for this description: Witcher, James C. "Geothermal Resource Data Base, New Mexico". Southwest Technology Development Institute, New Mexico State University: July 1995:
http://www.nmsu.edu/~tdi/pdf-resources/report.pdf (pages 18-19)

installed. Initial estimates for energy savings created by using the geothermal resource are ~$1.2 million each year, assuming a continued increase in the price of natural gas[71].

20 miles north of Las Cruces, an expansion of the Radium Hot Springs greenhouse complex is expected to more than double in size. The geothermal system currently saves the company $46,200 per acre per year, and the planned expansions will incorporate 40 acres when completed (employing an additional 4-8 workers per acre) [72]. The operator of the facility asserts that the installation of a geothermal binary-power unit would enhance these savings, but is not a necessary pre-condition to the expansion.

Another greenhouse project is in the planning stages that would take an existing greenhouse facility in Grants that is currently using fossil fuel sources for heating, and move it to another location where facilities would use a geothermal heating system. Developers say the project could be as large as 80 acres once fully completed.

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[71] Sources: "Tech Drilling Mountain In Search of Geothermal Energy" By John Larson for Mountain Mail. SmallTownPapers News Service, 12/08/2006: http://stpns.net/view_article.html?articleId=21246523219782639 & personal communication with researchers at New Mexico Tech.

[72] At the time of this writing, Masson Radium Springs was the 3rd largest geothermal-heated greenhouse in the country. Like AmeriCulture, they are also considering small-scale electrical power for on-site generation. The source of this information was provided by Alexander Masson, of Alex R. Masson, Inc.: ram@armasson.com

Utah

Lone Peak (11,253') from the geothermal direct use facility at the Utah State Prison – Photo by Daniel Fleischmann, GEA 2006.

Utah is home to a wide open landscape of mountains, forests, canyons, and towering rock formations. As of 2006, it is the only state in the continental U.S. to have a geothermal power plant outside of California and Nevada. There is currently one geothermal power plant in operation at Roosevelt Hot Springs in Beaver County near Milford. Another power facility was operating at Cove Fort-Sulphurdale about 50 miles east of Roosevelt Hot Springs that was decommissioned in 2003 and 2004. Several businesses in Utah currently utilize geothermal resources for direct use applications such as aquaculture, greenhouses, recreation, and space heating.

As new homes have expanded east, west, north and south from the population centers surrounding Salt Lake City, researchers suggest that a valuable opportunity exists to use the plentiful geothermal resources below the soil. While there new geothermal development in Utah was limited during the 1990s, new interest and activity has been picking up over the past few years and Utah is becoming one of the most active states for new geothermal development in the country.

New activity

In June 2006, GEA released a report entitled *Geothermal Development Needs in Utah* that studied new activity and how state and federal policies were affecting development. New power projects are under development in Cove Fort-Sulphurdale and Roosevelt Hot Springs. At Cove Fort, new facilities are under development to replace the recently decommissioned facilities -- and are expected to generate at least three times more power. At Roosevelt Hot Springs there are plans to expand the Blundell Plant by 11 MW through a bottoming cycle using an ORMAT Energy Converter. This expansion is expected to be completed in 2007. Additional power plants have been proposed for the site that (if added to the 11 MW expansion) would nearly triple the capacity of the existing plant. A power project has also been proposed at a third location near Brigham City, called Renaissance. A deep well was drilled near the city in 1974 where fluid discharged, but at temperatures insufficient for electric power production at the time.

While there has been increased activity in pursuing new geothermal electric power development, new direct use projects have also been proposed. The most recent direct use project to come online was a large geothermal space heating system at the Utah State Prison in Bluffdale, 30 miles south of Salt Lake City. The prison had a small space heating system installed in the early 1980s that ceased operation in 1985. In 2003, the system was revamped and new wells were drilled. By 2005, the facility was supplying heat and domestic hot water for 332,665 square feet of the prison, including five large buildings housing 1,460 beds. The system was expected to save the prison $344,000 in heating costs for FY 2006. Geothermal greenhouses and an aquaculture facility are also located nearby the prison, and currently use the resource. USDOE has recently funded a feasibility study to expand geothermal use at the greenhouse as well as upgrade the existing geothermal heating system.

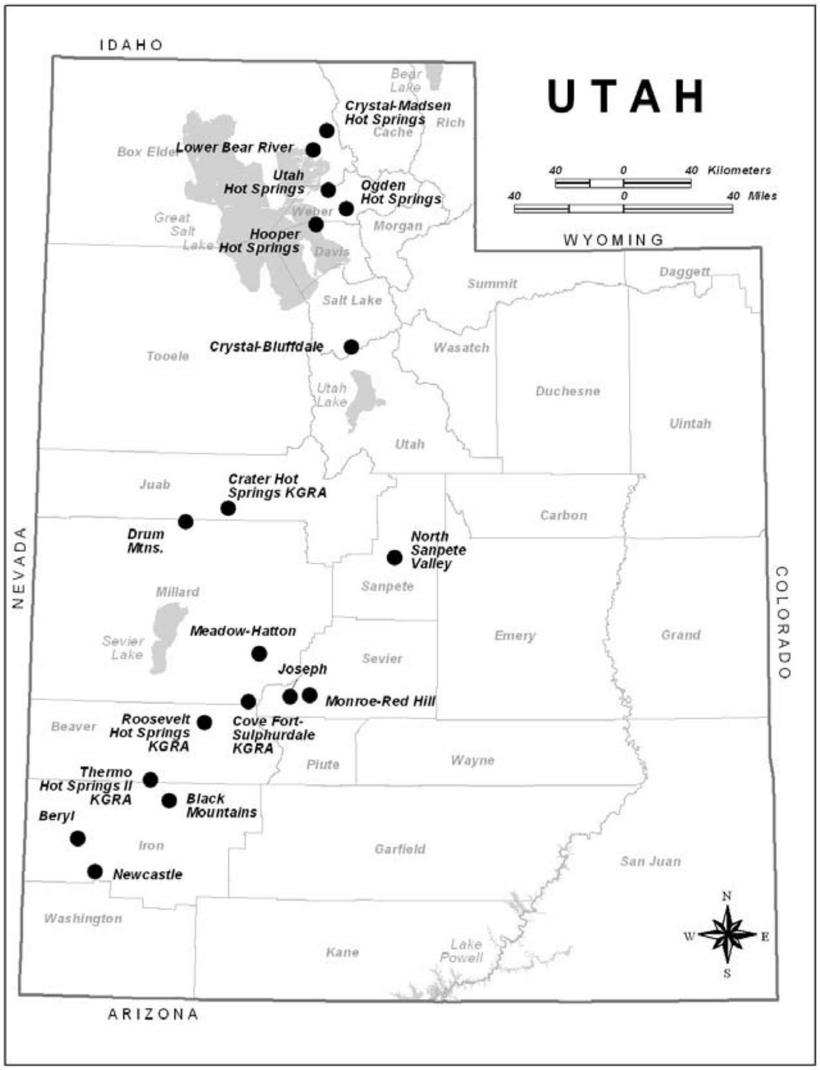
Potential

The primary areas for geothermal exploration in the state have been the Basin and Range province of western Utah and the Transition Zone of central Utah. Researchers say that high heat flow, active faulting, and young igneous rocks characterize these two broad regions. In northern Utah, geothermal resources are associated with the Wasatch fault zone, which defines the eastern edge of the Basin and Range Province, separating it from the Middle Rocky Mountains (Wasatch Range). These resources have similar characteristics to geothermal resources in Nevada, and western Utah is considered part of the Great Basin. Roosevelt Hot Springs is located within the Basin and Range Province and is the hottest known resource area in Utah. Reservoir temperatures typically between 464 and 514°F (240 and 268°C) are used for the power plant from production zone depths ranging generally between 1,253 and 7,321 feet (382 and 2,232 meters). It is undetermined whether other geothermal systems in the state may possess similar heat flows.

According to WGA Geothermal Taskforce Report, it is estimated that within these promising geological areas, Utah can economically develop ten times its current capacity by 2015 – an additional 230 MW[73]. If 230 MW were added in addition to the existing Blundell Plant, Utah could generate enough electricity to power nearly a quarter-million households (a tenth of the current population). This figure represents only identified resource areas and did not includes estimates for the proposed Renaissance power project.

[73] According to the WGA in 2006, Utah has several resource areas that could produce up to 230 MW of new capacity by 2015 economically, and up to 620 MW by 2025. Of the near-term potential by 2015, WGA identifies 210 MW from four resource areas, but leaves 20 MW of new capacity possible at other Utah prospects. Source – Western Governors' Association (WGA) Geothermal Taskforce Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (page 66)

Figure 7: Map of Utah's most promising geothermal resources
Map created by Bob Blackett of Utah Geological Survey (UGS)



Promising resource areas

Beyond Roosevelt, Cove Fort, and Renaissance, several areas have been identified throughout the state with electric power potential. These particularly include areas in southwest Utah such as Thermo Hot Springs KGRA, the Black Mountains, the Drum Mountains, and the Beryl area in Iron County. In addition, there are several areas with intermediate-temperatures that may have potential for small-scale electric power or distributed generation, including Crater Hot Springs, Monroe-Red Hill, and Newcastle. There are several other areas as well in other parts of the state. Figure 7 is a map of these potential sites.

According to the 2005 Geo Hills Associates report, Utah was third to only California and Nevada in its number of thermal gradient boreholes (1,019) and slim holes or exploration and/or production wells (77) -- most drilled in the 1970s. Researchers assert that much of the drilling was to shallow depths and that nearly all of the substantive subsurface exploration was performed at Roosevelt Hot Springs and Cove Fort-Sulphurdale. Outside of these two areas, well data show no more than 22 geothermal exploratory wells deeper than 1,000 feet (305 meters) have been drilled[74]. Researchers say that many of Utah's most promising resource areas may have yet to be discovered, and they need assistance with exploration that will be critical to identifying a queue of potential geothermal projects that could be part of Utah's energy mix in years to come.

Utah's geology suggests the existence of "blind" systems yet to be discovered that may contain sufficient conditions for power production. Through the IWGC, EGI at the University of Utah is planning on surveying a "quadrangle" in central and southwest Utah will include the Cove Fort-Sulphurdale area on the east, the Roosevelt Hot Springs KGRA on the west, the Meadow-Hatton area on the north, and the Thermo Hot Springs KGRA on the south. The region being studied is roughly 80 km (50 mi) long and 48 km (30 mi) wide[75]. (See Figure 7)

Programs
Utah has no state RPS and provides no state funding directly for geothermal research work. While general state funding is provided for the Utah Geological Survey (UGS), specific geothermal research performed there is funded by the USDOE. This includes the 2004 open-file report released by UGS, entitled *Utah's high temperature geothermal resource potential – analysis of selected sites*, which reviewed work performed in specific resource areas in Utah with potential for electric power generation. The release of this report followed the first GPW meeting held in 2003. Since that initial meeting, GPW, and the state working group it helped organize, has held meetings and created networks for communication to discuss Utah's resources and identify potential new projects. There have been five meetings of the Utah Geothermal Working Group in the past two years, the most recent being held in March of 2006. In addition to the activities by GPW, federal funding has sustained geothermal research activities by EGI at the University of Utah, which has performed critical geothermal studies and reports for geothermal development in Utah and elsewhere. USDOE also provided assistance to the new development at Cove Fort-Sulphurdale through the GRED program, providing funding for additional identification of the resource through geophysics and by drilling new wells.

Incentives
The only major government incentive for geothermal development at the state level is a sales tax exemption for the purchase or lease of equipment used to generate electricity from renewable resources, including geothermal power plants. In March of 2006, state legislators considered adding geothermal power plants and geothermal direct use heating facilities to an existing state renewable energy tax credit. However the legislation failed in committee and the existing credit is set to sunset on January 1st, 2007 without ever supporting a geothermal project[76].

Developers in Utah contend that their greatest incentive for new development has been the federal PTC. The expansion project at Roosevelt Hot Springs is expected to be completed in 2007, and the recent extension may be enough time to enable completion of the new facility at Cove Fort.

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[74] According to the research 22 "deep" wells may or may not be geothermal wells. However, it is more than likely that most of them are geothermal wells because of the location of the wells in areas known or presumed to have geothermal resource potential. This does not count shallow boreholes (including temperature gradient holes drilled at Thermo Hot Springs); only geothermal exploration wells that could later be modified into production holes. Source: Utah Geological Survey well spring data (File Name: well_spring3.xls) – For more information, contact Robert Blackett at robertblackett@utah.gov

[75] Source: Blackett, Robert E. and Powlick, Philip J. "Geothermal Development and Outreach in Utah – 2006." Utah Geological Survey. GRC Transactions, Vol. 30, 2006: Pg. 1016

[76] Source – Database of State Incentives for Renewable Energy (DSIRE): http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=UT09F&state=UT&CurrentPageID=1&RE=1&EE=1

However, developers indicate that for more geothermal prospects in Utah to become feasible, the PTC needs to be extended for a longer time period as many of these sites have major exploration work required before developers can commit to a project.

Power market

PacifiCorp is the only major private utility in Utah, and in 2004 accounted for 80% of state retail power sales. There are numerous small rural cooperatives and municipal utilities in Utah (the largest five of them produced 9.6% of Utah's energy in 2004) although they have not been active in geothermal development in recent years[77]. PacifiCorp has actively sought out geothermal projects, and now operates the Blundell geothermal plant at Roosevelt Hot Springs and is working with developers on the planned expansions. Future geothermal development is limited by inadequate transmission access to remote locations, especially areas in scenic and environmentally sensitive areas where commercial development is limited and may face additional restrictions. In addition, geothermal prospects in the Wasatch Front region face obstacles to siting a facility near locations experiencing population growth. This may be a concern for the Renaissance project; however it is considered a principal barrier to exploring for electric power development potential in the Crystal-Bluffdale area and at Ogden Hot Springs (See Figure 7).

Regulations

The regulations in Utah define a "geothermal resource" as "the natural heat energy of the earth, the energy in whatever form which may be found in any position and at any depth below the surface of the earth, present in, resulting from, or created by, or which may be extracted from natural heat and all minerals in solution or other products obtained from the material medium of any geothermal resource". To be considered a "geothermal resource" the resource must have a temperature of at least 248°F (120°C). Geothermal fluid below this temperature is defined as a "water resource" The Utah Department of Natural Resources, Division of Water Rights (DWR) is given jurisdiction and authority over all geothermal resources in the state, including low-temperature "water resources" which are regulated according to rules governing conventional water well applications[78].

State regulations apply to geothermal resources on all lands in Utah except for tribal land, which covers roughly 4.4% of Utah's land. The largest section of this land in Utah is located in the southeast, as part of the Navajo nation. Significant geothermal potential has not been indicated in this area, however, there are several Paiute reservations near Cove Fort and Roosevelt Hot Springs, as well as tribal land in southwestern Utah that may be promising for geothermal development. The site of the Renaissance project is near tribal land, and the developer is working with the Northwestern Shoshoni Tribe on the project[79].

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[77]PacifiCorp was acquired by the MidAmerican Energy Holding Company in 2006. PacifiCorp itself covers 6 Western States. UT, WY, ID, WA, OR, and 40 thousand customers in California. PacifiCorp is not the only utility in Utah, but is the only investor-owned utility (IOU). In 2004, PacifiCorp served 80% of Utah residents. For all 2004 utility data in Utah see: http://geology.utah.gov/sep/newdata/StatAbstract/Electricity5.0/T5.24.xls.

[78]Source – Bloomquist, Gordon. "A Regulatory Guide to Geothermal Direct Use Development: Utah". Washington State University, 2003: http://www.energy.wsu.edu/documents/renewables/utah.pdf

[79]Sources: Economic Development Administration, U.S. Department of Commerce: http://www.eda.gov/ImageCache/EDAPublic/documents/pdfdocs/40utah_2epdf/v1/40utah.pdf (see map on page 570) & Bureau of Land Management (BLM) (2002): Mineral and Surface Acres Administered by the Bureau of Land Management: http://www.blm.gov/natacq/pls02/pls1-3_02.pdf

Roughly two-thirds of Utah's land is managed by the federal government. The most promising geothermal resources in Utah often are located on or near federally-managed lands. Private lands tend to be predominantly near or within cities and towns and Utah state lands tend to be scattered, and do not cover large tracts of land by themselves. Most of the promising resource areas noted above are managed by the BLM. Projects at both Cove Fort and Roosevelt Hot Springs involve BLM land (with some of the land in the Cove Fort area on USFS land). While developers in Utah have not generally experienced lease backlogs, they say that development on federal lands in Utah may still face delays. Because geothermal prospects in Utah will require additional exploration before any projects can be adequately confirmed to suit a power project, most agree that the leasing process must be timely. Utah is no stranger to drilling projects on federal land. New oil and gas discoveries in the state have led to a surge in demand for oil and gas drilling permits. In 2004 and 2005, over 2,700 drilling permits were issued in Utah (with over 54% on federal lands). While oil and gas exploration remains a priority for federal land agencies, most agree that geothermal projects will not have to compete for time unless the volume of geothermal leases increases markedly[80].

Direct use

Outside of Cove Fort and Roosevelt Hot Springs, the discovery and utilization of additional high-temperature geothermal systems in Utah will require extensive exploration and deep drilling. However, the development of low-to intermediate temperature geothermal systems is more likely in the near-term. None of the existing facilities in the state are on federal lands, while this could also change with new regulations. Newcastle has the largest commercial geothermal direct use operation in the state. Three commercial greenhouses use geothermal heating for 25 acres of floor space and an LDS (Mormon) Chapel is also heated by geothermal water in the town.

Overall, researchers assert that Utah can greatly expand its utilization of direct use applications. According to resource maps, a majority of Utah's population lives in the vicinity of low-to intermediate temperature resources that could potentially be used for direct use heating applications. This includes most of the communities along the Wasatch Front where hot springs and geothermal wells have been discovered in multiple locations, and are currently used for various businesses including, greenhouses, aquaculture facilities and geothermal spas.

In fact, a geothermal direct use project has been proposed for a large maintenance facility near Wasatch Warm Springs in Salt Lake City. The facility would serve a 165,000 square-foot facility called the Warm Springs Service Center, which was recently acquired by the Utah Transit Authority (UTA), which is planning to expand the availability of public transportation along the Wasatch Front to serve a commuter rail system. This project would require a retrofit to support the geothermal system[81]. Retrofits are typically more expensive than installing geothermal systems from the start of construction. Therefore, researchers suggest that with population growing out from the Salt Lake City area, there are likely opportunities to develop geothermal heating projects or commercial developments to serve these populations and install as part of new

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[80]Sources:
Utah Division of Oil, Gas, and Mining – Utah Department of Natural Resources "Utah's Oil and Gas Program: Celebrating 50 Years". For more information see: http://www.ogm.utah.gov/
Total Permits: Utah Division of Oil, Gas, and Mining – Utah Department of Natural Resources: http://www.ogm.utah.gov/oilgas/PUBLICATIONS/Lists/list_index.htm
Federal permits: Utah BLM (File Name: Org_wkld.xls) – For more information, contact Robert Henricks (Utah BLM) at Robert_Henricks@blm.gov

[81]Source: Blackett, Robert E. and Powlick, Philip J. "Geothermal Development and Outreach in Utah – 2006." Utah Geological Survey. GRC Transactions, Vol. 30, 2006: Pgs. 1015-1016

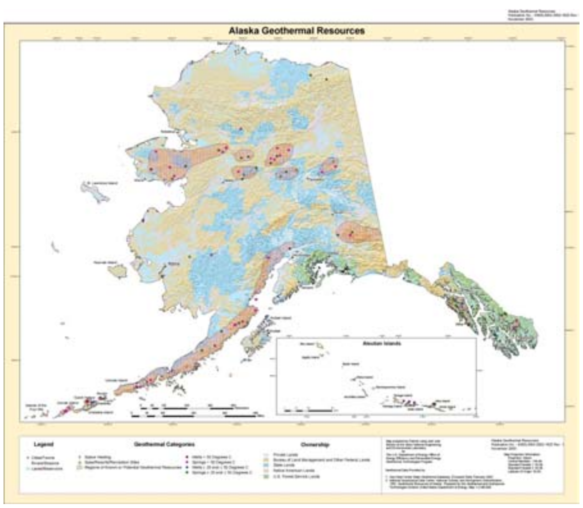
construction. For example, suburbs south of Salt Lake City in West Jordan are expected to expand by several hundred thousand people over the next decade, and as home heating costs rise, most agree it is prudent to examine possibilities for geothermal heating in this area.

States undergoing near-term geothermal power development

Alaska

Much of Alaska's southern coastal region is part of the Pacific Ring of Fire, "a zone of frequent earthquakes and volcanic eruptions encircling the basin of the Pacific Ocean", encompassing the entire West Coast of the U.S., including southern California[82]. With many volcanoes and hot springs in this region (and other parts of the state), geothermal resources are recognized as a source of energy that has significant potential for development. Much of Alaska is rural, relying heavily on isolated grids for its power supply. While the average retail rate for power in 2005 was just above the retail rate in California, this is misleading because many of Alaska's more isolated communities pay far more than that. For diesel-generated power, the fuel cost per kWh is approximately $0.20-0.25 at today's fuel prices. This does not include the cost of storing and handling the fuel.

Figure 8: Alaska Geothermal Resources. Source – Idaho National Laboratory: http://geothermal.id.doe.gov/maps/index.shtml



As of 2004, natural gas provided over half of the electricity in Alaska. Hydroelectric power made up just below 25%, and petroleum and coal chipped in just over 20%. Despite Alaska's geothermal potential, few of its resources are actually used for heating or energy. Part of this has to do with isolation and the costs of transmission. However, evidence shows that localized power

[82]For more information see: Wikipedia – "Pacific Ring of Fire": http://en.wikipedia.org/wiki/Pacific_Ring_of_Fire

generation is possible for a number of communities in the state which could greatly benefit from the use of the resource[83].

New activity

Alaska has recently established a Geothermal State Working Group with leadership from the Alaska Energy Authority. In July of 2006, Alaska became the 5th U.S. state to have an active geothermal power facility when the first ORC unit went online at Chena Hot Springs. The geothermal power facility replaces a diesel generator which was costing the owner roughly 30 cents per kWh. The unit already produces power at less than 25% of that, saving an estimated $365,000 a year in diesel fuel costs. When fully completed, the units installed at the resort will have a capacity of 1 MW of geothermal power. There may be potential to tap into a higher temperature in a deeper reservoir on the property sell to Fairbanks. However the existing unit uses shallow wells[84].

Outside of Chena Hot Springs, there are several small spas and resorts using geothermal resources for space heating, including Circle Hot Springs located near the Yukon River 162 miles northeast of Fairbanks, where the springs are used for a swimming pool, space heat for a hotel, and a greenhouse. There has not been any new geothermal direct use development in the past several years. However, interest in new development has increased as energy prices have hit communities hard and pressure builds to use indigenous renewable resources, like geothermal, as a hedge against fuel price volatility. Areas of interest include the volcanic area west of Anchorage which includes Mount Spurr, and Bell Island Hot Springs north of Ketchikan near Clarence Strait on Alaska's southern border with British Columbia. There are also a number of areas with potential in the Alaska Peninsula including the island of Akutan and other sites along the Aleutian Islands. For example, there has been interest for over a decade in constructing a geothermal power plant on the side Mount Makushin, a 6,679' volcano 12 miles from the City of Unalaska. The city is a major fishing port and seafood processing community with a population of over 4,300 (up to 10,000 during the prime fishing season). The site is considered a "proven geothermal resource" capable of producing more than enough energy to power the entire community and its processing facilities. The challenge for development is negotiating power sales agreements, financing the project, and connecting transmission across the large bay and difficult terrain that separates the community from the resource[85].

Potential

While there are active geothermal areas in the state too remote to exploit, Alaska does have opportunities to extract heat or power from geothermal resources within range of populations that can use them. Several areas were studied from 1971 through 1985 through a state-sponsored exploration effort. 111 resources were identified as potential areas, while four were explored in

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[83]Sources for this section: Energy Information Agency (EIA) – Average Retail Price of Electricity by State, 2005: http://www.eia.doe.gov/cneaf/electricity/epa/fig7p4.html & EIA (2004): http://www.eia.doe.gov/cneaf/electricity/st_profiles/alaska.pdf

[84]Sources on the Chena Hot Springs project – Chena Hot Springs: http://www.yourownpower.com & Geothermal-biz.com – August 2006: http://www.geothermal-biz.com/newsletter/Aug-2006.htm

[85]Sources for this description:
Geothermal Technologies Program: Alaska – State Fact Sheet: http://gpw.alaskaenergy.govtools.us/documents/supportDocuments/Alaska_factsheet.pdf
Kolker, Amanda and Yanity, Brian. "An Introduction To Geothermal Energy: Could It Power Alaska Communities?" Alaska Report, 10/09/2006: http://www.alaskareport.com/science10047.htm
University of Alaska, Fairbanks – Geothermal Power: http://www.uaf.edu/energyin/webpage/pages/renewable_energy_tech/geothermal.htm

greater detail, including Mount Makushin[86]. With Alaska's high costs of power, even projects requiring long transmission lines can be economical, depending on the total capital costs involved. For instance, the technology used at Chena Hot Springs may be applicable at several locations in Alaska where these units can tap shallow geothermal aquifers with similar temperatures and flow rates. The challenge for these projects remains the upfront costs. Although the cost of power for these units may be lower, financing these projects can be difficult for small communities which may not be able to pay for it, and whose energy requirements may not be large enough to allow for a significant rate of return for installing the unit. Developers say that capitalizing on these opportunities requires that a queue of projects be identified to justify investment. Researchers assert that in some cases, additional businesses, such as mineral recovery could potentially be established through geothermal development to increase the revenue generated by the facility. Most agree the spectrum of potential applications is still undetermined in Alaska and should be open to discussion as new opportunities arise.

Policies and next steps

As Alaska looks at its future energy supply, most agree that the use of geothermal resources must be part of the conversation. Alaska has existing incentives which support geothermal development including a power project loan fund, and small energy-efficiency credits that are available to developers of geothermal direct use projects. As of December 2006, the use of geothermal resources in Alaska for both heat and power is miniscule compared to the potential use of the resource within reach of communities to use for heat or power. Researchers contend that follow up needs to be performed on previous studies and economic feasibility for potential projects need to be examined in greater detail. Developers say that Alaska's resources can be used not just for power and heat, but also to produce alternative fuel for use by local populations. Geothermal heating can be used for greenhouses or aquaculture to produce goods in-state that otherwise would have to be imported from the continental U.S. or internationally. USDOE is currently funding a study at Manley Hot Springs—where geothermal heating was used over 100 years ago for a small resort—for multiple possible uses, including district heating, greenhouse heating and CO_2 production, lodge or resort development, or community cold storage and power production. Manley Hot Springs is a community of under 100 accessible by a road connected to Fairbanks 150 miles to the southeast[87].

California

In 2005, geothermal power plants provided 5.0% of California's energy, generating 14,379 GWh of electric power. This accounts for approximately 90% of total U.S. generation from geothermal power plants that year[88].

California has the largest energy demand of any U.S. state. It also has among the highest energy rates, especially in urban areas where peak demands are among the highest in the nation.

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[86]Source: Kolker, Amanda and Yanity, Brian. "An Introduction To Geothermal Energy: Could It Power Alaska Communities?" Alaska Report, 10/09/2006: http://www.alaskareport.com/science10047.htm

[87]Additional sources for this section:
Alaska Energy Authority – Geothermal Energy:
http://www.akenergyauthority.org/programsalternativegeothermal.html
Database of State Incentives for Renewable Energy (DSIRE):
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=AK&RE=1&EE=1
Geothermal-biz.com – Summary of 2006 Task Order Agreement (TOA) Awards
Open Distribution. August 9, 2006: http://www.geothermal-biz.com/Docs/2006%20TOA.pdf

[88]Source – California Energy Commission (CEC):
http://www.energy.ca.gov/electricity/gross_system_power.html

Concerns over energy prices, pollution, environmental preservation, and population growth have been prominent issues for Californian's for many years, and as a result the need to find sustainable sources of energy has been a consistent policy priority.

While geothermal is the largest producer of non-hydro renewable energy in the state, there remains significant potential. California is part of the Pacific "Ring of Fire". Geothermal activity is evident throughout the state, from the Sierra Nevada Mountains to the Cascade Volcanoes to the active fault zones along the coastline, to the active geothermal regions east of San Diego. Researchers have identified at least three different geothermal systems in California. The areas of northern California are part of the Cascade Range of resources extending into Oregon and Washington State, areas in the south and east are part of the Great Basin system, and in the very southernmost parts of the state lies the extensive Salton Sea geothermal system. Only the Central Valley area of the state appears to lack readily accessible geothermal resources.

The recent WGA report identifies 25 potential geothermal fields in the state that could support power production in these three areas. The WGA report estimates that these sites could produce 2,375 MW of additional power economically by 2015, and as much as 7,078 MW if higher prices or a longer time frame is considered.

California's first modern geothermal power plant went online at The Geysers in 1960. The state currently has over 40 operating geothermal power plants with a generation capacity of over 2,000 MW, and its existing facilities have a total capacity of nearly 2,500 MW. However, despite California's abundant resources and strong history of development in the past, less than 100 MW have been installed since 1992. That new development represents less than 4% of the total geothermal capacity developed overall in California's history. Since 1992, the population of California has grown by over six million, and geothermal development has not kept pace.

New activity

While California's history of geothermal development is generally considered impressive, developers say that the lag in new development since 1992 is partly due to the fact that state renewable procurements initiated under the Public Utility Regulatory Policies Act of 1978 (PURPA) ceased that year after the Federal Energy Regulatory Commission (FERC) disapproved California's proposed energy plan. Since then, however, rising energy costs, and an ambitious RPS have spurred efforts to develop new geothermal power plants in the state. In the November 10th, 2006 GEA power plant survey, California had 15 new projects under construction totaling up to over 869 MW, of which up to 73 MW is currently under construction and expected to be online by the end of 2007[89].

Geothermal direct use applications are located throughout California in a variety of sectors: district and space heating; greenhouses; spas, pools, and resorts; cogeneration; and, to a limited extent, industrial processes. The sector that has expanded the most—and the one in which verification is easiest to come by—is the spa/pool/resort sector, where a number of new facilities have been constructed in recent years. While most of California's existing geothermal greenhouses have closed in the last several years, at least one new facility is under development in the state. Of all the direct use sectors in the state, most experts agree that geothermal heating has the largest potential for expansion[90].

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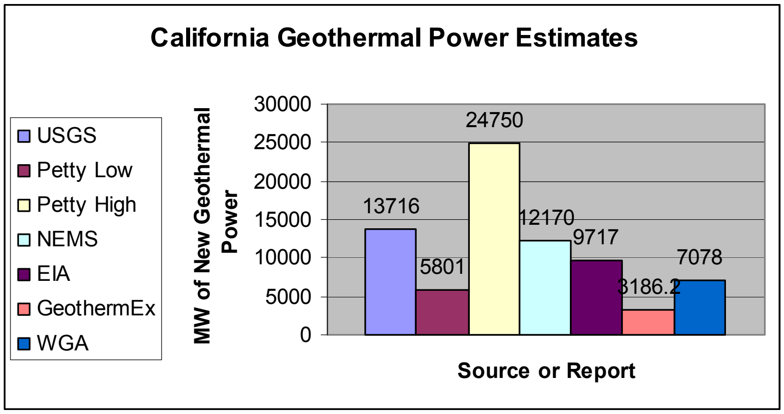
[89] *November 2006 Geothermal Power Production and Development Survey:* http://www.geo-energy.org/publications/reports.asp

[90] For more information see: Taylor, Robin. *Identifying New Opportunities for direct-use geothermal development*. Prepared by the Science Applications International Corporation for the California Energy

Figure 9: A Comparison of Recent Geothermal Power Supply Estimates for California



Source "California's Geothermal Resource Base 12-28-06" Geothermal Energy Association (GEA), http://www.geo-energy.org/publications/reports/CaliforniaGeothermalResourcesSeptember302006.pdf

Potential

In GEA's September 2006 report, they note that geothermal resource studies strongly indicate that California could support significant increases in renewable energy production to meet the state's RPS and Climate Change goals. As new technological applications have increased the available resource base in other states, California also has an opportunity to use its abundance of intermediate-temperature geothermal resources for small distributed generation projects. However, no assessment has been undertaken of California's distributed generation potential using small power technology, like that used at Chena Hot Springs, Alaska.

In addition, researchers suggest that California has significant potential to apply EGS techniques to its resource base, particularly in the Greater Salton Sea Geothermal Cluster.

Policies and next steps

The GRDA (mentioned earlier) is a state-funded program geared towards geothermal exploration and development. Funding from the program comes from a dedication portion of the federal royalties that the state received from federal leases. The GRDA has funded a range of power and direct use projects over the past two decades.

California's RPS was enacted on September 12, 2002 (SB 1078), it required retail sellers of electricity to purchase 20% of their electricity from renewable resources by 2017, and was already the most aggressive RPS in the country at the time. Because of perceived significant IOU progress towards this goal, the CEC and California Public Utilities Commission (CPUC) accelerated this goal of 20% renewables to 2010 and set the state's 2020 goal at 33%, with

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Commission (CEC): June 2005. (aka CEC-500-2005-108): http://www.energy.ca.gov/2005publications/CEC-500-2005-108/CEC-500-2005-108.PDF & Geothermal Energy Association (GEA): http://www.geo-energy.org/information/resources.asp ("existing direct use sites" and "developing direct use sites").

incremental gains each year. Municipal utilities are ordered by the legislation to implement RPS programs under their own direction.

Reaching these goals will require a tremendous amount of renewable energy. According to the November 2005 California Public Utilities Commission Report "Achieving a 33% Renewable Energy Target", geothermal is targeted to make up 30% of the total generation needed. This would mean 11% of California's energy mix would be expected to be powered by geothermal by 2020. This would require at least an additional 3,000 MW to be developed by that time. However, the state does not have a requirement that any one technology fulfill a specific percentage of the total, so the contribution of geothermal resources could be higher or lower depending on various factors[91].

For example, one factor very likely to have an impact on this goal is landmark legislation passed in California in September of 2006 restricting the emissions of greenhouse gases (GHGs) from its power facilities. Through this legislation, the state has made it a matter of public policy to prefer renewable technologies, like geothermal. Under the new law, the California Air Resources Board will develop a mandatory plan that will go into effect in 2009 to achieve these reductions.

Another factor is incentives. Through the RPS the state provides supplemental energy payments fund, which subsidizes renewable power above market cost (including geothermal projects). Although, outside the RPS there are no other major incentives for geothermal electric power development, California utilities offer a number of energy efficiency rebates and incentives that may apply to geothermal direct use. Geothermal projects are also affected by federal incentives like the PTC, and a number of those currently under development will hinge on its extension beyond 2008.

In addition to clean air policies and renewable energy incentives, a major factor in California has been and continues to be its regulatory process. California can be a difficult state to obtain leases, permits and licenses, and very often development includes federal lands as well which means a developer must meet both federal and state regulatory requirements and the two are not usually coordinated. As discussed later in this report, California BLM has not issued a geothermal lease in over two decades and this virtual moratorium on geothermal leasing has totally undercut new geothermal development in the state. Presently, the BLM and the USFS are beginning the process of preparing full scale Environmental Impact Statements for leases in two areas of the state – near Truckhaven in the South and Mount Shasta in the North. However, there is significant resource potential and leasing/development interest for other public lands in the state that will not be covered by these documents. The hope is that the BLM's new programmatic geothermal leasing EIS will cover these areas, and allow timely decisions to be made about geothermal energy development in California. The California Geothermal Collaborative (CGEC), supported by the CEC, brings together a wide range of interests from developers to environmental and tribal groups in the state to work collaboratively on utilizing the state's geothermal resources. The CGEC is viewing the programmatic EIS as its major focus for the coming year.[92]

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[91]Source of 30%: California Public Utilities Commission Report "Achieving a 33% Renewable Energy Target" (November 1, 2005): http://www.crs2.net/pub/Achieving_33_Percent_RPS_Report.pdf (Page 6)

[92] Personal communication, Karl Gawell, Chairman, California Geothermal Energy Collaborative, December 2006.

A multitude of government agencies and regulations are often involved in the permitting and environmental review process for geothermal activities in California. According to a geothermal permitting guide prepared for the CEC, "the permitting and environmental review process can be complicated and take between one to three years and in some cases longer due to appeals and lawsuits. Timing can depend on a number of things such as the environmental sensitivity of the project location and the amount of available environmental data for the site. Issues with endangered species/critical habitat, biological resources, cultural resources, etc. require field studies which usually have seasonal components that can take up to a year to complete."[93] It is clear the California needs a comprehensive approach to mitigate these issues in order to meet their goals for geothermal development.

Hawaii

Hawaii was the fourth U.S. state to develop a commercial geothermal power plant when the Puna Geothermal Venture (PGV) came online in 1993 on the "Big Island" of Hawaii. The Geo-Heat Center describes the geothermal activity in the Hawaiian Islands as lying "above a geological 'hot spot' in the earth's mantle that has been volcanically active for the past 70 million years." Geothermal activity is not unique to just the Big Island. However, as the youngest and largest geographically of all the Hawaiian Islands, it has the best promise for future geothermal development.

Like Alaska, Hawaii is isolated and faces high energy costs. In fact, the average retail energy rates for power in Hawaii are the highest in the country; more than double the national average. This provides an opportunity for geothermal power plants to be more competitive here than any state, especially because it is produced indigenously. Not only does Hawaii rely on imported oil for its transportation fuel, in 2005, according to the State of Hawaii Department of Business, Economic Development, and Tourism (DBEDT), 79.8% of its utility electricity was generated from petroleum-fueled facilities. Hawaii is the only U.S. state to generate a majority of its electricity from petroleum. Hawaii produces 14% of its electricity from coal, and 6.2% from renewable energy resources, including geothermal, wind, biomass, municipal solid waste, hydroelectricity, and photovoltaic. Although geothermal makes up a little less than 2% of the state's energy generation for utility sale, the 25-30 MW average power production from the PGV plant provided 18.1% of the utility electricity for the Big Island and it's over 167,000 residents (the second highest populated island after Oahu) in 2005[94].

New activity

Hawaii is anticipating expanding the use of its geothermal resources. Hawaii recently established the Hawaii Geothermal Working Group with leadership from the Strategic Industries Division of the DBEDT. The PGV plant has county permits that will allow it to expand to 60 MW and an initial 8 MW expansion is expected to be completed by 2008. While current direct use applications are limited and unsophisticated, there is interest in developing additional direct uses of geothermal heat. This includes a federally-funded feasibility study to examine if geothermal heat can support agricultural enterprises including greenhouses, aquaculture, pasteurization, and drying agricultural commodities such as papayas or lumber. This study addressed the possibility

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[93]Source: Geothermal Permitting Guide, by Paula Blaydes, Blaydes and Associates, 2006, prepared for the California Energy Commission (CEC) and California Geothermal Collaborative – Soon to be available on their website: http://cgec.ucdavis.edu/

[94]2005 data provided by the Hawaii Department of Business, Economic Development & Tourism Strategic Industries Division (DBEDT): http://www.hawaii.gov/dbedt/info/energy/ & http://www.hawaii.gov/dbedt/info/census/popestimate/2005-county-population/County_Population_Facts_2005.pdf

of using waste heat from the PGV plant, among other alternatives. USDOE is also providing funding to study how geothermal resources could be used to produce hydrogen for stationary power or transportation. Hawaii, with the highest gasoline costs in the country, is very vulnerable to the volatility of fuel prices. In addition to providing utility power, those working on the project suggest that geothermal energy converted to hydrogen can provide Hawaii with an indigenous alternative fuel supply[95].

Potential

Hawaii has significant potential for geothermal development. As noted above, while other islands have some low and intermediate temperature resources, the Big Island remains the central focus for new development. In 1976, an experimental well, drilled near the location of the PGV plant, obtained a bottom-hole temperature (BHT) of 676°F (358°C), at a depth of 6,450 ft (1,966 m). It produced 80,000 lb/hr (36.3 tonnes/hr) of a mixed fluid (57% liquid and 43% steam). This well, called HGP-A, was drilled in what is referred to as the Lower Kilauea East Rift Zone (KERZ). A 3 MW demonstration facility operated at this location for eight years in the 1980s with a surface temperature during production of 365°F (186°C). At the time, estimates for the recoverable geothermal resource on the Big Island were as high as 500 MW, significantly more than the island's energy needs. As a result, an underwater transmission cable system was considered to transmit excess electric power to Oahu. However, the project was challenged by both economics and controversy. Questions were raised about the environmental impact of the transmission lines as well as the impact of access roads, and emissions from the plant on forests and the local ecosystem. Inter-island transmission of geothermal electricity is no longer being pursued. More recent estimates of the recoverable resource range from 180 MW to 400 MW for the Lower KERZ, still enough to serve 100% of the energy needs for the Big Island[96].

Policies and next steps

As Hawaii looks ahead to future development, there is an emphasis on innovation. The state has established an RPS of 20% of utility electricity sales by 2020. With the high cost of fuel, hydrogen production is expected to be a high priority for geothermal development. While Hawaii provides no state tax credits for geothermal power generation, the state legislature authorized the creation of a High Technology Business Investment Tax Credit in 2001 to encourage innovative

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[95]Sources for this section:
Battocletti, Liz. "The Economic, Environmental, and Social Benefits of Geothermal Use in Hawaii". Bob Lawrence and Associates (June 2006): http://www.geothermal-biz.com/Docs/HI.pdf
"Feds to pitch in on geothermal study." Pacific Business News, 6/27/2006: http://pacific.bizjournals.com/pacific/stories/2006/06/26/daily17.html
Yuzugullu, Elvin, D.Sc. "Geothermal to Hydrogen on the Island of Hawaii"
SENTECH, Inc. National Hydrogen Association Renewables to Hydrogen Forum
October 4 –5, 2006, Albuquerque, NM:
http://www.hydrogenassociation.org/renewablesForum/pdf/geohydro_yuzugullu.pdf

[96]Sources for this section:
Geo-heat Center at the Oregon Institute of Technology (OIT): "Hawaii and Geothermal: What has been happening" – September 2002 GHC Bulletin: http://geoheat.oit.edu/bulletin/bull23-3/art4.pdf
GeothermEx, Inc. *Assessment of energy reserves and costs of geothermal resources in Hawaii*. Prepared for the Hawaii Department of Business, Economic Development & Tourism. September 30th, 2005: http://www.hawaii.gov/dbedt/info/energy/publications/geothermal-assessment-05.pdf
Western Governors' Association (WGA) Geothermal Task Force Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (page 65)
Yuzugullu, Elvin, D.Sc. "Geothermal to Hydrogen on the Island of Hawaii"
SENTECH, Inc. National Hydrogen Association Renewables to Hydrogen Forum
October 4 –5, 2006, Albuquerque, NM:
http://www.hydrogenassociation.org/renewablesForum/pdf/geohydro_yuzugullu.pdf

technologies including those that use renewable energy resources. The credit offers a 100% tax credit on an equity investment in a qualified high technology business with a current maximum of $2 million over five years. A business that uses geothermal resources to make alternative fuels (such as hydrogen) may qualify for the credit[97].

Ongoing studies are expected to continue for the next few years to analyze the range of opportunities for geothermal development in Hawaii. Industry stakeholders hope this effort will result in new investment in geothermal development which can mitigate energy issues on the Big Island and potentially help other islands by transporting alternative fuels or other products developed with help from the geothermal resource.

Oregon

Oregon contains one of the largest geothermal resources in the country, but does not have an operating geothermal power facility as of the end of 2006. Like its neighbors in California and Washington State, Oregon sits in the "Pacific Ring of Fire" with active volcanoes of the Cascade Range dominating the landscape in the west-central part of the state. In addition to the Cascade Range, Oregon has several other regions with high potential for geothermal development. This includes parts of the Oregon Plateau of central Oregon and the northwest extension of the Basin and Range Province in southeastern Oregon. Geothermal resources are also identified in eastern Oregon, at the western edge of the Snake River Plain (See Figure 10). Although no geothermal power plants currently operate in Oregon, geothermal electric power production has been demonstrated in the state. Three small binary units were installed in Hammersly Canyon near Lakeview in the mid-1980s that ran for several years until several of the units were sold to another developer[98].

The majority of electric power in Oregon is provided by hydroelectric dams, and the price of power remains below the national average. However, a rising population along with salmon recovery issues affecting hydroelectric dams has led to concerns over future energy production. Oregon has already developed a queue of utility-scale wind farms, and has been looking to procure more renewable power for sale in-state and into California. Efforts have also increased to develop geothermal direct use projects. Oregon already uses geothermal resources for a variety of thermal applications, including district heating and space heating for businesses and residences, agricultural drying, mushroom production, greenhouses, aquaculture, recreation, and snow melting[99].

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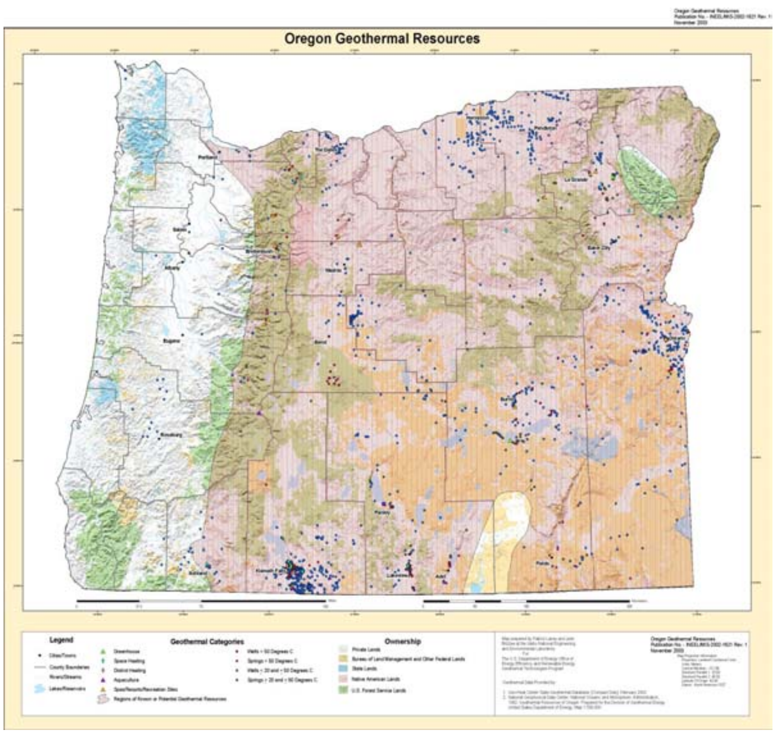
[97] Source for this section:
Database of State Incentives for Renewable Energy (DSIRE):
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=HI&RE=1&EE=1

[98] Source – "Small Geothermal Power Project Examples". Geo-Heat Center at the Oregon Institute of Technology: http://www.geothermie.de/egec-geothernet/prof/small_geothermal_power.htm

[99] Sources for this description:
Energy Information Agency (EIA) – 2004: http://www.eia.doe.gov/cneaf/electricity/st_profiles/oregon.pdf
Energy Information Agency (EIA) – Average Retail Price of Electricity by State, 2005:
http://www.eia.doe.gov/cneaf/electricity/epa/fig7p4.html
Geo-heat Center at the Oregon Institute of Technology (OIT) – Oregon State Geothermal Projects:
http://geoheat.oit.edu/state/or/or.htm
Geo-heat Center at the Oregon Institute of Technology (OIT): "Oregon Trail Mushrooms" – March 2004 GHC Bulletin: http://geoheat.oit.edu/bulletin/bull25-1/art5.pdf
GeoPowering the West (GPW) – Oregon State Profile:
http://www.eere.energy.gov/geothermal/gpw/profile_washington.htmlhttp://www.eere.energy.gov/geothermal/gpw/profile_oregon.html
Geothermal Technologies Program: Oregon – State Fact Sheet:

Figure 10: Oregon Geothermal Resources. Source – Idaho National Laboratory: http://geothermal.id.doe.gov/maps/index.shtml



New activity

Oregon is becoming one of the hottest states for new geothermal installations. Power projects are under development in four separate areas and there is new development of direct use installations, including activity in eastern Oregon with an expansion of geothermal use at a factory that produces motor homes in Hines and the re-opening of a greenhouse in Crane. In Lakeview, a small prison began using a geothermal heating system in 2005. In addition, a feasibility study on using a geothermal resource for an onion drying facility in eastern Oregon was performed in 2006 that concluded the project was technically feasible and offered further recommendations on how to proceed[100]. Three utility-scale geothermal power plant projects are planned at Crump Geyser (40-60 MW) in the Warner Valley of Lake County roughly 33 miles east of Lakeview, Neal Hot Springs (25-30 MW) near Baker City close to the Idaho border, and the Newberry Volcano project (120 MW total) which has already secured a PPA with Pacific Gas & Electric (PG&E).

One of the major continuing growth areas for geothermal use in Oregon is Klamath Falls. Located near the California border in Klamath County, the Klamath Basin has a population of about 50,000. The City of Klamath Falls operates the state's only district heating system, and also uses its resource for aquaculture, snow melting, and swimming pool heating. A geothermal

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http://www.nrel.gov/docs/fy05osti/36550.pdf

[100]See: Geo-Heat Center at the Oregon Institute of Technology (OIT) – *Feasibility Study for the direct use of geothermal energy for onion dehydration in Vale/Ontario Area, Oregon – Final Report*. May 1, 2006: http://www.oregon.gov/ENERGY/RENEW/Geothermal/docs/OnionDehydration-FinalReport.pdf

research program is run at the Geo Heat Center at OIT which heats its buildings with the geothermal resource. OIT is planning to install a small PureCycle™ unit similar to that installed at Chena Hot Springs in Alaska in 2007 that would provide power for a fourth of the campus, and plans to develop a small-scale geothermal power plant afterwards that would provide power for the entire campus of over 2,600 students. The community of Klamath Falls is also studying the potential to use its resource for a bio-diesel production plant on a farm outside of town, and a pilot project produced about 10,000 gallons of bio-diesel in the summer of 2006 using a geothermal heating system for thermal energy needs. A geothermal heating system for a local newspaper building is under construction, and OIT is looking into developing geothermal greenhouses and aquaculture ponds that companies could use to test products before opening a full-scale operation. This is similar to the "business incubator" program initiated by NMSU in Las Cruces, New Mexico in the 1990s.

Potential

Geothermal potential in Oregon has been known for some time. The most substantial exploration of Oregon's geothermal resources was performed during the 1970s when utilities pursued joint ventures with petroleum companies (and government money) to search for geothermal hot spots in the Cascade region. While a number of potential geothermal prospects were identified during this time, there were challenges to development that kept companies from moving forward. Geothermal projects in Oregon were competing with some of the lowest energy rates in the country, and most of the promising geothermal prospects, including those at Crump Geyser and Neal Hot Springs, were considered too remote or with insufficient resource conditions to be economical. Another issue has been resources located on scenic lands. The development of the project at Newberry Volcano has been in the works for over two decades, and has been stalled several times before progress was made to secure drilling permits for the new project under development. In a 2003 BLM report, the agency cited that over 80 applications for geothermal leases are pending on national forests in Oregon[101] (something that hasn't changed over the past three years with the exception of Newberry).

According to the WGA Geothermal Taskforce Report, Oregon has up to 380 MW of economically viable geothermal electric power potential by 2015 at eight specific resource areas, which are named in the report. It also mentions long-term potential near major Cascade volcanoes including the area around Mount Hood and the Three Sisters that could total up to 500 MW. The development of these areas will require close coordination with the USFS to ensure limited environmental impact, and may meet with considerable public opposition. Researchers suggest that Oregon has resource potential in areas throughout the state not explored in detail during the 1970s, but more exploration and drilling needs to be done to identify new prospects. Oregon has experienced little oil and gas production, which limits understanding of subsurface geology in its promising regions. Industry stakeholders suggest that the best near-term geothermal prospects in Oregon are those under development in southeastern Oregon on private and BLM lands (which have had fewer regulatory issues than Oregon geothermal projects on USFS lands). However, with OIT expecting to install a small-scale geothermal power plant using the technology demonstrated at Chena Hot Springs, Alaska, developers say that the available geothermal resource base in Oregon for electric power production has widely expanded[102].

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[101] Bureau of Land Management (BLM): "Opportunities for Near-Term Geothermal Development on Public Lands in the Western United States". 2003: http://www.nrel.gov/docs/fy03osti/33105.pdf

[102] Sources for this section:
Energy Information Agency (EIA) – Petroleum Profile: Oregon:
http://tonto.eia.doe.gov/oog/info/state/or.html
Geo-heat Center at the Oregon Institute of Technology (OIT) – Oregon Collocated Resources:

Policies and next steps

Similar to California, Oregon has been progressive in its environmental policy and support for energy efficiency and renewable energy. Although the state has yet to pass an RPS, the Governor has proposed one that would require Oregon utilities to generate 25% of their power from clean, renewable sources by 2025. Specific details on how the RPS might be structured are still under discussion, although it is clear that geothermal power projects will be included.

Currently, the state offers low-interest loans that apply to geothermal power projects. The state also offers a Business Energy Tax Credit (BETC). The credit covers 35% of tax liability for "costs directly related to the project, including equipment cost, engineering and design fees, materials, supplies and installation costs. Loan fees and permit costs also may be claimed." The credit currently has a maximum eligible project cost of $10 million (maximum credit of $3.5 million) and the credit is filed over five years. Projects with eligible costs of $20,000 or less may be taken in one year and unused credits can be carried forward for up to eight years. Since its enactment in 1980, more than 7,400 energy tax credits have been awarded to Oregon businesses. Geothermal developers in Oregon consider this credit to be very attractive and helpful in reducing their project costs. In the next legislative session that starts in January 2007, legislation will be introduced to increase this BETC to 50% with a maximum eligible project cost increase from $10 million to $20 million.

Geothermal power projects are also eligible for cash incentives from the Energy Trust of Oregon, which manages Public Purpose Charge funds for energy efficiency and renewable energy projects for the benefit of PG&E and Pacific Power's ratepayers.

For geothermal direct use, low interest loans and business tax incentives from the state are also available. In addition, there is a Residential Energy Tax Credit for geothermal heat pumps. The Energy Trust of Oregon also has incentives for geothermal direct use. Overall, most agree that the future for geothermal development in Oregon looks bright. New projects currently under development will raise awareness about the value of the resource and bring new investors into the state. Most agree that Oregon should continue to support geothermal projects and efforts for new exploration and new applications that can create opportunities for economic development[103].

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http://geoheat.oit.edu/oregon.htm
Oregon Geothermal Working Group:
http://www.oregon.gov/ENERGY/RENEW/Geothermal/geo_index.shtml
Western Governors' Association (WGA) Geothermal Task Force Report (January 2006):
http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (pages 64-65)

[103]Sources:
Database of State Incentives for Renewable Energy (DSIRE):
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=OR&RE=1&EE=1
"Oregon RPS" – Governor outlines agenda in State of the State speech, 2/24/2006:
http://governor.oregon.gov/Gov/p2006/press_022406.shtml
Oregon Geothermal Working Group – Oregon incentives for geothermal power:
http://www.oregon.gov/ENERGY/RENEW/Geothermal/Incentives.shtml

States without a history of geothermal power development

Colorado

Colorado is known for its lofty mountains and its thick alpine forests. Tucked below these mountains is an abundance of hot springs and geothermal activity. The Colorado Geological Survey lists "106 hot springs and 63 geothermal wells ranging in temperature from 68ºF to 181ºF across the state." These resources are concentrated west of the Front Range, particularly in the "Rio Grande Rift" and the Southern Rocky Mountain regions. Within these regions, geothermal resources are used in at least 30 resorts which are a major tourist attraction for visitors to the state. There are several aquaculture facilities where a variety of aquatic species are raised including lobster, shrimp, tilapia, catfish, salmon, trout, striped bass and even an alligator farm near Alamosa. In addition, geothermal resources are used to heat individual homes, businesses, greenhouses and a district heating system in Pagosa Springs a small community of just over 1,500, 60 miles east of Durango in Archuleta County. The system currently serves the town's three schools, as well as two churches, and additional homes, businesses, and government buildings. Geothermal water is also used to melt snow[104].

New activity and potential

Despite the active use of geothermal hot springs in the state, researchers say that geothermal resources in Colorado have traditionally been viewed as a tourist attraction rather than an energy source. New development stalled in Colorado over the past decade, however interest in development has increased as rising energy costs in Colorado and the rest of the country have led to new investment and study of alternative energy resources. Current projects include a technical feasibility study for a district heating system in the small community of Crestone, 50 miles north of Alamosa, consideration for using an existing geothermal well for a spa/eco-resort in Salida, and the city of Steamboat Springs is investigating the use of geothermal water for snow melting[105].

The Colorado Geothermal Working Group was recently established with help from the GPW program and the Governor's Office of Energy Management and Conservation (OEMC). OEMC has partnered with USDOE over the past several years to identify the existing uses of the state's geothermal resources and to identify new opportunities for both geothermal direct use and geothermal power. For geothermal power, efforts by the Colorado Geological Survey have identified areas with potential for high-temperature aquifers to be exploited. Thus far, the regions where researchers contend that there is potential for geothermal electric power production are located west of the Rockies in the southern half of the state, with particular areas of interest in the Arkansas River and San Luis Valleys.

Colorado geologists say they benefit from the history of deep oil and gas drilling in these regions, particularly the San Juan Basin where they have registered gas temperatures of 320°F (160°C) at 6,800 feet (2,073 meters). Furthermore, additional studies by the Colorado Geological Survey and the Idaho National Laboratory have "found promising conditions at nine areas in the state, most notably in the Chalk Creek area near Buena Vista, near the Mount Princeton Hot Springs Resort." Researchers suggest that most of these areas would be suitable for small power production with existing technology, although geochemistry for a few of these areas have

[104]Information on this section based on USDOE Geothermal Technologies Program: Colorado – State Fact Sheet: http://www.nrel.gov/docs/fy06osti/38241.pdf
[105]See: Geo-heat Center at the Oregon Institute of Technology (OIT): "Steamboat Springs, Colorado" – September 2006 GHC Bulletin: http://geoheat.oit.edu/bulletin/bull27-3/art4.pdf

estimated reservoir temperatures possibly higher than 302°F (150°C) at depth. According to the WGA taskforce report, estimates for economic near-term power production at these nine areas is 20 MW by 2015, although the Colorado Geological Survey says that the long-term potential is much higher because the resource is abundant when considering depths between 3 and 4 km[106].

Policies and next steps

With the establishment of the Colorado Geothermal Working Group and geothermal power prospects identified, most agree that interest in development will increase. Colorado's use of renewable power is relatively low, and the most recent installations of renewable power have been wind farms. Geothermal power projects are eligible for Colorado's RPS which requires all of its utilities with 40,000 or more customers to obtain 6% of their retail energy sales from renewable resources by 2011 and 10% by 2015. The state provides additional assistance to help utilities procure renewable power to meet their RPS. For geothermal direct use there are areas where new businesses can emerge and existing facilities that may expand operations. According to the July 2006 report, "The Economic, Environmental, and Social Benefits of Geothermal Use in Colorado" written by Liz Battocletti of Bob Lawrence and Associates, existing "geothermal businesses create an estimated 3,000 direct, indirect and induced jobs in Colorado" and the state contains a low-temperature geothermal resource capable of providing heat and hot water for 100,000 homes. Individual utilities in Colorado currently provide incentives, grants, loans, and rebates for energy efficiency which may apply to geothermal direct use[107].

Montana

Montana contains geothermal resources throughout the state useful for heating and agricultural use. While it borders Yellowstone National Park on its southwest edge, high-temperature resource potential outside of this protected area has been evidenced in several locations in the western part of the state. Western Montana includes the northern chain of the Rocky Mountains and much of the geology in the area is part of Boulder Batholith region that stretches into Idaho. This region is dominated by granitic rock formations where anomalous heat flow can be found in deep circulation of ground water in fault zones. It encompasses much of southwestern Montana, the most active geothermal region in the state, and contains several hot springs and geothermal wells

[106] Additional sources for this section:
Battocletti, Liz. "The Economic, Environmental, and Social Benefits of Geothermal Use in Colorado". Bob Lawrence and Associates (July 2006): http://www.geothermal-biz.com/Docs/Colorado.pdf
Governor's Office of Energy Management and Conservation (OEMC) – Geothermal Resources in Colorado: http://www.state.co.us/oemc/programs/renewable/geothermal.htm
Geo-heat Center at the Oregon Institute of Technology (OIT) – Colorado Collocated Resources: http://geoheat.oit.edu/colorado.htm
"Geologist Says State Has More Energy Resources Than Oil". Telluride Watch, 6/20/2006: http://www.telluridewatch.com/archive_news/2006/june/062006/briefs.htm
Geothermal Technologies Program: Colorado – State Fact Sheet: http://www.nrel.gov/docs/fy06osti/38241.pdf
Western Governors' Association (WGA) Geothermal Task Force Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (page 64)

[107] Sources for this section:
Battocletti, Liz. "The Economic, Environmental, and Social Benefits of Geothermal Use in Colorado". Bob Lawrence and Associates (July 2006): http://www.geothermal-biz.com/Docs/Colorado.pdf
Database of State Incentives for Renewable Energy (DSIRE): http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=CO&RE=1&EE=1
Energy Information Agency (EIA) – 2004: http://www.eia.doe.gov/cneaf/electricity/st_profiles/colorado.pdf

that are exploited for various uses, including aquaculture, greenhouses, spas and resorts, and industrial-heating for a laundromat.

New activity and potential

Industry stakeholders assert that Montana's geothermal resource has been overlooked due to its low energy prices, low population and its lack of transmission access to remote locations. More recently, there have been proposals and interest in expanding geothermal direct use in the state both at existing facilities and new locations. The cost of power in Montana is below the nationwide average and the state is a net-exporter of energy. However, prices have risen in recent years leading to increased interest in exploiting geothermal resources to contend with large heating loads experienced throughout much of the year.

The Montana Geothermal Working Group was recently established with help from the GPW program, and put together an educational website that describes more than 50 geothermal areas in the state where geothermal resources serve direct uses or have potential for either direct uses or electric power. According to the website, 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[108].

While these sites may hold future potential for development, near-term focus for state energy planning may be in eastern Montana. Several deep oil and gas wells discharge hot fluid at boiling temperatures, including at Poplar Dome in eastern Montana. These areas are considered candidates for small-power production using conventional geothermal binary units to produce electric power on-site and perhaps sell additional power to the local energy grids. Industry stakeholders in Montana assert that distributed generation is practical for Montana due its transmission constraints.

Policies and next steps

With the establishment of the Montana Geothermal Working Group most agree there will be more opportunities in Montana for investors, businesses, and the general public to pursue geothermal development. Montana has an RPS that requires its IOUs (which distribute nearly 2/3rd of its energy) to obtain 8% of their retail energy sales from renewable resources by 2010 and 15% by 2015—of which geothermal power is eligible. Montana also has tax credits and grants and loans, of which geothermal power and geothermal direct use projects are eligible. In the near-term industry stakeholders in the state are focused more on community-based geothermal direct use projects than on geothermal electric power. In general, oil and gas co-production and geothermal space heating is considered the greatest potential for using geothermal resources in Montana[109].

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[108] For more detailed information on these locations, see these sources:
Metesh, John."Geothermal Springs and Wells in Montana". Montana Bureau of Mines and Geology Open-file Report No. 415. July, 2000
http://www.montanagreenpower.com/renewables/pdfs/montange.pdf &
Montana Geothermal Program: http://geothermal.mt.gov & http://www.geothermal.mt.gov
National Center for Appropriate Technology – Montana Green Power:
http://www.montanagreenpower.com/renewables/geothermal/index.html

[109] Sources for this section:
Database of State Incentives for Renewable Energy (DSIRE):
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=MT&RE=1&EE=1 & the
National Center for Appropriate Technology – Montana Green Power:

Texas

As the largest state in the continental U.S., Texas has a variety of geological features from the Great Plains to desert to mountains to the low coastal plains in the Gulf of Mexico. Historically, geothermal use in Texas has been limited to a handful of small geothermal resorts and heating facilities. While small hot springs exist in several areas in the state, shallow high-temperature convective geothermal aquifers have not been discovered. However, oil and gas production in Texas has an infrastructure that enables geothermal development to become a viable alternative source of energy. Over 600,000 oil and gas wells have been drilled in the state providing widespread data on subsurface temperatures. High-temperature fluid has been encountered in a large number of these wells, many of which reach depths between 4 and 8 km. As noted earlier, there are opportunities to extract geothermal electric power from geopressured reservoirs or hot wastewater from oil and gas fields using a binary system. In addition, Texas has significant geopressured geothermal resources. The US Department of Energy built a geopressured demonstration plant at Pleasant Bayou near the Gulf Coast in southeast Texas that ran from January through May of 1990, using high-temperate fluid and natural gas to generate a consistent net production of 982 kW of electric power. A total of 3,445 MWh of power were sold to the local utility over the course of the test[110].

New activity and potential

The first Texas Geothermal Working Group Meeting was held in November of 2005 and a subsequent workshop was held in March of 2006 at the Southern Methodist University (SMU) campus in Dallas that generated considerable interest in geothermal potential in the state. With support from the USDOE Geothermal Technologies Program, programs at SMU and the University of Texas of the Permian Basin (UTPB) are leading the research effort to identify opportunities to generate electricity from hot water found in oil and gas wells. A second Texas Geothermal Working Group meeting was held in November of 2006 as part of the Texas Renewable Energy Industries Association meeting in Austin where there were geothermal breakout sessions during the two days of meetings.

Researchers have determined that Texas contains "at least five regions display potential for electrical energy production due to access to high temperatures" from its oil and gas wells. Through a grant from the USDOE, UTPB is cataloging up to 30,000 oil and gas wells in target areas for a database that will include subsurface temperature mapping. An interim report was released in 2006 that documents over 8,000 BHTs from over 5,000 wells to date. The data is recorded into Excel databases covering eight counties, from depths ranging between 1,000 to nearly 30,000 feet (305 meters to 9,144 meters). Temperatures for many of the wells 16,000 feet (4,877 meters) or deeper wells were above 250°F (121°C) with the highest temperatures above 400°F (204°C)[111].

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http://www.montanagreenpower.com/renewables/geothermal/index.html

[110] Sources:
Southern Methodist University – "Texas Workshop Opens Discussion of Major New Area for Geothermal Energy Production – Oil and Gas Fields":
http://www.smu.edu/geothermal/Oil&Gas/Oil&Gas_SMUmeeting_summary.htm
Battocletti, Liz. "The Economic, Environmental, and Social Benefits of Geothermal Use in Texas". Bob Lawrence and Associates (August 2006): http://www.geothermal-biz.com/Docs/Texas.pdf & Campbell, R.G. and Hattar, M.M., 1991, Design and Operation of a Geopressured-Geothermal Hybrid Cycle Power Plant; The Ben Holt Company, v.1, 180 p., DOE Contract No. DE-ACO7-85ID12578.

[111] Source for these numbers:
Geothermal-biz Newsletter (October 2006 – Texas): http://www.geothermal-biz.com/newsletter/Oct-2006.htm & The University of Texas of the Permian Basin, Center for Energy and Economic

According to the USDOE, more than 12 billion barrels of water are currently produced each year from oil and gas wells in Texas and researchers say that water with temperatures of at least 210°F and flow rates of at least 500 gpm are sufficient for electric power production. Given this criteria 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 once the technology is demonstrated.

In addition to the opportunities to extract geothermal power from deep oil and gas wells for power plants or distributed generation, researchers suggest that Texas has a wide range of potential areas where geothermal resources can serve various direct uses, including fish farming, greenhouses, space-heating, and spas and resorts. One of these areas is in western Texas along the Rio Grande River in the Trans-Pecos region where the population is sparse with the exception of El Paso. The other area is in Central Texas from the southern Rio Grande through the Balcones Trend where hydrothermal aquifers range from about 90 to 160°F (32 to 71°C) at depths from 500 to 5,000 feet (152 to 1,524 meters). Major cities located in this region include San Antonio, Austin, and Dallas. A recreational facility in the state capital of Austin currently uses geothermal water to heat an outdoor swimming pool and there has been recent interest in developing additional spas in the area[112].

Policies and next steps

With the establishment of the Texas Geothermal Working Group and ongoing research at its oil and gas wells, researchers may be on the verge of a breakthrough in clean energy technology. There are already several oil and gas companies in discussions with investors and developers to install the first commercial geothermal electric power units. In 2004, Texas had the highest energy demand in the U.S., eclipsing even California. This is due in part to its large industrial and manufacturing sectors, which includes oil and gas production. Texas has an RPS mandate that affects all utilities in the state and requires the procurement of 5,880 MW of renewable power by 2015 (roughly equal to between 4 and 5% of state energy supply) and includes geothermal electric power. The state currently provides a number of incentives for renewable energy production. However, incentives available to geothermal electric power produced at oil and gas wells has not yet been defined, and will likely be determined once the technology is demonstrated. Individual utilities in Texas currently provide incentives, grants, loans, and rebates for energy efficiency which may apply to geothermal direct use, including Austin Energy[113].

Diversification (CEED) – Geothermal in West Texas:
http://www.utpb.edu/ceed/renewableenergy/west_texas.htm & Erdlac, Jr., R.J., personal communication.

[112] Additional sources for this section:
Battocletti, Liz. "The Economic, Environmental, and Social Benefits of Geothermal Use in Texas". Bob Lawrence and Associates (August 2006): http://www.geothermal-biz.com/Docs/Texas.pdf
Geothermal Technologies Program: Texas – State Fact Sheet:
http://www.nrel.gov/docs/fy06osti/38242.pdf
Texas State Energy Conservation Office – Texas Geothermal Energy Resources:
http://www.infinitepower.org/resgeothermal.htm

[113] Sources for this section:
Database of State Incentives for Renewable Energy (DSIRE):
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=TX&RE=1&EE=1 &
Energy Information Agency (EIA) – 2004: http://www.eia.doe.gov/cneaf/electricity/st_profiles/texas.pdf

Washington State

As part of the area known as the "Pacific Ring of Fire", Washington State has active volcanoes and thermal wells have been measured throughout the state, with the largest concentration in the Cascades region and the Columbia River Basin. These areas are prime candidates for geothermal direct use projects with large heating loads throughout much of the year. While some of these areas are very rural, they are not as sparsely populated as in geothermal resources areas in nearby states like Idaho, Nevada, and eastern Oregon.

Most agree that the use of geothermal resources in Washington State is vastly under-utilized. Despite numerous wells and springs, the state only uses geothermal heating for several small spas and resorts.

New activity and potential

For many years, Washington State has had low energy prices, and still uses hydroelectric power as its main source of power. In 2005, the state still had among the lowest power prices in the country. However, like Idaho, Washington State faces issues related to salmon recovery which will continue to affect its hydroelectric dams as they renegotiate their power contracts.

While there has been an upswing of wind development in the state, geothermal development has still not gained a foothold. There have been no major geothermal direct projects built in the past few years, and there are not any currently under development as of November 2006. However, efforts are expected to pick up as geothermal development has increased in Idaho and Oregon, raising questions about why activity is slow in Washington State. Washington State University maintains a geothermal research program valuable to development throughout the Pacific Northwest and the country. Washington State shares a GPW-sponsored geothermal working group with Oregon.

Like Oregon, Washington State is not a producer of oil and natural gas. In addition, exploration drilling for geothermal resources has been very limited, particularly due to the fact that its best resource areas reside at or near scenic areas and often involve USFS land. The areas in the state with the greatest potential for power development are in the Cascades. This includes the Mount Adams area in the southern Cascades, the Wind River area east of Vancouver and the Mount Baker area in the northern Cascades. There are several pending leases to explore these areas for geothermal electric power potential, however environmental restrictions limit where projects can be sited, and little progress has been made over the past few years.

Recent assessments of the geothermal potential in these areas range from 50 MW in the near-term to 600 MW in the long-term. Like with similar resource areas in Oregon, development in these areas will require close coordination with the USFS to ensure limited environmental impact, and may meet with considerable public opposition. Industry stakeholders suggest that the best prospect for near-term development is for geothermal direct use. A 1994 assessment of direct use resources cited 941 thermal wells in the state primarily located in the Columbia Basin. USDOE suggests these resources can be used for large-scale residential heating or agricultural applications such as greenhouses and aquaculture[114].

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[114]Sources for this section: GeoPowering the West (GPW) – Washington State Profile:
http://www.eere.energy.gov/geothermal/gpw/profile_washington.html
Geothermal Technologies Program: Washington – State Fact Sheet:
http://www.nrel.gov/docs/fy05osti/36549.pdf
Western Governors' Association (WGA) Geothermal Task Force Report (January 2006):
http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (page 64)

Policies and next steps

As Washington State residents experience a rise in their heating costs, it is likely that they will seek out alternatives. Many residents currently use ground source heat pumps; however researchers say that low-temperature geothermal aquifers may be available through deeper drilling that can heat larger installations and even entire communities. Washington State passed an RPS in November of 2006 for 15% by 2020. The RPS includes geothermal electric power and applies to all utilities in Washington State with more than 25,000 customers. At the time of this writing, it still remains to be implemented. Washington State also has other incentives that may apply to geothermal development. Most of these incentives are run by utilities themselves that support energy efficiency projects that would include geothermal direct uses. In general, geothermal power projects still need to clear major hurdles before developers are able to begin development. However, there will likely be new geothermal direct use development in the near future in Washington State as new investment occurs throughout the western U.S. It is clear that much work needs to be done to evaluate specific development opportunities to begin to raise awareness about how geothermal resources can benefit the residents of Washington State.

Wyoming

Wyoming is a state known for its geothermal resources. Yellowstone National Park is a volcanic caldera created roughly 600 thousand years ago that contains "half of the earth's geothermal features and two-thirds of its geysers." Although commercial development is restricted in the park, researchers assert that geothermal resources can be utilized for various applications in other parts of the state. As of 2006, however, the use of these geothermal resources remains small, limited to a few geothermal spas, an aquaculture facility, and a small greenhouse.

While geothermal resources can benefit Wyoming, which has large heating loads given its northern latitude and high elevation, its energy prices remain among the lowest in the country—although rates have been rising in recent years. There are several areas of interest for new direct use development, but stakeholders in the state say that Wyoming lags behind neighboring states. Wyoming is the largest exporter of coal in the U.S. and is a major supplier of oil and natural gas. Wyoming remains the least populated of all 50 states, and the bulk of its population does not live in the most active geothermal regions[115].

New activity and potential

Like Montana, deep oil and gas wells in the state have discharged hot fluid from deep depths. A project at the Teapot Dome oil field (operated by the USDOE) is considering a demonstration project that would involve the installation of a distributed generation facility to turn the hot fluid into electric power to serve energy needs for oil production. There is additional interest elsewhere in the state to install small-scale distributed generation units using intermediate-temperature geothermal resources. In addition, other oil and gas fields in Wyoming may be able to use this technology if it is successfully demonstrated and is cost-effective.

The full potential of Wyoming's available geothermal resources in not fully understood. Outside of Yellowstone National Park, western Wyoming includes the middle Rocky Mountains and the Wyoming Basin. Hot springs and areas of high heat flows can be found throughout the area,

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[115]Sources for this section:
Geo-heat Center at the Oregon Institute of Technology (OIT) – Wyoming State Geothermal Projects: http://geoheat.oit.edu/state/wy/wy.htm & Geothermal Technologies Program: Wyoming – State Fact Sheet: http://www.nrel.gov/docs/fy06osti/38243.pdf

which contains most of the existing spas and direct use developments. Transmission access limits other promising areas. However, the potential within oil and gas fields may be extensive.

As for direct use, researchers say that opportunities need to be examined in greater detail. Efforts to help clarify these and additional opportunities have been undertaken by the USDOE through GPW, working with a non-profit economic development group called the Converse Area New Development Organization.

Policies and next steps

With the efforts of GPW and the opportunity for near-term power development at Teapot Dome, awareness of geothermal resources will likely gain momentum in Wyoming. Currently, the state has no active geothermal research programs geared towards new development. The only appreciable state incentive where geothermal development may apply is a sales tax exemption for equipment used to generate electricity from renewable resources. There are no state incentives directly for geothermal direct use or geothermal heating. Wyoming has no RPS, and most of the existing renewable energy facilities in the state (including 288 MW of wind capacity installed by September of 2006) are exported to neighboring states[116].

Geothermal development in the rest of the United States

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 direct use[117]. GPW has extended its activities into Kansas, Nebraska, and Oklahoma, and the Dakotas. While most of the activity regarding geothermal development in these states is through ground source heat pumps there are locations in these, and other states, where geothermal wells and hot springs are sufficient for larger thermal applications[118]. To date, the only significant development of geothermal resources in these Great Plains states is in South Dakota where geothermal heating is used for aquaculture, recreation, and heating for a school, a hospital, a hotel, and district heating systems in the small communities of Midland and Philip.

USDOE is currently providing funding for studies in Nebraska for geothermal heating for the Winnebago tribal group and at the University of North Dakota (UND) where researchers will conduct a two-year study to evaluate potential uses in the state, from direct use heating to ethanol production. Intermediate temperatures (showing potential for small-scale power production) have been encountered in deep wells in western Nebraska and in oil and gas wells in the Williston Basin of North and South Dakota.

To the east of these states, hot fluid has been encountered in oil and gas wells in the Midwest. In addition, a number of oil and gas wells in the Gulf Coast have discharged fluid hot enough for

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[116] Sources for this section:
American Wind Energy Association: http://www.awea.org/projects/wyoming.html & Database of State Incentives for Renewable Energy (DSIRE):
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=WY&RE=1&EE=1

[117] For more information see the Geo-Heat Center, Oregon Institute of Technology (OIT):
http://www.geothermie.de/egec-geothernet/ghc/21-1art1.pdf & http://geoheat.oit.edu/dusys.htm

[118] This document does not consider geothermal heat-pumps which can utilize temperatures as low as 50°F (10°C) without requiring the use of geothermal aquifers (although there is a general agreement by researchers that geothermal heat pumps would be useful at creating energy savings for communities, businesses, and industries).

small-scale power production, including a few sites in Louisiana. Alabama, Arkansas, Louisiana and Mississippi have used small-scale geothermal heating applications at a handful of locations. In addition, there are several small spas, hot springs, and geothermal wells used for direct use heating at locations in the eastern U.S., including the states of Georgia, New York, Virginia, and West Virginia. Geothermal hot springs and wells have been identified elsewhere in this region, but exploration and development has thus far been limited. It is unknown what potential resides in these areas in the future, particularly if deeper drilling becomes more economical.

PART III: Key issues affecting development – an analysis of similarities and differences in different parts of the country

Part III is a summary considering the research performed over the course of 2006. While five states were primarily studied for this research, all other states described in Part II are considered in this analysis.

Since 1992, the development of new geothermal electric power and direct use facilities in the U.S. has been limited in all states. Geothermal projects, particularly in California and Nevada were affected by changes in federal and state laws governing utility regulation and utility renewable contracts (*see descriptions of PURPA in the "need for adequate government incentives" section*), as well as changing economics due to increases in natural gas supplies and an overall decline in energy prices. Today, most states with identified geothermal resource potential are experiencing a resurgence in new development, while a few continue to lag behind. While some states require unique solutions, many common issues affect the geothermal industry on a broad, national level.

Booming populations—especially in California, southern Nevada, and the Wasatch Front area of Utah—coincide with soaring energy prices. These states and those surrounding them have begun to push for the deployment of renewable technologies to meet growing energy needs in a sustainable manner. Experienced industry experts often reference the significant untapped geothermal potential available for new development in these states. Certainly there are challenges to this development, both technological and economical. However, most agree that policymakers on the state and federal levels can help developers overcome these challenges by helping to create institutional structures that enable the energy market to meet the needs of the geothermal industry. The research performed for this report reveals consensus among a variety of state experts about six specific needs policymakers should address:

- Need to close the information gap;
- Need for adequate government programs;
- Need for adequate government incentives;
- Regulatory needs;
- Needs of the power market; and
- Need for greater utilization of direct uses.

The first five of these needs relates primarily to power plant development; the final need relates to geothermal direct use. The following section discusses issues that are common to all states, issues that affect only individual states, or issues that affect specific regions (such as the Pacific Northwest, the Rocky Mountain states, or the Southwest).

Need to close the information gap

In many ways, the U.S. geothermal industry is still immature. Exploration efforts for geothermal resources are far less mature compared to those for oil and gas (both in breadth and in technical experience). Geothermal resource development cannot succeed if researchers don't know the location of the resource. The problem of resource identification is exacerbated by the scarce funds and investment capital available for exploration to characterize resources and assess subsurface geology.

To understand subsurface geology, one must consider the history of geothermal exploration. Mining, oil and gas drilling, and water wells have given geologists a better understanding of the geology below the surface. States with substantial oil and gas drilling are also at an advantage, although in some cases states have a natural advantage because of the level of geothermal activity noticeable at the surface (such as in states like California and Nevada).

Resource characterization

From state to state there is a lot of uncertainty as to the size of the available resource. While there are geological maps that display the location of hot springs and wells located throughout the U.S., researchers consider these maps rudimentary. Researchers say that while many potential resource areas have been identified, the significant majority of them have not had deep drilling performed. The 2005 Geo Hills Associates report found that Arizona, Colorado, Montana, Washington State, and Wyoming were well behind other western states in geothermal exploration. According to their findings, by the time the report was written, none of these states ever had a slim hole drilled for geothermal exploration. (However, slim holes were drilled in Arizona at Clifton Hot Springs in 2005).

Most agree that Idaho and Oregon are also vastly under-explored given their potential resource base. Although power projects are under development in Idaho and Oregon, there are no operating geothermal power facilities at this time. The small geothermal electric power units in Idaho and Oregon that ran in the early 1980s did not exceed more than 10 MW combined. The best explored states are California and Nevada; however, researchers contend that even these states have many promising geothermal resource areas without any substantive exploration.

Geothermal resources are buried well below the surface of the earth and are difficult to model and verify without well drilling. While well data shows that while drilling has occurred at "greenfield" areas most of these wells were drilled to shallow depths, including temperature gradient holes, and thus failed to provide adequate information about the resource potential of the area. For example, while spring temperatures of 183°F (84°C) have been measured at the Crater Hot Springs KGRA in Utah and geochemistry estimates temperatures of up to 116°C (241°F) at depth, the hottest temperature found in a drilled well was 73.4°F (23°C) at 151 feet (46 meters). At the Glass Mountain KGRA in northern California in the Medicine Lake Highlands, exploration wells encountered high temperatures at relatively shallow depths below 1,000 feet (305 meters), but numerous shallow wells in the vicinity recorded only lower temperatures ranging from 50°F to 54°F (10°C to 12°C). In these cases, cold water aquifers can mask deep temperatures and skew temperature gradient readings. Researchers assert that shallow wells like these do not help characterize the subsurface geology or help map the structure of the geothermal system. Researchers suggest this is an issue in the Snake River Plain in Idaho. Several intermediate-temperature resources have been measured at shallow depths in this region, including a resort located near Hagerman on the south side of the Snake River. The resort currently pipes geothermal water at just under 200°F (93°C) from a 200-foot (61-meter) well. There has been interest in drilling near the resort on the north side of the Snake River to determine the source of the heat and to locate a higher temperature. However, researchers contend that a cold-water aquifer is located above the resource, masking accurate temperature gradient readings. Well data from several other western states show a number of prospects believed to have high-temperatures at depth where drilling efforts were abandoned because of this same phenomenon[119].

According to GEA's "Update on US Geothermal Power Production and Development" released on March 14, 2006, about half of all U.S. projects listed as under development were expansions of existing well fields or expansions of existing power facilities, and 75% of Phase 3 and Phase 4 projects met this criteria. In GEA's November update, the number of projects under development that were expansions of existing well fields or power facilities had dropped to 40%, while about 60% of Phase 3 and Phase 4 projects still met this criteria (See Table 1). Most of the other planned projects in these surveys are located in resource areas that have been known for years to have high potential for geothermal development, such as the Truckhaven KGRA in California, Great Boiling Springs (Gerlach) in Nevada, and Newberry in Oregon.

Although many areas throughout the western U.S. have geological features that suggest the presence of geothermal activity, many are blind systems. At such locations, investors are less likely to explore unless previous drilling has been completed in the area. In fact, numerous geothermal resources have been discovered serendipitously, in locations where no exploration has taken place beforehand. For example, both Raft River in Idaho and Carson Lake in Nevada were discovered when ranchers drilled water wells that were too hot (both have projects under contract to develop and may sustain as much as 290 MW). The geothermal resource at the Salton Sea KGRA in California was discovered when the area was explored for oil and gas.

Photo: Newberry Volcano Monument, Oregon. U.S. Geological Survey (USGS): http://vulcan.wr.usgs.gov/Volcanoes/Newberry/description_newberry.html

As noted above, oil and gas drilling has played a part not just in discovering geothermal resources, but also in improving our understanding of subsurface geology. A fair share of oil and gas drilling has taken place in New Mexico and Utah, while drilling has not occurred as regularly in Idaho. Idaho is considered one of the most promising states for geothermal development, yet researchers estimate that less than a dozen deep oil and gas wells have been drilled in the state. In fact, Idaho is one of the least drilled states in the U.S. The *Idaho Geothermal Energy Development Strategic Plan*, when it was written in 2002, contended that Idaho is hampered by a "lack of data and understanding on existing resources to support additional development"[120]. These challenges also face Oregon,

[119]California: Southern Methodist University (SMU): http://www.smu.edu/geothermal/georesou/alldata.csv
Utah: Utah Geological Survey well spring data (File Name: well_spring3.xls) – For more information, contact Robert Blackett at robertblackett@utah.gov
Idaho: – INL Geothermal Program, 2000. Source: Idaho-collocated_Keller_revised.xls
For more information, contact: Patrick.Laney@inl.gov

[120]Idaho Department of Water Resources Energy Division and the Idaho Geothermal Energy Working Group – Strategic Plan (2002): http://www.geothermal-biz.com/ID_strategic_plan.pdf (page 6)

Washington, and Arizona, where little drilling of this type has taken place. In Arizona, the AZGS was recently given the green light to scan all geophysical well logs from oil and gas wells drilled in the files of the OGCC, but the number of wells is only about 1,100. The depths of the cataloged wells range from a few hundred feet to over 18,000 feet (5,486 meters)[121]. While oil and gas drilling in Arizona is far more substantial than in the Pacific Northwest, the state pales in comparison to Texas, which has at least 550 times as many wells as Arizona. Researchers suggest that there are abundant high-temperature geothermal resources in Arizona. But because its geothermal resources are generally considered deep-seated (at depths greater than three kilometers), the lack of oil and gas drilling is a barrier in the state.

Databases

Most agree there is a need to review and update existing data that may pertain to geothermal resource identification. For instance, besides oil and gas drilling, well over a century of mining and mineral exploration, geological reports, documents, and studies are sitting in archives in western states. At the time this information was compiled, the discovery of high-temperature fluid may not have been considered valuable, and thus was not publicized. Most agree that such data has been helpful to geothermal developers in states like California and Nevada, but not so much in other western states. Some say this is one reason why California and Nevada received more attention and more development in the first place.

Experts suggest that we do not have to “reinvent the wheel” on the discovery of resources. While the USGS is in the process of updating their reconnaissance work from USGS Circular 790, individual states are taking on this challenge as well. As noted above, several states are digitizing temperature and log data from oil and gas wells. However, other institutions are documenting well data in Excel files from all over the western U.S. Work like this was performed by SMU in Texas and additional work to follow up on this data is being performed in states like Colorado and Montana to identify specific locations that could support geothermal electric power projects in the future. Utah has catalogued its well-drilling history (where temperature logs were available) as has New Mexico. Several states have created interactive maps showing the location of hot springs and geothermal wells; although researchers say these maps remain works in progress. In addition, the USDOE has been preserving previous studies of geothermal resource areas in its Office of Scientific and Technical Information (OSTI) database, which allows these documents to be searchable. Over the course of the research for this report, OSTI data has been helpful in examining a variety of valuable research archives. In particular, OSTI was helpful in clarifying prior research of the Mount Bennett Hills area in Idaho, which was not described clearly in any web-accessible reports available outside the OSTI database.

Perhaps the furthest ahead in the process of cataloging data is Nevada, where the Great Basin Center has a database of more than 200 geothermal resource areas. Descriptions of these areas have been updated over the past few years to include information on well drilling, existing facilities, and geophysical and geochemical studies. Although Nevada is further ahead on its data collection than in other states, researchers there and across the country say they would like to review even more archive data, but the necessary time and funding are not available.

Public awareness

Most agree that geothermal development requires public support and awareness. While residents of western states may have used geothermal resources for many years, still do not understand the many ways in which they can be used or how valuable they are. Researchers say that despite its usage, the public is still more aware of wind and solar resources, in part because wind turbines

[121]For more information, see the Arizona Geological Survey (AZGS): http://www.azgs.az.gov/

and solar panels are considerably more recognizable and visible than geothermal applications, even in states like Idaho which has used geothermal resources far more than solar.

Another issue brought up repeatedly is the attitude of local communities. Developers assert that the appeal of a geothermal project to a community relates partly to economic needs and partly to perceptions about geothermal energy. Developers stress the importance of involving and addressing the concerns of sensitive groups (including tribal leaders, environmentalists, and community and civic groups) upfront so as to avoid future confrontation. Developers assert that these efforts facilitate a mutual understanding about the impacts of projects so that all involved—from the concerned citizens to the developing companies—can work through differences and reach shared goals.

However, even when different interest groups are engaged, developers warned that vocal opposition may still delay projects, or kill them altogether. Perhaps the most striking example of this is in Northern California. According to the 2006 WGA Geothermal Taskforce Report the Glass Mountain KGRA is estimated to contain up to 480 MW of near-term power potential[122]. In 2002, federal drilling permits were granted to developers; however despite receiving these permits as well as support from local governments, the project has been subject to continued litigation and protests by one tribe and some local environmental groups who say the project will adversely affect the environment and both "tangible and intangible" cultural values of these lands. Although the leases are not located on tribal lands, the fact that these are public lands in National Forests has allowed resistance to the projects to cause prolonged delays. In November of 2006, the 9th U.S. Circuit Court of Appeals determined that the term of some of the existing leases on the property were extended improperly because the federal agencies had not conducted a full environmental impact statement before extending the term of the leases, and it is unclear at the time of this writing how this will impact the development process on those leases. As noted in Part II, similar concerns affected the scope of development of the KERZ area of Hawaii.

Conversely, discussions with developers and project consultants indicate that numerous projects have received widespread support. For instance, in the recent purchase of PacifiCorp by MidAmerican Energy Holdings Company, clean energy advocates in Utah successfully lobbied the Utah Public Service Commission to include language encouraging the expansion of geothermal production capacity at Roosevelt Hot Springs. Projects in Churchill County, Nevada have benefited from a strong relationship between developers and the County government. In addition, those familiar with projects being proposed at the Pyramid Lake Paiute Reservation in Nevada and the Fort Bidwell Reservation in California report that tribal leaders have been active proponents of development on their land.

Need for adequate government programs

Most agree that to capture vast potential geothermal resource in the U.S., government programs are essential to help provide research, technical assistance, and outreach. Government programs reduce the risks of private investment in innovative projects and help facilitate the study of potential resource areas not likely to be undertaken by private investors without an expectation of an adequate return on their investment.

[122] 480 MW of near-term potential according to WGA Geothermal Task Force Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf - page 61

The level of geothermal research and development varies from state to state. In California and Nevada, the industry presence, paired with the prior government exploration and research, are enabling developers to complete new power projects. Although government programs remain critical in these states, most agree that government support is needed to induce further geothermal development across the country.

While certain geothermal sites may be developed through private efforts, most new developments are re-powering, or expanding upon well-fields that already produce power. Most greenfield projects were initiated by the GRED program. Only in California, Nevada, and Oregon are greenfield projects under development at sites that did receive technical support or funding from the federal government agencies since they were proposed[123].

Extracting geothermal resources from areas that are not "proven resources" is difficult for the geothermal industry where developers do not have significant capital on-hand. High upfront costs make it particularly difficult to drill in some locations because it is hard to raise the required venture capital without a market to sell the power. As noted above, the understanding of subsurface geology is limited in most U.S. states, particularly as it pertains to geothermal resources. Exploration is a time-consuming process that generally involves high upfront costs with high risks and uncertainties. Developers say they lack the capital to pursue projects without some degree of certainty that the development of the resource will be economically viable. Getting the first well drilled is often considered the hardest part of a geothermal project.

According to an August 2005 report by GEA, exploration (including geological studies, drilling, and confirmation) is typically up to 1/3rd of the overall costs of a geothermal project. Drilling can be up to 1/4th of the overall costs—considering the cost of a geothermal exploration well ranges from \$1 million to \$9 million—depending on the depth, the type of material being used, and the current market for drilling rigs. According to the report, an average well "would probably be in the range of \$2-5 million."[124] However, this does not take into account the costs of regulatory delays, and recent spikes in demand for steel and drilling equipment that are unpredictable and have increased markedly throughout the first six months of 2006 when oil prices escalated.

High upfront costs pose substantial risks and uncertainties, especially for greenfield prospects. According to the same report, projects in a producing geothermal field have drilling costs that can be 37% lower than drilling costs of a similar project located in a greenfield prospect. By the late-1980s, the success rate for finding a producible well in a greenfield was approximately 20%[125]. Although most agree that new technology will improve this number in future exploration, they also believe that the uncertainties involved with drilling will still turn back investors.

Federal programs

Most states which actively use geothermal resources provide little financial assistance for geothermal research and development. This leaves the industry and the federal government to

[123] Most of these areas received some federal funding during the 1970s or 80s for exploration, but have not received technical assistance or other funding since the current project developer initiated the project now under development at those sites.

[124] Source: Geothermal Energy Association (GEA) – *Factors Affecting Costs of Geothermal Power Development* (August 2005): http://www.geo-energy.org/publications/reports/Factors%20Affecting%20Cost%20of%20Geothermal%20Power%20Development%20-%20August%202005.pdf (page 18)

[125] Source: Geothermal Energy Association (August 2005) – http://www.geo-energy.org/aboutGE/powerPlantCost.asp

provide funding for these activities. Funding from the federal government has been limited in its scope in part due to the risks and uncertainties involved with development. Federal funding is often seen as a waste if it doesn't result in a completed project. As a result, most agree that the challenge for both the state and federal government is spending money effectively to get the most out of their investment and to demonstrate results.

Geothermal Resource Exploration and Development Program (GRED)

As noted in the state summaries, the USDOE has assisted initial exploration and development efforts at a number of geothermal prospects in the western U.S. in recent years through the GRED program. The GRED program has supported efforts at 22 prospects in seven states (Alaska, Arizona, California, Idaho, Nevada, New Mexico, and Utah) with technical assistance, geophysics, temperature gradient holes, and the drilling of 13 exploration wells. As of December 12, 2006, six of these prospects are expected to have geothermal power projects completed in the next 2-3 years. In addition, geothermal power projects have begun development in another 11 prospect areas, and another two projects have been proposed. This was all accomplished by spending only $12.5 million over three funding cycles (the last ending in 2004).

Most agree that GRED was successful, and helpful to jumpstart the industry. The most beneficial aspect was that it involved projects in multiple states. While the program certainly helped California and Nevada, where studies of 15 prospects were funded, the studies of the other seven helped lay the groundwork for the first commercial geothermal power plant in Idaho (expected to be online in 2007), the first new geothermal power plant under development since 1990 in Utah (expected to be online by 2008), and the first ever power plant in Alaska (now with a small unit already online).

GeoPowering the West (GPW)

As the industry has begun its resurgence in the 21st Century, most agree that development needs to take place in as many states as possible. For this reason, most industry stakeholders have been pleased with the efforts of GPW to expand efforts into a greater number of states. In fact, outside of California and Nevada, the November GEA power plant survey reports 17 geothermal power projects are under development in seven other states. To date, only three power plants are online in these states with a capacity of 61.2 MW, and the capacity of these 17 projects would represent an increase of 644% (See Table 1). Since its creation GPW has formed State Geothermal Working Groups in 11 states and helped in the release of strategic plans in Idaho and New Mexico, and a similar document in Utah. Other states are currently working on these types of documents through their state working groups.

Together, through the work of GPW and other efforts, developers have been able to keep abreast about new development across the country. With the possibility for using geothermal resources from geopressured reservoirs or hot wastewater from oil and gas wells, it is likely that geothermal power developments could extend to as many as 13 states in the next three to five years, with prospects in Louisiana, Montana, Texas, and Wyoming adding to the mix.

Exploration support

Most agree that exploration efforts are critical in states where the resource potential is still poorly defined. While exploration via technical assistance has been very important to new projects under development in Nevada, researchers say that other states remain far behind. For instance, in the states with electric power potential ranked 3, 4, and 5, in the WGA Geothermal Taskforce Report (Idaho, Oregon, and Utah) only a few resource areas in those states have had any substantive exploration or subsurface drilling. As a result, the IWGC was created to help guide exploration efforts in these states. The IWGC is comprised of members from academic institutions in Idaho, Nevada, Utah and Oregon and geothermal research staff from the Idaho National Laboratory[126]. According to the director of the IWGC, Dr. Walter Snyder, its function is to target both on-the-ground research applicable to both exploration and development, and to provide new data, readily accessible to make use of this information easier and to maximize the impact of the research investment dollar.

Idaho, in particular, is considered a state that is a prime candidate for an exploration drilling program. Such a program helped characterize the resource base in California and Nevada in the 1970s (leading to the nearly 40 geothermal power plants built in those states during the 1980s). Most agree that the volume of geothermal prospects in Idaho is impressive given the lack of subsurface exploration. 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. Where the resource falls between these two extremes depends on how much of the resource contains deep aquifers with substantial flow rates or whether high temperatures encountered in deep wells lack fluid, or rest in confined structures that are not accessible through conventional hydrothermal wells. Researchers classify this uncertainty as a lack of understanding of how geothermal systems in Idaho operate. However, most agree that because Idaho is not well defined, there exists a unique opportunity for new discovery.

Federal funding

One issue that has come up repeatedly is the importance of the overall USDOE Geothermal Technologies program in funding exploration, assisting new development, and fostering technological breakthroughs. High energy prices are fueling the demand for alternative energy, and planned geothermal power projects currently under development could represent an increase of over 67% in total geothermal power capacity in the next five years alone[127]. However, despite the need for greater government support when the industry is re-emerging, funding for the program has declined significantly in recent years. In fact, the FY 2006 appropriation for the USDOE Geothermal Technologies program is 16% lower than the average budget from 1990-1999, even without accounting for inflation[128]. Of more pressing concern, at the time of this writing FY 2007 funding is still uncertain, and might possibly be zeroed out. Most agree this will hamper efforts in emerging states, and limit development efforts elsewhere to private investment where risk factors may overwhelm developers of innovative projects so they do not see the light of day.

Developers say that the efforts of USDOE have mitigated many risks and uncertainties that they would be unlikely to take on themselves. In addition, the research funded by USDOE has been essential to the learning process and has helped correct mistakes. For example, according to

[126]Source: Statement of Walter S. Snyder. Director, Intermountain West Geothermal Consortium, Before the Energy and Natural Resources Committee U.S. Senate, July 11, 2006: http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=1576&Witness_ID=4455&SuppressLayouts=True

[127]The reason I refer to these resources as "being considered over the next five years" is based on the 3-5 years it takes to develop a project once the project is underway (i.e. further exploration, drilling, etc.). The 67% estimate is based on the "November 2006 Geothermal Power Production and Development Survey" 11/10/2006 – Geothermal Energy Association (GEA): http://www.geo-energy.org/publications/reports.asp

[128]These are calculations based on the annual appropriations for the USDOE Geothermal Technologies Program from 1990 to 1999. The average appropriation during the 1990s was $27.75 million as compared to $23.299 million for FY 2006. When considering inflation (real dollars), the 2006 appropriations are more than 16% lower than the average appropriations from 1990 through 1999. Source of budget: USDOE.

several interviewees, initial geothermal development and exploration efforts during the 1970s and early 1980s were unsuccessful when individuals new to geothermal were put in charge of drilling. However, these early efforts have at least helped correct past mistakes. Continued government involvement has protected against further mistakes by employing experienced researchers to help on new projects and by utilizing the most advanced methods to analyze resource areas.

If the program remains, and is expanded, cost-shared drilling (of which was an aspect of the GRED program) is cited as one of the most effective government programs because it helps reduce risks. Smaller developers say that loan guarantees, in particular, are helpful at overcoming this challenge. According to a report done by SENTECH, Inc. in March of 2005, the federal Geothermal Loan Guarantee Program (GLGP) that ran in the 1970s and early 1980s had a corresponding subsidy rate of approximately 3.6 MW per million dollars of expenditure. If this subsidy rate was held constant, it would translate to $1 billion spent (at that time) leading to 3,600 MW of baseload geothermal power. Most agree that loan guarantees can be effective anywhere, as long as the project is a viable one. Smaller developers benefit because their projects are often put on hold until they can get financing. A number of projects in "Phase 1" and "Unconfirmed" (See Table 1) are experiencing this delay, and many of those working on them say that loan guarantees could take these projects to the next phase. A new round of loan guarantees for several alternative energy sources has recently been proposed by the USDOE, although geothermal was explicitly excluded from consideration.

The GLGP is still authorized by law, and the recent review by SENTECH concluded that it would make sense to revitalize the program in a targeted manner. This report examined several alternatives and "a loan guarantee for exploratory and initial production well drilling—is recommended. This option would provide [US]DOE with a program that would narrowly focus on the development stages at which the geothermal industry is currently lacking access to commercial financing. This option would also use program resources most efficiently by striking a balance between having the flexibility to pursue different kinds of projects and limiting the cost of each project."[129]

State programs

On the state level, there are programs that can facilitate development, but are generally limited by available funding for research programs and major grants or loans. State governments do not have adequate budgets to take on the risk (both economic and political) to fund drilling if they are uncertain of the results. Several states with geothermal potential have provided sales tax exemptions, property tax exemptions, and grants and loans for geothermal projects. However, the only state with an active state-funded geothermal research program is the GRDA and PIER in California. Combined, these programs have several million dollars available for project support—more than every other state spends directly on geothermal research and development combined.

There is a general consensus that state governments could do more to reduce the reliance on federal money for geothermal research programs and provide a hedge for the cyclical nature of federal funding. At a time when new projects are under development in nine states, state programs provide them with limited resources. While state programs are critical for all states, most agree that these programs are most needed in states where the first commercial power plant projects are under development, such as Alaska, Arizona, Idaho, New Mexico, and Oregon. Most

[129]Assuming this would mean an initial capital investment of roughly $10 billion, the program would appear to have a favorable record. Source of "3.6 MW per million dollars of expenditure": SENTECH, Inc. (3/28/2005) *An analysis of Federal Loan Guarantees for Geothermal Energy Development*. (page 1).

agree that after their initial geothermal power plants are completed, investors will be encouraged to provide support for other projects in these states. Idaho is a prime example based on the response to the project currently under construction at Raft River. At the time of this writing, at least three other geothermal power projects are under development in the state and another five geothermal prospects have at least a lease application filed for further exploration.

University programs

Many experienced geothermal professionals, near retirement, have expressed their urgent desire to share their knowledge with the next generation. University programs facilitate this knowledge-sharing. Due to the volume of new projects under development, funding is needed to further help experienced geothermal professionals teach and take students out into the field to participate in exploration tests and new drilling. Furthermore, as new geothermal power or direct use facilities develop in states where these funding programs exist, facilities can be used as teaching tools. This educates students about how to develop projects and how to use geothermal reservoir management strategies to ensure sustainable production during operation.

Most agree that the lag in geothermal resource development from the late-1980s through today has created an experience gap in the industry, which highlights the importance of funding college and university programs. University research programs offer opportunities to perform exploration studies at low costs. For example, using new computer technology, several existing programs have enabled students to review satellite imagery of geothermal resource areas from on-campus computer labs. Graduate students already participate in drilling and project development activities at New Mexico Tech. Students also participate in drilling activities at EGI at the University of Utah, the Great Basin Center at UNR, the Geo-Heat Center at OIT, and the Stanford Geothermal Program at Stanford University in California. In New Mexico, the SWTDI geothermal program at NMSU trained students on a number of projects before geothermal research funding was no longer available.

Geothermal programs are emerging at colleges and universities in other western states, including Boise State University in Idaho, Northern Arizona University, Washington State University, and SMU and UTPB in Texas (as described in the Texas summary). Geothermal research is also being performed through the Massachusetts Institute of Technology (MIT)—although geothermal resources are not available to research near the campus. These do not represent all of the geothermal research programs in the U.S., but these are the programs that have been the most active in the past few years.

The majority of funding for geothermal research work performed at these universities comes from USDOE. Most agree that this reliance on federal funding is not sustainable considering the cyclical nature of current funding. In fact, at the time of this writing, the cuts to the FY 2007 budget of the Geothermal Technologies Program threaten the existence of a number of the programs listed above. Researchers say that while federal funding should be increased before any of these programs run out of money, other funding sources should be considered to fill in the gap. This includes state funding, industry funding, and private endowments if possible. In the future, most agree there should be more access to federal and state grants, scholarships, and other public financial sources. Clean energy advocates say that private endowments are worth pursuing for the long term to expand existing programs. As a clean renewable energy source, geothermal development may offer viable funding projects to many private or even corporate foundations with interest in alternative energy research. Educating foundations about geothermal energy requires outreach, as well as efforts by universities and the federal government to highlight geothermal achievements. Most agree these efforts can be completed without significant expense.

Outreach

Among government programs, both federal and state, a relatively inexpensive approach is outreach. Outreach requires no drilling, no leases, and no transmission lines. Both the state and federal government can be involved, as well as industry. Outreach allows more people to be involved in educating the public, policymakers and utility regulators about the viability and benefits of geothermal energy. Outreach may include state agencies working with non-profit organizations and encouraging volunteer grassroots efforts towards educating the public about geothermal resource development. According to clean energy advocates, there are numerous innovative ways to approach this such as developing internet resources, holding public awareness events, and encouraging youth projects in public schools or encouraging youth field trips to geothermal power facilities and direct use facilities.

Outreach efforts on the state level about the benefits of geothermal resource development have been minimal, but there is evidence that efforts are picking up. As noted above, the GPW program has been the major federal effort in this regard. GPW has engaged the state government and helped foster greater activity in networking and outreach to local communities. However, some states have taken a more active role in bringing events to the public. For example several events have been held in communities interested in geothermal development in Idaho.

Based on both the number and variety of individuals who attended geothermal working group events held in multiple states (including investors, small businesses, large corporations, utility representatives, regulators and other state agency representatives), it is clear that there is interest in development adequate to maintain industry momentum if government programs continue to receive funding support.

Regulatory needs

Acquiring a resource is often one of the most challenging aspects of any geothermal project. When regulators work together with developers, communities, and other state and federal agencies, history reveals that projects can be completed on a timely basis. As noted in the state summaries, Nevada has made the effort to process backlogged federal leases and perform necessary environmental reviews. This has resulted in ongoing drilling for projects on federal lands in that state. Federal leases have been issued for more greenfield projects currently under development in other states, including California, Idaho, New Mexico, Oregon, and Utah.

Regulatory issues have been particularly critical in California, Nevada, and the Pacific Northwest. Some of the more complicated issues have occurred on USFS lands in California, Oregon, and Washington State. Regardless of the existence of an RPS or even a long-term PTC extension, most agree that the geothermal industry will not succeed unless the regulatory process is timely and adequate to provide investors with greater certainty.

Water issues

For all lands in the western U.S., one of the main concerns for regulators is protecting scarce water resources. The scarcity of water is commonly cited as the reason for small populations in the states in the Intermountain West (such as Idaho, Montana, New Mexico, Nevada, Utah, and Wyoming). Unlike solar and wind, geothermal production involves the use of water–geothermal fluid–by pumping from underground. Thus, the process of drilling into geothermal systems brings up issues concerning water rights and questions about the impacts on local water supplies (including agricultural, municipal, and domestic users, and resources used for irrigation).

Water rights are complex, and establishing clarity of ownership of these rights is essential to help developers avoid lengthy disputes with neighboring users before projects get too far along. The regulation of geothermal resources and water resources are separate in most states, however, water issues are still inherent in geothermal development. In some cases, there is concern from regulators that a geothermal operation may interfere with a nearby water right, drying up wells used for various purposes, such as hot springs, domestic water, or irrigation. Although such an occurrence is rare (and less common today with current technology) in an extreme case, this concern could cause a project to be shelved or perhaps even a power plant to be shut down. Developers say that these issues are more problematic in states where geothermal development is not commonplace—which causes the regulatory process to not be well-defined. This particularly affects Arizona and New Mexico, but is also a major concern in Idaho where water adjudication is underway for the Snake River Plain.

Water issues also affect the ability of geothermal projects to use water-cooling. Water-cooling is generally considered more efficient than air-cooling (especially in locations with warm climates). Plants can use geothermal water for evaporative cooling, and some might supplement this with other ground or surface water sources. Thus, developers may be tempted to obtain water rights, if feasible, in states where such cooling measures have a greater impact on plant efficiency. Water-cooling is used for the existing Blundell Plant at Roosevelt Hot Springs in Utah, although the new unit being installed there will use air-cooling. In California, geothermal plants and Coso, The Geysers, and the Salton Sea (which make up nearly 2/3rds of existing geothermal capacity in the U.S.) all use water-cooling.

Conversely, water use can been an advantage for geothermal development. This is because even geothermal power plants that utilize water-cooling, typically consume far less ground and surface water per kWh than conventional fossil fuel sources such as coal-fired power plants, natural gas plants, and nuclear power facilities. Also, water cooling reduces the variability in output that is inherent in air cooling systems, and in some cases utilities purchasing power may indirectly encourage or require water cooling by placing penalties on changes in power production.

Federal land

Ultimately, one of greatest challenges to developing geothermal electric power projects is that many of the best geothermal resources are on federal land or involve the use of federal mineral resources. In fact, 34 existing power plant projects involve federally-managed resources, including Coso, The Geysers and Salton Sea, California and Dixie Valley, Nevada[130] and according to the November GEA power plant survey, over 30 additional projects are under development on federal lands, including projects in California, Nevada, Oregon, and Utah, and proposed projects in Idaho.

While there are complexities to developing on private and state lands, acquiring access to resources on federal lands has always been a challenging prospect for developers. For one thing, the developer of a geothermal project is not only subject to complying with federal laws and regulations, but is also subject to state and local regulations. These include the regulatory requirements necessary to obtain drilling permits, construction permits, commercial use permits,

[130]Source: Statement of Brenda Aird, Senior Renewable Energy Advisor, Office of the Assistant Secretary, Land and Minerals Management, U.S. Department of the Interior before the House Resources Committee Subcommittee on Energy and Mineral Resources Oversight Hearing on the Role of the Federal Government and Federal Lands in Fueling Renewable and Alternative Energy in America. 4/6/2006: http://www.doi.gov/ocl/2006/RenewableAndAlternativeEnergy.htm

right-of-way grants for roads, pipelines, transmission lines, and communication sites, along with accompanying environmental reviews. These considerations are usually considered in some manner before leasing through land-use planning and accompanying environmental analysis, as well as considered in much more detailed fashion when development permits are applied for post-leasing. Also, while geophysical exploration may take place without a lease; making significant exploration expenses prior to obtaining a lease could result in a financial risk if the lease is not issued—although the information would still have prospective value to the lease holder.

For states that have experienced lease backlogs (particularly California and Nevada), developers say they have been stymied by a lack of adequate staff to process them. In addition the lag in geothermal development on federal lands over the past two decades has resulted in a shortage of experienced federal agency staff to work on geothermal leases and permits. Furthermore, as the volume of lease applications have increased significantly, the budget to process them has increased only slightly. Without new geothermal projects producing on federal lands, federal agencies have not been able to take advantage of the royalties that come from geothermal power projects on federal lands, which help fund the permitting process.

Leasing

Leasing has been a challenge for geothermal developers throughout the western U.S. While geothermal leasing on federal lands has not been significant outside of California and Nevada, there has been concern that inexperience within regulatory agencies in other states with geothermal projects may complicate matters, or lead to problems down the road.

Data also shows that many states containing known high-temperature geothermal resources have a large percentage of their land managed by the federal government. Over 52% of Oregon; over 63% of Idaho; over 69% of Utah; and over 83% of the mineral acreage in Nevada are managed by the federal government. In addition, the majority of geothermal resources in New Mexico and California are located on federal land or mineral acreage[131].

In California lease application backlogs for prospects on BLM lands date back more than a decade, even longer for some leases on USFS land. Acquiring leases on USFS lands has generally been most difficult for geothermal prospects in any state. The USFS and the BLM are under the direction of two different federal agencies [USFS is part of the U.S. Department of Agriculture (USDA) and the BLM is part of the U.S. Department of Interior (DOI)]. However, when developing on USFS land, projects are subject to regulations from both agencies. While the BLM ultimately processes the lease, exploring for geothermal resources on USFS land may require changing a forest plan to incorporate geothermal development. Issues with the USFS have been most profound in Idaho and the Cascades of northern California, Oregon and

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[131]Much of the land in the western U.S. managed by the BLM happened by default because it hadn't been sold for private use before 1976 when the Federal Land Policy and Management Act of 1976 (FLPMA) was passed. Through FLPMA, Congress declared that all remaining public lands would remain in federal ownership (by the BLM) unless specific determinations are made to exchange or dispose of the land. New Mexico and California have less than 50% of their land managed by the federal government, but maps clearly indicate that the majority of their geothermal resources are located on federal land. Percentage figures may have changed slightly since the sources below were released.
University of Nevada-Reno, University Center for Economic (1999):
http://www.unce.unr.edu/publications/FS01/FS0132.pdf
Idaho BLM (2002): http://www.id.blm.gov/publications/02update/state5_10.pdf (based on calculations)
Idaho National Laboratory – Geothermal land use maps for the 13 Western States:
http://geothermal.id.doe.gov/maps/index.shtml

Washington State. 39% of Idaho's land is managed by the USFS[132], and many of the high-temperature resources in the Cascade region are located on USFS land, including Glass Mountain, California and Newberry, Oregon. Valles Caldera, New Mexico has also been affected by regulatory issues on USFS land.

Nevada has about two-thirds of the total federal acreage leased for geothermal development in the U.S. For several years, the volume of federal lease applications had created a significant backlog which stifled new development, and little processing was done. For example during the period from 1997 through 2001, BLM Nevada issued only 20 leases that included almost 30,000 acres, while in the five year period from 2002 through 2006, BLM issued 278 leases that included over 455,000 acres. The reduction in the lease application backlog in Nevada has been an important contributor to the surge in new development.

But, while most agree the reduction in the backlog has allowed new projects to move forward, the provisions in EPAct did not authorize transition rules, thereby restricting BLM from accepting nominations for competitive leasing until new regulations are implemented to conduct competitive leasing. While EPAct was passed in November 2005, as of January 2007 the BLM has not issued new regulations to implement the new law. There is concern by developers and researchers that this delay will impact new exploration in promising areas on federal lands that currently do not have a lease. However, current projects on federal lands will be able to continue as the new regulations do not affect leases applications filed prior to the enactment of the new regulations, and the BLM is continuing to process lease applications and drilling permits for these projects.

Conversely, California did not process any federal leases (competitive or non-competitive) for two decades prior to 2006, and still has a significant lease backlog that has caused delays for developers and limited new development. Although the lease backlog in California was far smaller than Nevada to begin with, some of the relatively smaller backlog may simply be due to the fact that developers and others knew BLM was not processing lease applications in the state, so they did not file applications. Also, despite the smaller backlog the need for funding to process leases in California is greater due in part to the additional concerns brought about by the public's active interest in any activities on public lands in the state. A May 2006 report by the Government Accountability Office (GAO) notes that in California, federal leases typically require an Environmental Impact Statement (EIS), which can take often as long as two years to complete and cost roughly $2 million, each, to produce. In addition, state regulations in California are often more lengthy than in neighboring states. For instance, they cite a June 2005 CEC report which reported that in California, "the entire process from exploration to the first production of electricity can take more than a decade and that it was not unusual to redo environmental documents because they became outdated."[133]

According to the BLM, in addition to California and Nevada, Oregon had a significant lease backlog. The areas of interest in Oregon are generally in National Forests and have high scenic and natural values. In March of 2003, BLM's records indicated that there were 70 pending lease applications in Oregon, covering some 137,000 acres of public lands.

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[132] Idaho BLM (2002): http://www.id.blm.gov/publications/02update/state5_10.pdf (based on calculations).
[133] Source: Government Accountability Office (GAO) – "Increased Geothermal Development Will Depend on Overcoming Many Challenges". May 2006 Report to the Ranking Minority Member, Committee on Energy and Natural Resources, U.S. Senate: http://www.gao.gov/new.items/d06629.pdf (pages 21-22).

Also, as noted in the state summary, Idaho has become more active in federal leases, jumping for zero lease applications in 2002 to 12 as of December of 2006, with three already issued, and more lease applications expected to be either submitted or issued in 2007.

Environmental reviews

There is no denial by developers that environmental reviews and regulations are important to ensure protection of secure water resources and for quality control to ensure drilling and construction has a limited impact on the local environment. However, the primary regulatory concern for developers is not the requirements themselves, rather the lack of adequate manpower to process them. In addition, most agree that it is critical that adequate funding is provided to enable these agencies to perform environmental reviews in accordance with NEPA.

Despite the fact that most geothermal projects are environmentally benign, especially compared to fossil fuel sources, there is a general agreement that environmental concerns about these projects are sometimes warranted. Even with zero-emission binary geothermal power plants, impacts to the land are caused by transmission lines, drilling, and construction. These issues have been most severe in areas in California and the Pacific Northwest, but were also a major point of conflict in New Mexico at the Valles Caldera.

The Energy Policy Act of 2005 (EPAct)

In 2005, EPAct amended the Geothermal Steam Act of 1970 to contend with regulatory issues that had become barriers to development in recent years. Although EPAct was designed to resolve issues in several key states, it has affected development throughout the western U.S. There appears to be an attitude common to regulators in most western states that developing geothermal resources is of critical importance. Therefore, reluctance to process geothermal leases has diminished, although resistance to development is certainly still an issue.

Several actions were taken to facilitate geothermal development on federal lands. In addition to providing funding to help BLM process backlogs, the law increases rental fees over time to discourage speculation, and requires all future USFS and BLM resource management plans to consider geothermal leasing and development in areas with high geothermal resource potential. A policy change in EPAct led to the MOU between the USFS and BLM that affects developments on both types of land, mandating that geothermal leases be executed in a timely manner. Leasing can be extremely complicated on USFS land. Regulators say that the MOU, signed in the spring of 2006, has already improved interagency coordination in states where projects have been proposed on USFS land, including California, Idaho, and Oregon. Regulatory issues on USFS lands have not yet affected geothermal development in Nevada because most of its promising resources on federal land are managed by the BLM.

Not all of these changes have yet been implemented, although some have begun the process. One change that has begun to occur is new regulations on the royalty structure for power plants that send 25% to county governments along with, and in addition to, a 50% federal royalty sent to the state and the other 25% sent to the federal government[134]. Several interviewees touted this policy because they believe it will be an effective incentive for communities to pursue geothermal projects to benefit economic development. One example of this is in Churchill County, Nevada where five geothermal power facilities are currently operating with another two under

[134]For more information on new regulations see the U.S. Department of Interior: http://www.doi.gov/iepa/2005_results.pdf (Section 222-224)

development[135]. At the time of this writing, Churchill County, which is about 90% federal lands, has already received several hundred thousand dollars in royalty payments from existing facilities and is planning to use the money for its schools and roads.

Additional concerns for federal regulations

While issues at the state level have been most complicated in California, the most significant development issues generally regard federal lands or mineral acreage. Nevada has been more active than other states in processing geothermal leases and permits, however, new projects are under development or have been proposed for development using federal resources in California, Idaho, Oregon, and Utah. This new activity will increase the workload for regulators in these states.

Most agree that to fully absorb all of the leasing and permitting for geothermal resources, the BLM and the USFS need adequate funding and dedicated staff to process regulations and ensure that developers are not forced to wait too long until the next lease sale. For instance, even with new federal regulations requiring the BLM and USFS to process lease applications, funding for this activity is still far behind what was appropriated to these agencies during the 1980s (even without accounting for inflation). While funding naturally declined during the 1990s when there was less activity, most agree that the recent surge in lease applications mirrors the conditions of the early 1980s and justifies a similar appropriation of funds.

With lots of potential resource on these lands, most agree that reform of federal regulatory policy should be a top priority for policymakers if they wish to expand geothermal development. Developers say that regulations have yet to become a high priority. Industry stakeholders assert that federal funds should first address projects nearing completion that are struggling to meet the deadline to qualify for the PTC (particularly if it is extended for only two to three years in the next legislative session).

The May 2006 GAO report discusses the challenges of lease backlogs and delays in the federal permitting process as a principal barrier to geothermal development. Among the issues they discuss are the challenge of processing leases when, as some BLM officials noted for the report, "some developers have reported difficulty in consolidating the various geothermal leases into an economically viable project that can recover the costs of the power plant and transmission line. These developers, according to these BLM officials, say that speculators often lease geothermal resources not for development purposes but rather to resell the leases at a significant profit, running up the cost of the project."[136] This has mostly been a concern in California and Nevada and is evident in locations where multiple developers have leases for one specific resource area (such as the Truckhaven KGRA in California). Several interviewees say that mitigating this issue requires a "carrot and stick" approach. For example, most agree there is a need to encourage development, while allowing adequate time for exploration. At the same time, lessees must also be discouraged from sitting on property without performing any geophysical or exploration work. Thus, many believe that an effective program would at the very least require meeting specific (reasonable) benchmarks for progress.

[135]There are actually three power facilities currently under development; however an existing geothermal project at Stillwater is being decommissioned to build a larger power plant on the site.

[136]Source: Government Accountability Office (GAO) – "Increased Geothermal Development Will Depend on Overcoming Many Challenges". May 2006 Report to the Ranking Minority Member, Committee on Energy and Natural Resources, U.S. Senate: http://www.gao.gov/new.items/d06629.pdf (pages 22-23)

For environmental reviews, there is concern about how they will be handled in the future. Currently, most projects with federal leases issued have gone through an environmental assessment (EA). However, there is ongoing consideration to develop a Programmatic Environmental Impact Statement (PEIS) process that would cover all BLM and USFS lands in the Pacific Northwest and the Great Basin in order to conduct these efforts in a broader context (similar to the effort performed for wind development, except that the wind PEIS was only conducted for resources on BLM lands)[137]. Although all projects with federal leases must go through NEPA analysis, they have not been generally required to go through an EIS. In many cases a less expensive EA has been sufficient, and an EA can be completed in much less time.

Developers say they might be discouraged by a PEIS review system if they believe that leases will not processed in a timely manner. Some developers prefer a process similar to that used for oil and gas development, which they say has a simple, standardized approach. They are concerned that a lengthy environmental review process would put geothermal at a disadvantage compared to the oil and gas industry (although the oil and gas industry is less involved in states like Idaho and Nevada than the geothermal industry). Regulators assert that projects already undergoing NEPA analysis would not be affected by the new regulations, nor would projects with lease applications still under review. Furthermore, regulators say that the PEIS effort has secure funding due to the changes in the law that earmarks royalty funds for the BLM. This should allow BLM's effort to be designed to create certainty and encourage investment by effectively streamlining the process to support new projects.

Overall, most agree that the progress made in Nevada on geothermal leasing and permitting has been the most successful in the country. The BLM has coordinated with the state and built an active partnership. Most agree that efforts being made in California will improve conditions there as well, although a lot of diverse interests must be met with the process, especially on USFS land. Most agree that continued support from the federal government and active participation by individual state governments can help geothermal development throughout the country. Plenty of geothermal prospects requiring federal leases or permits can be exploited for viable power projects—while continuing to mitigate environmental consequences—without significant delays.

Need for adequate government incentives

While government programs may help identify geothermal resources, and regulatory changes have the potential to facilitate exploration and development, geothermal developers say these changes need to be coupled with appropriate government programs and incentives that enable geothermal projects to become more competitive. Government incentives reduce risks, reduce upfront costs, and encourage investment that could help spur growth in the development of geothermal technologies.

Most agree that incentives will help geothermal power remain competitive in the near term. In the past, government incentives have been used to help developers' secure needed financing for geothermal projects. Given rising energy costs, there is a general agreement that adequate incentives applied today could also help developers secure financing. As the industry grows and gains equity, incentives may not be necessary for the competitiveness of the industry. However, considering the benefits of geothermal energy in reducing our reliance on conventional fuels and

[137]For more information see U.S. Bureau of Land Management (BLM) – Wind Energy Development Final Programmatic EIS: http://windeis.anl.gov/eis/index.cfm

reducing emissions, particularly GHGs, there are ample justifications for providing such incentives.

Typically, the various state and federal incentives that apply to geothermal power development work best in states where the industry is already pursuing development. Developers indicate that increased incentives will more likely benefit them in California and Nevada than in states like Colorado or Montana, where less development is in process. However, it is clear that incentives are helpful no matter where they are applied. If a state only has one or two projects under development, the cost of an incentive to the taxpayer is minimal. While a state tax incentive for geothermal power plants in California and Nevada (which have over half of new geothermal projects currently under development) would have a larger impact on public budgeting than in all other states combined, these incentives would likely produce a similar return on the investment based on the ultimate cost.

Federal incentives

As noted earlier, the PTC is considered the most critical policy to spurring near-term growth to the geothermal industry. Since the Richard Burdette plant became the first to take advantage of the PTC, there are as many as 15 more grid-connected geothermal power plants expected to be built in the U.S. by the time the of current expiration date, which includes projects in California, Hawaii, Idaho, Nevada, and Utah[138].

Although policymakers in the U.S. Congress have indicated that the PTC is likely to be expanded beyond December 31st, 2008 in the 110th Congress, uncertainty has continued to impact projects under development. Prior to the most recent extension, utilities passed on a number of projects not expected to meet the previous PTC deadline of December 31st, 2007. This issue is not expected to change significantly due to the most recent extension. Developers assert they are unable to move ahead on financing projects in which the completion date is unknown, and thus the qualification for the PTC is unclear. This uncertainty has already held up and continues to impact specific projects in a number of states, including Arizona, California, Nevada, New Mexico, Oregon, and Utah.

Based on the volume of new projects under development in the U.S. and the renewed interest in geothermal power projects in multiple states, it is clear that the recent extensions of the PTC (including those in 2004, 2005, and December 2006) immediately enabled more planned geothermal projects to move forward. However, most agree that due to high upfront costs, and the length of time required for exploration, property acquisition, and regulatory compliance, at least a five year extension of the PTC is required to provide certainty for developing geothermal projects. Such an extension is particularly critical to states where the geothermal industry is not well-established, but where plants are under development and not expected to be completed until after the current deadline. Such projects include those in Arizona, Idaho, New Mexico, Oregon, and Utah. Although a five year extension of the PTC will not undue the uncertainties inherent in geothermal resource exploration, most agree that if policymakers are serious about reducing GHG and other emissions, as well as increasing efforts towards energy independence, then a long-term extension of the PTC is justified.

Several geothermal developers have been promoting an alternative policy to a long-term extension where a project can qualify for the PTC as long as the project has begun construction

[138]This estimate is based on GEA's *November 2006 Geothermal Power Production and Development Survey* (See Table 1, in Part I), and personal communication.

by the placed-in-service date. For instance, the current credit stipulates that projects operating on December 31st, 2008 would get the PTC for ten years, and projects online on January 1st, 2009 or afterwards would get nothing (if the PTC is not extended by that time). In the alternative policy a plant would need only to start construction by the placed-in-service date to qualify for the PTC, but would not be able to claim the credit for the entire ten years. This would mean, under the current PTC deadline, if a plant is under construction on December 31st, 2008, and comes online in 2009, it gets the credit for nine years; online in 2010, it gets credit for eight years; online in 2011, it gets the credit for seven years, etc. Developers say this policy change would stop the "placed-in-service cliff" that occurs when the PTC expires; making the cost of power more predictable.

There is a general consensus that some form of an extended PTC, combined with effective government programs and outreach efforts, will reduce uncertainties and risks for developers and encourage more private investment. Other incentives, including CREBs, are not considered as critical as the PTC.

Distributed generation incentives

While most agree that federal incentives can encourage the power market to purchase power from geothermal projects, incentives are meaningless if a resource cannot be properly transmitted to the power market. Utilities assert that transmission access and current market costs generally limit the economics of geothermal power plants (especially when these plants can only produce small amounts of power). Therefore, proponents suggest that incentives should target distributed generation technologies. One incentive that most agree would be effective is to give credits to alternative fuel production facilities that use renewable resources, like geothermal energy. In addition, small geothermal distributed generation could benefit from the federal investment tax credit (ITC) currently awarded to solar and wind installations. With several new geothermal distributed generation projects expected to come online in the next few years (including alternative fuel plants, oil and gas co-production facilities, aquaculture and greenhouse facilities, and any number of PureCycle® units), most agree that providing incentives for these technologies are crucial to maintain the momentum for innovation.

Renewable Portfolio Standards (RPS)

While developers generally agree that federal programs and incentives are the largest drivers for new development, most agree that a state RPS can be just as valuable. While an RPS is not technically an incentive, it can create a market for renewable energy sources by encouraging utilities to sign PPAs for geothermal power plants. Of the 9 states where geothermal power projects are under development, five have a RPS (Arizona, California, Hawaii, Nevada, and New Mexico) and four do not (Alaska, Idaho, Oregon, and Utah). However, to measure the impact of the RPS, it is prudent to examine the 11 states where WGA estimates geothermal potential and note how the RPS has made an impact.

By December 12th, 2006, of the 11 western states that WGA deemed have economically developable potential by 2015, it includes the five states listed above and Colorado (where no projects are currently under development). In these states, the number of projects under development encompasses a combined 46 totaling up to 1839.3 MW. Of the states without an RPS, it includes the four states listed above, and Washington State—which only passed their RPS, but has not yet implemented it—(and where no projects are currently under development). In these states, they are developing only ten projects totaling up to 195.4 MW. These five states have over 37% the resource potential in these 11 states, but are developing less than 18% as many projects and less than 10% as many MW[139].

In some ways, the RPS has been similar to PURPA. Unlike PURPA, however, most state RPS laws do not provide a financial incentive. PURPA created a market for small renewable energy projects by obligating regulated utilities to purchase the power, at rates equal to the utility's avoided cost (i.e., "the incremental cost to an electric utility of electrical energy or capacity or both which, but for the purchase from the qualifying facility, such utility would generate itself or purchase from another source")[140]. In the 1970s and 80s, the avoided cost of new power was generally higher than the current market price, resulting in contracts for new construction at attractive prices to developers. Nearly all geothermal projects in the U.S. in the 1980s and early 1990s had PURPA contracts. However, since the Congress moved to deregulate wholesale power in 1992 and a natural gas supply boom drove the avoided cost of power to historic lows at the same time, there is a general consensus that PURPA has not been a significant driver for geothermal development since 1992.

While PURPA is still part of federal law, the implementation of PURPA has and continues to vary from state to state and in 2005 EPAct removed the mandatory purchase requirements of Section 210 of PURPA from federal law. The only state where industry stakeholders indicate that PURPA still has an impact is Idaho. According to utility regulators in Idaho, there are at least three reasons for this. 1) Idaho has no RPS that would compete with PURPA. 2) In Idaho, avoided cost rates for renewable facilities averaging 10 MW or less (like the Raft River plant) are based on the cost of a natural gas-fired combined cycle combustion turbine, which results in a higher value for the "avoided cost" than might be encountered in other states. These rates are adjusted periodically based on natural gas forecasts. 3) The maximum length of a PURPA power contract in Idaho is currently 20 years—more than is usually offered in other states. Although PURPA has been recently amended on the federal level, Idaho regulators say this will not change existing regulations in Idaho.

State incentives

State governments in the western states (outside of California) do not have sufficient budgets to provide large financial incentives or to appreciably assist projects at existing sites; nor to help fund exploration and drilling at undeveloped geothermal prospects. Federal incentives continue to play a significant role in encouraging geothermal exploration and development. However, several states have provided incentives available to geothermal projects that have been helpful to

[139] Numbers based on the GEA Update on US Geothermal Power Production and Development (11/10/2006) and GEAs December report on Nevada, *Geothermal Resource Development in Nevada – 2006*. Nevada has an additional five projects under development as of 12/12/2006 and those are added into the equation. In addition, the two projects at Newberry Volcano in Oregon are considered "California" projects in this calculation. The reason is that the California Public Utilities Commission (CPUC) is still considering a 120 MW project at Newberry in Oregon that would sell power to California customers and has a delivery point within the California Independent System Operator (CA ISO) control area. Projects outside California that deliver the energy into the ISO control area can be eligible. The project (which has two phases) has a PPA with Pacific Gas & Electric (PG&E) in California, and there is evidence that the California RPS was part of the driver for this project. However, if this project is considered an "Oregon" project, then the numbers would go this way: Non-RPS states would be developing 21.4% as many projects and 15.5% as many MW, although they have 37% of the potential of all 11 states.
For "potential" of the 11 states, see the WGA Geothermal Taskforce Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf

[140] Source: "Avoided costs" – Electronic Code of Federal Regulations (e-CFR) – Title 18: Conservation of Power and Water Resources: http://ecfr.gpoaccess.gov/

some degree, including sales tax exemptions, property tax exemptions, and grants and loans, among other incentives.

Most agree that for incentives to be effective at the state level, they should be tailored to the types of projects that would be most likely and most beneficial to the state. For example, as noted in the description in Part II, the generous High Technology Business Investment Tax Credit in Hawaii is geared towards technologies that can reduce their reliance on imported fuel. Developers say that in oil and gas producing states like Texas, an industrial tax credit for facilities using geothermal binary units from oil and gas wells would be more effective than a tax credit for conventional geothermal power plants. In states where intermediate-temperature hot springs can be used for localized power projects (such as in Alaska, Idaho, and Oregon in particular) a tax credit for those installations could be considered. In fact, such a tax credit already exists in Oregon through the BETC, which geothermal developers consider one of the best state incentives currently available for geothermal power projects.

Not all states have embraced geothermal technologies in their incentives. In fact some of the larger incentives have left out geothermal projects entirely. For example, renewable energy tax credits in Utah and New Mexico do not include geothermal power plants. In addition, as noted earlier, the Arizona RPS did not include geothermal power plants in its eligible renewable technologies until it was amended in the fall of 2006.

One state that some suggest could have more significant incentives is Nevada. Several interviewees assert that they prefer to develop alternative energy projects in states with better incentives, such as California and Oregon, than in Nevada. Further, developers note that Nevada's utilities do not offer the scope of utility rebates and credits that are offered in states like California, Oregon, and Washington State. Geothermal projects in the Pacific Northwest may also be eligible for grants from the Bonneville Environmental Foundation (BEF). BEF is a private grant-giving institution that provides funding for renewable power projects up to 33% of total capital costs. These grants are available in Idaho, Montana, Oregon, and Washington State, but not in Nevada[141].

Geothermal advocacy

While there has been a great deal of recent interest and conversation about energy efficiency and renewable energy in the western states, clean energy advocates say that an absence of geothermal industry presence in some states has been one reason that geothermal resources have been overlooked in state programs and incentives.

As noted earlier, geothermal resources are already at a disadvantage because they are less known to the public than wind and solar resources. Clean energy advocates working with state legislatures assert that in order for geothermal resource development (both power production and direct use) to receive broader inclusion in future policy decisions, more outreach and a unified advocacy effort from the geothermal community is essential. This is particularly an issue in states where development is not advanced, such as Idaho, New Mexico, and Utah. Clean energy advocates in these states suggest that geothermal needs a larger presence. This includes the industry working more closely with other clean energy advocacy groups on state legislative

[141] BEF – Renewable Energy Grant sources: Database of State Incentives for Renewable Energy (DSIRE): http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=WA11F&state=WA&CurrentPageID=1&RE=1&EE=1 & Bonneville Environmental Foundation (BEF): http://www.b-e-f.org/grants/renew_intro.shtm

issues. One example is in Utah where, according to Sarah Wright of Utah Clean Energy, there are few groups active in the state promoting geothermal energy. Wright notes there is a dire need to increase outreach to educate the public, policy-makers and utility regulators about the viability and benefits of geothermal energy.

While most agree that the geothermal industry has a history of being involved in the policy debate in California and Nevada, and in recent years the geothermal community has had a growing presence in Idaho, there has not been a significant presence elsewhere. However, the geothermal community needs to work more effectively with local advocacy groups. This includes groups such as the Coalition for Clean and Affordable Energy (CCAE) in New Mexico, the Northwest Energy Coalition in Idaho, Utah Clean Energy in Utah, and the Denver, Colorado-based Western Resource Advocates which has been active in multiple states on geothermal issues including New Mexico, Nevada, and Utah.

Needs of the power market

Changes in the power market affect geothermal development. Some states have adequate supply, while others need to increase capacity to meet expanding load growth. Some states have higher retail power rates, meaning a project that is competitive in one state may not be competitive in another. Some states may require the procurement of renewable power through an RPS, while others have no such policy. Some utilities may be very willing to pursue geothermal power projects, while others may prefer other technologies. It is clear that the high cost of power has been a major driver for geothermal development in Alaska, California, Hawaii, and Nevada. Conversely, developers involved with projects in Idaho, Oregon, and Utah have had more trouble getting projects off the ground because of the competition with fossil fuels and hydroelectric power. In fact, there is a general consensus that inexpensive power rates of traditional sources is a major reason certain states were slower to develop their geothermal resources in the 1970s and 1980s.

As mentioned earlier, another impetus for geothermal development involves water use, or its lack there of. Conventional fossil fuel sources, such as coal, natural gas, and nuclear power use lots of ground and surface water for cooling. Coal is already the primary source of fuel for power plants in the 13 states in the west from the Rockies to the West Coast (as well as Alaska and Hawaii) followed by natural gas and then by hydroelectric power. As of December 2005, EIA reports there are four nuclear facilities operating in the western U.S. with a total capacity of 9,257 MW. This capacity is not likely to increase in the near future due to concerns over water use, public opposition, and the fact that new nuclear power facilities generally take up to a decade or more to build. While the USDOE has been working on new reactor designs, it's not clear to what extent they will resolve these issues. Further, according to USDOE none of these new reactor designs are expected to be proposed for permitting until 2010 with the earliest operation possible by 2014 or later[142]. Utilities say that coal remains a preferred baseload alternative when near-term cost is the primary concern. However, maintaining adequate coal supply is difficult for states like California, Nevada, and the Pacific Northwest because nearly all of their coal is imported from out-of-state[143]. Coal plants typically use far more water per equivalent generation than a

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[142]Source: U.S. Department of Energy – "DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment Report." (October 21, 2005): http://www.ne.doe.gov/np2010/reports/mpr2776Rev0102105.pdf

[143]Sources – Energy Information Agency (EIA): http://www.eia.doe.gov/cneaf/nuclear/page/at_a_glance/reactors/states.html

geothermal power plant that utilizes water-cooling. Although the use of air cooling—common among geothermal plants—may reduce efficiency, this type of cooling avoids water use restrictions in place in some areas. Some geothermal developers have considered hybrid systems that use water-cooling in the summer and air-cooling in colder months. Hybrid or strictly air-cooling systems are often not a viable option for coal plants, especially for large facilities, due to associated economic and technical limitations.

As many western states have passed an RPS and western utilities have scrambled to boost their renewable portfolios, geothermal energy has become an attractive alternative to utilities because it is one of the few renewable resources that is also baseload. With populations growing in these states, there is a constant need for load growth. Thus, when renewable facilities are built, they help meet this growth. Utilities say that geothermal plants will compete for contracts with new coal and gas facilities rather than replace them.

However, most agree the power market still is reluctant to take on geothermal projects unless the power rates are low enough. Many projects hinge on the extension of the PTC, and remote resources remain at a disadvantage due to transmission access. The PTC is only eligible to power sold to IOUs, which are more likely to take on geothermal projects in the first place. Municipal utilities and rural cooperatives, particularly in the Pacific Northwest, remain heavily reliant on inexpensive hydroelectric power from the Bonneville Power Administration (BPA), and have not been active in financing geothermal projects even though Congress has provided a significant incentive for them to do so through the CREB provisions of EPAct. While both developers and utilities stress the importance of federal tax credits like the PTC, CREBs, and state renewable procurement standards like the RPS, they assert that additional efforts are necessary to induce greater geothermal development. Overall, the general criteria for a successful geothermal project include the right location (i.e. proximity to markets and/or power grids and approximate population served) and the potential for electrical generation (i.e. water temperature, water flow rates, aquifer geology, and the sustainability of geothermal flows)[144]. These criteria will dictate the electricity rates sold by a geothermal project and the likelihood of utilities purchasing electricity from the project, no matter what state its customers are located.

The Boiling Springs steam vent rests in a national forest in Valley County, Idaho – considered part of the Idaho Batholith region. Photo by Josh Laughtland – webmaster@idahohotsprings.com: Used by permission

While coal is produced in the Rocky Mountain States, the only state of those listed that produced coal in 2004 was Washington State, but only 0.5% of U.S. supply. See the National Mining Association (NMA) – "U.S. Coal Production by State by Rank (Thousand Short Tons)": http://www.nma.org/pdf/c_production_state_rank.pdf

[144]Source – Marie, Jim St., Mink, Leland, Mink L., and Neely, Kenneth W., Idaho Department of Water Resources. "Examination and Evaluation of Geothermal Sites in the State of Idaho with Emphasis Given to Potential for Electrical Generation or Direct Use". September 2002: http://www.idwr.state.id.us/energy/alternative_fuels/geothermal/reports/exam_eval_200209.pdf (page 12).

Transmission

There is a general consensus that transmission access remains a barrier to geothermal development in the western U.S. While transmission is an issue for any energy source, it is particularly a problem for geothermal projects. Unlike oil, coal, and natural gas, geothermal resources cannot be shipped. Geothermal power plants must be built at the location where the resource exists, and the power transmitted to populations within the region. Because utilities are not required to cover the transmission costs for projects that they do not own, these costs fall onto the developer, which can be prohibitive for remote resources.

Such has been the case in California, where resources in its southeastern desert require transmission to cross rugged terrain with very hot ambient temperatures. Utilities say that Nevada's open valleys and open spaces mitigate some of these issues for geothermal projects in that state, because these transmission lines cross undeveloped land and terrain that isn't very rugged, and many are within a short distance from the transmission corridor running alongside Interstate-80. Even though transmission lines from these resources may cross BLM land, few cross USFS land. This is an advantage over locations in California, Idaho and the Pacific Northwest where transmission lines and access roads may cross through national forests. This is particularly an issue in the Idaho Batholith region of Idaho. Issues like these also affect a number of geothermal prospects in Alaska, Hawaii, New Mexico, and Utah.

In delineating how to utilize renewable resources in the western U.S., CDEAC considered where resources are located to be able to plan a transmission corridor to exploit them. CDEAC is part of the major push for renewable power development that began several years ago through the WGA. CDEAC released a final report in the June of 2006 that evaluated all energy sources in the western U.S. and created goals that include:

- 30,000 megawatts of new clean and diverse energy generation by 2015
- A 20% increase in energy efficiency by 2020
- Adequate transmission capacity for the region over the next 25 years[145]

To achieve this, transmission studies have taken place for several years, including transmission studies for areas with renewable potential. Among several transmission line projects, one of the most significant proposals is for a Frontier Line from Wyoming to California, capable of delivering up to 12,000 MW of new renewable and conventional energy once construction is completed[146]. Part of the impetus for CDEAC is unyielding population growth in the region (particularly in California) and the viability of renewable resources in the Intermountain West. Given the fact that geothermal, solar, and wind power do not require excess water consumption, its development in this part of the country is more viable.

Transmission planning is critical to the long-term success of the geothermal industry. For one thing, transmission lines are expensive. Utilities indicate that a 10 MW geothermal prospect close to transmission lines stands a better chance of development than a remote 30 MW prospect. Building transmission from remote sites requires coordination. Some lines are nearly maxed out or require upgrades to add new power. In cases where a geothermal prospect is remote, utilities say that multiple sites in the same area present less of a challenge. Building transmission and performing upgrades for each new project (one at a time) is contrary to effective strategic

[145]For more information see Western Governors' Association (WGA) – Clean and Diversified Energy Initiative – CDEi: http://www.westgov.org/wga/initiatives/cdeac/index.htm
[146]Source – Interwest Energy Alliance – Renewable Energy Highlights of 2005 (12/30/2005): http://www.interwestenergy.org/2005_highlights.htm

planning. An example of early efforts towards planning in this regard can be seen in California, where new wind projects in Tehachapi are being built in a coordinated fashion, so as to make sure individual projects do not interfere with one another. Such planning also ensures that the costs of transmission are spread out over a longer time period by developing a larger transmission project. Several interviewees suggest that a similar methodology might work for locations in Nevada, including areas on the California border near the Fish Lake valley, areas near Winnemucca, and areas in Nevada's northwest corner. California has laid out plans to add additional capacity to connect the significant geothermal resources in southern California (within the Salton Sea KGRA area) to its transmission system serving major urban centers—but the transmission projects continue to face regulatory hurdles and public opposition to some portions of proposed routes.

Most agree that effective interagency coordination is critical to achieving a workable transmission policy. This means that state governments, including state regulators, and federal agencies such as the BLM, USFS, and FERC, need to work together towards a unified transmission policy. Transmission lines to geothermal prospects are especially affected by regulations on federal land. Even geothermal prospects on private land must often cross transmission lines over federal lands, and this process requires NEPA compliance; which can lead to further delays. Regulatory overlap regarding transmission is especially an issue in Nevada, but affects nearly all states planning geothermal power projects.

Regional Transmission Organizations (RTOs)

To simplify transmission planning, one solution that has had a great deal of consideration has been the establishment of Regional Transmission Organizations (RTOs). Geothermal developers note that because a project is localized, in most cases they do not have the option of negotiating with utilities other than the one with the closest utility lines. Thus, proponents say that if RTOs are expanded throughout the western U.S., they might possibly reduce transmission tariffs to postage stamp transmission rates for electric generation traveling across utility wheels. Such a system might be structured to avoid rate pancaking across multiple owners, and enable a more transparent market conducive to broader, long-term planning needs for entire regions. RTOs may encourage coordination on transmission projects cost-shared by multiple partners to serve a larger volume of customers and disperse the costs and risks.

An RTO based on this model was first proposed in 2000, later called the Grid West RTO. Grid West defined its purpose as "creating a new, independent, non-profit corporation that plans and manages certain operational and commercial functions of the regional transmission grid." The RTO would have covered the Pacific Northwest and parts of the Intermountain West (including Idaho, Oregon, Washington State, Nevada, Utah and parts of Montana, Wyoming and California) and would have had authority to raise transmission rates and build infrastructure. While some say this was a revolutionary concept and there was considerable interest when originally proposed, as the project moved ahead there were concerns over bureaucracy and complexity. After several years of negotiating between major utilities in the Pacific Northwest, the Grid West RTO was scrapped. More recently, a new RTO has been proposed called the "Columbia Grid" that would have less authority on rates and infrastructure, but would be able to help guide planning and centralize information[147]. However, it is still uncertain what regions (besides the Pacific Northwest) the Columbia Grid, if implemented, would cover. Currently, utilities in Arizona, California, Colorado, Nevada, New Mexico, and Texas belong to a transmission planning entity called WestConnect. While WestConnect is not an RTO, it is a regional collaboration composed of 12 utilities in these six states considered part of the "Desert Southwest" and facilities

[147]Citizens' Utility Board of Oregon – Grid West RTO and Columbia RTO: http://oregoncub.org/archives/2006/08/transmission_10_1.php

coordination on transmission projects in the region through discussion on utility practices, with a purpose to "achieve as much consistency as possible in the Western Interconnection."[148]

While most agree that RTOs might be helpful to the transmission planning process, they are by no means a panacea. Even geothermal power projects with adequate transmission access have had trouble obtaining contracts, due mostly to concerns over the cost per kWh and utilities' lack of familiarity with geothermal technologies.

Investor-owned utilities (IOUs)

The significant majority of geothermal power generated in the U.S. is sold to IOUs. As noted in the state summaries, IOUs make up the majority of all electric power production in the western U.S.; providing the majority of energy in every western state, except for Alaska and Washington State.

While the state RPS in Colorado, Texas, and Washington State require all its utilities to comply (above a minimum number of customers for utilities in Colorado and Washington States), the RPS in Arizona, California, Hawaii, Montana, New Mexico, and Nevada only regulate compliance by its IOUs or privately-run power marketers. However, even in non-RPS states, geothermal projects are beginning to be developed by IOUs. The challenge in these states is ensuring that utilities will procure these projects if tax credits like the PTC are uncertain. With the exception of Alaska, non-RPS states in the western U.S. tend to have the lowest power rates in the country. States with low power rates include Idaho, Oregon, Utah, Washington State and Wyoming. Although costs have been comparatively low in Colorado, Montana, and New Mexico, other factors have led to the acquisition of an RPS (such as the heavy reliance on fossil fuels in those states). As noted earlier, Washington State recently passed an RPS, while one has been proposed in Oregon. While their retail power rates have historically been low, both states have experienced price increases in recent years and are experiencing issues with salmon recovery issues that affect their hydroelectric dams. In addition, both states have strong laws concerning environmental protection.

Integrated resource plans (IRPs)

Any utility that considers a geothermal project will weigh costs and benefits to determine the levelized cost of power of geothermal compared with other renewables and non-renewables. Based on the near-term costs of geothermal power plants, new projects may pose a risk to utilities rather than a benefit. Benefits of geothermal plants may only be salient in the long-term, and the resource potential for geothermal prospects still in their early stages pose high risk and require considerable upfront capitals. Thus, based on the risk-adverse nature of utilities, the vast majority of state PUCs requires regulated utilities to prepare IRPs that forecast supply and demand and specify options that could meet load growth considering cost reliability, long-term risks, and environmental impacts. Most agree that these IRPs serve as roadmaps upon which utilities can plan for future load growth responsibly. IRPs have had a larger impact on renewable power projects in general in states without an RPS. With RPS states, the role of the PUC in overall renewable energy procurement is worked into the IRP. Regulators say that a geothermal power plant project offers several advantages in the IRP process: it is baseload, its fuel-price is stable, and its environmental benefits (including low emissions of GHGs) are considerable. With

[148]Sources:
These six states in the "Desert Southwest" with utilities involved in WestConnect include Arizona, California, Colorado, Nevada, New Mexico, and Texas. For more information see WestConnect: http://www.westconnect.com/ & "Nevada Power Joins WestConnect" – Nevada Power Company, 1/17/2006: http://www.nevadapower.com/news/releases/ShowPR.cfm?pr_id=4684

legislation already passed in California regulating GHGs like carbon dioxide, there is a general consensus that carbon legislation will remain one of largest issues about which policy may be enacted during the next few years. Though the extent of this legislation remains unknown, most agree that the potential for carbon taxes or carbon trading credits will benefit geothermal projects.

Most agree that IRPs are effective in helping utilities to consider power within a long-term framework, rather than focusing on providing the lowest rates possible in the near-term. While keeping electricity rates low may be the most important criteria for power procurement by utilities, other issues are also considered by government. Government considers economic development, environmental quality, and the benefits of energy independence, as well as cost. Although utilities assert that the costs for geothermal power have not necessarily been the most competitive in states where plants are currently operating, they do agree that geothermal costs have been relatively stable. In fact, utilities in several states have recently issued RFPs for renewable power that include geothermal. Already, RFPs have led to contracts for geothermal power projects in California, Idaho, Nevada, Oregon, and Utah, with Idaho specifically requesting up to 150 MW of geothermal energy development.

Green power programs

Most utilities run green power programs that allow customers to make a minimum monthly contribution to be added to their energy bill. IOUs in the western U.S. generally charge a minimum of between $1 and $3 for these programs. While some programs have had moderate success, particularly in the West Coast, green power programs in the Intermountain West have lagged in customer participation. To promote their green power program, many of these utilities have run print ads, held events, and provided pamphlets to its customers, among other efforts. Clean energy advocates assert that utilities will only do so much marketing themselves and it is essential that other entities, including environmental groups and the state government, be involved as well. Clean energy advocates assert that greater public awareness of these programs is crucial and that individual state governments can establish awareness campaigns promoting them. In addition, they recommend that states work with utilities to prepare presentations or videos that show actual projects these programs help finance to give customers an objective understanding of how their contribution makes a difference in the energy they use. Several interviewees suggest the federal government engage in a nationwide campaign to get customers to join these programs, and help fund grassroots efforts to coordinate action with individuals and communities.

Rate flexibility

Beyond green power programs, there are other ways for states to allow utilities greater flexibility in the cost recovery of geothermal projects. While an IRP attempts to guide sensible planning, and an RPS attempts to set a minimum standard for development, utilities are still discouraged by the risk they incur when they purchase geothermal power from an outside developer. Utilities are generally disinclined to build geothermal project themselves because of the risk involved, and joint ventures have thus far been rare.

When an IOU purchases any power from a plant owned by an outside party, the power purchased becomes imputed debt for the utility. This may be shaky with shareholders because it can affect bond ratings. The California energy crisis that began in 2000 and ended in 2001 forced several utilities into bankruptcy because when prices skyrocketed. When the price shocks first happened, state laws restricted rate increases, and rates remained artificially low, at the forecasted price of power. After this debacle spread to other western states, several State PUCs gave utilities more flexibility to raise rates when securing renewable power projects, including Nevada.

Among the methods for cost-recovery that have been utilized at the state level are mark-ups and system benefit funds (sometimes called public benefit funds or system benefit charges). These are utilized in Arizona, California, Montana, and Oregon. System benefit funds were used in New Mexico during the 1980s to allow utilities to increase rates that would go towards funding alternative energy projects, but are not currently in place. In 2005, the Nevada PUC created a similar type system through the creation of the Temporary Renewable Energy Development (TRED) Program. While the TRED program is intended to aid developer financing for small companies without strong bond ratings, the program also gives IOUs the flexibility to recover the costs of purchasing these projects and providing "prompt payment to renewable energy providers in order to encourage completion of renewable energy projects." To do this, the TRED program established:

> (1) A TRED Charge allowing investor-owned utilities to collect revenue from electricity customers to pay for renewable energy separate from other wholesale power purchased by the electric utilities; and
>
> (2) An independent TRED Trust to receive the proceeds from the TRED Charge and remit payment to renewable energy projects that deliver renewable energy to purchasing electric utilities[149].

Municipal utilities and rural cooperatives

While IOUs serve the majority of customers in the western U.S., many of the smaller rural communities are served by their local municipal utilities and rural cooperatives. Because many geothermal resources are located in rural areas, most agree it is prudent to consider encouraging greater use of geothermal power by municipal utilities and rural cooperatives. The ORC units being utilized at Chena Hot Springs, Alaska has created renewed interest in using small power units to serve local loads. For example, 1 MW of baseload geothermal can serve nearly 1,000 homes and many communities served by small utilities in western states have fewer than that.

One suggestion offered by several interviewees is for an analysis of geothermal resources located near existing transmission serving rural cooperatives and municipal utilities. This analysis could evaluate local hot springs and geothermal resources based on development potential of small power projects. Technological and resource parameters, the distance from transmission lines, and the potential price of power could be assessed. In addition, economic development potential and employment needs in the community could also be factored in to determine how this development might benefit the local area. This includes consideration of local industry and mining operations which may be located in rural areas, and can utilize small-scale power units. Existing studies of geothermal resources in several states indicate potential for these types of projects. In particular, municipal utilities and rural cooperatives in Alaska, Idaho, Montana and Oregon may have potential to use these types of units. Because of the colder climate in these states, researchers contend that lower temperatures can be utilized there than would be necessary in states like Arizona, New Mexico, and Southern California.

In northern Nevada and the Pacific Northwest (even into Montana) many of the small rural cooperatives and municipal utilities communities have been served by out-of-state hydroelectric power from BPA. However, after drought has reduced hydro supplies to the region and higher

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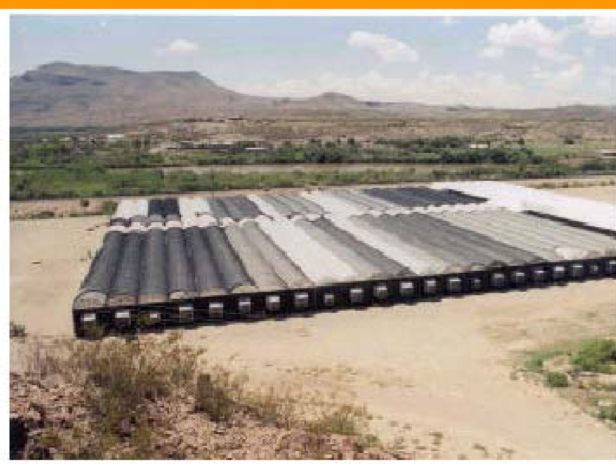
[149]Source – Database of State Incentives for Renewable Energy (DSIRE), "Energy Portfolio Standard": http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NV01R&state=NV&CurrentPageID=1&RE=1&EE=1

energy costs in California have affected BPA's load growth, rate increases have affected customers being served by BPA all over the Pacific Northwest. Higher rates have not only initiated changes in how BPA may serve its customers in the future, it has also raised awareness of the potential to use local renewable resources to serve rising load growth in some of these small communities. Currently, the prospects for using small-scale geothermal power units depend, in part, on the outcome of ongoing regional dialogue between BPA and its customers. This dialogue will determine how the BPA load will be allocated, and whether or not utilities will be able to serve their own additional load using indigenous resources, like geothermal. Such development may be enhanced by the availability of incentives through the CREB program, which effectively provides a tax subsidy for the interest payments on development financing by these entities, resulting in a financial incentive comparable to the PTC. However, in the first round of projects announced by the Treasury Department, there were not geothermal projects despite the significant overlap of geothermal resources and areas within territory served by rural cooperatives and municipal utilities. However, in August of 2006, due to the impact of the state RPS in Colorado (which includes these utilities) U.S. Geothermal signed a ten-year, $4.6-million deal to sell excess RECs from its Raft River geothermal facility in Idaho to Holy Cross Energy, a rural cooperative utility in the state[150].

Need for greater utilization of Direct Uses



Masson Greenhouses at Radium Springs – Source of photo: Geo-Heat Center at the Oregon Institute of Technology (OIT) – GHC Bulletin, December 2002

Most agree that reducing energy needs through energy efficient technology is just as important as meeting growing energy needs through new development. Geothermal direct use facilities can utilize low-to intermediate temperature resources to reduce energy needs by providing thermal heating. Geothermal direct use systems replace thermal uses otherwise produced through electricity or boilers using conventional fuels. While these applications have generally been used for residential heating, domestic hot water, or district heating (for small or large communities), there are also several major commercial uses. Among these are agricultural drying, food processing, mineral processing, heap-leaching, bio-fuels refining, greenhouses, spas and resorts,

[150]Source – U.S. Geothermal, 8/10/2006: http://www.usgeothermal.com/news/03Aug2006

aquaculture, laundromats, snow melting, and heating for schools, hospitals, prisons, and business districts.

Spas and resorts, sometimes including space heating through the piping of geothermal water, are the most common use. Geothermal space heating has been installed at universities in four states: Cayuga Community College (New York), College of Southern Idaho, Oregon Institute of Technology, and NMSU. Boise State University in Idaho and New Mexico Tech are likely to become next on that list.

District heating systems have been installed in seven states in at least nine locations where geothermal heating is sufficient for entire neighborhoods, and in some cases large business districts. The four systems in Boise make up the largest use of district heating in the U.S. As for commercial uses, at least 11 states have used geothermal heating for greenhouses (this includes all 13 western states except for Arizona and Washington State) and at least 11 states have used geothermal for raising aquatic life, from common fish species like bass, catfish, salmon, and trout, to tropical fish, to crayfish, lobsters, and shrimp, and even alligators in several locations. Industrial uses such as heap-leaching (described in Part II in the Nevada section) and vegetable drying have generally required intermediate-temperature resources. The states where these have been used have been limited to California, Nevada, and Oregon.

The variety of direct use applications is likely to grow in the near-term including uses such as bio-fuels refining (currently being done in Oregon and Nevada). As energy prices rise, different interviewees suggest other opportunities such as hotels, milk and cheese processing facilities, mineral processing, and garlic, onion, or other agricultural processing facilities, among other potential uses.

Geothermal resources sufficient for direct use applications can utilize temperatures as low as 85°F (29°C) (including aquaculture in some locations), although large-scale heating for residencies or commercial greenhouses usually requires temperatures at least between 131-158°F (55-70°C). In fact, the Boise Front geothermal aquifer produces from a temperature of up to 194°F (90°C). However, researchers contend that the overall temperature range for the many existing direct use facilities varies significantly depending upon the location of the resources.

Overall, direct use installations are more common in the western U.S. where all geothermal greenhouses, aquaculture facilities, and industrial facilities are found. With the exception of South Dakota, only spas and space heating are found east of the Rocky Mountains (none exist in the eastern parts of Colorado, Montana, New Mexico, or Wyoming).

Despite a history of geothermal usage in many communities in the western U.S., researchers frequently express exasperation that these resources are vastly under-utilized. Besides energy savings, proponents of these technologies tout the contribution to economic development, particularly of geothermal-heated greenhouses, which currently employ hundreds of workers in both Idaho and New Mexico, and several hundred more in other states with these operations. In his July 11th, 2006 testimony in front of the U.S. Senate Committee on Energy and Natural Resources, IWGC director, Dr. Walter Snyder, said that the utilization of direct use applications "has allowed local business enterprises to flourish that would not have otherwise been possible."[151]

[151]Source: Statement of Walter S. Snyder. Director, Intermountain West Geothermal Consortium, Before the Energy and Natural Resources Committee U.S. Senate, July 11, 2006: http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=1576&Witness_

Although geothermal direct use applications are believed to be in use in nearly half of all U.S. states, few communities in these states have utilized enough of the resource sufficient to represent any more than a small percentage of their overall thermal use. Geothermal direct use projects have primarily been used in areas with obvious resources. Most of the available resource base is still unknown. New development overall has been limited by the upfront costs of drilling, the lack of a coherent "direct use" industry, the low level of public awareness, and the absence of any large-scale government effort to capitalize upon the resource base. In addition, direct use facility operators say there are few incentives for communities and businesses to pursue these projects beyond the energy savings themselves. Many of the direct use facilities still in operation today benefited from tax credits and government loan guarantee programs in place during the 1980s that enabled their construction. However, although the upfront costs were financed, in part, through government money, most of these businesses and facilities are still operating profitably and have been beneficial to the local community and the local economy.

Despite a lack of government funding in recent years for incentives, grants, or loans, new interest in geothermal direct use development has risen as high energy costs, especially heating costs, have increased with the prices of natural gas and propane. In FY 2006, the USDOE provided its most comprehensive funding this decade for new studies and on-the-ground work for geothermal direct use projects in 12 states. The applications these projects encompass include aquaculture, greenhouses, district and space heating, recreation, as well as funding to examine multiple uses such as alternative fuel production[152].

The analysis below identifies three specific issues evaluated through research: (1) the impact of state and federal regulations, (2) the challenges to creating markets for these applications, and 3) the challenges in closing the information gap. In each of these sections, the analysis examines what is being done, state by state and overall, to overcome these challenges and move projects forward.

Impact of state and federal regulations

The regulatory definitions for "geothermal resources" were noted in this paper's previous discussions of individual states. Not all states have a defined process for direct use permitting. In Arizona, for example, the regulatory process is relatively new, and regulators say their lack of familiarity with geothermal projects in the state creates a less defined permitting process. However Arizona regulators are working with researchers and the State Geothermal Working Group, and all generally agree that a routine for dealing with direct use water issues will arise over time. Even though California, Idaho, New Mexico, and Utah are states with active geothermal direct use development (and thus areas with more defined regulatory processes) projects there still run into regulatory issues. In his 2003 reports on direct use regulations, Professor Bloomquist notes that the best structured regulations exist in Nevada which is "somewhat unique among western states" in that there is a "developed a regulatory path" for geothermal direct use applications[153].

ID=4455

[152]Source: Geothermal-biz.com – Summary of 2006 Task Order Agreement (TOA) Awards Open Distribution. August 9, 2006: http://www.geothermal-biz.com/Docs/2006%20TOA.pdf

[153]Source: Bloomquist, Gordon: "A Regulatory Guide to Geothermal Direct Use Development: Nevada". Washington State University Extension Energy Program, 2003: http://www.energy.wsu.edu/documents/renewables/nevada.pdf

Water issues
In general, most states classify "low-temperature" geothermal resources as a water resource. There is a general consensus that water remains a primary issue for geothermal direct use development. A rapidly increasing population and overproduction of aquifers by the agricultural sector have exacerbated water scarcity in areas in the Southwest, and drought has affected all western states, particularly with fires devastating many acres of cropland. Water is a constant source of legal dispute and water rights are often a source of conflict. Even if money is not an object for a developer, they still may face regulatory hurdles in using a water resource, even for a beneficial use like geothermal heating.

Over the course of the research, it was clear that the findings of the May 2006 GAO report give an accurate description of how water affects geothermal direct use development. In the report they note that "obtaining water rights can be a significant challenge to direct use development… [because]…Western states are not uniform in classifying geothermal resources, considering them legally to be mineral, water, or having characteristics of both minerals and water. Depending sometimes on the depth and/or the temperature at which they occur, geothermal resources can be subject to state water laws in the western states and are then managed by the state agency responsible for protecting groundwater. Even when not legally classified as water, the production of geothermal resources for direct use applications may still fall under regulations enforced by a state agency responsible for groundwater protection." In addition, they note that in "areas of high groundwater use, the western states generally regulate geothermal water according to some form of the "Doctrine of Prior Appropriation", under which specific amounts of water are appropriated to users in the order when they first made beneficial use of the water. Those that have more senior rights have priority in using the water when use exceeds supply, such as during a drought. Western states that generally follow the prior appropriations doctrine when managing the production of geothermal water for direct use include [Idaho, Nevada, New Mexico, Oregon, and Utah]."

This finding was generally concurrent with what Professor Bloomquist notes in his 2003 state reports. Further, the GAO report specifically notes issues in Idaho where "developers of geothermal resources for direct use face obstacles obtaining appropriations in the Snake River [Plain]…which consists of much of the state below the panhandle, because groundwater is fully appropriated there and used predominantly for irrigation."[154] Water adjudication is ongoing in Idaho, currently focused on the Snake River Plain, and this may affect geothermal direct use development. There has been an impetus to pass rules and regulations that encourage these projects across the western U.S.; however, geothermal direct use receives less attention from regulatory agencies in these states when compared with other high-priority water issues.

In most states, as long as there is "minimal consumptive use" of the water, it is deemed as a beneficial use. In general, for most states unless a user is grandfathered in, the permitting of surface disposal of water may be limited, thus making it difficult for new homes or businesses to use geothermal without irrigating, re-injection, or using a close-looped system; a method where the thermal energy is transferred from the water in the well bore to a closed-looping piping system that is filled with water, from which no water is extracted[155]. Using the close-looped

[154]In the report, it is referred to as the "Snake River Basin". Source: Government Accountability Office (GAO) – "Increased Geothermal Development Will Depend on Overcoming Many Challenges". May 2006 Report to the Ranking Minority Member, Committee on Energy and Natural Resources, U.S. Senate: http://www.gao.gov/new.items/d06629.pdf (page 26)
[155]Source – IDWR Energy Division – "Domestic Heating": http://www.idwr.idaho.gov/energy/alternative_fuels/geothermal/detailed_history.htm

method or re-injection is critical because in some cases geothermal resource users from artesian wells have affected other users in the area.

Endangered species issues

Another issue of concern for geothermal direct use projects is the presence of endangered species. While endangered species affects geothermal power projects as well, their presence in warm springs has also impacted geothermal direct use development in the past. For example, in Idaho, parts of the Bruneau-Grandview KGRA have been restricted to development due to endangered snail species habitat. While this does not affect two nearby aquaculture facilities currently in operation, it restricts development in most of Bruneau and Hot Creek Valleys, including Bruneau Canyon.

Perhaps the most bizarre case concerning endangered habitat involved an aquaculture project in Sodaville Springs, just south of an old mining town in Mineral County, Nevada, 30 miles southeast of Hawthorne. Starting in the late 1980s, property around Sodaville Springs was leased in preparation for an aquaculture business. Part of the customer base was derived from tourists traveling from Las Vegas to Reno on U.S. Highway 95. In 1995, the operation began after permits were secured from the state government. However, as the business continued on into the next decade, argument arose over a stipulation in the permit from the Nevada Department of Wildlife (NDOW). Situated in a series of warm fish ponds, the owner was selling imported Australian crayfish, considered an exotic species to Nevada that could potentially harm local endangered habitat if they escaped or, as the NDOW puts it, were "released from captivity". The permit stipulated that the crayfish could not be sold alive to tourists driving along the highway. Concerned that dead crayfish would not remain fresh as tourists drove several hours to Las Vegas or Reno, the owner continued to sell the crayfish alive. He did this for several years until the business was featured in a Las-Vegas Review article that discussed the operation and provided photos. With the owner visibly defying the permit, the business was raided by the NDOW in July of 2002 and shut down, with the remaining crayfish killed[156].

Researchers say that issues with endangered habitat like this are not uncommon in warm and hot springs throughout the western U.S. and the possible presence of these species must be taken into account whenever a geothermal direct use project is considered.

Federal lands

As noted in Part II, geothermal direct use projects on federal lands (or using federal mineral acreage) have been hindered by a complicated process for calculating the associated royalties. The calculations considered the cost of the energy saved often based on the cost of natural gas at the time. This method resulted in royalties that shifted the economics so that these projects were generally uneconomical. It is clear that this method of calculation resulted in the closing down of geothermal direct use sites using federal resources in California, New Mexico, and Nevada. This issue was particularly brought to light in July 2003 when Jim Witcher testified before the House

[156]This description is based on conversation and confirmation on the details with representatives familiar with the case from the Nevada Department of Wildlife (NDOW) as well as an article by the Las Vegas Review Journal entitled: "The little fish were 'threatened'... and the bureaucrats killed them all" (editorial) – Las Vegas Review Journal 7/27/2003: http://www.reviewjournal.com/lvrj_home/2003/Jul-27-Sun-2003/opinion/21794609.html
Nevada Bureau of Mines and Geology – "Sodaville Springs": http://www.nbmg.unr.edu/geothermal/site.php?sid=Sodaville%20Springs

Energy and Minerals Subcommittee and stated "I believe the current royalty structure is the main obstacle with federal direct-use geothermal in NM." [157]

In fact, only a few geothermal direct use facilities were ever constructed at locations using federally-managed resources—none in Arizona, Idaho, Utah, and Oregon (all states with extensive federal lands and geothermal resource potential on those lands). Out of the 1300+ facilities estimated to be currently operating in the U.S., only one commercial geothermal direct use facility uses federally-managed resources (a vegetable dehydration facility in Nevada). The only other uses of geothermal direct use on federal lands have special use permits and do not require royalty payments. These include a number of areas where hot pools are used for soaking and the visitor's center at Hot Springs National Park in Arkansas which still pipes geothermal water to heat the building.

As noted above, the policy changes authorized by EPAct regarding geothermal direct use development on federal lands provide a simpler and reduced royalty structure, a streamlined leasing approach for "direct use" only leases, and make other changes intended to promote more direct uses of geothermal energy on public lands. Because so many western states have significant acreage managed by the federal government, industry stakeholders believe that EPAct's changes could make hundreds of resource areas attractive for businesses opportunities. For example, there are numerous hot springs on USFS land in the Pacific Northwest that produce significant amounts of fluid that could support large geothermal direct use operations. In addition, BLM land is nearby small communities in the western U.S., particularly in Nevada where federal lands encircle most communities within a few miles of the population. Researchers assert that there are plenty of undeveloped geothermal resources on these lands across the western U.S. that may be able to serve local populations with space heating or be able to support commercial or industrial production. However, as noted earlier, the BLM has yet to promulgate the regulations for the new law, which is adding to the problems for new direct uses from federal lands.

Challenges to creating markets

Geothermal resources provide not only opportunities for energy savings, but also for profit. Most agree that geothermal direct use systems, when operated successfully, produce a reliable heat source that is renewable and does not fluctuate with the cost of oil, propane, or natural gas. Geothermal resources can serve residents with an alternative heating source in a multitude of areas across the country, with particular room for growth in the Pacific Northwest and the Rocky Mountain States (including Colorado, Montana, Utah, and Wyoming). Resources can be used to heat buildings, melt snow, and provide hot water if the water quality is sufficient. Geothermal resources can offset high energy prices and help spur economic development, particularly in rural and agricultural areas throughout the Southwest, struggling to compete with foreign competitors in various markets. In fact, there are many direct use facilities in the U.S. that have served communities well.

When the levelized cost and ancillary benefits are considered, geothermal direct use facilities appear to be a better investment than conventional fossil fuels. However, high upfront costs and other issues have kept geothermal direct use from becoming competitive. Many such projects have been proposed or planned in the past that did not come to fruition due to a lack of financing

[157] Source: Statement of James C. Witcher, Southwest Technology Development Institute, New Mexico State University, Before the Subcommittee on Energy and Mineral Resources of the House Committee on Resources. July 22, 2003: http://resourcescommittee.house.gov/108cong/energy/2003jul22/witcher.htm

or long payback periods due to the low costs of natural gas and propone during the late-1980s and 1990s. The May 2006 GAO report, explains the issues this way: "While the amount of capital to start a business that relies on geothermal resource is small compared with the amount of capital necessary to build a geothermal power plant, this capital can be large relative to the financial assets of the small business owner or individual. Unforeseen problems in well construction, piping, and water disposal can also increase original funding estimates. Obtaining funding is difficult as commercial banks are often reluctant to loan money for unproven projects and ideas that appear risky."[158]

These findings generally concur with the discussions throughout the states; in particular those given by geothermal experts Leo Ray and Jim Witcher who have made presentations on creating markets for geothermal direct use projects at multiple events throughout the last few years. For example, in a March 2006 Utah Geothermal Working Group meeting in Salt Lake City, Jim Witcher notes that in order for businesses to be successful using geothermal direct use applications, there needs to be a market to sell the product, a sound business plan, and an expert to manage the product (whether it be aquaculture, greenhouses, dairy processing, or other commercial or industrial geothermal applications). According to the presentation, this includes the need for a good transportation route and year-round product availability[159]. While many geothermal resources are located in rural areas, in analyzing opportunities in many western states, it is clear that plenty of resources exist near population, road, and rail and remain unused.

In his presentation at the "Using the Earth's Energy: Arizona Geothermal Direct Use Conference" in Tempe, Arizona in May of 2006, Leo Ray notes that the major barrier to these projects is that those interested in such a project have generally had to do all the work themselves[160]. Furthermore, because geothermal direct use applications are generally a small part of any business, there are limits on time and money for small businesses to dedicate to developing the resource. According to Leo Ray, this is a task that most businessmen are unable to undertake without mastery of both their business and geothermal resource development -- a rare combination of skills.

While geothermal direct use success stories are common, a multitude of failures are also apparent. Research has indicated that failure was rarely related to the quality of resource. Various reasons have been cited for failure: incompetence or inexperience by the developer, failure to comply with environmental regulations, and losing money for a business. However, perhaps the greatest reason for failure has been the remoteness of the installation. According to the findings of the GAO report, "the remote location of many geothermal resources hampers their development for direct use. Geothermal direct use is constrained because the geothermal waters cannot be economically transported over long distances without a significant loss of heat."[161]

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[158]Source: Government Accountability Office (GAO) – "Increased Geothermal Development Will Depend on Overcoming Many Challenges". May 2006 Report to the Ranking Minority Member, Committee on Energy and Natural Resources, U.S. Senate: http://www.gao.gov/new.items/d06629.pdf (page 23)
[159]Source – Jim Witcher (March 2006):
http://geology.utah.gov/emp/geothermal/ugwg/workshop0306/ppt/Witcher0306_1.ppt
[160]Sources:
Ray, Leo. "Geothermal: Our Most Underutilized Natural Resource". Presentation given on 5/18/2006 at the Using the Earth's Energy: Arizona Geothermal Direct Use Conference in Tempe, Arizona
[161]Source: Government Accountability Office (GAO) – "Increased Geothermal Development Will Depend on Overcoming Many Challenges". May 2006 Report to the Ranking Minority Member, Committee on Energy and Natural Resources, U.S. Senate: http://www.gao.gov/new.items/d06629.pdf (page 24)

Furthermore, all projects in remote locations are hampered by distribution challenges. The projects that have been most affected are those in states with large resource bases in remote areas, including Oregon and Nevada. Remote resources in most other states have not been utilized, either because the resources are on federal land, or because they weren't considered good investments in the first place. Projects that have utilized resources in remote locations have faced trade-offs. While geothermal direct use applications may protect an operation from fuel price volatility, geothermal projects may be just as vulnerable to transportation fuel price volatility that is used to distribute their product to market.

Even a profitable operation in a remote location can go under because they are more vulnerable to setbacks. For example, an aquaculture operation in Duckwater, Nevada -- 268 miles from Las Vegas, 313 miles from Salt Lake City, Utah, and 374 miles from Reno -- operated from 1982 through the early 1990s. It produced an average of over 300,000 lbs of catfish filets annually. The combined population of this area is less than 500 people. No community with over 10,000 residents is within 150 miles. Despite this distance, the business managed to stay profitable for eight years until the manager, and technical expert, died in a plane crash. After the accident, the facility went out of business. One has to wonder if the facility had been closer to the marketplace, whether another owner might have stepped in.

Re-injection

Re-injection is a major issue for geothermal direct use facilities throughout the western U.S. In 1999, it was utilized to end degradation and return stable production of the Boise Front Geothermal aquifer in Idaho. Most facility operators say they would re-inject if the economics were feasible. Capacity has reduced for resources at a number of sites, and re-injection could both stabilize resources and allow for expansion. At certain areas, re-injection has not been necessary because resource pressure has not diminished. This has been the case in Elko, Nevada where two district heating systems currently operate, and the larger of the two is currently expanding. While this system does not inject water back into the geothermal aquifer, the resource has not degraded since its initial development, nor has the temperature declined. Researchers suggest this is evidence that the heat capacity of the aquifer is not yet near its limit.

Most agree that re-injection is critical for resources where the capacity of the aquifer is approaching its limit. One good example of this is in Twin Falls, Idaho. Twin Falls is a small city of 34,000 in south-central Idaho along the Snake River Plain. Two fish farms use geothermal heating, along with a high school, a swimming pool, and a church. A major user of geothermal direct use heating is the College of Southern Idaho (CSI), a two-year community college with a campus population of about 7,500 students. Using relatively low temperatures, about 100°F (38°C) from relatively shallow wells, CSI is able to make significant use of their resource. The geothermal heating system heats nearly 100% of the campus. However, withdrawals from the geothermal aquifers in the Twin Falls area may be exceeding recharge as indicated by progressive water level declines. This has prompted additional regulation of the use of the aquifer and a moratorium on development. Re-injection at these facilities currently using the geothermal aquifer could mitigate these problems, and alleviate concerns over re-opening the aquifer to further development.

Direct use facility operators agree that re-injection must be addressed before new installations can become a more viable alternative. One suggestion is to establish a loan guarantee program that enables the drilling of re-injection wells. While the costs of such a program may be high, clean energy advocates suggest that such a program is win-win because it would simultaneously encourage both geothermal development and water conservation. However, researchers warn that the design of a re-injection well, requiring technical experience, is critical to the success of the geothermal project as a whole. Technical expertise could be secured through companies that specialize in well drilling, thereby bringing more business to these companies. If re-injection is not the lowest cost option, another alternative is to use a close-looped system (as described in the direct use "regulatory issues" section above).

Incentives

Overall, there was a consensus that before the market will induce new businesses that rely on thermal energy from geothermal resources, adequate incentives must be offered. In his presentation at the March 2006 Utah Geothermal Working Group meeting, Professor Bloomquist notes that costs and risks (particularly to prove a geothermal resource) play a large part in determining the decision to pursue a geothermal direct use project[162]. As the costs of drilling has increased, even for direct use wells, it has become risky to take on projects without first being assured that the costs will not rise significantly during the course of construction. These high upfront costs (which include the costs of injection wells and/or close-looped systems), are often the principal barrier to determining the economics of new development.

Economic incentives provide a simple way to attract investors. Several interviewees suggest that on the federal level, direct use applications would benefit from a thermal (Btu) utilization incentive. On the state level, most agree sales tax exemptions for construction equipment could help. Sales tax exemptions are available for geothermal power plants in Arizona, Idaho, New Mexico, Utah, Washington State, and Wyoming. However, as of December 2006, geothermal direct use projects were not explicitly eligible for any of those incentives. In fact, geothermal direct use installations are not explicitly included in many of state incentives for renewable technologies or energy efficiency. One reason for this is because these types of installations have not seen significant growth since the 1980s; unlike solar installations which have become increasingly popular over that time especially in the Southwest and in California where the most significant incentives for solar technologies are available.

Another issue for states to consider is including geothermal direct use in thermal provisions in the RPS (to date geothermal direct use applications are eligible technologies in the Arizona and Nevada RPS). To capitalize on thermal provisions, another suggestion, notes several interviewees, is to establish a minimum standard of energy efficiency for all commercial or residential buildings, including incentives for compliance and/or fees for non-compliance. Because land developers do not pay the energy bill once they sell a property, they may avoid installations that would increase bottom-line costs. Therefore, proponents of these policies suggest that minimum standards might correct this market failure, while at the same time encourage the development of geothermal direct use heating systems, particularly in areas with colder climates like the Pacific Northwest and the Rocky Mountain states.

Agricultural communities

Most agree that geothermal direct use development should be encouraged for the benefit of the agricultural community. While many of the geothermal resources in the western U.S. are located near mountainous areas where agriculture may not be a primary part of the economy, there are also many exceptions. States like Arizona, California, Idaho, New Mexico, Oregon, and Utah have successfully incorporated geothermal direct use applications into their agricultural production for such processes as aquaculture, greenhouses, or irrigation. Researchers say that agriculture is a more fitting application of geothermal direct use facilities in the Southwest, where

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[162]Source, Gordon Bloomquist (March 2006): http://geology.utah.gov/emp/geothermal/ugwg/workshop0306/ppt/Bloomquist0306_3.ppt

higher average temperatures make residential geothermal space heating developments not as attractive.

In fact, numerous interviewees, direct use facility operators in particular, stress the importance of re-investment in agricultural extension programs operated by land-grant universities. These programs can employ staff familiar with geothermal resource development that can reach out to farmers and ranchers. Geothermal resources currently used in agricultural areas range from advanced geothermal heating facilities for aquaculture and greenhouses to simple irrigation for fruits and other agricultural products. There is a general agreement that whatever the product (be it aquaculture, greenhouses, irrigation for table grapes, etc.) using geothermal resources creates a competitive advantage over foreign competitors who benefit from cheaper labor costs (especially competitors in warm climate locations, such as Latin America and Southeast Asia). In addition to agricultural extension programs, several interviewees suggest that funding is made available through larger institutions such as the Western Regional Aquaculture Consortium, the USDOE, or the USDA. In fact, the USDA is offering grants for renewable energy projects in agricultural areas that would include demonstration projects using geothermal resources.

Retrofits vs. new construction

Often the best opportunity for a geothermal direct use project is through the expansion of an existing facility or through the use of a geothermal resource to serve a new business or residence that has yet to be constructed. Retrofitting is generally not as economic. For instance, even geothermal direct use projects where retrofitting is not involved often require the drilling of new wells, installing piping and a heat exchanger, along with other construction activities.

For this reason, project developers assert the importance of a proactive outlook towards development opportunities in areas undergoing new development. As cities expand and plan new housing and business developments, geothermal direct use for heating is becoming an increasingly viable option, particularly in areas with high elevation or cold climates, where heating needs are significant. Specific development efforts to capitalize on this expansion are occurring in Boise, Idaho, Albuquerque, New Mexico, Elko and Fernley, Nevada, and several other locations with smaller populations.

Challenges in closing the information gap

The prospect of developing direct use facilities is lost when not considered in the first place. Most agree that when new communities and new businesses are built, there is often little discussion about how to plan energy usage, especially since energy prices have only begun to rise to significant levels. In a 1994 report, the Geo-Heat Center at OIT estimated there are 404 communities in 16 western states that can use (or expand their use of) geothermal resources for district heating and other applications. Among these communities are some of the largest cities in their state. This includes the cities of Mesa and Tucson, Arizona; Los Angeles and San Diego, California; Glenwood Springs, Colorado; Helena and Bozeman, Montana; Carson City and Reno, Nevada; Las Cruces, New Mexico; and Salt Lake City, Utah[163]. Although these communities (and many others throughout the U.S.) could potentially benefit from the utilization of direct use heating applications, there is concern that direct use heating is not being considered by communities where potential exists. Furthermore, there are repeated concerns that community leaders may not understand how to go about pursuing a direct use heating project, and may be generally unaware of the technology.

[163]Source: http://geoheat.oit.edu/colres.htm (1994)

Resource assessments are one of the most critical needs for the geothermal industry, as outlined in existing reports on state development. Exploration technology is limited, and the cost of drilling new wells can be prohibitive. A challenge, according to land developers of residential or business geothermal direct use applications, is the lack of money available for drilling and exploring expressly for geothermal resources. According to these developers, finding geothermal water, even in areas where the resource is prevalent, is hit or miss. In the past, geothermal heating was usually developed only where availability was clearly demonstrated. Like with geothermal power projects, this availability was often based on existing hot springs or serendipitous discoveries, rather than substantive exploration and planning.

While state geological surveys and other entities have received some funding to update state-level geothermal databases (including recent efforts in Arizona, Idaho, Montana, New Mexico, and Utah), most agree that a comprehensive program involving state, university, and federal institutions is necessary to adequately catalog resource data. This data can then be used to assess planning opportunities for state and local governments.

Overall, there is a pervasive concern that the academic and business communities have not been adequately linked, leaving geological studies to generally not consider business opportunities and economic development as key components of their research. In order to bring more projects into the mainstream, state and federal agencies have been reaching out to those who have successfully developed geothermal direct use projects -- including businesses, companies, consultants, and contractors -- and encouraging them to share their knowledge. Clean energy advocates say this effort should both continue and expand. Several interviews suggest that experienced entities could be encouraged to report on geothermal direct use projects in industry trade magazines, such as greenhouse and aquaculture industry publications that provide visibility about geothermal technology to a broader audience.

While there are numerous users of geothermal resources in the U.S. the actual numbers and locations of these installations are undetermined. The last comprehensive update of known facilities was performed in the mid-1990s by the Geo-heat Center. Other data on existing facilities vary from source to source. A number of changes have occurred since the 1990s, including aquaculture development in New Mexico, two large space heating projects in Idaho, space heating for prisons in Oregon and Utah, and bio-fuels refining in Oregon, to name a few. While new facilities have opened and other facilities have closed since the mid-1990s, there are also facilities already existing at the time the reconnaissance was performed that have since been confirmed by various sources. Most agree a new reconnaissance would be useful in evaluating how facilities have grown and changed. There is an impetus to conduct new reconnaissance on the state level as part of the activity of the state geothermal working groups. However, before this can take place, most agree that the quality of information is of critical importance. Such an update may necessitate traveling to locations and/or checking with regulators and local chambers of commerce.

This type of work must not necessarily come from the state level. In areas where geothermal resources are prevalent, local governments have expressed interest in how they can use resources in their community. A recent example of this is ongoing planning in Valley County, Idaho and the community of Cascade where geothermal industry stakeholders, IDWR, and county leaders have coordinated on a "Geothermal Strategic Plan" to guide actions to be taken to utilize the resource in their area. While it is uncertain at this time what projects will emerge from these efforts, most agree that regardless of what happens, the level of coordination and the commitment to identify and examine potential resource uses should serve as a model for other counties in the western U.S. with similar resource potential.

Raising public awareness

While residents of western communities may have used geothermal resources for many years, they still might not understand the many ways in which they can be used or how valuable they are. One example in is Tonopah, Arizona (about 50 miles west of Phoenix) where a space heating system was installed at El Dorado Hot Springs in 1996 which pipes hot water from an underground well to heat buildings, showers, baths, and rental rooms, and then irrigates the water for bamboo, trees and desert plants used on the premises. The original owner who installed the system, Bill Pennington, recently retired and sold the business (which still uses the geothermal heating system). According to Pennington, hot wells exist throughout the town of Tonopah. However, despite a general awareness of the geothermal resource in the community, he is the only one in town to have installed a direct use system. Other businesses in town have chosen conventional heating sources, although several of them are located near enough to existing wells that they could use them for various purposes, including space heating, showers and baths, and preheating for dishwashing at restaurants[164]. Most agree that this lack of knowledge is pervasive throughout the western U.S., even in places where geothermal use is commonplace, and is what prevents the public from clamoring for more development.

Even areas with existing geothermal district heating systems have a limited number of customers. For example, in Boise, Idaho, four district heating systems provide heating to hundreds of homes and buildings. However, those familiar with the system say that based on the square-footage of the city, no more than 1% of Boise is heated by geothermal. Another issue brought up by operators of the systems in Boise, as well as Elko and Reno, Nevada, is the difficulty in finding additional customers willing to sign up to use the system. Many are reluctant because they are either unfamiliar with the system, or concerned about the upfront costs. Developers maintain that they will be unlikely to expand an existing system without customers to use the additional power. Furthermore, most additions to district heating systems are best suited large buildings, where enough heat is used to make the expansion economical.

There is a general consensus that efforts to increase education and information is helpful to increase awareness and knowledge about using geothermal resources for communities. This includes highlighting existing direct use applications, and using the Internet, speaker's bureaus, and fact sheets, which can be disseminated to the public. Furthermore, states could sponsor educational programs, workshops and symposiums to promote the uses of geothermal applications to various groups, including businesses and local governments. Researchers say that geothermal direct use facilities can be used to teach youth about sustainable development. For example, Edwards Greenhouse, just outside of Boise, Idaho welcomes grade school students each year to visit their geothermal heating system and to learn how it operates. While this is a common activity for them, this is not part of any organized state-level curriculum.

Determining potential

The overall potential for geothermal direct use applications is still undetermined. While most agree these resources are available throughout the country, the temperature, depths, and discharge rates vary from location to location. Researchers say there are clearly opportunities that make sense economically. For example, the district heating system at NMSU has been idle for several years, although the campus population has grown (along with its heating costs). Also, district

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[164]Source: Camilla Van Sickle & Bill Pennington
Casa Blanca Hot Spring
POB 10, Tonopah, Arizona 85354
CasaBlancaHotSpring@mindspring.com
623-203-2230

heating was once used in Ketchum, Idaho for about 60 homes, but during the 1990s many of the geothermal systems went off-line, and few still exist in the area. A couple of hot springs are located in the region, the closest being Guyer Hot Springs which has surface temperatures ranging from 131-158°F (55-70°C) with discharges of 1,000 gpm. The community is currently negotiating with the owner of Guyer Hot Springs to expand the system[165].

In addition, most agree there are opportunities to utilize resources for projects that have never had a system installed. An example of this is in Owyhee County, Idaho at the Castle Creek KGRA. The Ward family, who operates a 3.5 acre geothermal-heated greenhouse at Garden Valley in Boise County, Idaho, owns property and water rights in the Castle Creek KGRA, including property with existing greenhouses, not currently in operation. They are considering the construction of an 18-acre greenhouse to produce potted plants, flowers, and vegetables to sell to Boise and its surrounding communities. The greenhouse would use an existing artesian well, and the developer would consider using the water to irrigate alfalfa plants outside the greenhouse. While piping for the geothermal water exists, additional piping would need to be installed to complete the project. A feasibility study is underway through a grant from USDOE to evaluate the project in greater detail and to move forward with the next steps of development.

An overall estimate for direct use potential was made in the November 2006 NREL report discussed in Part I. While its predictions of the total estimated accessible resource were >60,000 MWt, its predictions in the shorter term were 1,600 MWt by 2015 (an increase of roughly 1,000 MWt from the existing estimated capacity of 617 MWt) and 4,200 MWt by 2025[166].

Most agree that the technology used to extract low-temperature geothermal resources for direct use applications still has significant potential for growth and advancement. Advancements in technology may make possible the development of systems that serve entire cities. For example, one Icelandic company is currently working with the Chinese government to develop a geothermal district heating system that would serve nearly half-a-million residents in one of China's largest cities. Another Icelandic company came to Boise, Idaho in March of 2006 to discuss advancements in geothermal district heating systems and ways in which these advancements could help existing users make better use of the resource. Boise is one of several large communities in the U.S. where a more extensive resource may be available. To date, the only city of comparable population in which an extensive resource base may exist that is capable of serving thousands of residents is Las Cruces, New Mexico. However, many researchers and consultants from the U.S. and overseas suggest reviewing the Icelandic model for development to determine how the Icelandic methods may be applied to other U.S. cities and communities.

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[165] Sources: Idaho Mountain Express and Guide. "Ketchum considers cutting cord with Idaho Power". Rebecca Meany, 8/30/2006: http://www.mtexpress.com/index2.php?issue_date=08-30-2006&ID=2005112020 & Idaho Water Resources Research Institute (IWRRI) at the University of Idaho. "Overview of Geothermal Investigations 1980 to 1993". (December 1994): http://boise.uidaho.edu/documents/GeothermalSiteReport.pdf&pid=33484&doc=1 (pages 17-18)

[166] Source: National Renewable Energy Lab (NREL) – "Geothermal—The Energy Under Our Feet Geothermal Resource Estimates for the United States." November, 2006: http://www1.eere.energy.gov/geothermal/pdfs/40665.pdf

Websites with more information

Geothermal Energy Association (GEA) Publications

California's Geothermal Resource Base: Its contribution, future potential, and a plan for enhancing its ability to meet the states renewable energy and climate goals (September 2006)
Factors Affecting Costs of Geothermal Power Development (August 2005)
Geothermal Development Needs in Arizona, Geothermal Energy Association, (September 2006)
Geothermal Development Needs in Idaho, (November 2006)
Geothermal Development Needs in New Mexico, (September 2006)
Geothermal Development Needs in Utah, (June 2006)
Geothermal Resource Development in Nevada – 2006
November 2006 Geothermal Power Production and Development Survey
What Can We Do? Meeting the challenges to developing our geothermal resources (Sepr 2006)

All reports available at: http://www.geo-energy.org/publications/reports.asp

Resource Assessments

Geothermal Energy Association (GEA) – "Potential use": http://www.geo-energy.org/aboutGE/potentialUse.asp

GeothermEx, Inc. New Geothermal Site Identification and Qualification. Prepared For the California Energy Commission (CEC) Public Interest Energy Research Program (PIER). April 2004: http://www.energy.ca.gov/reports/500-04-051.PDF

National Renewable Energy Lab (NREL) – "Geothermal—The Energy Under Our Feet Geothermal Resource Estimates for the United States." November, 2006: http://www1.eere.energy.gov/geothermal/pdfs/40665.pdf

Western Governors Association (WGA) Geothermal Task Force Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf

Other sites and reports of interest

Geothermal-biz.com: http://www.geothermal-biz.com

Geothermal Energy Association (GEA) – Developing Plants in the U.S.: http://www.geo-energy.org/information/developing.asp

Geothermal Energy Association (GEA) – Power Plants: http://www.geo-energy.org/information/plants.asp

Government Accountability Office (GAO) – "Increased Geothermal Development Will Depend on Overcoming Many Challenges". May 2006 Report to the Ranking Minority Member, Committee on Energy and Natural Resources, U.S. Senate: http://www.gao.gov/new.items/d06629.pdf

GeoPowering the West (GPW): http://www.eere.energy.gov/geothermal/gpw/