GEOTHERMAL DEVELOPMENT NEEDS IN UTAH

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Photo: Lone Peak from the geothermal direct use facility at the Utah State Prison – Daniel Fleischmann, GEA 2006.

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Preface

Every state with geothermal resources faces different challenges for utilizing those resources to help meet their energy needs. The purpose of this report is to combine an analysis of relevant literature and interviews with industry stakeholders in Utah to understand what it types of policies and actions public institutions can take to encourage greater development of Utah's geothermal resources. Over the course of my research I interviewed over 50 leading experts in the geothermal field in the United States, more than 25 of whom have worked specifically with geothermal resources in Utah.

The interviewees consulted included: Representatives from three different development companies who had interest in developing projects in Utah; two utilities with power facilities in Utah; regulators at the Utah Trust Lands Administration, the Utah Public Service Commission and the Utah Division of Water Rights; consultants at Black Mountain Technology, GeothermEx, Bob Lawrence & Associates, and Jim Witcher & Associates; researchers and geologists at the Utah Geological Survey (UGS); operators of aquaculture facilities and the Utah State Prison space heating project at Crystal-Bluffdale; congressional staff for Utah Congressmen; clean energy advocates at the Renewable Northwest Project and Utah Clean Energy; officials and staff at the National Bureau of Land Management (BLM) in Washington DC and Utah; Researchers at the Idaho National Laboratory, the National Renewable Energy Lab (NREL), Sandia National Laboratory; the U.S. Department of Energy (USDOE) Geothermal Technologies Program, and the U.S. Geological Survey (USGS); and university researchers and geologists at Boise State, the Geo-Heat Center at the Oregon Institute of Technology (OIT), the Great Basin Center for Geothermal Energy, at the University of Nevada-Reno, the Massachusetts Institute of Technology (MIT), Southern Methodist University (SMU), Washington State University (WSU), and the Energy and Sciences Institute (EGI) at the University of Utah.

From March 21 through March 25 of 2006, I journeyed to Salt Lake City where I attended a two day workshop sponsored by the Utah Geothermal Working Group; met individually with staff at EGI, UGS, and Utah Clean Energy; and asked prepared questions based on my initial research. When I returned to Washington, I did several follow up interviews, and started working on a first draft. On April 7, I sent a completed first draft to 22 targeted individuals and gave them two weeks to return comments, asking some to review the entire document, and others to review sections relevant to their expertise. After thorough comments were received, I then made appropriate changes, and followed up with individuals for clarification on their edits.

During the course of the interview process, I found that opinions differed on several issues. In some cases my original thoughts over the key issues were challenged. For instance, my original concept of location being a barrier in and of itself changed over the course of the writing process. My concept of direct uses from low-to moderate temperature resources being under-utilized was expanded to consider the under-utilization of distributed generation using moderate-temperature resources. Ultimately, after taking into consideration the broad spectrum of opinions (from different perspectives), the findings of this report represent my own personal conclusions as to the general consensus (or majority viewpoint) of what these experts believe are the overall needs to unlocking greater geothermal development in Utah. The help I received, whether informative, critical, or "filling in a gap" of information, was indispensable to the final product. I want to thank all who contributed time and effort to help me to bring this to final publication.

Introduction

The United States needs alternative forms of energy. According to the U.S. Department of Energy's Energy Information Agency (EIA), electricity demand in the United States is expected to grow by 8.4% by 2015. Concerns over energy prices, environmental quality, climate change, and increased reliance on imported energy drive home the immediate need to advance the development of domestic renewable energy resources.

Throughout the western U.S., clean and sustainable geothermal resources provide heat for direct uses and electric power for homes, businesses, and industry. In the U.S., there is currently 2,825 MW of installed electric capacity from geothermal power facilities, and 617 MWt of installed heating capacity from facilities utilizing geothermal resources[1]. However, the vast majority of this capacity was developed in the late 1970s and the 1980s, and only recently has new development started to come online.

According to interviews and recent literature, the primary impetus for these new developments is high energy prices and the availability of advanced technology. According to research performed by the Geothermal Energy Association (GEA) in March of 2006, there are currently 35 new power plant projects with the potential to produce up to 1,465.9 MW under development in 9 western states (including Utah); and 44 new projects up to 2,054.9 MW in nine western states if you count projects that are unconfirmed[2].

If you ask people who have spent years working with geothermal resources in the U.S., they will probably tell you that Utah has among the greatest potential for new development. Certainly there are challenges to this development, both technological and economical. However, most agree that policymakers in Utah and Washington D.C. can help moderate these challenges to facilitate an energy market that encourages greater development of those resources in years to come.

This paper is focused specifically on Utah's geothermal resources, and how policymakers at the state and federal level can meet the needs of the industry to propel new development. For the purposes of this document, "geothermal resources" are defined as resources with temperatures at least sufficient for direct-use heating: 38°C (100°F). The primary focus of this document is electric power production, however the underutilization of geothermal resources for direct uses (i.e. direct-use heating from low-to moderate temperature resources) and distributed generation (i.e. on-site electric generation from small-scale power units) and is intertwined into the literature, and analyzed specifically at the end of the report.

This report is one of several examinations of obstacles and opportunities for geothermal energy on the state level being conducted by GEA. The final report will bring together these reports and offer cross-cutting analysis of the barriers and needs identified in different Western states.

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

Current Development and Potential

Cove Fort power facilities – Source: http://www.ampresources.com/projects.php?page=cove (used by permission)

Current Development and Potential

Utah is seeing a resurgence in development of its geothermal resources. Utah's power production from geothermal energy is expected to triple by the end of 2007. PacifiCorp is planning to expand the 26 MW Blundell geothermal facility at Roosevelt Hot Springs by 11 MW and Amp Resources is developing a new power plant in the Cove Fort-Sulphurdale KGRA with an anticipated capacity of 36.6 MW. In addition, a space heating project was recently completed at the Utah State Prison. It now supplies direct heat to 332,665 square feet of the facility.

The resource area at Cove Fort-Sulphurdale previously had several producing geothermal plants that came online in 1990, but they were recently decommissioned[3]. With Cove Fort I running for half the year, Utah's geothermal plants generated 202 GWh in 2004. With only the Blundell plant running in 2005 that number likely dropped by between 10-15 GWh[4]. Since the Cove Fort plants were decommissioned two years ago, Utah gets roughly 1% of its electric energy from geothermal sources[5].

According to the latest report from the Geothermal Task Force of Western Governor's Association (WGA), it is estimated that Utah can economically develop 10 times its current capacity by 2015 – an additional 230 MW[6]. If 230 MW were added in addition to the existing Blundell Plant, Utah could generate enough electricity to power over a quarter-million homes.

Beyond 2015, the potential is far greater. Researchers and developers see opportunities far beyond electrons on the electric grid. They believe that small power units can provide distributed generation for emerging industries such as alternative fuel production and they believe that direct heat from low-temperature resources could have widespread applicability for numerous businesses and communities in the state.

Proponents of geothermal resource development in Utah often tout energy independence as important incentive to pursue new projects, which could make a significant contribution to a state that ranks 34th in total population. Furthermore, advocates point to the opportunity this development creates for employment, investment in the infrastructure, and creating tax revenue. Utilities tend to prefer geothermal power to other renewable power sources because it is base-load. The environmental community touts low emissions of pollutants and greenhouse gases, low water use relative to traditional fossil fuel sources, and limited impacts on wildlife and natural scenery.

Utah's Most Promising Geothermal Resources

Utah's Most Promising Geothermal Resources

There are four known geothermal resource areas (KGRAs) in Utah as classified by USGS and BLM (see Table 1) and geological studies and well data have revealed several other areas in the state that have shown potential for electrical production. Furthermore, Utah's geology suggests that there are hidden geothermal resources without apparent surface manifestations yet to be discovered. This section highlights those resource areas that have the most promise for electrical production, and analyzes actions that could be taken to capture that potential.

Geologists and researchers at EGI and UGS contend that the areas with the greatest geothermal resource potential are located within the Basin and Range province of western Utah and the Transition Zone of central Utah. 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, which has similar geology and is also part of the Basin and Range province.

In 1978, the USGS released USGS Circular 790 which estimated geothermal power potential from identified resource areas in Utah at 1,300 MW and a total of 4,600 MW for identified and undiscovered resources in the long-term[7]. A new USGS assessment of geothermal resources is planned to update resource potential estimates from the 1978 Circular 790 report. This new assessment has been encouraged by researchers throughout the geothermal energy field 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.

When the USGS performed its assessment in 1978, no power plants existed in Utah, and not much was known about the resources that had been discovered. For instance, the range of estimates made in the USGS Circular 790 of Cove Fort-Sulphurdale and Roosevelt Hot Springs are greater than estimates made since the resource areas were developed, suggesting overestimation of those resource areas in the original report. Conversely, the USGS only considered resources above 150°C (302°F) as viable for electrical generation, although advanced binary plants currently produce power from temperatures considerably lower. Furthermore, the authors only considered resources shallower than 3,000m (9842ft), although geothermal production has been utilized at depths greater than 3,000 meters in other parts of the world.

According to Jim Witcher of Witcher & Associates and Bob Blackett (UGS), deep conductive resources may be available for production throughout Utah at depths exceeding 3,000 meters, depending on the permeability and the flow of the reservoir. The challenge is the cost of drilling deep wells to get at these resources, but oil and gas wells in the state have been drilled to far deeper depths.

In a report published in 2004, the Utah Geological Survey (UGS) in coordination with the U.S. Department of Energy (USDOE) identified nine unique resource areas in Utah considered promising for geothermal electric production[8]. The descriptions below discuss these resource areas, as well as additional resource areas mentioned in the Utah report. Several other resource areas not mentioned in the Utah report are considered in this report based on additional research of well data and previous studies, and verification with Bob Blackett and Joe Moore (EGI), who agreed these areas were worthy of consideration (see Figure I for the location of each area).

Table I: Current KGRAs in Utah:

Current KGRAs (59,125ac):
1) Cove Fort – Sulphurdale (24,853ac)
2) Crater Hot Springs (8,320ac)
3) Roosevelt Hot Springs (25,311ac)
4) Thermo Hot Springs (641ac)
Source: ***Utah Geological Survey: http://geology.utah.gov/emp/geothermal/ugwg/index.htm***

What are the nine most promising geothermal resource areas in Utah?[9]

What are the nine most promising geothermal resource areas in Utah

1) Roosevelt Hot Springs

The Roosevelt Hot Springs KGRA is located in Southwest Utah in Beaver County. The KGRA is on a mixture of private, Utah State Trust, and BLM land, with a majority of the land managed by the BLM. It is the hottest known geothermal resource identified in the state. In 1984, the Blundell power plant at Roosevelt Hot Springs became the first geothermal power plant in Utah (and remains the only plant still producing power in Utah today). The production zone depths range generally between 382 and 2,232 m (1,253 and 7,321 ft). Reservoir temperatures are typically between 240°C and 268°C (464°F and 514°F). PacifiCorp may incrementally expand the facility up to 100 MW. As of now there are plans to expand the Blundell Plant by 11MW before 2008, by adding a bottoming cycle using an ORMAT Energy Converter[10]. Estimates for the ultimate recoverable potential for the entire resource area have varied since the Blundell Plant was completed in 1984; ranging from 120 MW to 500 MW[11].

2) Cove Fort-Sulphurdale (aka Cove Fort)

The Cove Fort-Sulphurdale KGRA is located in Southwest Utah about 50 miles east of Roosevelt Hot Springs. Amp Resources is developing a new power plant on the site that will initially be 36.6 MW, and could be expanded to 69 MW. Estimates for the ultimate recoverable potential for the entire resource area have varied since the original Cove Fort facilities were completed in

1990. These estimates have ranged from 105 MW to 500 MW[12]. The reason for this wide range is that the resource has not been clearly defined throughout the KGRA. Over 90% of the Cove Fort-Sulphurdale area is located on federal land – split about evenly between BLM and the U.S. Forest Service (USFS). Native American land and some Utah State Trust Land are also located within the KGRA. Amp Resources plans to build the new plant on private land. Dry steam at about 150°C (302°F) is produced from relatively shallow production wells at 180-400m (600 to 1,300 ft) deep. However, new production wells for the new plant will likely tap a deeper, liquid-dominated resource.

3) Thermo Hot Springs

The Thermo Hot Springs KGRA is located in Beaver County southwest of Roosevelt Hot Springs. The area of the KGRA (640 acres) is small compared to the extent of the suggested thermal anomaly. Thermal gradient holes were drilled in the KGRA in 1973 and 1977, only two of which were deeper than 1,000 feet (305 meters)[13]. A deep test well was drilled in 1978. While sufficient temperatures were found, there was a lack of permeability and fluids were not sufficient for production in the wells. Although the exploratory well did not find a producible resource, additional exploration is warranted. The maximum temperature found was 160°C (320°F) at a depth of 2,221 m (7,287 ft). Data shows significant temperatures in several areas throughout the KGRA with potential for development. The majority of the land is managed by BLM, but there are tracts of private and Utah State Trust land in the KGRA. Thermo Hot Springs is located relatively close to transmission lines.

4) Newcastle

Newcastle is a small farming community located in Iron County in Utah's southwest corner. The Newcastle geothermal system was discovered serendipitously in 1975 as a result of water well drilling. Seven production wells are currently used for space heating in three commercial greenhouses that cover an area of 25-acres (the second largest geothermal-heated greenhouse in the United States). The wells are approximately 500 – 600 ft deep and produce geothermal water at temperatures in the range of 82 – 93°C (180 – 200°F). An LDS (Mormon) Chapel is also heated by geothermal water. While most of the area is on private land, it is thought that the source zone for the geothermal fluid lies beneath nearby BLM land. Newcastle has had wells drilled that could be utilized for electrical production. A well drilled in 1981 to a depth of 913m (2995ft) encountered a maximum temperature of 130°C (266°F). A more recent thermal gradient exploration hole, located nearby, found a maximum temperature of 117°C (243°F) at similar depths, and a small power facility was considered on the site. Newcastle may have the potential for a small power facility at the existing site, although the areas around Newcastle may have potential for larger electrical production, and should be considered for further exploration.

5 & 6) Wasatch Front (Ogden Hot Springs and Utah Hot Springs)

There is likely geothermal potential along the Wasatch Front as the Wasatch Fault Zone forms the western boundary of the Wasatch Range for over 100 miles from the Idaho border southward to Nephi along Interstate 15. Two resource areas of particular interest along the Wasatch Front are located in the vicinity of Ogden, Utah (Ogden Hot Springs and Utah Hot Springs).

Ogden Hot Springs is located on private land at the mouth of Ogden Canyon in Weber County. Surface temperatures at the hot springs average 57ºC (135°F). Geothermometers have suggested resource temperatures of up to 190ºC (374ºF) at depth. No geothermal exploration beyond the surface springs has been reported and there is no direct-use heating facility on the site (although the hot springs have been used for local recreation). Ogden Hot Springs is located near transmission lines; however its proximity to residential neighborhoods could make new exploration drilling complicated.

Utah Hot Springs is located on private land near Pleasant View on the Weber-Box Elder County line, less than 10 miles northwest of Ogden Hot Springs. Temperatures at the surface of the springs have been measured at 59ºC (138°F). Geothermometers have suggested that temperatures of the resource fluids at depth may exceed 192ºC (377ºF). The springs were used for a time at a now-defunct resort, and are now used to heat a small commercial greenhouse operation. While minor geothermal exploration was conducted in the early 1980s, the resource is poorly defined and more exploration is warranted.

7) Crystal-Madsen Hot Springs

Crystal-Madsen Hot Springs is located on private land, north of Brigham City, near Honeyville. The Crystal (Madsen) Hot Springs Resort uses direct heat from the springs at roughly 60°C (140°F) to fill therapeutic hot tubs, mineral pools, and flows into the swimming pool. Beyond the direct-use heating facility, drilling has been limited. Geothermometers have suggested temperatures of near 150ºC (302ºF) at depth. While the hot springs are on private land, they are located within two miles of a USFS designated wilderness area.

8) Hooper Hot Springs

Hooper hot springs is located on the eastern shore of the Great Salt Lake about 10 miles southwest of Ogden on Utah State Sovereign Lands and Utah Division of Wildlife Resources lands. The resource temperature at the surface is 57ºC (135°F). Geothermometers have suggested temperatures of up to 135ºC (275ºF) at depth. While the area has potential for geothermal development, environmental and wildlife concerns in the area may restrict exploration. Hooper Hot Springs in not the only potential resource in this region. Bottom-hole temperatures measured in wildcat oil and gas wells have indicated that potential for high-temperature geothermal resources may extend beneath the Great Salt Lake.

9) Drum Mountains

The Drum Mountain-Whirlwind Valley area is located in Western Utah in Juab and Millard counties. The area was explored during the late 1970s and early 1980s. There was no developable geothermal resource identified from this exploration, although measured temperatures as high as 70ºC (158ºF) were found in a shallow borehole at 150m (492 ft). The UGS Open File Report has suggested that this area be subject to deeper drilling, and may have potential for electric production. The land is located in close proximity to the Crater Hot Springs KGRA (described below) and is mostly on BLM land with a scattering of Utah State Trust lands.

Resource areas “considered, but not analyzed” & other areas of interest in Utah

Lower Bear River (Northern Wasatch Front Valleys)

The Lower Bear River is west of Brigham City in Box Elder County. It was the site of the Davis No. 1 Geothermal Well drilled in 1974 by the Utah Power & Light Company (now PacifiCorp). The depth of the well was 3,354 m (11,005 ft), and the bottom-hole temperature was 105°C (221°F). Recent re-examination of drilling records suggests that bottom-hole temperatures are near 132°C (270°F). However, at the time the reported temperatures were much lower than anticipated, and exploration has been limited in this area for the past three decades. The area is located on mostly private land near the Northeastern shore of the Great Salt Lake. In the spring of 2006, Idatherm leased private land adjacent to the Davis Well, northwest of Brigham City, and they are considering electrical geothermal development on the site.

Monroe-Red Hill

Monroe hot springs and Red Hill hot springs are located on mostly private land near the town of Monroe, which is south of Richfield and east of Cove Fort in Sevier County in central Utah. Surface temperatures are relatively hot at both locations: 77° C (171°F) at Red Hill and 76° C (169°F) at Monroe. The resource area is currently used for direct heat by the Mystic Hot Springs resort, which offers a geothermal-heated swimming pool, therapeutic baths, camping facilities, and tropical fish ponds. Geothermometers have suggested temperatures of 110ºC (230ºF) at depth. Exploration in the vicinity may be complicated because to the east of the hot springs are mostly BLM lands and USFS lands (with some Utah State Trust lands).

Beryl Area

The Beryl area is located in Iron County, to the northwest of Newcastle. The land in the vicinity of the thermal wells is privately-owned, but surrounded by federal lands and Utah State Trust lands. Drilling records with Division of Water Rights show that in 1976 a deep well was drilled in the area indicating a resource of 149ºC (300ºF) at a depth of 2,134 meters (7,000 feet). Although subsequent drilling found lower temperature resources in the region, this area is a good target for future exploration.

Crater Hot Springs – KGRA

The Crater Hot Springs KGRA has seen much less exploration than the other three KGRAs in Utah. The area is far from nearby communities, located about 50 miles west of Nephi in Juab County. It is located in a young volcanic area, with some private land and some Utah State Trust land, but mostly BLM land. There has been little geothermal development in the area, beyond past mining of the hot spring deposits for manganese. Surface temperatures of up to 84°C (183°F) have been recorded at the springs. A few shallow water wells have been drilled in the surrounding area, but recorded no elevated temperatures. Geothermometers have suggested temperatures of up to 116°C (241°F) at depth.

Crystal-Bluffdale

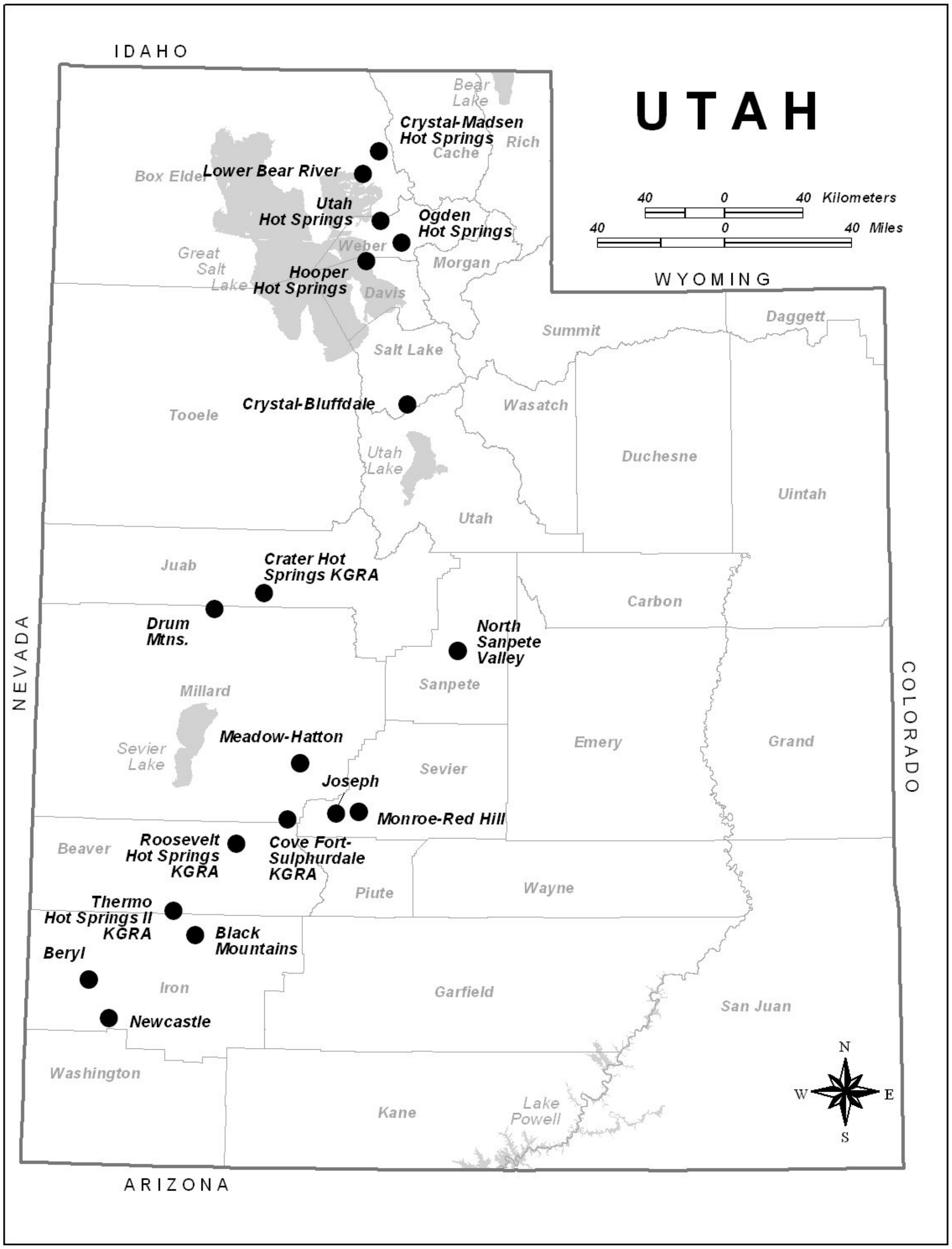
Crystal-Bluffdale is about 20 miles south of Salt Lake City. Wells run as deep as 306m (1,004ft) with temperatures as high as 85°C (185°F). It is the site of greenhouses, an aquaculture facility, and a space heating project at the Utah State Prison. The prison used geothermal heating in the early 1980s, but the system was shut down in 1985. In January of 2004, new facilities came online, and subsequent additions completed in the fall of 2005 have expanded the utilization of space heating. The direct-use heating facility currently supplies heat and domestic hot water for 332,665 square feet of the prison (including five large buildings housing 1,460 beds). Water is not re-injected, but is instead fed to the aforementioned aquaculture facility located about a half-mile to the west. The prison expects to save up to $344,000 in natural gas prices in the next fiscal year. The Crystal-Bluffdale area is entirely on private land, however further exploration drilling of the area in the near-term may be limited because the surrounding land is undergoing rapid urbanization, and water rights issues may be complicated[14].

Lands between Roosevelt Hot Springs and Cove Fort Sulphurdale

The region between Roosevelt Hot Springs and Cove Fort-Sulphurdale may be a continuation of the Roosevelt Hot Springs and Cove Fort thermal anomalies, although the region is outside KGRA boundaries. The land includes the northern part of the Mineral Mountains and extends northeastward to Cove Fort Volcano. As of now, no leases are held on the land, which is mostly managed by the BLM (although there are some Utah State Trust lands and some private lands in the area). Limited exploration was done in this area in the 1970s, however the wells drilled were shallow and significant temperatures were not found. Although there were no indications at the time of significant resources, there is reason to do more exploration. The geology of the area suggests the potential for high-temperature resources and the area has few transmission problems due to the proximity to power lines coming from Cove Fort and Roosevelt Hot Springs. The Intermountain West Geothermal Consortium is interested in gathering geological, geophysical, and geochemical data on the area directed at fostering development. They will not only study this area, but also areas north to Crater Hot Springs and south to Thermo Hot Springs, including the valleys below the Tushar Mountains and the southwest flanks of the Pahvant Mountains. These areas have also seen some limited exploration, although well and spring records from the UGS show no deep exploration wells had been drilled[15].

Of the resources described above, some may have development potential at greater depths, while others may not. Geochemical and geophysical studies suggest that a number of other resource areas (such as the Meadow-Hatton area in the Black Rock Desert, Joseph Hot Springs near Monroe Red Hill, the North Sanpete Valley, and the Black Mountains south of Thermo Hot Springs) may have development potential. There are resources outside of those mentioned above being used for direct-use heating, and others yet to be discovered. These resources represent only what has been found with minimal exploration over the last 30 years within the state. Most of this exploration took place in the mid-to late 1970s and early 1980s. This amounts to about a decade of exploration (much of it cursory), compared to a century of exploration for oil and gas. Geologists at UGS and EGI suggested an overall re-examination of Utah's geothermal resource areas with respect to existing, available information is needed to properly evaluate resource assessment needs.

Figure I: Map of Utah's Most Promising Geothermal Resources
Map created by Bob Blackett of Utah Geological Survey (UGS)



What can be done to utilize more geothermal energy in Utah?

What can be done to utilize more geothermal energy in Utah?

Since 1990, no new power plants have been developed in Utah. Direct-use heating facilities have not grown significantly either, with the exception of the Utah State Prison project. A general consensus over this lapse in development has been lack of favorable economics in comparison to other energy sources and the lack of need for load growth. Utah is currently a net-exporter of energy. Natural gas prices and coal prices have been relatively low in the past several years; and the state has had few problems with air quality compliance for stationary source emissions.

However, it was clear in my discussions that institutional barriers have also played a major part in this lapse in development. Once I completed my analysis, I determined that 5 specific needs stood out which categorize the overall issues that need to be addressed to encourage geothermal resource development in Utah. These include:

- Need for greater exploration and study of the resource;
- Regulatory needs;
- Need for adequate government incentives;
- Needs of the power market; and
- Need for greater utilization of direct uses and distributed generation.

For each of these needs, my analysis identifies key barriers and proposed policy alternatives that a general consensus believes can alleviate these constraints to facilitate new exploration and development. The first four relate primarily to power plant development and the final need relates specifically to off-grid uses of geothermal resources, including distributed generation of electric power and direct heat for low-temperature geothermal resources.

Need for greater exploration and study of the resource

Need for greater exploration and study of the resource

Currently, geothermal power plant development has been limited to Cove Fort and Roosevelt Hot Springs. Outside of these two areas, little exploration has been done beyond minor exploration drilling at shallow depths. Overall, research data shows that Utah's resources have been inadequately identified and inadequately explored; a point in agreement with the consensus of interviewees.

Resource Identification

Outside of Roosevelt Hot Springs and Cove Fort, well data show no more than 22 geothermal exploratory wells deeper than 1,000 feet (305 meters) have been drilled[16]. Numerous interviewees cited the cause to be high upfront costs coupled with a lack of demand for the resource. Unlike solar and wind, geothermal resources are buried well below the surface of the earth, and are difficult to model and verify without well drilling. Geologists will tell you that exploration for geothermal energy sources is still nascent compared to exploration techniques for oil and gas. Developers who have considered geothermal prospects in Utah say they lack the capital resources to pursue a project without confidence that the resource could be developed economically.

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"[17].

These high upfront costs pose substantial risks and uncertainties, especially for sites that have never had a producing well (aka a greenfield). According to the same report, projects in a well-known 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%[18]. Although most researchers interviewed who were experienced with geothermal exploration agreed that new technology will improve this number in future exploration, they also believe that the uncertainties involved with drilling will still turn back investors. Greenfields account for every resource area in Utah without a producing well for electric turbine production (i.e. every resource area, but Cove Fort and Roosevelt Hot Springs)[19].

Government programs

There was a general consensus that government programs have been an essential source of funding and assistance for new exploration and development in the past three decades. Research shows the majority of that funding and assistance has come from the federal government. Past programs that were generally considered successful used cost-shared drilling, technical assistance, grants, and loan guarantees to reduce upfront costs and financial risks.

The most recent federal endeavor directed at promoting new exploration and development was initiated in 2000 by USDOE and named GeoPowering the West (GPW). The first GPW working group meeting in Utah took place 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. In addition to GPW, USDOE has provided funds to the Utah Geological Survey and the Energy and Geosciences Institute (EGI) at the University of Utah. USDOE also provided assistance to geothermal exploration through the Geothermal Resource Exploration and Development (GRED) program. In Utah, this program provided funding for additional identification of the resource at Cove Fort-Sulphurdale through geophysics and by drilling new wells.

Researchers in Utah contend that despite these efforts, there remains much work to be done before development approaching Utah's full potential can be realized. For instance, Robert Blackett of UGS noted that while maps show the location of hot springs and wells, these maps remain rudimentary; Joe Moore of EGI agreed that even resource areas where geochemistry has indicated a resource, drilling had been limited. Reviewing well data reveals that most wells drilled on identified resource areas or hot springs in the state date back two or three decades. There is a general consensus that the more exploration that is done, even in known areas, the greater the opportunity to discover new resources that may have been previously unidentified[20]. Indeed, not all geothermal sites are obvious at the surface. Numerous "blind" resources have been discovered serendipitously throughout the U.S. through oil drilling or water wells, including Salton Sea, California, Raft River, Idaho, Fallon, Nevada, and Newcastle in Utah.

One point that came up repeatedly is the importance of the USDOE Geothermal Technologies program in funding new exploration and aiding new development. High energy prices are fueling the demand for alternative energy developments and planned geothermal power projects currently under development could represent an increase of over 50% in total geothermal energy capacity in the next 5 years alone[21]. 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[22].

Regulatory needs

Regulatory needs

69% of the land in Utah is federally managed, with approximately 15% of that land managed by the USFS. Much of this land is federally-managed 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 unless specific determinations are made to exchange or dispose of the land[23]. 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 wide swaths of acreage by themselves

Regulatory requirements

There is a general agreement that the regulatory process for developing geothermal resources on federal land is generally more rigorous than developing on state and private land. For one thing, drilling on federal land requires both state and federal permits[24]. Federal requirements on these lands include obtaining federal leases, drilling permits, construction permits, a commercial use permit, right-of-way grants, etc. along with accompanying environmental assessments. While some exploration can take place without a lease, well-drilling cannot. Environmental assessments must be completed before a lease can be granted. While there was a general agreement that environmental assessments are important to measure the environmental impacts of projects, developers throughout the country have pointed out that prior to the Energy Policy Act of 2005 (EPAct) these environmental reviews were a discretionary act, and BLM was not required to perform them.

Throughout the interview process, people exercised caution with the consideration of lands managed by the USFS. The USFS and the BLM are in two different federal departments [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 a USFS lease, exploring for geothermal resources on USFS land may require changing a forest plan to incorporate geothermal development. However, developers and geologists contend that the regulatory complexity of exploration drilling on either USFS or BLM land makes the process of finding willing investors difficult, and prohibitive in some cases.

Recent statistics reveal that this is not the case with oil and gas. Oil and gas resources have been utilized for over a century in Utah, and as a result more resource areas were included in land use plans. There was a general agreement that oil and gas resources benefit from an active market (especially given the high prices) and a recognized need by regulators to develop the resource. In fact, new discoveries in the state[25] 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). 2005 broke state records for new permits with 1,628; almost double the amount of permits issued in 2003[26].

Implementation

There is a general consensus that for geothermal prospects in Utah to be developed, BLM and USFS need adequate funding in order to work faster and more efficiently to implement new regulations, process lease applications, conduct environmental assessments, and permit drilling and other requirements without prolonged delays.

EPAct took several actions that facilitate the BLM in implementing new regulations addressing these issues. For instance, the Act authorizes funding for the regulatory agencies to manage duties involved in processing permits for geothermal prospects and projects. 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[27]. Furthermore, the act changed the royalty structure for power plants, sending 25% to county governments. Several interviews touched on this subject because they believe this policy will be an effective incentive for communities to pursue geothermal projects as economic development. At the time of this writing not all these changes have been implemented or received full appropriations. There is concern, particularly from developers, that delaying these changes will stunt current development and planning.

Need for adequate government incentives

Need for adequate government incentives

In the past, government programs and incentives enabled geothermal projects to become more competitive. There was a general agreement that adequate incentives could be applied today, in light of high energy prices, and produce a similar result. Ultimately, the best scenario for Utah might be doing exploration drilling on as many resource areas as possible, to increase the volume of projects and decrease the risk. Those who have been in the industry for many years suggested this is neither impossible nor unprecedented.

Federal incentives

When I asked my interviewees why the Utah government hadn't done more to support geothermal exploration and development, the answer I heard most often was that in general, state governments in the West (outside of California) do not have a budget sufficient enough to appreciably assist projects at existing sites; nor to help fund exploration and drilling at undeveloped geothermal prospects. Therefore, they contend, federal incentives play a large part in encouraging geothermal exploration and development in the state.

The most important incentive that came up time and time again has been the inclusion of geothermal power projects in the Production Tax Credit (PTC). In EPAct, the PTC was extended until January 1, 2008. Based on the volume of new projects being developed in the U.S. and Utah, it is clear that the PTC extension immediately enabled more planned geothermal projects to move forward on drilling and construction. However, developers indicated that for more geothermal prospects in Utah to become feasible, the PTC needs to be extended for a period that realistically covers the 3-5 year time frame for development of a geothermal project. The consensus is that an extended PTC, combined with effective government programs and outreach by GPW will reduce uncertainties and risks for private investment in geothermal exploration and development.

State incentives and policies

On the state level, Utah currently provides state sales tax exemptions 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, geothermal heat pumps, 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[28]. Clean energy advocates suggested that the emergence of geothermal development (and its accompanying benefits in Utah) merits reconsideration of the expiration of this tax credit, and the inclusion of geothermal technologies.

The Utah State government funds less than 1/3 of the Utah Geological Survey budget that goes directly towards geothermal work[29]. The rest of the money going towards geothermal research comes from the USDOE Geothermal Technologies program. Geothermal work at EGI is funded 100% through USDOE, as are other geothermal programs throughout the Western U.S. University researchers contend that declining federal support is a serious problem. There were repeated concerns from numerous interviewees that experienced geothermal professionals are retiring. Some noted the importance of funding for college and university programs to create opportunities for experienced geothermal professionals to share their knowledge with the next generation. While some pointed to increased access to state grants and scholarships, it might be worth considering greater pursuit of private endowments that can expand existing programs. Since geothermal energy is a renewable power source, there might be an untapped impetus for private contributions to this field.

There is a general consensus that recent efforts towards outreach have helped geothermal energy development on the state level. Independent organizations such as Utah Clean Energy and Western Resource Advocates have promoted renewable energy production in the state and testified in front of the state legislature. However, budgets are tight, and according to Sarah Wright of Utah Clean Energy, there are few groups active in the state in promoting geothermal energy and the biggest challenge is getting more people involved to educate the public, policy-makers and utility regulators about the viability and benefits of geothermal energy. Among the proposed options discussed in my research, were the state government working more closely with non-profits and independent organizations and encouraging volunteer grassroots efforts towards educating the public about geothermal resource development (and energy alternatives in general). There are numerous innovative ways to approach this (such as developing internet resources, holding public awareness events, and encouraging youth projects in public schools).

Clean energy advocates noted that the public in Utah is generally more aware of wind turbines and solar panels than geothermal energy, even though geothermal resources have been a more predominant provider of their energy and heat. Wright, who works with the state legislature on a regular basis, suggested that the benefits of outreach to the public and policymakers could serve to advance sound state policy decisions that would support geothermal energy development.

The Renewable Portfolio Standard (RPS)

Although there is a general agreement from interviewees that current state incentives and programs in Utah cannot match the impact of federal programs, a majority of them agreed that an RPS could make a difference. 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. While PacifiCorp (which includes Utah Power) has voluntary renewable energy purchase goals and an incentive to accumulate Renewable Energy Credits (RECs), recent figures back up the claim that an absence of a mandatory state RPS is a limiting factor for geothermal development. For instance, 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 out these 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[30].

Recent efforts made in the Utah legislature to establish an RPS were unsuccessful. However, it is clear from my research and from my conversations with developers, that an RPS coupled with an extension in the Federal PTC could greatly enlarge the market for geothermal energy in the state. Data on Utah's renewable resources (including geothermal, wind, solar, and biomass) indicate that an RPS of 10% by 2020 (that matches the proposed federal RPS that passed the Senate in 2005) would likely be economically attainable[31].

Needs of the power market

Needs of the power market

Often in the course of my research I was reminded of the limits of geothermal resources based on its location. After all, unlike oil, coal, and natural gas, geothermal energy cannot be shipped. Geothermal resources require a power plant be built on the site where the resource exists, and the power transmitted to populations within the region. However, despite this natural impediment my research indicates that location is not the largest barrier to development. Rather, a reason often given for few proposals for geothermal projects in Utah was the lack of identification and study of Utah's resources, and the need for more extensive exploration.

Transmission Access

Indeed, some of Utah's geothermal resources with potential for electric production are remote or located in scenic areas and this may cause transmission access to be complicated and expensive. Furthermore, the two resource areas currently being developed (Cove Fort and Roosevelt Hot Springs) have an advantage because transmission infrastructure already exists and transmission upgrades may not be necessary to accommodate their new projects.

However, even for these two sites, being in the right location has not necessarily led to new development. Through my discussions, I was reminded that while transmission is a factor in decision-making about potential projects in Utah, you cannot justify transmission unless you know you have a resource in the first place.

Furthermore, I was reminded in my discussions with utilities that issues with transmission access are applicable to all energy resources, even those that are transportable. In fact, due to population increases throughout the West, there are plans to construct the Frontier Line Project from Wyoming, through Utah, Nevada and out to California to deliver up to 12,000 MW of new renewable *and* conventional energy once construction is completed.

Power Market economics

Utah's population is growing rapidly, and new power demand in the West is spurring new energy projects[32]. However, without an RPS and without a long-term PTC, utilities are reluctant to sign a PPA for sites that might not be able to be developed by the time the PTC expires. As a result, developers in Utah may not be able to secure financing for new projects at a reasonable interest rate. Indeed, the PTC enabled projects at Roosevelt Hot Springs and Cove Fort to become more cost-competitive. However, in my interviews with those familiar with the power market, I learned that utilities generally look to develop large power plants to take advantage of economies of scale. For instance, several 10-20 MW power plants may be more capital intensive than one 500 MW coal plant, even if the utility or developer is paying millions of dollars for additional pollution controls[33].

Developers noted difficulties finding a utility to buy geothermal power projects. In addition to the small size of most geothermal projects (and high upfront costs), they point out that because a project is localized, in most cases they do not have the option of negotiating with utilities outside the area due to the costs of wheeling. Thus, they contend that selling geothermal power out of the utility area may be less economical because each transmission wheel is subject to a FERC Tariff. FERC has considered a Regional Transmission Organization (RTO) structure throughout the western U.S. that would abolish this tariff. RTOs are a popular concept for clean energy advocates because they open up renewable energy to larger markets where clean energy is in greater demand and where its costs are more competitive (e.g., California). When I discussed these topics in several interviews, there was a general agreement that along with expansion projects like the Frontier Line Project, RTOs could open more of Utah's geothermal prospects to larger energy markets[34].

There are some policies affecting the power market that encourage the inclusion of geothermal power in Utah. For instance, PacifiCorp considers environmental costs (and the possibility of carbon regulations relating to climate change concerns) in their integrated resources plans (IRP) and request for proposals (RFP). [PacifiCorp is the only major private utility in Utah, and accounted for 80% of power sales in Utah in 2004]. There are also numerous small rural cooperatives and municipal utilities in Utah (the largest five of them produced 9.6% of Utah's energy in 2004)[35]. Although they are not eligible for the PTC (and an RPS would not apply to them) they are eligible to receive tax incentives through the Federal Clean Renewable Energy Bonds (CREB) program. Several of those interviewed mentioned that PURPA still plays a role in the consideration of smaller renewable qualifying facilities, although most agreed that in its current form PURPA will not be a critical incentive for new projects in the state [36].

Among the utilities I interviewed, there was the contention that any utility which considers a geothermal project must go through the process of costs and benefits to determine the levelized cost of power versus 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, because the benefits of geothermal plants may only be salient in the long-term and have little to do with today's economics. There was a general consensus that in order to rectify these issues, state and federal incentives are essential in reducing risks to make geothermal projects more attractive to utilities, especially for near-term development.

Need for greater utilization of Direct Uses and Distributed Generation

Need for greater utilization of Direct Uses and Distributed Generation

Throughout the interview process, people frequently expressed exasperation over the lack of utilization of low-to moderate temperature geothermal resources. Direct-use heating facilities can be developed from low-to moderate temperature geothermal resources and some moderate-temperature geothermal resources may be suitable for distributed generation through small power units. There are currently no off-grid geothermal-powered facilities in Utah being used for on-site electrical generation, however low-to moderate temperature geothermal resources are being used for direct-use heating in the form of aquaculture, greenhouses, recreation, and space heating at 12 resource areas throughout the state (see figure II)[37].

In my interviews with researchers and geologists, there was a consensus that direct uses of geothermal heating have primarily been used in areas where the resource was obvious, and that exploration could reveal extensive heat systems available for near-term utilization. The four sections below discuss what needs to be done to encourage the development of low-to moderate temperature geothermal resources. The first three needs relate specifically to the development of direct-use heating facilities, and the final need relates specifically to opportunities for distributed generation through small power units.

Need to implement new federal regulations

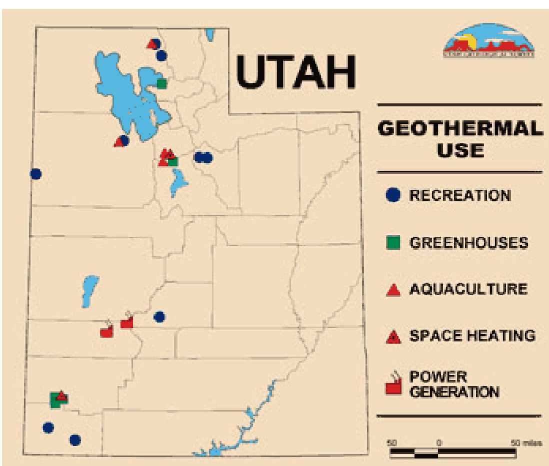
Direct uses of geothermal heating on Utah's private lands and Utah's state trust lands must meet regulatory requirements[38], however developing on federal lands has proven substantially more complex and costly. In fact, there are no direct-use heating facilities currently operating on federal land in Utah. During the course of my interviews, I was repeatedly told how the existing royalty structure on federal land has made direct-use heating facilities prohibitive, particularly by those who have been involved with geothermal research since the 1970s and 1980s. There was a general consensus that even if a developer found temperatures sufficient to create energy savings, the cost of paying the royalties would likely overwhelm the cost of the project. In 2005, EPAct authorized new royalty provisions to simplify this process, but the final regulations are still under review and until the public comment process is completed the same system will be in place. Considering the fact that 69% of Utah is federal land, this leaves less than 1/3rd of the state's geothermal resources reasonably available for direct-use heating until new federal fee-based leasing for direct-use projects is implemented[39].

Need to establish markets

Direct-use geothermal heating systems are suggested as alternatives for boilers, producing heat from the geothermal resource instead of using conventional fuels. During my travels throughout the Southwest, I was repeatedly reminded of the opportunity that geothermal resources have to mitigate high energy prices and help spur economic development. In my meeting with EGI, we specifically discussed whether businesses in Utah (such as greenhouses, aquaculture, etc.) could be created *because* of the presence of geothermal resources. In the March 2006 working group meeting in Utah, Jim Witcher noted that in order for these businesses to be successful, 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 or greenhouses, hotels and spas, district or space heating, or other geothermal heat uses)[40]. While direct-use heating projects require electrical power for pumps and motors, the Utah State Prison project demonstrates that a geothermal heat source can result in significant energy savings with a short payback period.

Although direct-use heating facilities exist in 25 U.S. States, there is an overall concern over the lack of a coherent "direct-use" industry or any large-scale government effort to utilize low-to moderate temperature geothermal resources as an alternative heating source. In his presentation at the Utah working group meeting, WSU professor Gordon Bloomquist noted that costs and revenues (particularly the cost to prove a geothermal resource) play a large part in determining the decision to pursue a direct-use heating project[41]. In subsequent conversations and interviews, the concept of replacing infrastructure in major cities (such as downtown Salt Lake City) was not considered a cost-effective option in the near-term. However, small towns and suburbs are growing in Utah, and when I met with EGI and UGS, we discussed the possibility that new or planned communities might benefit from utilizing direct-use heating as part of their energy infrastructure. Clean energy advocates suggest the state can play a role in encouraging new businesses to use direct-use heating facilities through outreach; through reinstating the renewable energy tax credit based on the new language including direct-use heating facilities; and through requiring the inclusion of geothermal resources in regional planning.

Figure II: Geothermal direct-use heating facilities in Utah



Source: *Utah Geological Survey: http://geology.utah.gov/emp/geothermal/geothermal_use_utah.htm*

Need to close the information gap

According to resource maps, a majority of Utah's population lives in the vicinity of low-to moderate temperature resources that could potentially be used for direct-use heating applications. In 1994, the Geo-Heat Center at the Oregon Institute of Technology (OIT) identified 23 communities in Utah that could potentially utilize geothermal resources for district heating and other direct-use heating applications including Logan, Ogden, Salt Lake City, and Sandy[42]. Although these communities (and possibly others throughout Utah) could potentially benefit from the utilization of direct-use heating applications, there was a general concern that direct-use heating is not being considered by communities where potential exists. Furthermore, there were 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.

There was a general consensus that in order to bring these types of projects into the mainstream, companies, consultants, and contractors who have used or developed direct-use heating facilities in the past should be encouraged to share their knowledge. Fortunately, recent efforts to bring attention to these technologies have led to new funding opportunities for direct-use heating projects. In FY 2006, the USDOE has provided funding for feasibility studies of direct-use heating facilities in six states[43]. Unfortunately, none of these studies are in Utah, despite the obvious availability of unused resources throughout the state. Hopefully efforts within the state and the nation will produce more possibilities for Utah in the future.

Need to examine opportunities for small power units to produce on-site electrical generation

It was clear in my research that on-site electrical generation of geothermal power (aka distributed generation) is receiving renewed interest. Researchers in Utah contend that in the past numerous resource areas have been abandoned or overlooked because they were not found suitable to sustain large-scale power production (i.e. at least 10-20 MW) or they were remote from transmission lines. They claim distributed generation solves this dilemma by enabling resource areas believed capable of only sustaining small amounts of power (or too remote for transmission access) 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 that an ethanol, bio-diesel, or hydrogen development plant could use small-scale geothermal power units (5-10 MW), and potentially provide more revenue and more jobs than would a power plant of equivalent size. Furthermore, several of Utah’s remote resources are near rail lines that can transport alternative fuels to emerging markets in California.

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 sites with existing direct-use heating facilities (if sufficient temperatures are present). In fact, several direct-use heating facilities in Utah are located in areas with geothermal resources potentially capable of small-scale power production.

Cascaded systems have been contemplated for greenhouses and aquaculture facilities in several states, including Utah. In the late-1990s, this concept was studied in Newcastle, when the USDOE provided funding for exploratory drilling to test the feasibility of a small binary unit to be used at the Milgro greenhouses; unfortunately, sufficient temperatures were not found at the time to make the project economical. However, as energy prices rise and distributed generation technology improves, the economics of small geothermal power units will become more competitive with conventional power sources and on-grid power. Developers claim that while small power units might cost more per kWh than a utility would pay, when used for on-site generation, they might still be lower than retail power costs. Considering the lack of availability of PPAs and the costs of providing transmission access can complicate development as it is, there is a general agreement that small power units represent a great opportunity to open up more of Utah’s geothermal resources to development.

Web Resources with more information for Utah

Energy Atlas.org – Geothermal atlas and info on Utah:
http://www.energyatlas.org/PDFs/atlas_state_UT.pdf
Geo-Heat Center at the Oregon Institute of Technology (OIT) – Geothermal projects:
http://geoheat.oit.edu/state/ut/ut.htm
Geo-Heat Center at the Oregon Institute of Technology (OIT) – Quarterly Bulletin article on Utah, December 2004:
http://geoheat.oit.edu/bulletin/bull25-4/bull25-4.pdf
Geo-Heat Center at the Oregon Institute of Technology (OIT) – Utah communities with geothermal resource development potential:
http://geoheat.oit.edu/utah.htm
Geothermal Energy Association (GEA) – Current Plants in Utah:
http://www.geo-energy.org/information/plantsNow/utah/blundell.asp
Geothermal Energy Association (GEA) – Developing Plants in Utah:
http://www.geo-energy.org/information/developing/Utah/utah.asp
Geothermal-biz.com – Utah contacts and resources:
http://www.geothermal-biz.com/States/UT.asp
University of Utah, Energy and Geosciences Institute (EGI):
http://www.egi.utah.edu/
U.S. Department of Energy (USDOE) – GeoPowering the West (Utah):
http://www.eere.energy.gov/geothermal/gpw/wkgrp_utah.html
Utah Geological Survey (UGS) – Geothermal Index:
http://geology.utah.gov/emp/geothermal/index.htm
Utah Geological Survey (UGS) – Geothermal resource maps:
http://www.maps.state.ut.us/ugs/geotherm.htm
Utah Geological Survey (UGS) – Open-File Report 431DM:
http://geology.utah.gov/emp/geothermal/pdf/utah_high_temp6.pdf
Utah Geological Survey (UGS) – Power Plant data in Utah:
http://geology.utah.gov/sep/newdata/elecpage2.htm
Utah Geological Survey (UGS) – Presentations at Utah Geothermal Working Group events:
http://geology.utah.gov/emp/geothermal/ugwg/index.htm
Utah Geological Survey (UGS) – Renewable Energy Incentives in Utah:
http://geology.utah.gov/sep/rincentives.htm#solargeo
Utah Geothermal Working Group:
http://geology.utah.gov/emp/geothermal/index.htm

Endnotes

[1]For 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%20Production%20and%20Developmentx.pdf
Direct-use heating capacity – Geo-Heat Center at the Oregon Institute of Technology (OIT): http://geoheat.oit.edu/pdf/tp121.pdf
[2]See 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 in these calculations.
[3]In June 2003, Amp Resources acquired the Cove Fort geothermal facilities and decommissioned them in order to develop the new planned facility on the existing well field. Cove-Fort II was decommissioned in June of 2003 and Cove-Fort I was decommissioned in June of 2004.
[4]Blundell alone generated 184 GWh in 2002. The geothermal facilities at Cove Fort averaged 34.66 GWh from 1992 to 2002. In 2002, the production was 29.7 GWh with all facilities running. The 10-15 GWh is based on one facility being in operation for one half of the year, and comparing that number to the 184 GWh for Blundell in 2002. Source for 1992 to 2002 numbers: Blackett, R.E., and Wakefield, Sharon, 2004: Geothermal resources of Utah – 2004: Utah Geological Survey Open-File Report 431DM (compact disk): http://geology.utah.gov/emp/geothermal/pdf/utah_high_temp6.pdf
Source for 202 GWh in 2004:
http://geology.utah.gov/sep/newdata/StatAbstract/Electricity5.0/T5.12%20&%20F5.2.xls
[5]Number based on estimates from the Energy Information Agency (EIA) and Utah Geological Survey (UGS):
EIA: http://www.eia.doe.gov/emeu/states/sep_sum/html/sum_btu_eu.html
EIA: http://www.eia.doe.gov/cneaf/electricity/st_profiles/utah.pdf
UGS: http://geology.utah.gov/sep/newdata/StatAbstract/Electricity5.0/T5.24.xls
[6]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 4 resource areas, but leaves 20 MW of new capacity possible at other Utah prospects. *Also see* – WGA:
http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (page 66)
[7]These numbers are based on discussions with researchers at USGS and reviewing data in USGS Circular 790 (1978): http://www.geo-energy.org/aboutGE/potentialUse.asp. Table 8 on page 33 gives the breakdown of identified and undiscovered accessible geothermal resource by geologic province (shown on the map on page 32). The identified/undiscovered ratio in the Wasatch Front and northeastern margin of the Basin and Range (western Utah and southeastern Idaho) is 67/170, and this would be the ratio to use to give a rough estimate of the undiscovered resource in Utah. In USGS Circular 790, the estimated total identified electrical energy potential from geothermal resources in Utah is 1300 MW (Table 5, pages 56 and 57). Using the same assumptions as were used in USGS Circular 790 and the ratio of 67/170, you get the estimated undiscovered electrical energy of 3300 MW, which adds to a total of 4,600 MW.
[8]See: http://www.eere.energy.gov/geothermal/gpw/wkgrp_utah.html &
http://geology.utah.gov/emp/geothermal/pdf/utah_high_temp6.pdf
[9]Blackett, R.E., and Wakefield, Sharon, 2004, *Geothermal resources of Utah* – 2004: Utah Geological Survey Open-File Report 431DM (including compact disk):
http://geology.utah.gov/emp/geothermal/pdf/utah_high_temp6.pdf
Other sources noted in the descriptions of the resource areas include WGA (2006):
http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (page 66) & GEA range of estimates:

http://www.geo-energy.org/information/resources/Western%20States%20Geothermal%20Power%20Potential%20Data.xls & Robert Blackett. *Utah Geothermal Developments 2005*. 8/17/2005: http://geology.utah.gov/emp/geothermal/ugwg/workshop0805/index.htm

[10]Source: http://www.utahpower.net/Press_Release/Press_Release64306.html

The bottoming cycle at Roosevelt Hot Springs will not require new well drilling. According to Joe Moore of EGI, a bottoming cycle consists of a small binary plant. When a well is produced, the steam is separated from the water and sent to the turbine (at Roosevelt this is 25-35 percent of the fluid because lower temperature fluids produce less steam). The remaining water is then circulated through a binary plant (or bottoming cycle) before being re-injected, so no additional wells are required. Because the water is cooled more than normal, since it must give up additional heat to the binary plant and the organic fluids used to generate the additional electricity, there is a greater chance for silica to deposit in the surface piping or in the reservoir rocks around the injection well. There is a balance between how much cooling can occur before scaling is a problem and how much it will cost to mitigate problems that do occur. That is why bottoming cycles are not used in all fields. Source: Joe Moore – University of Utah – EGI: jmoore@egi.utah.edu

[11]These recent estimates were re-evaluations of potential capacity since the Blundell facility was built. In 1992, a Sandia Report estimated a near-term potential of 250 MW and a high of 500 MW for the Roosevelt Hot Springs KGRA. In 2004, GeothermEx estimated 120 MW of mean resource base of the existing producing well field. The entire KGRA makes up 25,311 acres, not all of which has been thoroughly explored. Because of the large acreage of the KGRA, there may be more opportunities for development.

Sources

Supply of Geothermal Power from Hydrothermal Sources: A Study of the Cost of Power in 20 and 40 Years, (Petty S., Livesay B., Long W. & Geyer J., 1992) http://www.prod.sandia.gov/cgi-bin/techlib/access-control.pl/1992/927302.pdf (Appendix D, page 117)

"National Assessment of U.S. Geothermal Resources – A Perspective" (September 2004) by Subir K. Sanyal, Christopher W. Klein, James W. Lovekin, and Roger C. Henneberger (page 356)

[12]These recent estimates were re-evaluations of potential capacity since the Cove Fort facilities were built. In 1992, a Sandia Report estimated a near-term potential of 100 MW and a high of 500 MW for the Cove-Fort Sulphurdale KGRA. GeothermEx estimated 105 MW of mean resource base of the existing producing well field. The entire KGRA makes up 24,853 acres, not all of which has been thoroughly explored. Because of the large acreage of the KGRA, there may be more opportunities for development.

Sources

Supply of Geothermal Power from Hydrothermal Sources: A Study of the Cost of Power in 20 and 40 Years, (Petty S., Livesay B., Long W. & Geyer J., 1992) http://www.prod.sandia.gov/cgi-bin/techlib/access-control.pl/1992/927302.pdf (Appendix D, page 117)

"National Assessment of U.S. Geothermal Resources – A Perspective" (September 2004) by Subir K. Sanyal, Christopher W. Klein, James W. Lovekin, and Roger C. Henneberger (page 356)

[13]Source: Utah Geological Survey borehole data (File Name: tg_boreholes_thermo.xls) – For more information, contact Robert Blackett (Utah Geological Survey) at robertblackett@utah.gov

[14]Source: Greg Peay, Director of Facilities and Construction, Utah Department of Corrections – gpeay@utah.gov

[15]Based on my discussions, it was apparent that oil and gas companies tended to drill deep wells to look for reservoirs only once they had determined high temperatures may exist at a specific site. In these resource areas, well spring data shows no wells drilled at depths in excess of 610m (2,000 ft). Although it is possible that some wells were drilled that are not mentioned in the well data, it is unlikely that large numbers of deep wells that found temperature would go unreported and knowledge of the site would be lost if any interest was had in developing the site. Source: Utah Geological Survey well spring data (File Name: well_spring3.xls) – For more information, contact Robert Blackett at robertblackett@utah.gov

[16]According to my research I found these 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 slim 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

[17]Source: Geothermal Energy Association (GEA) – August 2005: http://www.geo-energy.org/publications/reports/Factors%20Affecting%20Cost%20of%20Geothermal%20Power%20Development%20-%20August%202005.pdf (page 18)
[18]Source: Geothermal Energy Association (August 2005) – http://www.geo-energy.org/aboutGE/powerPlantCost.asp
[19]Based on interviews with developers, even wells producing direct heat at several sites in Utah can still be considered greenfields if there is no geothermal electric production on the premises. This includes sites that have deep producing wells for direct heat, such as Newcastle and Crystal-Bluffdale, because those wells are not used for electric production and the heat source is considered low-to moderate temperature (below what is required for electric production with current technology).
[20]According to Joe Moore at EGI, even when fractures are found, and some are always present, we do not know if they will produce fluids, and if the production can be sustained. This can only be determined by flow testing full size wells. This is expensive, but once there is confidence that a resource is present, only production holes would be drilled. Future drilling at Roosevelt will probably only involve production wells even though we do not know in detail where all the fractures are at depth. Source: Joe Moore – University of Utah – EGI: jmoore@egi.utah.edu
[21]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 50% estimate is based on the 2006 Update on US Geothermal Power Production and Development (GEA) (3/14/2006): http://www.geo-energy.org/publications/reports/2006%20Update%20on%20US%20Geothermal%20Power%20Production%20and%20Developmentx.pdf
[22]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.
[23]69% and 15%: http://www.ut.blm.gov/FactsFigures/FactsFigures00/ff15.html
Federal Land Policy and Management Act of 1976 (FLPMA): http://www.blm.gov/flpma/
[24]The Utah Department of Natural Resources, Division of Water Rights (DWR) is given jurisdiction and authority over all geothermal resources in the state, even for private lands and federal lands. For more information see: Bloomquist, Gordon. *A Regulatory Guide to Geothermal Direct Use Development – Utah:* http://www.energy.wsu.edu/ftp-ep/pubs/renewables/utah.pdf
Also see: Utah Geothermal Resource Conservation Act, Utah Code, Title 73, Chapter 22
[25]A new oil field was discovered in 2003 in the Central Utah Overthrust Belt area that could yield 100-200 million barrels over its lifetime. Developers believe up to a billion barrels can be found in the area. News reports and press releases have suggested expectations of potentially one billion barrels located in the area, from the 25 deposits currently being explored.
See: http://deseretnews.com/dn/view/0,1249,600131526,00.html
In 2004, Utah was producing about 5 days worth of U.S. oil consumption and about 1 days worth of natural gas consumption. Ultimately, these new oil and gas discoveries in Utah will increase these numbers, however, statistics show that despite these new discoveries, Utah will only provide a fraction of future domestic oil and gas supplies.
SOURCES
Energy Information Agency (EIA): Natural gas consumption and production:
http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm
http://tonto.eia.doe.gov/oog/info/state/ut.html &
http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_070.pdf & 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/
[26]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
[27]The Energy Policy Act of 2005 authorized the U.S. Department of the Agriculture to include areas with high geothermal resource potential in all future forest plans and resource management plans. National

Forest lands cover large parts (7.2 million acres) of northern, central, and southern Utah and are adjacent to several geothermal areas such as the Cove Fort-Sulphurdale and the Monroe-Red Hill and Joseph areas. Language in regulations: http://www.doi.gov/iepa/2005_results.pdf (Section 222-224)

[28]The renewable energy tax credit currently provides up to $50,000 for commercial development (or 10% of the cost if the project is less than $500,000) and up to $2,000 residential. The same amount would have applied to geothermal facilities if the credit had passed. The last reauthorization was in 2001. Other programs in Utah include: Utah Power's green pricing program; Blue Sky (however, the program doesn't include geothermal facilities) & Several Utah cities are purchase renewable energy including Moab, Salt Lake City, and Park City (however, these purchases do not include geothermal energy, direct use, or geothermal heat pumps). The sales tax exemption covers geothermal power facilities as long as units are greater than 20kw or no less than 1 MW expansions on existing facilities (this includes geothermal power facilities built on federal lands). Source: http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=UT09F&state=UT&CurrentPageID=1&RE=1&EE=1

[29]According to Rick Allis of UGS, some state funds go indirectly towards geothermal work at the Utah Geological Survey. For work directly related to geothermal research, specific grant money varies from year to year. The majority of direct funding comes from USDOE grants. This funding is normally below $100,000. For more information, contact Richard G. Allis (Utah Geological Survey) at rickallis@utah.gov

[30]See 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.

Also see the Western Governor's Association Geothermal Taskforce Report (January 2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf

[31]In fact, based on 2002 and 2004 numbers of electricity demand in Utah, less than 300 MW of base-load renewable energy would suffice to get to 10%. This is very possible given estimates for geothermal resource potential, and potential for wind, solar, and biomass in the state. See EIA and UGS: http://www.eia.doe.gov/cneaf/electricity/st_profiles/utah.pdf & http://geology.utah.gov/sep/newdata/StatAbstract/Electricity5.0/T5.24.xls

[32]Utah's population increased from 2,233,169 in 2000 to 2,547,389 in 2005. This is according to the Utah Population Estimates Committee. This is an increase of 78,159 persons (approximately the population of Ogden, Utah), or 3.2%, over the 2004 estimate of 2,469,230. The population increase is the largest in Utah's history, and the growth rate is the largest since 1992. See: http://www.vote-smart.org/speech_detail.php?speech_id=138199&keyword=alternative&phrase=&contain

Recently, an article was released about plans to build a "Mega-suburb" in West Jordan, Utah. Feasibility studies might examine this new housing area to see if they could benefit from direct-use heating: http://www.cnn.com/2006/US/04/07/new.town.ap/index.html

[33]Although, based on my interviews, I found that utilities are not always pursuing large plants, because ultimately the cost of the power is of greater concern. Currently economics and technology limits the size of some geothermal facilities, which could be larger in the long-term. The basis for expecting small plants in Utah is based on WGA Geothermal Task Force Report which suggested in the near-term the availability of small power production at sites in Utah as well as other sites throughout the Western U.S. of 10, 20, 25, and 30 MW.

See WGA (2006): http://www.westgov.org/wga/initiatives/cdeac/Geothermal-full.pdf (pages 60-66)

[34]RTOs could be useful at alleviating constraints and relieving the need for a tariff to protect line loss. Line loss refers to the loss of power when transferring electrons to another utility line. In the case of PacifiCorp, FERC takes 4.48% for each wheel. While these tariffs apply to traditional fossil fuel sources as well,

feedback from my interviews suggested this particularly affects geothermal developers because they are generally not as well capitalized as developers of traditional fossil-fuel plants. Thus, due to the costs of wheeling, geothermal projects may become less competitive unless they sell to only the local utility. An RTO would enable the transmission system to become more of a common carrier. It limits inefficiencies that restrict flow (such as different owners). An RTO would create "postage stamp" rates to transfer power to certain points on the ground. As of right now, not everyone is subject to FERC rules. Information on how the 4.8% affects PacifiCorp can be found on: http://www.utahpower.net/File/File43340.pdf (Sheet No. 265)

[35]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 independently owned utility. 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.

[36]The Public Utility Regulatory Policies Act of 1978 (PURPA) obliged utility companies to purchase energy from qualifying facilities (QF) that represent more energy-efficient and environmentally friendly commercial energy production. These QF generally represented smaller figures (below 80MW), although the limit was waived by Congress in subsequent legislation, and recent amendments have limited the scope of FERC in enforcing purchases under PURPA.

General description of PURPA: http://www.energyvortex.com/energydictionary/public_utility_regulatory_policies_act_of_1978_(purpa).html

PURPA changes: http://www.ucsusa.org/clean_energy/clean_energy_policies/energy-bill-2005.html

[37]OIT put the production figure at about 33 MWt, however, the Utah State Prison project has increased this number. Furthermore, while only 12 unique resource areas are known to be utilizing direct uses of geothermal heat in Utah, there may be homes and businesses using direct heat in Utah that have not been documented. Researchers familiar with direct-use heating facilities suggest the reason for this may be that a complicated facility may not be required to utilize direct heat, and many sites may have been built years ago, and were not recorded as a result. The Utah Geological Survey describes 11 unique resource areas: http://geology.utah.gov/emp/geothermal/geothermal_use_utah.htm The Geo-Heat Center at the Oregon Institute of Technology: http://geoheat.oit.edu/state/ut/ut.htm & http://geoheat.oit.edu/bulletin/bull25-4/bull25-4.pdf (Dec. 2004) note an additional site at Lehi (Saratoga Springs).

[38]In general, there was a consensus that the Division of Water Rights has not provided a tremendous obstacle to direct-use heating utilization in Utah. The Division of Water Rights administers permits for drilling and exploration. The process for developing a low-temperature, direct-use geothermal well mirrors that for a conventional water well. Water resources in Utah are owned by the State, but the ownership of high-temperature geothermal resources above 120^{o} C (248^{o} F) is based on ownership of the mineral rights or surface rights, which are usually obtained by direct ownership or by leasing. For more information see: Bloomquist, Gordon. *A Regulatory Guide to Geothermal Direct Use Development – Utah: http://www.energy.wsu.edu/ftp-ep/pubs/renewables/utah.pdf* Also see: Utah Geothermal Resource Conservation Act, Utah Code, Title 73, Chapter 22 *(http://www.le.state.ut.us/~code/TITLE73/73_1D.htm*

[39]Utah state lands only collect royalties for power plant projects that qualify as high-temperature geothermal resources. The royalties are based on steam produced, and this only affects the Blundell Plant at Roosevelt Hot Springs. See Utah Trust Lands Administration: http://www.utahtrustlands.com/

There are no royalty payments required on state lands, and royalties on private lands are determined between the developer and the land owner, which is often one and the same. The "less than 1/3rd" is assuming the low-temperature resources available for production are evenly distributed, which may be the case +/- a few percentage points.

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

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

[42]Source: http://geoheat.oit.edu/utah.htm (1994)

[43]Source: Geothermal Energy Association (GEA) – GEA Update (May 11, 2006): http://geo-energy.org/publications/updates/2006/GEA%20Update%20May%2011%202006.pdf (pages 13-14)