# What Can We Do?
# Meeting the Challenges to Developing our Geothermal Resources

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## ABSTRACT

This report is a broad overview of the challenges to developing geothermal resources in the U.S. and the policies that can enable greater development. This paper summarizes six months of research that included an extensive literature review and interviews with more than 70 industry stakeholders and experts. Those interviews included discussions with developers; utility representatives; consultants; geologists; direct-use heating facility operators; policymakers; university researchers; clean energy advocates; directors of non-profit organizations; researchers at the Idaho National Laboratory, National Renewable Energy Lab (NREL), Sandia National Laboratory, the U.S. Geological Survey (USGS), and the U.S. Department of Energy (USDOE) Geothermal Technologies Program; and state and federal regulators (including utility, water rights, and land regulators on the state level, and representatives from the national and state offices of the Bureau of Land Management (BLM) at the federal level).

During the course of the interview process, opinions differed as to what the challenges were, and what could be done about them. Ultimately, after taking into consideration the broad spectrum of opinions (from varying perspectives), the findings of this report represent my own personal conclusions as to the general consensus (or majority viewpoint) of what these stakeholders and experts believe is needed to achieve greater development. The help I received, whether informative, critical, or "filling in a gap" of information, were all indispensable to the final product. I want to thank all who contributed time and effort to help bring this document to final publication.

## Introduction

As gasoline and natural gas prices reach historic highs, it is increasingly evident that the United States 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 and according to the Energy Information Agency (EIA), U.S. electric energy consumption is projected to grow by another 8.4% by 2015[1]. We have to ask ourselves if we will be ready in the event of a prolonged energy crisis. We have to wonder whether we will be able to develop a diversity of domestic energy resources while preventing further damage to our environment.

The choice is clear. We can pursue alternative energy sources today, or we can wait until we have run out of options. In the electric energy sector, we consume 2% of our electric

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energy from a diversity of non-hydro renewable energy sources, including wind, solar, biomass, and geothermal. While this percentage is poised for an increase as new developments become more cost-competitive with traditional fossil fuel sources, there is an urgency to do more, and to find innovative ways to expand uses to meet rising energy demands.

Geothermal resource development, in particular, holds promise in years to come. New power projects and direct-use heating facilities are being developed and the potential applications for geothermal technologies are being expanded -- raising the awareness of investors and policymakers throughout the country. This report seeks to ascertain America's geothermal potential in meeting our future energy needs, and to identify what policymakers can do to help capture that potential.

## What is the Near-term Potential?

Of the 2,825 MW of geothermal power plant capacity and the 617 MWt of direct-use heating capacity currently installed in the United States, the vast majority of it was developed in the late-1970s and the 1980s after the two previous energy crises[2]. There was a general consensus throughout the interview process that we had the capability to develop more 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.

However, geothermal resource development is clearly making a comeback. In March of 2006, the Geothermal Energy Association (GEA) took a survey of new power projects and found 35 new projects in various stages of development. Together, these projects have the potential to produce up to 1,465.9 MW of new geothermal power plant capacity in the next 3-5 years. If you consider projects that are unconfirmed or in the early planning stages, there are 44 projects with the potential to produce up to 2,054.9 MW of new capacity[3]. The 1465.9 MW by itself is enough to boost total power capacity by 50%. While the GEA survey did not cover direct-use heating projects, the volume of new projects encountered over the course of my research point to similar increases in development over the same time period.

Frequently, industry stakeholders are asked if near-term potential is enough to 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 gigawatt hours (GWh) of electricity[4]. In 2005, just considering electric production, geothermal power plants produced a net generation of roughly 16,000 GWh[5]. If we calculate 95% availability and an additional 2,054.9 MW of projects currently being considered, geothermal power could generate an additional 18,000.9 GWh in 9 western states. The Western Governor's Association (WGA) estimated in their 2006 Geothermal Task Force Report that there is up to 5588 MW of economically developable capacity by 2015 in 11 western states (see Table I)[6]. The development of 5588 MW of geothermal power could generate an additional 46,503 GWh by 2015, enough to meet 13.9% of new U.S. demand. While this number may not seem significant, consider that geothermal energy could power up to 1/3rd 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 10 states could meet nearly 80% of their new electric energy consumption from geothermal power. Furthermore, these estimates predict that the states of Nevada and Idaho have the potential to meet over 1/3rd of their total energy consumption from geothermal sources by 2015[7]. Keep in mind that these numbers do not reflect the potential for uses of direct-use heating, which experts say could have a significant impact on energy savings by that time.

**Table I.** 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** |

*Estimates for 2025 are not discussed in the above analysis, because this report is focused primarily on near-term development. Source: WGA Geothermal Task Force Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf – (pages 60-66).

## What Needs to be Done to Develop More of our Geothermal Resource?

Since 1992, the development of new geothermal power plants and new direct-use heating facilities in the U.S. has been limited. However, if you ask long-time industry experts, they will tell you that there remains significant untapped potential for new development. Certainly there are challenges to this development, both technological and economical. However, most agree that policymakers on the state and federal levels can help moderate these challenges by helping to create parameters that enable the energy market to meet the needs of the geothermal industry. Once my analysis was complete, I determined 6 specific needs stood out for policymakers to address; these include:

- Need to address barriers related to the location of the resource;
- Regulatory Needs;
- Financial Commitment;
- Need to close the information gap;
- Need to establish uses for distributed generation; and
- Need for greater utilization of direct uses.

For each of these needs, this analysis identifies key barriers and proposed policy alternatives where there was a general consensus on relevant policy measures that could facilitate new

*"Winter view of the entire Newberry area from 35,000 feet"* – Photograph by Don Nelson of http://www.summitpost.org (used by permission).
*A development project in the vicinity of the Newberry Crater is currently under contract with Pacific Gas and Electric Company (PG&E) to sell up to 120 megawatts (MW) of electricity.

exploration and development. The first four of these needs relate primarily to power plant development and the final two needs relate to off-grid uses of geothermal resources, including one section discussing distributed generation of electric power from moderate-to high temperature geothermal resources and one section discussing direct-use heating from low-to moderate temperature geothermal resources. Examples from different states and regions are included in the analysis.

### *#1: Need to Address Barriers Related to the Location of the Resource*

Often during the course of my research I was reminded of the limits of geothermal resources based on their location. Unlike oil, coal, and natural gas, geothermal resources cannot be shipped. Geothermal resources must be utilized where they are found, and transmitted to populations within the region. Many high-temperature geothermal resources are remote or located in scenic areas where transmission access and regulatory hurdles prevent development. However, over the course of my research I found this definition does not represent the whole issue of location. According to most industry stakeholders, location also has to do with the factors affecting the power market and the attitude of the community towards geothermal energy.

In my discussions with developers and utilities, I was reminded that even when a resource has been discovered suitable for electric production, there is no guarantee that a utility will be willing to sign a contract to purchase the power. It was clear in my discussions with utilities serving power markets in western states, that they are risk averse when considering geothermal power. Furthermore, they claim the market is still adjusting to high energy prices. However, despite this adjustment period, some utilities have taken proactive steps towards securing contracts for geothermal power. For example, in 2004, Idaho Power issued a Request for Proposal (RFP) for 100 MW of geothermal power by 2008, and has already contracted with US Geothermal, Inc. to develop up to 30 MW at the known geothermal resource area (KGRA) at Raft River. Similar RFPs have been proposed by other utilities serving western power markets, but these tend to include renewable power plants in general, and do not typically single out geothermal as the required power source.

Clean energy advocates claim these RFPs result from integrated resource plans (IRPs) recognizing risks deriving from environmental costs, being driven by decisions from state public utility and public service commissions. However, developers still noted the difficulty of finding a utility to buy geothermal power projects, stating that because a project is limited by location, it is often impossible to negotiate with utilities outside the area, especially due to the costs of transporting energy across multiple utility grids (aka wheeling).

An option proposed in discussion with several interviewees was rapid establishment of Regional Transmission Organizations (RTOs). According to those familiar with the RTO structure, they claim that if expanded throughout the western U.S., RTOs would effectively abolish FERC tariffs and apply postage stamp rates for electric generation traveling across utility wheels. RTOs are especially popular with clean energy advocates because they open up projects to larger markets where clean energy is in greater demand and where its costs are more competitive (i.e. California).

Another issue brought up repeatedly over the course of my research was the attitude of the local community. Developers claim that the appeal of a geothermal project to a community has partly to do with their economic needs, and partly to do with their perception of geothermal energy. They stressed the importance of involving and addressing the concerns of sensitive groups (including Native Americans, environmentalists, and community and civic groups) so as to avoid future confrontation. Furthermore, they claim these efforts facilitate an understanding of the impacts and benefits brought by the project at all stages of the development process.

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 the Glass Mountain KGRA in Northern California. Very high temperatures have been discovered at the Glass Mountain near Medicine Lake. According to the 2006 WGA Geothermal Taskforce Report the resource area is estimated to contain up to 480 MW of near-term power potential[8]. In 2002, the Federal government granted permits to allow drilling to commence, however developers pointed out that despite receiving these permits as well as support from local governments, the project has been subject to litigation and protests by Native American and environmental groups who claim the project will adversely affect air and water quality and impact culturally significant Native American lands. Although neither Glass Mountain nor Medicine Lake is located on officially designated Native American land, the resistance to the project has proven significant enough to cause prolonged delays. While Glass Mountain is not the only geothermal prospect to have faced litigation or protest, the site contains more geothermal resource potential than most other sites that have faced such resistance.

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 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 (where two power plants are currently online, and expansions of existing well fields are being planned for development) 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 Indian Reservation in California claim that in those cases, tribal leaders have been active proponents of development on their land.

While many industry stakeholders tout the benefits of geothermal power plants as generating economic development, there was a general agreement that environmental concerns about these projects are not unwarranted. Even with zero-emission binary geothermal power plants, there are impacts to the land caused by transmission lines, drilling, and construction. In its recognition of this impact, developers praised language included in the Energy Policy Act of 2005 (EPAct) which authorized 25% of royalties from existing and future geothermal power plants to be paid to county governments. Several interviewees particularly emphasized the importance of this policy change, because they believe it will be an effective incentive for communities to encourage more geothermal development and to work harder to mediate conflicts.

### *#2: Regulatory Needs*

Developing a geothermal power project is a time consuming process due to technical considerations and red tape. Developers claim this is more of concern on federal land than on state and private land. There were repeated concerns that pursuing prospects on Bureau of Land Management (BLM) and United States Forest Service (USFS) land can run into lengthy delays. Data shows that BLM is backlogged with lease applications, some dating back more than a decade (even longer for some leases on USFS land).

There was no denial that 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. In fact, the primary concern was not the regulations themselves, rather the lack of staffing to process them. For instance, developers expressed concerns over the processing of environmental assessments, pointing out that prior to EPAct these environmental reviews were a discretionary act, and BLM was not required to perform them. Several regulators pointed out that processing these regulatory requirements have been stymied by inadequate funding and decreased man hours. There was a general consensus that increased funding for these purposes should be a top priority for policymakers, especially due to the recent increases in lease applications and post-lease permits resulting from the high volume of new projects. Developers pointed out that to encourage near-term development, existing funds could be best directed if focused on projects nearing completion that are struggling to meet the deadline to qualify for the federal production tax credit (PTC).

More recently, there has been an upsurge in developing projects on federal lands (including Glass Mountain, California, Emigrant and Blue Mountain, Nevada, and Newberry, Oregon). Although there was a general consensus that private or state lands are preferable, most agreed that the reality is that federal lands provide the best opportunities for near-term development. Data shows that many of the best geothermal resources are located on lands that involve federally-managed resources, many of which involve potential to expand existing power facilities (or existing well-fields). In fact, 34 existing power plant projects involve federally-managed resources, including Coso, The Geysers and Salton Sea, California and Dixie Valley, Nevada[9].

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 nearly 83% of Nevada are managed by the federal government. In addition, the majority of geothermal resources in New Mexico and California are located on federal land[10].

Frustration regarding the lack of access to resources on USFS land was common among those interviewed. 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. I discovered in my research that issues with the USFS have been most profound in Idaho and the Cascades of Oregon and Washington. 39% of Idaho's land is managed by the USFS[11], and many of the high-temperature resources in the Cascade region are located on USFS land, including Newberry in Oregon.

In 2005, EPAct took several actions that facilitate the BLM and USFS in addressing these issues. It requires the BLM to hold competitive leases every two years and requires all future USFS and BLM resource management plans to consider geothermal leasing and development in areas with high geothermal resource potential[12]. The USFS is currently processing backlogged leases in Northern California and updating forest plans in the Pacific Northwest that will include the possibility for geothermal development. However, at the time of this writing not all the changes included in EPAct have been implemented or received full appropriations, and there was concern, particularly from developers, that delaying these changes would stunt current development and planning.

### *#3: Financial Commitment*

Interviews with geothermal developers indicate that the risks of private investment for geothermal resource development are greater than for fossil fuel development. Most industry stakeholders agree that financial commitment from the private sector requires financial commitment from the public sector to provide incentives for exploration and development, and to reduce the financial risks that prevent the market from growth. Several interviewees pointed out that continued government support for traditional energy sources (such as oil, natural gas, nuclear power, and coal) have helped improve technology and efficiency in these already mature industries, while, comparatively, government support for environmentally-friendly, less mature technologies like geothermal energy is lacking.

Developers expressed concern that they lack the capital resources to pursue new prospects without confidence that the resource can be developed economically. Researchers expressed concern that they lack the funding to perform new exploration. According to an August 2005 report by the Geothermal Energy Association (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 products). According to the report, an average well "would probably be in the range of $2-5 million"[13].

Not surprisingly, developers say that their biggest challenge is obtaining the financing to fund the first exploration well. Financing is a considerable challenge, especially without a clear market to sell the resource before exploration begins. Developers claim that without a clear market, they are unable to secure competitive interest rates, and financial risks often overwhelm the ability to get a project off the ground. A clear solution, according to those interviewed, was cost-sharing and assistance by public institutions.

Throughout my research, I was reminded again and again of the impact that government programs have had on developing the industry. Numerous projects have received government funding, mostly from the USDOE. In fact, the USDOE has been one of the only sources of funding and assistance for new exploration in the past quarter-century. Developers cite past programs such as cost-shared drilling, technical assistance, grants, and loan guarantees as having been helpful in reducing upfront costs and financial risks.

Loan guarantees, in particular, stood out as one of the most successful programs. According to a report done by SENTECH, Inc. in March of 2005, the federal loan guarantee program 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 3.6 GW of base-load power. That is enough capacity to generate electricity to serve the current needs of a state the size of Nevada or Utah, or the states of Maine, New Hampshire and Vermont combined[14].

Others emphasized the importance of research programs that fund new exploration. According to several researchers and project consultants, the best scenario might be cost-shared federal funding for a major exploration drilling program to explore as many resource areas as possible in the same timeframe. Those supportive of such a program, claim this would increase the volume of new development and decrease the risks. They also claim it would result in some resource areas being larger than expected, and some being smaller, but the overall return on the investment would likely be larger than the initial funding for the program. Long-time industry experts suggest that such a program is neither impossible nor unprecedented.

Overall there was an agreement that funding for the USDOE Geothermal Technologies Program is too low, particularly with the volume of new projects and the increasing costs of energy. Numbers show that funding for the program has declined, especially over the past 6 years. For instance, the FY 2006 appropriation for the USDOE Geothermal Technologies Program is 16% lower (in nominal dollars) than it was for the average annual budget of the 1990s[15]. Considering high energy prices today, and that 6 years ago an energy crisis sent a shockwave through California, there was a general agreement that such a decline in funding for an alternative energy program is a backwards policy.

Beyond government programs, there were numerous references to the importance of government incentives. The most important incentive that came up time and time again was the inclusion of geothermal power projects in the PTC. In July of 2005, the PTC was extended until January 1st, 2008, and advocates of geothermal energy claim new projects under development wouldn't have been possible without this credit. This includes two projects in Utah which will triple that State's geothermal capacity by the end of 2007, an addition to the Puna Plant in Hawaii, the Raft River project in Idaho, and at least 8 new projects in California and Nevada.

Furthermore, developers claim that if the PTC is extended through January 1st, 2012 (which is currently being proposed in Congress) many planned projects cited in the March 2006 GEA survey will likely complete development in time to qualify for the PTC. This means Alaska, Arizona, New Mexico and Oregon will likely see their first geothermal power plant, and both Nevada and Hawaii will see their online capacity double. According to the survey, California alone may see another 752.9 MW of capacity[16]. In addition, developers agreed that such an extension could expand opportunities for new exploration of geothermal prospects (including those in several other states) because once a resource is discovered the permitting and construction of a geothermal power plant can be completed within 3-5 years[17].

The option of a long-term extension of the PTC is not the only solution of the table. Some developers noted the possibility of changing the definition of the placed-in-service date for the PTC. For instance, the current credit says that projects operating before January 1st, 2008 would get the PTC for 10 years, and projects built afterwards would get nothing (if the PTC was not extended by that time). Under their proposed definition, a plant would need only to start construction by the placed-in-service date. If they miss the date, then the length of the credit would be reduced. For example, if the plant was under construction by the placed-in-service date of January 1st, 2008, but did not get the plant online until January 1st 2009, they would get the credit for 9 years, instead of 10. Developers claim this would enable more projects to be developed, because some of the costs and complications involved with completing a geothermal power plant (including transmission, procurement of equipment, and regulatory delays) are out of the control of the developer.

On the state level, incentives and programs can facilitate development, but are generally limited by available funding. Several states with geothermal potential have provided sales tax exemptions, property tax exemptions, and grants and loans for geothermal projects. However, in my discussions with industry stakeholders from several states, it was clear that only California has provided state funding substantial enough to impact geothermal power projects or large-scale direct-use heating facilities.

While developers generally agreed that federal programs and incentives are the largest drivers for new development, most concurred that a state renewable portfolio standard (RPS) can be just as valuable. While an RPS is not technically an incentive, they point to its ability to create a market for renewable energy sources, by encouraging utilities to sign power purchase agreements (PPA) for renewable power plants. For instance, according to the March 2006 update by GEA, of the 11 western states that WGA deemed have economically developable potential by 2015, Arizona, California, Colorado, Hawaii, Nevada, and New Mexico have an RPS, and five out of six of those states are developing a combined 29 projects totaling up to 1315.9 MW. Of the 5 states without an RPS (Alaska, Idaho, Oregon, Utah, and Washington) four of the five states are developing only 6 projects totaling up to 150 MW. These 5 states have over 37% the resource potential of these 11 states, but are developing only 20% as many projects and only 10% as many MW[18].

### #4: Need to Close the Information Gap

Geothermal energy is one of the least known renewable energy sources produced in the U.S. Clean energy advocates say that the public is more aware of wind turbines and solar panels than geothermal power plants or direct-use heating facilities, despite the fact that geothermal resources have traditionally produced a greater percentage of energy than wind and solar combined[19]. When discussing policies affecting geothermal development, it was clear that state governments themselves are not immune to ignorance about geothermal energy. For instance, alternative energy legislation has been passed in numerous states without including geothermal resources, including renewable energy tax credits in Utah and New Mexico and the original Arizona RPS which failed to include geothermal power projects or direct-use heating facilities.

To ensure future legislation does not exclude geothermal resources, advocates claim that increased outreach is essential. One advocate claimed the biggest challenge is getting more people involved to educate the public, policymakers and utility regulators about the viability and benefits of geothermal energy. Several others claimed that getting investors to network greatly increases the transparency of the technology. One program that received widespread praise in this area was GeoPowering the West (GPW), initiated by USDOE in 2000. Since its inception, GPW has established working groups in 11 western states, has held multiple conferences and events, and has created networks within each state to coordinate outreach, and focus on relevant legislation, investment opportunities, and new development.

Fortunately, for GPW and those involved, resource data shows no shortage of potential geothermal energy left to develop. According to data from the USGS Circular 790 and subsequent resource estimates, the majority of high-temperature geothermal resources in the western U.S. have gone unidentified and the majority of identified resource areas (including KGRAs) have gone untested and under-explored. Recently, the USGS was authorized to conduct a new assessment of geothermal resources to update the 1978 Circular 790 report. This new assessment has been encouraged by researchers in part because there is a broad spectrum of opinions about the size of the available resource and there is a need for reliable information to guide new exploration based on advanced information technology and field data not available in 1978.

Furthermore, when the USGS suggested a potential from identified and unidentified resources of 150,000 MW in 1978, most power plants existing today, had yet to be constructed. After new geothermal sites were established and geothermal research expanded, the accuracy of the USGS data was put into question. In the 1978 Survey, USGS estimated there was 22,990 MW of resource potential recoverable from identified resources. But according to a 2004 report by GeothermEx, some of those identified resources were overestimated[20]. On the other hand, most researchers agree that USGS underestimated the value of resources at deep depths and resources of lower temperature. They point out that in their assessment USGS was only considering hydrothermal resources that were exceeding 150°C (302°F) and depths shallower than 3,000 meters (9,843 feet). However, binary geothermal plants are in operation today using temperatures below 150°C and geothermal wells have been drilled to depths greater than 3,000 meters. According to several prominent geologists and researchers, deep conductive resources at depths exceeding 3,000 meters may be available for production throughout entire regions of the Western U.S., depending on the permeability and the flow of the reservoir.

However, researchers claim that regardless of what comes out of the new USGS assessment, it will not resolve the issue of the lack of new exploration. Because geothermal heat is located well below the surface of the earth, the size of a geothermal resource is difficult to model and verify without well drilling. As a result, many believe there is a lack of reliable data about the overall resource base, or where it may be found. Part of the problem, researchers claim, is that many geothermal resources are "blind" (i.e. without surface manifestations). In fact, numerous geothermal resources have actually been discovered serendipitously. For example, both Raft River in Idaho and Fallon in Nevada were discovered when ranchers drilled water wells that were too hot, and the Salton Sea in California (considered among the largest geothermal resource areas in the U.S.) was discovered when the area was explored for oil and gas.

However, whether geothermal resources were discovered through oil and gas drilling, hot water wells, or apparent surface manifestations, it is clear from research on these resources that most do not see any development towards power production. For example, well data in Idaho indicates only 9 geothermal exploratory wells deeper than 305 meters (1,000 feet) have been drilled specifically for geothermal exploration outside of the Raft River resource area[21], and in Utah, well data shows no more than 22 geothermal exploratory wells deeper than 305 meters have been drilled, outside of the Roosevelt Hot Springs and Cove Fort-Sulphurdale resource areas[22]. Data shows this trend continues today. For instance, according to the March 2006 survey by GEA, about half of all U.S. projects currently under development are expansions of existing well fields or expansions of existing power facilities. Most of the other planned projects in the survey are located in resource areas that have been known for years to have high potential for geothermal development.

According to the August 2005 GEA report, projects in a well-known geothermal field have associated drilling costs that can be 37% lower than drilling costs of a similar project located in a site that has never had a producing well (aka a greenfield). Developers claim that by the late-1980s, the success rate for finding a producible well in a greenfield was approximately 20%[23]. While most researchers agreed that new technology will improve this number for future exploration, there was still concern that these uncertainties will still turn back investors, and thus reduce the potential for new discoveries.

Well data shows that while drilling has occurred at many greenfield areas, most of these wells were drilled to shallow depths, and thus failed to provide adequate information about the resource potential of the area. For example, while spring temperatures of 84°C (183°F) have been measured at the Crater Hot Springs KGRA in Utah, the hottest temperature found in a drilled well was 23°C (73.4°F) at 46 meters (151 feet). At Glass Mountain exploration wells encountered high temperatures at relatively shallow depths below 305 meters (1,000 feet), but numerous shallow wells in the vicinity found only lower temperatures ranging from 10°C to 12°C (50°F to 54°F). Well data from several western states show a number of areas believed to have high-temperature resources were abandoned because of this same phenomenon[24].

Although there was a general consensus that the exploration and development of geothermal resources is still a maturing industry, recent innovations in technology, combined with improving economics for alternative energy resources, has expanded the range of applications for geothermal energy. These innovations include a variety of technologies, both old and new, including stimulation techniques such as enhanced geothermal systems (EGS); using geo-pressured reservoirs of hot water and natural gas (primarily methane) for power production (and the co-production of natural gas); utilizing hot wastewater from oil and gas fields to produce geothermal power; and using small binary units for distributed generation (the two latter applications will be discussed in the next section).

However, there were repeated concerns that regardless of new technology, closing the information gap requires training the next generation of industry professionals to conduct new exploration and development. Many experienced geothermal professionals are retiring, and there is urgency among them to share their knowledge with the next generation. They noted the importance of funding for college and university programs to create opportunities for experienced geothermal professionals to teach and to take students out into the field to participate in exploration tests and new drilling.

While there are geothermal programs performing these activities at several colleges and universities in the U.S. (mostly located in the western states), the majority of their funding comes from USDOE. While increased access to federal and state grants, scholarships, and other public financial sources is one possibility, most agreed it was not practical for the long-term. In several discussions, some pointed out that it may be worth considering greater pursuit of private endowments to expand existing programs. As a clean renewable energy source, geothermal development may be on the agendas of many private foundations.

### *#5: Need to Establish Uses for Distributed Generation*

Over the course of my research, there were repeated concerns that few geothermal resource areas were being considered for distributed generation. There was a general consensus that the development of small power units for distributed generation can enable more geothermal resource areas to be considered profitable. Long-time industry experts contend that in the past when resource areas were not found suitable to sustain large-scale power production (i.e. at least 10-20 MW), they would be abandoned over concerns that a utility wouldn't purchase the power. They claim distributed generation solves this dilemma by enabling resource areas, believed capable of only sustaining small amounts of power, to be developed for another purpose.

For instance, several consultants and researchers throughout the Western U.S. have noted recent interest in using geothermal resources to produce alternative fuels (which are notoriously energy intensive to develop). Some suggested an ethanol, bio-fuel, or hydrogen development plant could use small-scale electric power (5-10 MW), without requiring the electric grid, and with the ability to potentially provide more revenue and more jobs than a power plant of equivalent size. These developers pointed out that while small power units might cost more per kilowatt hour (kWh) than a utility would be willing to pay, the cost might still be lower than the retail power cost. Furthermore, many remote geothermal resources in the West are nearby rail lines that can transport alternative fuels to emerging markets in California (see Figure 1, overleaf).

This small unit concept is not restricted to alternative fuels. For instance, several consultants pointed out how small power units can be used to both produce power and cascaded heat for multiple uses all in one integrated system. According to researchers, this concept can 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 heating facilities (if sufficient temperatures are present). In the 1990s, a cascaded system was successfully demonstrated for a direct-use heating facility in New Mexico where binary units (totaling 750 kW) were used to power greenhouses at the Lightning Dock KGRA.

Cascaded systems have been contemplated for other greenhouses and aquaculture facilities in several states. One

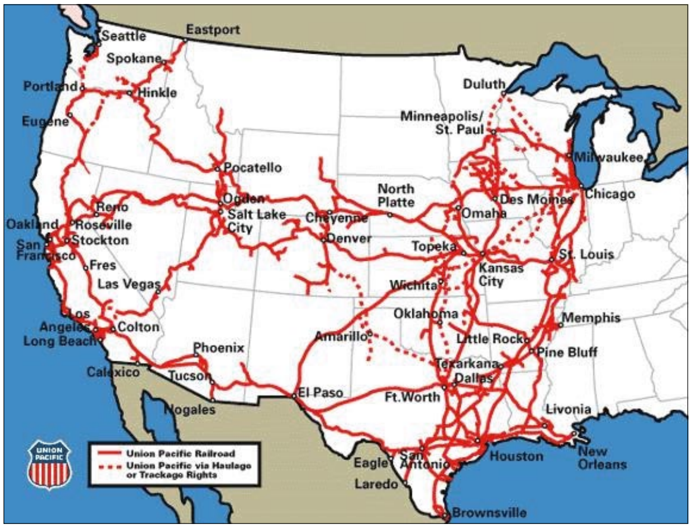


**Figure I.** Map of the Union Pacific Railroad.
The Union Pacific Railroad runs in the vicinity of many moderate-to high temperature geothermal resource areas in the Western U.S. Source of map – Union Pacific: http://www.uprr.com/aboutup/maps/sysmap/index.shtml

example of a project being considered is the development of a 1 MW binary unit at the aquaculture facilities at AmeriCulture in New Mexico. The feasibility of such a project was demonstrated through recent testing at the site, cost-shared by the USDOE. Currently, AmeriCulture produces roughly 250 thousand pounds of fish per year, and utilizes geothermal resources to heat culture water for tropical fish production. They claim that if they had a 1 MW binary unit to meet their electrical needs, they could save 30% on their total costs and expand production to 10 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 claim they could hire another 80 workers (in a county with a population of just over 5,000)[25].

Interviewees were also enthusiastic about the potential for efficient small units, such as the one currently being demonstrated in Alaska, where two 200 kW units will provide electric power for the Chena Hot Springs Resort using low-temperature resources. These units can be applied at moderate-temperature resource areas throughout the Western U.S., or in oil and gas wells where hot waste water is pumped from great depth and re-injected with no benefit to oil and gas producers. Researchers involved with these projects claim that small power units may be applicable at thousands of sites throughout the oil and gas producing states (including sites in Louisiana, Montana, New Mexico, Texas, and Wyoming).

It was clear in my research that distributed generation projects can have advantages over power plant projects. For instance, several consultants pointed out that resources in remote areas can be utilized because transmission access is not a concern, and in some cases (such as with hydrogen production) a remote resource might be preferred. Furthermore, they point out that distributed generation not only avoids the need to find a utility to purchase the power, it also avoids the delays caused by working through the utility regulatory process.

Developers considering small power units claim the challenge is in creating a market. For instance, they claim that in order to produce small power units they need enough resource areas and enough willing buyers to enable mass-production. One challenge, they point out, is whether these units will need to be custom made for each individual site, or whether they can operate (with only small adjustments) anywhere a suitable resource exists. Proponents of these projects claim that as the technology continues to advance, these units will enable even lower temperatures to be used for power production.

### *#6: Need for Greater Utilization of Direct Uses*

As important as meeting growing energy needs through new development, is reducing those energy needs through energy efficient technology. Time after time interviewees expressed frustration with the lack of emphasis on direct uses of geothermal resources. Direct uses utilize low-to moderate temperature geothermal resources as a heat source. A general starting temperature cited for direct-use heating applications is 38°C (100°F). Researchers claim this casts a wide net for available locations.

Twenty-five U.S. states currently use low-to moderate temperature geothermal resources as a heat source for industrial facilities, greenhouses, resorts and spas, fisheries, and residential and business districts[26]. According to research done by the Geo-Heat Center at the Oregon Institute of Technology (OIT) there are currently over 1300 facilities utilizing heat from geothermal sources in the U.S. (although, researchers who compiled the list claim the exact number is unknown, because not all the existing facilities have been identified)[27].

Despite the fact that geothermal resources are used for direct-use heating in 25 U.S. states, researchers claim the overall resource base is vastly under-utilized. Project consultants point out the problem to be the lack of a coherent "direct-use" industry, or any large-scale government effort to utilize low- to moderate temperature geothermal resources. This is not to imply that nothing is happening in this field. According to consultants familiar with direct-use heating projects, high energy costs have begun to increase their transparency. In fact, in FY 2006, the USDOE is funding feasibility studies for nine direct-use heating projects in six states (one of which involves a greenhouse that went out of business when they couldn't pay their energy costs). Furthermore, due to favorable economics, expansions of existing facilities are also likely to commence. For instance, the greenhouses at Masson Radium Springs in New Mexico currently employ 100 workers on 16 acres. The direct-use heating system saves $46,200 per acre per year, and the owner plans to expand to 40 acres in the near future (employing 4-8 workers per acre)[28]. There are also plans to expand the already extensive district heating system in Boise, Idaho which currently provides heating through 4 systems that warm over 300 homes, government buildings, and businesses, totaling over 4 million square feet. The energy savings from the system afford operators the ability to set their pricing structure at 30% below the cost of natural gas[29].

However, despite these gains, there was a general agreement that more has to be done to increase the volume of these projects. 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[30]. Although these communities (and many others throughout the U.S.) could potentially benefit from the utilization of direct-use heating applications, there was concern that direct-use heating is not being considered by communities where potential exists. Furthermore, there were 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.

One promising change, however, involves new regulations authorized for direct-use heating projects on federal lands. Currently, of the estimated 1300+ direct-use heating facilities in the country, less than ½ of 1% are on federal lands[31]. For many years, there were complaints that the royalty structure for direct-use heating on federal lands made most projects economically prohibitive. In 2005, EPAct authorized new royalty provisions to simplify this process. At the time of this writing, the final regulations are still under review and until the public comment process is completed, the same system will be in place. Considering the opportunity these technologies have for economic development, there was an urging for quick implementation. Because so many western states have significant acreage located on federal lands, numerous industry stakeholders believe this new policy could make hundreds of resource areas attractive for businesses opportunities.

Ultimately, to increase the use of direct-use heating technology, most agreed that government support and incentives are needed to facilitate the market. Clean energy advocates suggest that states can play a role in encouraging new businesses and communities to use direct-use heating facilities through tax incentives; re-investment in extension programs from agricultural departments of land grant universities; and through requiring the inclusion of geothermal resources in regional planning. However, there was a general consensus that before these incentives can be effective, information on how to develop the technology must be more readily available.

For instance, in his March 2006 presentation in Utah, Jim Witcher contended that in order for a business to capitalize on a geothermal resource, there needs to be an established market to sell the product, a sound business plan, and an expert to manage the product (whether it be aquaculture, greenhouses, hotels and spas, district or space heating, or other uses)[32]. There was a general agreement that consultants and businesses experienced with these types of projects need more opportunities to share their knowledge. It was clear from my research that a variety of businesses can be created because of the presence of geothermal resources, providing needed employment and revenue for cash-starved communities. Furthermore, energy savings from existing projects indicate geothermal use has the potential to offer businesses a competitive market advantage. Overall, there was a consensus that before the market will induce new businesses that rely on heat from geothermal resources, information must be made available and adequate incentives must be offered.

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## Endnotes

1The 8.4% is based on calculations using a base year of 2004 for electric energy usage. 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. The 50,000 is based on estimates from the U.S. Census: http://www.census.gov/. The estimated population in 1990 was 248.7 million and is over 298.7 million today.

2For the purposes of this report, MW refers to MW of electricity, and MWt refers to Megawatts thermal. Electric Power capacity – Geothermal Energy Association (GEA): http://www.geo-energy.org/publications/reports/2006%20Update%20on%20US%20Geothermal%20Power%20 Production%20and%20Developmentx.pdf. Direct-use heating capacity – Geo-Heat Center at the Oregon Institute of Technology (OIT): http://geoheat.oit.edu/pdf/tp121.pdf

3The 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.). Source: 2006 Update on US Geothermal Power Production and Development (Geothermal Energy Association) (3/14/2006): http://www.geo-energy.org/publications/reports/2006%20Update%20on%20US%20Geothermal%20Power%20Production%20and%20Developmentx.pdf. The additional 11 MW represents an addition to the Blundell Plant at Roosevelt Hot Springs in Utah.

4The 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

5California: 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 in Utah. 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.

6Western Governors Association (WGA) Geothermal Task Force Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf

7These 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 1/3 of new electric power from geothermal power projects. 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 79.8% 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

8480 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

9Source: U.S. Department of Interior 4/6/2006: http://www.doi.gov/ocl/2006/RenewableAndAlternativeEnergy.htm

10New 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.

11Idaho BLM (2002): http://www.id.blm.gov/publications/02update/state5_10.pdf (based on calculations)

12Source: http://www.doi.gov/iepa/2005_results.pdf (Section 222-224)

13Source: Geothermal Energy Association (GEA) – August 2005: http://www.geo-energy.org/publications/reports/Factors%20Affecting%20Cost%20of%20Geothermal%20Power%20 Development%20-%20August%202005.pdf (page 18)

14Source 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). Estimates on states which could be served by this development based on calculations from state profiles by the Energy Information Agency (EIA): http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html

15These are calculations based on the annual appropriations for the US-DOE Geothermal Technologies Program from 1990 to 1999. The average appropriation during the 1990s was $27.75 million as compared to $23.3 million for FY 2006. Although 2006 appropriations are 16% lower in nominal dollars, based on inflation (real dollars), the 2006 appropriations are more than 16% lower than the average appropriations from 1990 through 1999. Source of budget: USDOE.

16Source: GEA Update on US Geothermal Power Production and Development (3/14/2006): http://www.geo-energy.org/publications/reports/2006%20Update%20on%20US%20Geothermal%20Power%20Production%20and%20Developmentx.pdf. In Nevada, there are three projects under construction. In California, a project is under construction at Heber. However, and a 25 MW plant is currently being developed at the Salton Sea: http://www.geo-energy.org/information/developing/CA/saltonSea6.asp

17According to GEA, it takes 3-5 years or more to develop a project once the project is underway (i.e. applying for leases, initial exploration, etc.). Source: Statement of the Geothermal Energy Association 5/24/2005: http://waysandmeans.house.gov/hearings.asp?formmode=view&id=4069

18Numbers based on the GEA Update on US Geothermal Power Production and Development (3/14/2006): http://www.geo-energy.org/publications/reports/2006%20Update%20on%20US%20Geothermal%20Power%20Production%20and%20Developmentx.pdf – The new 11 MW expansion to Blundell at Roosevelt Hot Springs in Utah was added to the projects under development. The CPUC is still considering a 120 MW project in Oregon that would sell power to California customers and has a delivery point within the CA ISO control area. Projects outside CA that deliver the energy into the ISO control area can be eligible. The power plant has a PPA with Pacific Gas & Electric (PGE) 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 25% as many projects and 22.5% 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.

19This includes heat pumps and direct-use heating facilities. Source – EIA: http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table5b.html

20Source: Henneberger, Roger C., Klein, Christopher W., Lovekin, James W., and Sanyal, Subir, K. *"National Assessment of U.S. Geothermal Resources – A Perspective"*. GeothermEx, September 2004.

21Since 2000, there were 2 wells drilled in Valley County. There were 7 wells prior to 2000 – Source: INL Geothermal Program, 2000: Idaho-collocated_Keller_revised.xls. Contact: Patrick.Laney@inl.gov. For information on Valley County wells contact Ken Neely at the Idaho Department of Water Resources: Ken.Neely@idwr.idaho.gov

[22]Based on my discussions with researchers in Utah, I determined these 22 "deep" wells may or may not be geothermal wells, however, it is more than likely that most, if not all 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 slim temperature gradient holes drilled at Thermo Hot Springs) only geothermal exploration wells that could later be modified into production wells. Source: Utah Geological Survey well spring data (File Name: well_spring3.xls) – For more information, contact Robert Blackett at robertblackett@utah.gov

[23]According to developers, greenfields are considered any resource area that has never had a producing well used for electrical production. Source of 37%: Geothermal Energy Association (August 2005): http://www.geo-energy.org/publications/reports/Factors%20Affecting%20Cost%20of%20Geothermal%20Power%20Development%20-%20August%202005.pdf (page 17). Source of 20%: SENTECH, Inc. (3/28/2005) "An analysis of Federal Loan Guarantees for Geothermal Energy Development" (page 50). There was a general agreement in my discussions with developers and researchers that 20% was accurate during the late-1980s.

[24]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

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

[26]25 U.S. states: Geothermal Energy Association, and Geo-Heat Center, Oregon Institute of Technology (OIT): http://www.geothermie.de/egec-geothernet/ghc/21-1art1.pdf & http://geoheat.oit.edu/dusys.htm

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

[28]Masson Radium Springs is 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

[29]Sources: Idaho Department of Water Resources – Energy Division: http://www.idwr.state.id.us/energy/alternative_fuels/geothermal/detailed_district.htm. Boise Public Works: http://www.cityofboise.org/public_works/services/water/geothermal/

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

[31]Several sites have used low temperature resources on federal lands, but have shut down or are currently not in operation. Calculating the number of facilities is complex, because it is hard to know which unknown facilities might be on federal land. Furthermore, not all direct-use heating facilities operating on federal lands pay royalties or necessarily fall under the category of a direct-use facility. Based on my research, the overall number of direct-use heating facilities currently operating and paying royalties to the federal government is as low as 1, but it most likely less than 10, and more likely in the range of 1 to 5.

[32]Source, Jim Witcher (March 2006): http://geology.utah.gov/emp/geothermal/ugwg/workshop0306/ppt/Witcher0306_1.ppt