Geothermal Resource Development Needs in New Mexico

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

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Preface

Every state with geothermal resources faces different challenges to 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 New Mexico with different perspectives, to understand what types of policies and actions public institutions can take to encourage greater development of New Mexico's geothermal resources. For this report, there are interviews with over 45 professionals that are involved with the geothermal field in the United States, over 20 of which have worked specifically with geothermal resources in New Mexico.

The interviewees consulted include: Representatives from three different development companies who have had interest in developing projects in New Mexico; two utilities with power facilities in New Mexico; regulators at the New Mexico State Land Office and the New Mexico Public Regulation Commission; consultants at GeothermEx, Bob Lawrence & Associates, and Jim Witcher & Associates; operators of New Mexico aquaculture facilities and greenhouses; staff for New Mexico Congressmen; clean energy advocates at the Regional Development Corporation (RDC) and the Coalition for Clean and Affordable Energy (CCAE); environmental protection advocates at the Valles Caldera Coalition; staff at the National Bureau of Land Management (BLM) and the New Mexico BLM; Researchers at the National Renewable Energy Lab (NREL), Idaho National Laboratory, Sandia National Laboratories, and the U.S. Department of Energy's Geothermal Technologies Program; and university researchers at the Geo-Heat Center at the Oregon Institute of Technology (OIT), New Mexico Institute of Mining and Technology (New Mexico Tech), Southern Methodist University (SMU), Washington State University (WSU), and the Energy and Sciences Institute (EGI) at the University of Utah.

The research was aided by a previous research report on Utah, which was completed in May of 2006, and released in June of 2006. To get a closer look at New Mexico's resources, research encompassed travel through the state from May 16 through May 17th, 2006 and attendance at a one day conference in Tempe on May 18th entitled "Using the Earth's Energy: Arizona Geothermal Direct Use Conference". After returning from the trip, drafts were organized for both Arizona and New Mexico, and in early July of 2006, a first draft for New Mexico was completed and sent out for review.

Ultimately, after taking into consideration the broad spectrum of opinions, the findings of this report represent a general consensus (or majority viewpoint) of what those working with geothermal resources believe are the overall needs to unlocking greater development in New Mexico. The help received, whether informative, critical, or "filling in a gap" of information, was indispensable to the final product. Thank you to all who contributed time and effort to help bring this report to final publication.

Introduction

As energy demand continues to rise throughout the U.S. (particularly in the West) states are forced to grapple with their reliance on fossil fuels. Despite being a state with plentiful natural resources, New Mexico gets over 95% of its electric power from fossil fuel sources (primarily from coal). Renewable energy sources (hydro included) currently make up little over 4% of New Mexico's energy consumption[1]. Although New Mexico is currently a net-exporter of energy, there has been growing concern that the state's energy production has been overly reliant on fossil fuels. Recent efforts by the state government have begun to address these concerns through policies that promote greater alternative energy production and development. As these efforts to pursue alternative energy solutions move forward, there is increasing evidence from research and exploration that geothermal resources can contribute to New Mexico's energy infrastructure by providing base-load electric power, distributed generation, and direct-uses. The question posed in this report is what programs and policies the state (as well as the federal government) can pursue to more effectively encourage development of these resources, and how industry can work with policymakers to take these programs and policies from discussion to implementation.

New Mexico currently utilizes low and intermediate temperature geothermal resources for aquaculture, greenhouses, recreation, district heating and space heating. By far, the most significant application of geothermal resources in New Mexico is for greenhouses. New Mexico leads the nation in geothermal greenhouse acreage (making up nearly half the total greenhouse acreage in the state) and geothermal-heated greenhouses have been one of the most lucrative agricultural products in the state, employing several hundred workers, and producing over $30 million in annual sales[2].

Proponents of geothermal resource development in New Mexico often tout these greenhouses as examples of the opportunities geothermal resources create for employment, investment in the infrastructure, and creating tax revenues. Clean energy advocates tout the contribution these resources make towards increased energy independence and reducing emissions of pollutants and greenhouse gases.

Although geothermal hot springs resorts and spas have operated in New Mexico for decades, the utilization of geothermal resources are rather modest considering New Mexico's overall energy use. Efforts to develop and explore for high-temperature geothermal resources (capable of power production) began in New Mexico in the early 1970s after the first energy crisis. Large amounts of land were leased for geothermal exploration in the state during the 1970s and 1980s. However, only a few areas were seriously drilled during that time, while many other potential resource areas were left unexplored.

Interest in developing these resources has re-emerged in recent years with new projects proposed and new drilling performed. In August of 2004, the Southwest Technology Development Institute at New Mexico State University released *A Strategic Plan for New Mexico Geothermal Resources Development.* In the Plan, they noted priorities for power plant development, on-site electrical production (aka distributed generation), and direct-use applications (focusing on space and district heating for cities and continued expansion of the geothermal greenhouse and geothermal aquaculture industries for economic rural development).

This report incorporates the findings of the Strategic Plan, along with other relevant literature and interviews with numerous stakeholders in New Mexico. Its purpose is to determine how policymakers on the state and federal level can meet the needs of the industry to encourage new development in the state. For the purposes of this report, "geothermal resources" are defined as resources with temperatures at least sufficient for thermal use in New Mexico's climate: 38°C (100°F) (however higher temperatures may be needed in some cases while lower temperatures may be possible in other cases). Like the Strategic Plan, this document focuses on both power production (i.e. power plants and distributed generation from intermediate-to high-temperature resources) and direct uses (i.e. direct-use applications using low-to intermediate-temperature resources). The first part of the report discusses promising geothermal resource areas in the state and the efforts to develop them. The second part of the report discusses power production for the electric grid and distributed generation. The final section of the report discusses direct-use applications.

This report is one of several examinations of obstacles and opportunities for geothermal energy on the state level being conducted by GEA. A 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.

New Mexico's Geothermal Resource Potential

According to researchers in New Mexico, there are several promising resource areas in that state that are well-known, however, many believe New Mexico contains substantial untapped geothermal resources yet to be discovered. This section highlights regions and resource areas that have the greatest potential for power plants, small-scale electrical production (i.e. distributed generation), or large-scale direct-use applications; and analyzes actions that can be taken to capture that potential in the near-term.

New Mexico's geological features contain a mix of volcanic and tectonically active regions that indicate the presence of geothermal resources usable for development. According to the Strategic Plan, "hot dry rock represents a mostly deep-seated geothermal resource base that exists across the state and most accessible geothermal resources and reserves in New Mexico are the hydrothermal or water-dominated variety of reservoirs"[3]. According to geological studies of New Mexico, the most promising resource areas for power production potential are in the Basin and Range Province (BRP) and the Rio Grande rift (RGR) (See Figure I) where temperature gradients are higher than in the rest of the state. Researchers say that low-temperature resources sufficient for direct-use applications can be found in nearly every part of the state[4].

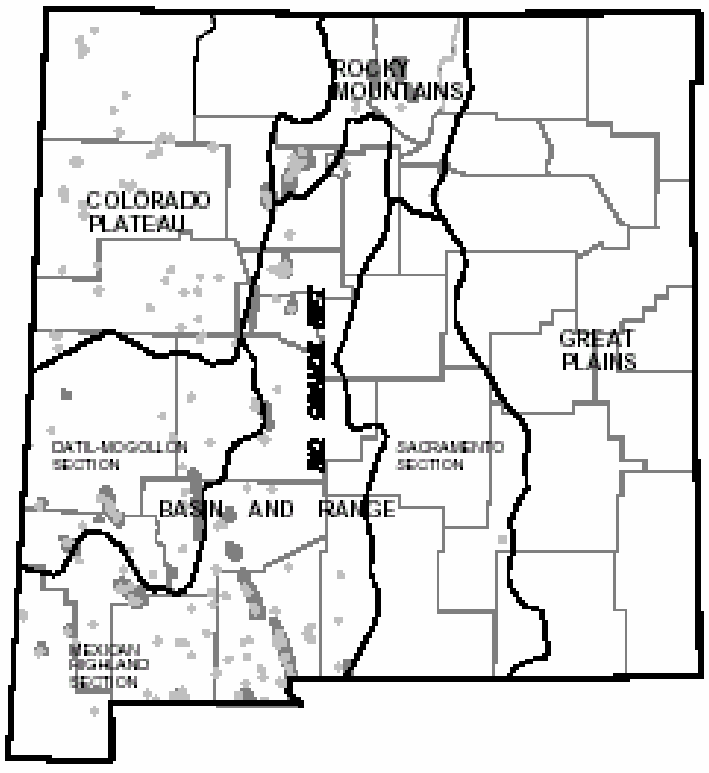

Figure I: Physiographic provinces and major geothermal fields in New Mexico (Witcher, 1995): http://geoheat.oit.edu/bulletin/bull23-4/art2.pdf

Although exploration in New Mexico has identified intermediate-to high-temperature resources suitable for electric production, there are currently no power plants in New Mexico generating geothermal power to the electric grid. There are geothermal electric binary units in New Mexico (three units totaling 750-kW) at Burgett Geothermal Greenhouses in the Lightning Dock Known Geothermal Resource Area (KGRA); however they are currently offline.

According to the Western Governor's Association (WGA) Geothermal Taskforce Report (January 2006), there are 80 MW of near-term power potential in New Mexico (compared with 5,508 MW

in the 10 other western states discussed in the report)[5]. These resources are located mostly in southwestern New Mexico; stretching from the Arizona border to Las Cruces.

The resource area commonly considered to have the largest available power production potential in New Mexico was actually left out of the WGA Report: The Valles Caldera. The Valles Caldera is 15 miles wide, covering about 125 square miles in north-central New Mexico. In 1978, when the U.S. Geological Survey (USGS) released USGS Circular 790, the Valles Caldera was identified as the only high-temperature geothermal system in the state[6]. Temperatures as high as 342°C (647.6°F) have been discovered in the western part of the caldera. A 50 MW power plant was proposed in 1977 after confirmation drilling took place. The proposed plant, a joint venture between the USDOE, PNM Resources, and UNOCAL Geothermal, would use an air-cooled condenser. At the time, an air-cooled structure had never been demonstrated on a large-scale geothermal power plant. Drilling continued until January 1982 when the project was terminated due to a myriad of complications. The primary issue with the project was that only 20 MW was able to be proven sustainable at Valles; using technology available at the time[7].

Although those who have worked in the area believe that advanced plant technology (not readily available when the project was undertaken) could likely increase that number, there are other issues standing in the way of new development. In 1999, the Federal government purchased 7/8ths of the mineral rights to the entire Valles Caldera National Preserve after legislation was passed referred to as the "Valles Caldera Preservation Act". This legislation protects most of the Valles Caldera from development. However, several researchers and developers suggest an open review of the area, considering new technology, could show that development would have a limited impact on the local environment (although most agree that transmission lines would be the largest point of controversy). If large-scale energy production is not an option, several interviewees suggested the possibility of using small-scale power in the area for localized uses. Even with the restrictions, interest in developing Valles Caldera continues to this day[8].

Although developers and researchers contend that developing Valles Caldera may be a possibility in the future, they point out that there are other sites in New Mexico that are solid prospects in the near-term. 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 currently available technology and advanced computer modeling for geological data, not available in 1978. Furthermore, they point out that when USGS performed their assessments in 1978, exploration done in New Mexico had been limited and numerous studies and field data has been compiled since the report was completed.

Another fact that researchers point out about the USGS report is that the authors were only considering resources above 150°C (302°F), although advanced binary plants currently produce power from temperatures considerably lower. Furthermore, USGS was only considering 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 researchers, deep conductive resources may be available for production throughout southwestern New Mexico, and other parts of the state, at depths exceeding 3,000 meters (depending on the permeability and the flow of the reservoir). The challenge is the cost (and financial risk) of drilling deep wells to utilize these resources; although oil and gas wells in the state have been drilled to far deeper depths.

Below is an analysis of sites identified in recent reports and studies, interviews, research of well data, and verification with Jim Witcher, and other researchers familiar with New Mexico's resources, who agree these areas are worthy of consideration. Besides Valles Caldera, there are at least four other areas in New Mexico with power production potential, and several others areas of interest that experts agree should also be considered. Hidden resources yet to be identified may exist throughout the southwestern part of the state that may have potential for small-scale electric production or large-scale direct-use applications (such as district heating or thermal uses for large agricultural businesses); and oil and gas wells in the northwestern and southeastern part of the state may have potential as well.

Four resource areas with near-term electric potential

Lightning Dock KGRA/AmeriCulture/Animas Valley[9]

Photo: Pyramid Peak from the Lightning Dock Geothermal Resource Area. – Photo by Daniel Fleischmann, GEA 2006.

Outside of Valles Caldera, the Lightning Dock KGRA is one of the most heavily explored geothermal resource areas in New Mexico. It is located in the Animas Valley of southwestern New Mexico in Hidalgo County, is home to the only existing geothermal power facility in the state, and houses the largest geothermal-heated greenhouse complex in the country.

The Lightning Dock KGRA is a "blind" resource (i.e. without apparent surface manifestations), discovered by a farmer who drilled an irrigation well in 1948. It is located on a mixture of state, private, and federal land. The geothermal-heated greenhouses were established on the site in 1977, and now encompass 32 acres. The KGRA first saw exploratory drilling for power production in 1983 when 4 deep gradient holes were drilled. The Steam Reserve Corporation drilled a deep well in 1984 that found temperatures greater than 302°F (150°C) and fluid at a depth of about 1,150 feet (350 meters). The power facility at Lightning Dock was installed in 1995 by Dale Burgett and ran for two years, capable of producing 750 kW from a 235°F (113°C) resource at depths just below 600 feet (183 meters). Design problems (and the cost of correcting them) forced a shutdown of the facility in 1997, but operators claim the system is still viable if those issues are corrected.

From 2001 through 2004, the U.S. Department of Energy (USDOE) provided cost-shared funding for new study, exploration, and drilling to Lightning Dock Geothermal, Inc. through the first funding cycle of the Geothermal Resource Evaluation and Definition (GRED) program -- GRED I. The project entailed looking for deeper resources and testing temperature and water flow to determine whether the resource area might be suitable for power plant production. According to the final technical report on the GRED study by USDOE, the test well drilled at Lightning Dock found a temperature of 280°F (137°C) at 2,528 feet (771 meters). The project is currently in the confirmation stage.

Adjacent to the greenhouse facilities and the Lightning Dock Geothermal, Inc leases is another, separate business, where an aquaculture facility owned by AmeriCulture has been operating since 1995, using the geothermal resource for direct-use heating. AmeriCulture uses shallow wells with intermediate temperatures (temperatures in the most recent well averages approximately 230°F (110°C) in the open portion of the hole). In 2004, USDOE provided cost-shared funding to study power production capability for the AmeriCulture facility. The feasibility of a 1 MW project has been demonstrated at the site[10].

The Animas Valley as a whole is complex, demonstrated by the widely differing structure, stratigraphy, and ages of rocks exposed in the surrounding mountain ranges. According to studies of the Animas Valley geology, several young volcanic structures exist in the area, and, in fact, intermediate temperatures were found two miles north of Lightning Dock in 1969, when a deep oil well found 251°F (122°C) at 2.2 kilometers of depth (over 7200 feet).

Radium Springs KGRA[11]

Radium Springs is a KGRA that extends across an area 3 miles (4.8 km) wide by 10 miles (16 km) in length in south-central New Mexico about 15 miles northwest of Las Cruces on BLM land. The extreme southern and northern areas of the KGRA are located adjacent to fresh water that occurs in Rio Grande flood plain alluvial deposits. The springs were discovered in the late-19th Century, and have since dried up. In the late 1970s numerous temperature gradient holes were drilled in the KGRA. In the early 1980s, Hunt Energy drilled two deep geothermal exploration wells 8,000 to 9,000 feet (2,438 to 2,743 meters). The wells found potentially productive reservoirs with temperatures of 225°F (107°C) at shallower depths less than 3,000 feet (915 meters).

In 1986, greenhouses were constructed just outside the KGRA on private lands and have since extended to 16 acres, using the geothermal resource for direct-use heating. Heating costs at Masson Greenhouses are less than $1.50 per million Btu (even with the payback for the direct-use facilities) and the owner is planning future expansions. Although the greenhouses have remained lucrative, those familiar with the site maintain that there is still consideration for electric power development in the KGRA. In 2000, a new 800 foot (244 meters) production well found intermediate-temperature resources above 200°F (93°C). Developers who have worked on the site believe they can drill deeper in an existing well and obtain enough of a resource to produce ample power for the greenhouses; even enough for planned expansions.

Because deeper temperatures are believed to range up to 225°F (107°C) and because the resource is expansive, there is presumed to be additional capability to produce small-scale electric power elsewhere in the KGRA. The Radium Springs KGRA is located along I-25, near transmission lines and rail lines that could provide rapid distribution of any product produced on the site. However, further development on the Radium Springs KGRA requires consideration of development access. The mineral rights to the geothermal resource are managed by the BLM, while the surface area is owned by New Mexico State University (NMSU). NMSU operates a research ranch on part of the KGRA.

Rincon[12]

Rincon is located roughly 19 miles north-northwest of Radium Springs on BLM land. Similar to Lightning Dock, the Rincon geothermal system is a blind system (without surface hot springs). In the late 1980s, Rincon was explored by researchers at NMSU, and subsequently the New Mexico State legislature provided funding for exploration drilling. In 1992, a borehole was drilled to 1,218 feet (371 meters) and the site indicated a shallow, highly-fractured reservoir from 300 to 600 feet (91 to 183 meters) with a temperature of 185° to 194°F (85° to 90°C). Between

600 and 1,218 feet (183 to 371 meters), the core hole encountered a bottom hole temperature of 212°F (100°C) and geothermometers estimate reservoir temperatures between 248 and 347°F (120 and 175°C). According to those familiar with the site, if a significant resource exists, Rincon is ideal for development due to its close proximity to transmission lines, rail lines, and Interstate-25.

Hillsboro Warm Springs[13]

Hillsboro Warm Springs is located on BLM land about 30 miles southwest of the town of Truth and Consequences near the historic mining community of Hillsboro. The Hillsboro Warm Springs were first studied for geothermal resource potential in the 1980s by students at NMSU. Subsequently, cooperative work between industry and NMSU resulted in temperature gradient and heat flow studies. This area has been considered for development in recent years; however no deep exploration drilling has been performed. Past temperature gradient tests and geothermometers estimate reservoir temperatures between 250-300°F (121-149°C). The resource area is favorably located adjacent to transmission lines leading to a major copper deposit and mine in the area[14]. Those familiar with the location suggest that financing additional exploration drilling has been a primary challenge to development.

Other sites of interest

According to studies and prior research, there are several areas in New Mexico that have potential for small-scale power production. Other areas may be able to provide large-scale direct-use applications, with extensive low-temperature heat systems near population centers. Some of these areas have seen little exploration and their full potential is still unknown.

Electric potential

Two resource areas that may have potential for small-scale electric power development include the McGregor Range (on US Army land operated by Fort Bliss near El Paso, Texas) and San Diego Mountain (north of Radium Springs). Both of these areas are within the Rio Grande rift. Researchers in New Mexico point out that because Rio Grande rift is relatively unexplored due to its lack of apparent surface manifestations (i.e. hot springs), it may contain numerous sites where power potential exists. One potential area outside the Rio Grande rift, noted in numerous studies, is the Lower Frisco Hot Springs in western New Mexico, near the Arizona border in Catron County. Lower Frisco Hot Springs is located on U.S. Forest Service (USFS) land in the Southern Basin and Range Province.

In addition to the sites above, several potential resource areas have been uncovered as a result of deep oil and gas deep drilling. For example, natural gas exploration drilling in the Albuquerque basin has encountered high-temperatures -- greater than 300°F (150°C) -- at depths shallower than 10,000 feet (3,048 meters). There has been consideration of searching more oil and gas wells in the state for potential heat flow, although studies have been limited thus far. New Mexico is one of the top oil and gas producing states (In 2004 they were ranked 5th in crude oil production and produced over 8% of U.S. dry natural gas)[15]. Deep wells have encountered water over 212°F (100°C) in oil and gas producing areas in New Mexico, including the San Juan Basin in northwestern New Mexico. Disposing of hot waste water is considered a burden in several oil and gas fields, and the heat from deep-seated oil field brines could possibly be used to generate power[16].

Another alternative discussed in the interviews is using Hot Dry Rock (HDR) and Enhanced Geothermal Systems (EGS). While New Mexico has several identified resource areas with

intermediate-temperatures, not all of them have sufficient fluid or fracturing. EGS is a process where resources with low permeability can be stimulated to create a conductive fracture network and a reservoir that operates like conventional hydrothermal reservoir. This process can also serve to extend the margins of existing geothermal systems or to create entirely new ones[17].

HDR targets resources that lack both permeability and fluid, and has been proven technically feasible at Fenton Hill (on the western rim of the Valles Caldera), after two decades of study culminated in confirmation of power production from the technology. This work, while expensive, was able to spawn research abroad into this technology and has potential for future application[18].

Large-scale direct-use potential

Several areas have been noted in various studies as having potential for large-scale direct-use applications. For example, low-temperature systems have been encountered near Albuquerque and may have potential for use in metro areas near the city. This includes the new Mesa Del Sol development south of the city, where they are considering installing direct-use heating for new homes not yet under construction.

Geothermal resource potential around New Mexico's second largest city, Las Cruces, is even more promising. According to studies and well data for the area, a vast low-temperature geothermal system is located below and around Las Cruces in the Las Cruces East Mesa KGRA (comprising Tortugas Mountain -- also referred to as "A Mountain"). The Las Cruces East Mesa is a blind geothermal system which parallels the east side of I-10/I-25 from the Texas line to Hwy 70 northeast of Las Cruces and several researchers familiar with the area contend that the resource could provide significant heating for Las Cruces if fully developed. A district heating system already exists at the NMSU campus in Las Cruces, and FY 2006 funding from USDOE with Millennium Energy has been provided to evaluate the system and further study the resource[19].

Another potential geothermal system is located at Socorro Peak in central NM, where thermal gradient wells drilled over the past 30 years have indicated an apparent geothermal resource located on the campus of the New Mexico Institute of Mining and Technology (New Mexico Tech). New Mexico Tech received GRED III money in 2004 to assess the feasibility of installing a campus geothermal district heating system. According to a synopsis by researchers at New Mexico Tech, Phase I was completed in the fall of 2005. In the synopsis, they report "Phase I of the GRED III work included detailed subsurface exploration of the resource using both traditional geophysical methods and non-traditional geochemical methods." Drilling is being performed over the summer of 2006 to determine resource temperature and flow. The original appropriation by USDOE included $632,000 (an 80% cost-share) to which $187,500 was added because of increased drilling costs. Researchers at New Mexico Tech suggest that with rising natural gas prices, estimates of energy savings from the resource are ~$1.2 million in heating costs for the campus each year. An infrastructure exists for this type of system due to a solar installation that once provided heating on the campus. Furthermore, researchers working on the project suggest it is feasible that Socorro Peak may contain a resource capable of electric power production. If developed, it is possible that a small power facility could provide campus power and cascaded heating. Additionally, the geothermal resource may be significant enough for a power plant to sell power back to a nearby cooperative, or possibly for a utility-scale power plant. Most agree that before such a system could be considered, more testing would have to be done, and deep drilling would be required[20].

Another potential area being studied by USDOE is in the Jemez Mountains (in the vicinity of Valles Caldera). From 2002-2004, the Pueblo of Jemez worked with USDOE who cost-shared a geothermal direct-use heating feasibility study. The study concluded that there were business opportunities related to geothermal resources, but further drilling is needed before these applications can be developed on the site[21].

Geothermal Power Production in New Mexico

No commercial geothermal power facilities have ever been constructed in New Mexico. Research indicates that multiple factors have prevented development, including the lack of identified high-temperature resources (besides Valles Caldera), and relatively inexpensive fossil fuel electricity prices that compete with geothermal prices. Until recently, these prices had been relatively low compared with rates in other parts of the country (particularly rates in California). Furthermore, New Mexico's record of regular air quality compliance has not mandated significant regulation on stationary sources.

According to researchers, the geothermal resources found to date in New Mexico are suitable for large-scale direct-use applications and small-scale power production. In the near-term, opportunities for new power production in New Mexico are perhaps better suited for distributed generation projects than power plants. The challenge for distributed generation is determining what the power would be used for, how much revenue would be generated, and how business deals would be developed, even though companies are generally unfamiliar with the technology.

Regardless of whether power is on-grid or off-grid, most agree that policymakers on the state and federal level can play a large part in meeting the needs of the industry to continue its growth in the state. The analysis below identifies four specific needs for policymakers to address. These include:

- Need for greater exploration and study of the resource;
- Need to establish uses for distributed generation;
- Regulatory Needs; and
- Need for adequate government incentives.

For each of these needs, key barriers are identified along with proposed policy alternatives that could alleviate constraints and provide incentives to facilitate new development.

Need for greater exploration and study of the resource

New Mexico has seen exploration at several resource areas within the state. However, researchers assert that New Mexico has not commanded similar attention as states where resources have been deemed more significant. When New Mexico was explored, developers were looking for "big hits" where a large power facility could be constructed, and by the early 1980s attention had shifted away from New Mexico and onto development prospects in California and Nevada. While exploration and drilling was performed at several notable sites (mentioned above), researchers contend that exploration of New Mexico's resources is still in its early stages.

Resource Identification

There is a general consensus that resource identification should be a priority for state and federal programs to enable near-term developments and encourage greater exploration efforts. According to the Strategic Plan, most of the potentially economic and accessible geothermal resource base in New Mexico is unexplored and inferred, and has not been drilled, tested, or confirmed. According to developers and project consultants, the expense for new exploration drilling coupled with a lack of demand for the resource has been a limiting factor for development in New Mexico. Another challenge to developing New Mexico's resources is that many of them are "blind" systems without apparent surface manifestations. In fact, "blind" resources throughout the western U.S. have been discovered serendipitously through oil drilling or water wells, including the Lightning Dock KGRA.

Exploration efforts for geothermal resources are still nascent compared to those for oil and gas (both in breadth and in technical experience). Geothermal resources are buried well below the surface of the earth, and are difficult to model and verify without well drilling. Exploration is a time-consuming process that generally involves high upfront costs with high risks and uncertainties. Developers say they lack the capital resources to pursue a project without confidence that the resource can be developed economically. According to an August 2005 report by GEA, exploration (including geological studies, drilling, and confirmation) is typically up to 1/3rd of the overall costs of a geothermal project. Drilling can be up to 1/4th of the overall costs -- considering the cost of a geothermal exploration well ranges from $1 million to $9 million -- depending on the depth, the type of material being used, and the current market for drilling rigs. According to the report, an average well "would probably be in the range of $2-5 million"[22] however recent spikes in demand for steel and drilling equipment have markedly increased these costs in the past year.

Government Programs

According to developers in New Mexico, government programs, including grants and loans, are tools that can be used to reduce the risks inherent in geothermal resource development. The USDOE has assisted projects in New Mexico in recent years through the GRED program and other efforts, while the state legislature provided funding to NMSU for the core hole drilled in Rincon in 1992.

The primary source of government funding for geothermal exploration and development in New Mexico has been the USDOE. Since 2000, in addition to GRED, the USDOE established GeoPowering the West (GPW). GPW established a New Mexico Geothermal Energy Working Group in April of 2002. Since its initial presence in New Mexico, GPW, and the state working group it helped organize, have held conferences, performed outreach, created internet resources, and released the aforementioned Strategic Plan.

Other federal programs utilized in New Mexico included the Fenton Hill Hot Dry Rock testing by Los Alamos National Laboratory and the Sandia Geothermal Technology program which is still active and has existed for more than three decades. New Mexico State University in Las Cruces has also received federal funding over the years for geothermal research at the Southwest Technology Development Institute (SWTDI). The Institute built up a considerable resume of work in the geothermal field between the late 1970s and the time the program stopped geothermal research in 2004; after it was unable to obtain additional geothermal research funding. The rest of the program has been incorporated into the newly formed 'Institute for Energy and the Environment'.

Numerous interviewees express concern that there is a lack of available funding on the state and federal level specifically geared to limit the risks of exploration and development. In particular, they stress the need to increase funding for the USDOE Geothermal Technology program. Despite increased interest in new geothermal prospects and a high volume of new power and direct-use projects under development throughout the western U.S., funding for the USDOE Geothermal Technologies 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[23]. Subsequently, there is a concern that there is a misperception by policymakers in New Mexico and Washington DC that exploration and development in the 1970s and 1980s was sufficient to identify New Mexico's resources. Researchers assert that these early programs pre-dated current advancements in technology, and that many of these past programs (including loan guarantees and cost-shared drilling) would be useful today, especially with more favorable economics for geothermal projects.

In addition to funding for new development, several interviewees note the need to re-examine existing information on New Mexico's geology. Well over a century of oil and gas data, mining and mineral exploration, along with geological reports, documents, and studies are sitting in archives. These documents may show evidence of resource potential, which were not publicized if the documents' authors were not seeking geothermal resources at the time. Interviewees also stress the need to revisit data on both past exploration and initial development of current installations to ensure that the knowledge contained therein is not lost (many of these documents are only available in archives as well).

Jim Witcher asserts that those exploring geothermal resource areas must understand how identified geothermal systems work if they are to find and develop lesser known or undiscovered geothermal systems. During the 1970s and 1980s, initial efforts towards geothermal exploration and development were often unsuccessful when individuals inexperienced with geothermal development were put in charge of drilling. Considering the renewed interest in geothermal development in New Mexico and elsewhere, experienced professionals must be present to work on new geothermal projects to ensure mistakes made in the past are not repeated.

The problem is that many experienced geothermal professionals are nearing retirement. Therefore, it is crucial that these professionals share their knowledge with the next generation of geothermal professionals. The lag in geothermal resource development from the late-1980s through today has created an experience gap in the industry that highlights the importance of funding college and university programs. According to the Strategic Plan, when new power or direct-use facilities are being developed, these programs can use the facilities as teaching tools. This will educate students about how to develop projects and how to use geothermal reservoir management strategies to ensure sustainable production once projects are in operation.

While geothermal programs are performing some activities at New Mexico Tech, researchers consider the program at NMSU an important one because it provides close access to existing geothermal installations. Most agree that the NMSU program should not only return, but should expand. However, a pervasive concern is that if the NMSU program continues to rely on federal funding, it may meet the same fate as before. Therefore, in order to expand existing programs, it may require greater pursuit of private endowments or other sources of funding. Clean energy advocates suggested that since geothermal energy is a clean renewable energy source, other sources of funding may be available as non-governmental organizations seek to promote alternative energy development.

Need to establish uses for distributed generation

There is a general consensus that distributed generation is a practical way to use New Mexico's geothermal resources. While there are currently few opportunities in the state to develop large power plants, research shows there are numerous resource areas with the potential for small-scale power for other uses.

For example, several consultants pointed out how small power units can be used to produce both power and cascaded heat for multiple uses all in one integrated system. This is especially relevant to sites with existing direct-use facilities (if sufficient temperatures are present) and was demonstrated in Lightning Dock, when the binary system installed there in 1995 provided cascaded heating for the greenhouse facilities.

Two companies in New Mexico are currently considering installing cascaded systems, including AmeriCulture and Alex F. Masson, Inc. (which owns the greenhouses at Radium Springs). AmeriCulture currently produces roughly 250 thousand pounds of fish per year, and utilizes geothermal resources to heat culture water for tropical fish production. Their data suggests that if they install an electric 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 report they could hire another 80 workers (in a county with a population of just over 5,000 which had recently seen massive unemployment resulting from the loss of manufacturing jobs)[24]. At Masson Radium Springs, they have also considered a small binary unit to offset all of their electricity costs, which they believe would facilitate the economics of planned expansions.

So far, economics has limited the opportunity for development of these projects, however new technology creates promise. For example, several interviewees are 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 may be applicable at intermediate-temperature resource areas throughout the western U.S.

Several consultants and researchers note recent interest in another potential use for geothermal resources: Producing alternative fuels. Several of New Mexico's resource areas (including Radium Springs and Rincon) are nearby both rail lines and major interstate highways that can transport alternative fuels to emerging markets in California. Alternative fuel production is notoriously energy intensive to develop and an ethanol, bio-fuel, or hydrogen development plant could utilize small-scale geothermal electric units (5-10 MW).

In general, proponents of distributed generation projects suggest the advantage of these units are that they can be off-grid, not requiring additional transmission lines or procuring a Power Purchase Agreement (PPA); and they do not have to work through a lengthy utility regulatory process. Furthermore, because they produce a product to sell beyond electrons for the electric grid, they have the potential to provide more revenue and more jobs than a power plant of equivalent size. While those considering these projects point out that the capital costs of small power units might cost more per kilowatt hour (kWh) than a utility would be willing to pay, they claim that the cost might still be lower than the retail power cost the utility would charge.

In general, most agree that the range of possibilities for these technologies has not yet been fully considered. Some suggested that small-scale geothermal power could be combined with

concentrated solar power (CSP) or be used for desalinization. As noted above, small-scale binary production was proved feasible in New Mexico in 1995, and the operator of that facility, along with other proponents of geothermal distributed generation projects agree that what is needed are more demonstrations of these technologies to expand their transparency to attract new investors and establish new markets for the technology.

Regulatory Needs

Before a developer can obtain the adequate financing to perform exploration drilling on a geothermal prospect, they need to have access to the land where the resource can most successfully be tapped. This is where regulations come into the picture. Among those interviewed, there is no denial that regulations are important to ensure protection of secure water resources and for quality control to ensure drilling and construction have a limited impact on the local environment. However, the primary concern for developers and researchers in New Mexico is not the regulations themselves, rather the processing of them.

Water

One of the main concerns for regulators in New Mexico (both state and federal) is protecting scarce water resources. The scarcity of water is commonly cited as the reason for New Mexico's small population. Unlike solar and wind, geothermal production involves the use of water by pumping from underground reservoirs. Thus, the process of drilling into geothermal reservoirs brings up issues concerning water rights and the impacts on local users (including agricultural, municipal, and domestic users, and resources used for irrigation). Water rights are complex, and establishing clarity of ownership of these rights is essential to help developers avoid lengthy disputes with neighboring users before projects get too far along. The regulation of water resources, including low to intermediate-temperature geothermal resources, is under the jurisdiction of the Office of the New Mexico State Engineer (NMOSE) and involves all land in New Mexico, regardless of whether it is private, state, or federal.

Regulatory requirements on federal lands

Although efforts to explore and drill for geothermal resources in New Mexico are not as active as in states like California and Nevada, regulatory issues remain impediments to exploration and drilling activities, especially when conducted on federal land. Many of New Mexico's most promising geothermal resources (as mentioned above) are located on or near lands where the federal government manages the surface or mineral acreage. Private and state lands are predominant in the eastern half of New Mexico, and federal lands are predominant in the western half, particularly in National Forests and the southwest desert[25].

Most interviewees agree 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. 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 and National Environmental Protection Act (NEPA) compliance. While initial exploration efforts can take place without leases or permits, exploration drilling cannot.

According to the BLM, 34% of the surface acreage in New Mexico is federally managed, with approximately 16.5% managed by the BLM. However, in terms of mineral acreage, nearly 35% is managed by BLM and 46.3% of the total mineral acreage is managed by the federal government[26]. The U.S. military manages about 4% of the land in New Mexico, while USFS

manages large portions throughout the state (roughly 14-15%). State lands make up approximately 17.5%; Native American lands make up approximately 6%; and private lands make up approximately 21%[27].

Developers have been reluctant to consider lands managed by the USFS. Land adjacent to the Valles Caldera, which is managed by USFS, exemplifies the regulatory hurdles that can be encountered when planning a geothermal project. Several significant geothermal resource areas being considered for development are located on USFS land, including Newberry in Oregon and Glass Mountain in California. Leasing on USFS land requires approval from both the USFS and the BLM. These agencies comprise 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). Recent changes, including a Memorandum of Understanding (MOU) between the BLM and the USFS have attempted to improve interagency coordination and reduce delays responding to leasing and permitting requests.

Implementation

For more geothermal prospects in New Mexico to be developed, state and federal regulators need adequate funding for a larger, more experienced staff to ensure that the resource is being carefully developed while still being permitted in a timely manner to avoid project delays. There is a general consensus that, in their existing capacity, regulatory agencies in New Mexico (both state and federal) lack both the experience and the quantity of staff sufficient to handle a large increase in geothermal lease and permit applications.

For this reason, most agree that increased funding for these agencies should be a priority for policymakers (especially for federal land agencies), due to a high volume of new projects in several western states, and increased interest in New Mexico. In the Energy Policy Act of 2005 (EPAct) the U.S. Congress took several actions that facilitate the BLM and USFS in implementing new regulations addressing these issues. For instance, EPAct authorized additional funding for regulatory agencies to meet new requirements for processing leases and permits for geothermal prospects and projects, and requires all future USFS and BLM resource management plans to consider geothermal leasing and development in areas with geothermal resource potential. Furthermore, new regulations changed the royalty structure for power plants to send 25% to county governments[28]. Several interviews touted this policy because they believe it 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 and there is concern, particularly from developers, that delaying these changes will limit current development and planning until full implementation is complete.

Need for adequate government incentives

Although regulatory changes and government research programs have the potential to facilitate exploration and development in the future, industry stakeholders say they need to be coupled with appropriate government incentives to enable geothermal projects to become more competitive. Incentives are helpful coming from either the state or federal government, but ultimately, to receive continued support and appropriation, these incentives need to drive near-term development.

While there is agreement that several incentives can encourage the power market to purchase geothermal power projects, most agree incentives are meaningless without a resource to sell. Utilities assert that transmission access and competitive market costs generally limit the

economics of geothermal power plants (especially when these plants can only produce small amounts of power). Therefore, most agree incentives should target the most practical uses for geothermal resources in New Mexico. Below are several issues that need to be examined to better target the New Mexico energy market.

Federal tax incentives primarily affect utilities

Existing federal incentives for renewable energy production primarily focus on power for the electric grid. In conversations with developers in multiple states, the Federal Production Tax Credit (PTC) is regarded as the most promising federal incentive for renewable energy production. However, those considering small-scale geothermal distributed generation projects in New Mexico suggested that a similar tax incentive should apply to businesses generating their own power from renewable sources because they also have near-term development potential.

Another issue with the PTC is that it only affects investor-owned utilities (IOUs). While some researchers point to the possibility that geothermal projects could benefit from the Clean Renewable Energy Bond (CREB) program authorized in EPAct (which affects rural cooperatives and municipal utilities)[29], there is concern that CREBs, like the PTC, affects utilities exclusively, rather than businesses or industries that wish to produce their own off-grid power systems.

While there are indicators that geothermal power plants can be developed in New Mexico, and the power sold to local utilities, the consensus of research indicates that any resource areas currently being considered for development in New Mexico would not be able to meet the expiration date of the PTC of January 1st, 2008. There is a general agreement that a long-term extension of the PTC is needed for any power plant project in New Mexico to qualify.

The State Renewable Portfolio Standard (RPS) must target geothermal projects effectively

On the state level, there is a Renewable Portfolio Standard (RPS) aimed at increasing the generation of renewable power by utilities in New Mexico. While the RPS is not technically an incentive, developers say it helps create a market for renewable energy sources by encouraging utilities to sign PPAs for renewable power plants or to develop their own renewable power projects. So far, statistics show that the RPS has led mostly to the development of New Mexico's wind resources.

Similar to the PTC, the RPS primarily affects IOUs in New Mexico; requiring them to generate 10% of their power from renewable sources by 2011 (although there are stipulations requiring all rural co-ops in the state to offer green pricing programs). There are three IOUs in New Mexico, which combined made up just over 68% of sales in New Mexico in 2004[30]. Those utilities serving rural cooperatives and municipal utilities make up the other 32% (with much of that power coming from Tri-State Generation & Transmission facilities serving several of New Mexico's largest rural cooperative utilities with large coal and gas-fired power facilities).

The RPS does contain a design element that *specifically* encourages geothermal development. While every kWh of wind generation receives one renewable energy certificate (REC), geothermal energy receives two RECs for every kWh of generation. This requirement took effect on January 1st, of 2006[31]. However, despite extra credit for geothermal production, there is concern by geothermal developers that the incentive does not discriminate whether or not the generation is during peak-load hours, or whether or not the generation is produced in New Mexico, and that the RPS should encourage in-state production and peak-load generation.

Another issue brought up by developers is that the RPS has a "reasonable cost" threshold for geothermal and biomass of 6.3 cents per kWh (although a utility can ask for a variance on this). Solar power gets a higher threshold of 10 cents per kWh and wind a lower threshold at 4.9 cents per kWh[32]. They also point out that the "reasonable cost" threshold for geothermal power plants of 6.3 cents per kWh is unrealistic for sites in New Mexico where developing a power plant might be possible. In addition, those professing the need to promote distributed generation or direct-use projects point out that the RPS does not specifically encourage geothermal distributed generation, or geothermal direct-use, although the PRC could consider these projects in the future. Such an incentive could induce utilities to participate in the funding of such projects if they can get credits for them.

Transmission constraints for geothermal power projects must be addressed

As mentioned above, transmission access is a clear limitation for geothermal power projects. While efforts are being made by the New Mexico State legislature to finance renewable transmission projects (including efforts to pass the Renewable Energy Transmission Authority Act[33]), progress has been limited thus far. There is concern that several of New Mexico's promising resource areas, particularly in southwestern New Mexico, may be in remote areas removed from major utility lines. Furthermore, the lines that exist may have limited transmission capacity to deliver power without transmission upgrades or new transmission construction.

Transmission costs are unlikely to be incurred by utilities in New Mexico. Utilities are not required to cover the transmission costs for projects that they do not own, so transmission costs usually increase the cost to the developer. In fact, when utilities purchase power from another party (such as a geothermal developer) the power purchased becomes imputed debt for the utility. According to interviews with utility representatives, aside from the PTC, rate flexibility would be an effective policy to induce utilities to pursue geothermal projects. In several states, policies have been utilized that allow utilities to recover the cost of purchasing renewable power. This includes rate flexibility mechanisms such as mark-ups and systems benefit funds. System benefit funds were used in New Mexico during the 1980s to allow utilities to increase rates that would go towards funding alternative energy projects. Ultimately, rate flexibility, transmission funding, or any other mechanisms to reduce the price of power, can limit the cost impact of building additional transmission, making power plant projects more viable.

State incentives should incorporate geothermal distributed generation projects

During the interview process, several interviewees indicated that incentives and policies primarily affecting utilities (such as the PTC, CREB, and the RPS) may have little impact on geothermal resource development in New Mexico. They point to the limited effectiveness that the Public Utility Regulatory Policies Act of 1978 (PURPA)[34] has had on geothermal development over the last three decades.

A state incentive in New Mexico that could potentially affect distributed generation projects is the State Renewable Energy Production Tax Credit. When the credit was enacted in 2002, it only included wind. In 2005, the credit was expanded to include biomass and solar. In its current form, it does not include geothermal power (although it does not specifically exclude it). While the credit is directed towards utility-scale projects, there are no specifications excluding distributed generation. One restriction that is specified, is that the power needs to be sold to an "unrelated person" or entity who does not own 50% or more of the generator. Currently the tax credit is 1 cent per kWh (which can be added to the federal PTC) and only applies to facilities larger than 10 MW. There are restrictions that mandate only New Mexico companies can build

the power facility; the incentive being that the credit reduces state income tax liability. To date, the credit has not yet been utilized for a producing facility, although projects are in the pipeline.

According to clean energy advocates, state legislators are considering changing the credit language to expand the list of eligible projects. Including geothermal power projects, reducing size requirements to 1 MW, and including projects where a New Mexico company has at least invested in part of the project have all been proposed. For geothermal resource development, most agree the credit would be more effective for distributed generation projects, because these projects would likely have in-state investors[35].

Another potential program that could impact geothermal projects is the Energy Efficiency & Renewable Energy Bond program. Passed in April of 2005, the program can apply to geothermal power plants, distributed generation, or direct-use applications; although the program does not specify "geothermal" applications in the text of the legislation[36].

What can Industry do?

While clean energy advocates agree that there has been a great deal of recent interest and conversation about energy efficiency and renewable energy by the New Mexico state government, they point out that beyond the RPS, additional incentives have left out geothermal resource development, in part, due to a lack of a geothermal advocacy presence. Geothermal resources are already at a disadvantage because they are less known to the public than wind and solar (wind turbines and solar panels are more recognizable than geothermal installations). Clean energy advocates working with the state legislature assert that in order for geothermal resource development (both power production and direct use) to receive broader inclusion in future policy decisions, more outreach and a unified advocacy effort from the geothermal industry is essential to remain on the public and government radar. This includes working more closely with other clean energy advocacy groups on state legislative issues, and joining the Renewable Energy Industries Association of New Mexico.

Efforts have been undertaken by independent organizations such as Western Resource Advocates and the Coalition for Clean and Affordable Energy (CCAE) to promote geothermal energy production in the state and both have testified in front of the state legislature on issues specifically concerning geothermal energy. However, clean energy advocates say these efforts have been small considering the wide array of energy legislation that has been passed or debated in recent years.

According to the Strategic Plan, there needs to be more dialogue between those familiar with the industry and the state legislature and regulatory bodies to determine which policies and regulatory actions will be most effective at targeting near-term development opportunities. In the Plan, suggestions include:

- Holding hearings to review policies and regulations that impact geothermal resource development;
- Reviewing applicable laws and regulations on geothermal leasing, drilling, and utilization for unnecessary impediments to New Mexico geothermal development and use;
- Determine the most effective and suitable incentives to development that may include production tax credits, streamlined leasing and royalty assessment, cost-share, and low-cost loans;
- Providing information to policy makers and advocate inclusion of geothermal energy in policies of the executive branch of New Mexico government, the Public Regulation Commission, and other agencies that regulate or promulgate renewable energy, land use,

natural resources, and water utilization rules so that incentives for wise development are maximized and barriers are minimized;
- Need for organized curriculum for education about geothermal (and other renewables) in the schools and universities in New Mexico[37].

In addition, the contributors to the Strategic Plan suggest that favorable impacts compared with traditional fossil fuel sources deserve consideration when developing policies affecting geothermal energy. Because geothermal has significant upfront capital costs compared to other energy technologies, financing decisions are frequently made in favor of non-geothermal projects with lower upfront costs without first examining the life-cycle costs of a geothermal project. Thus, these financing decisions often fail to consider the hidden long-term costs of other conventional energy technologies when compared to geothermal; such as emissions of pollutants and greenhouse gases, and volatile fuel costs and other costs related to operations and maintenance[38]. Subsequently, in interviews with project developers, several pointed out that geothermal development would benefit if there are carbon tax incentives aimed at reducing the impacts of climate change. They point to New Mexico's entry into the Chicago Climate Exchange in February of 2006 as an indication that low-emissions technologies might receive preferences in future development plans.

Geothermal Direct Uses in New Mexico

Left: Masson Greenhouses at Radium Springs – Source of photo: http://geoheat.oit.edu/bulletin/bull23-4/art9.pdf

Numerous interviewees express frustration that direct-use applications are vastly under-utilized in New Mexico. Currently, there are less than a dozen different resource areas in New Mexico using direct-use applications. According to research compiled in May of 2006, existing direct-use facilities in New Mexico save equivalent to an estimated 85.6 GWh per year with estimates of emissions offsets by these facilities of 141 tons of nitrogen oxides (NO_x), 98 tons of sulfur dioxide (SO_2), and 66,480 tons of carbon dioxide (CO_2)[39]. Consultants working with direct-use projects currently under development say these numbers are poised to increase significantly in the near-term.

There is a general consensus that direct-use applications have primarily been used in areas where the resource is obvious, and that exploration could reveal extensive heat systems available for near-term utilization, far beyond current and planned installations. The analysis below identifies three specific needs for policymakers to address to greater encourage geothermal direct-use development in New Mexico. These needs include:

- Need to implement new federal regulations;
- Need to establish markets; and
- Need to close the information gap.

Need to implement new federal regulations

Direct-use applications on New Mexico private lands and state lands must meet regulatory requirements[40] however, there have been repeated concerns expressed (particularly by those who have been involved with geothermal research since back when direct-use installation was more active) over the structure of calculating royalties on federal land and how it has made direct-use heating facilities prohibitive. In addressing geothermal development issues, EPAct authorized changes to these policies in 2005; however the final regulations are still under review.

There are two areas in New Mexico where direct-use facilities have utilized federal geothermal leases in the past. In Las Cruces, J&K Growers operated a small greenhouse facility and purchased the hot water from the owner of the well who had the federal geothermal lease. In this case, the royalty was based on the arms length sale of hot water between the well owner and J&K Growers and the royalty determination was simple and straight forward. At Lightning Dock, Burgett Geothermal was required to install metering equipment that cost more than the cost of a geothermal well in order to determine the equivalent energy use needed to calculate a royalty. In addition, the calculated royalty was more than the royalty that an electrical power plant would pay for the equivalent amount of energy use. As a result, the owner shut down all facilities that were affected by the federal lease.

Ultimately, there is a consensus that federal royalty regulations have been a disincentive to development (i.e. a perfect case of government failure since these facilities were clearly a public good and had both met required environmental and land regulations). Furthermore, from research in other states, it is clear this problem has not been isolated to New Mexico. The difference, evidently, is that in most states (including Arizona, Idaho, and Utah) no one has bothered to build a direct-use facility on federal land in the first place.

Considering the opportunity these technologies have for economic development, there is an urging for quick implementation. Because large portions of land in the vicinity of known low-to intermediate temperature geothermal resource areas in the state have significant land and mineral acreage located on federal lands, numerous industry stakeholders believe this regulatory change will lead to new development in the near-term – if markets are effectively established.

Need to establish markets

There is a general consensus that federal and state energy policy can do more to encourage geothermal direct-use endeavors in New Mexico. When traveling throughout the Southwest, it is clear that geothermal resources have an opportunity to quell high energy prices and help spur economic development, particularly in struggling rural and agricultural areas.

In discussions with consultants and direct-use facility operators, they note that several factors have been drivers for these technologies. Of these, the most significant include the escalating costs of natural gas and high unemployment rates in New Mexico's rural counties[41]. In addition, they stress urgency that more direct-use projects need to be developed as soon as possible to provide energy savings before energy and heating costs drive more companies out of business and more people to the unemployment office.

Ultimately, the consensus of interviewees point to two essential questions that should be asked when considering what needs to happen in order to develop more direct-use facilities in the state:

1) What industries can utilize direct-use applications? (See Table I); and
2) What policies can encourage these developments?

1) What industries can utilize direct-use applications?

Direct-use geothermal systems replace thermal uses otherwise produced through electricity or boilers using conventional fuels. When talking with direct-use facility operators in New Mexico, they are vehement about their status as models on how to use sustainable renewable resources to benefit New Mexico communities. For example, the greenhouses at Masson Radium Springs in Dona Ana County currently employ 100 workers on their 16 acres. The direct-use heating system saves $46,200 per acre per year, and the planned expansions will incorporate 40 acres when completed (employing an additional 4-8 workers per acre) [42].

It is clear from discussions that direct-use applications can either help existing businesses and communities, or create new businesses on geothermal resource areas. For instance, there are industries with an existing infrastructure that could feasibly be retro-fitted with a geothermal direct-use system (such as greenhouses or milk and cheese processing facilities). However, retro-fitting is not as economic as using resource areas for new residential buildings or resource areas where businesses could locate (or relocate) to use the resource as a competitive advantage for developing their product. USDOE is currently funding a feasibility study for geothermal heating for the Sunnyland Farms Tomato Greenhouse in central New Mexico (near Grants in Valencia County). The greenhouses currently use fossil fuel sources for thermal energy and have faced dire financial problems due to increased energy costs. Investigations are underway to determine if a geothermal direct-use facility can be used for the Sunnyland operations, which may be relocated closer to the resource area.

In a March 2006 working group meeting in Utah, Jim Witcher noted that in order for businesses to be successful using direct-use applications, there needs to be a market to sell the product, a sound business plan, and an expert to manage the product (whether it be aquaculture, greenhouses, dairy processing, or other geothermal heat uses). According to the presentation, this includes the need for a good transportation route and year around product availability[43]. Jim Witcher is familiar with the process of developing businesses using geothermal direct-use applications, in part because of his experience working with the SWTDI at NMSU to develop a geothermal direct-use "Business Incubator" in the 1990s. The "Business Incubator" was a University program that recruited out-of-state businesses to use aquaculture and greenhouse facilities located on the campus.

Aside from the efforts of the SWTDI, there is a general consensus that several of New Mexico's businesses could benefit from geothermal resource development. For instance, geothermal resources can impact New Mexico's rapidly growing dairy industry. Milk and cheese processing are very energy intensive, and a high quality, easily accessible geothermal resource can create energy savings and economic benefits for processing and pasteurization. Other potential users include process heat for bio-fuels, refining, and chili and onion processing.

Table I: Strategic Plan – Potential uses for direct uses identified in the Strategic Plan

- Milk drying
- Mineral processing/crop and food processing
- Aquaculture
- Greenhouse technology
- Agricultural processing
- Spas

Source: New Mexico Energy, Minerals and Natural Resources Department (EMNRD). "Strategic Plan for New Mexico Geothermal Resources Development". Prepared by James C. Witcher 8/31/2004: http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/documents/NMGeothermalStrategicPlan.pdf (Appendix B, page B-5)

2) What policies can encourage these developments?

There is a general consensus that favorable government policies can play a part in expanding direct-use applications in more areas across the state. Government programs and incentives can reduce the risks and high upfront costs associated with proving and developing a resource (including the drilling of production and re-injection wells). On the federal level, USDOE is pursuing several new projects. In FY 2006, the USDOE has provided funding for feasibility studies of direct-use facilities in eight states, including two studies in New Mexico[44].

Developers and researchers in the state claim these efforts, while a good step, are insufficient by themselves to encourage an industry for direct-use applications to develop on its own. Part of the issue is bringing investors to the table. A simple way to do this is through economic incentives. According to the Strategic Plan, on the federal level, direct-use applications would benefit from a thermal (Btu) utilization incentive. On the state level, sales tax exemptions for construction equipment could help, along with thermal provisions in the RPS (mentioned above).

Another simple way to induce direct use development is by working with the agricultural community. Numerous interviewees, particularly direct-use facility operators and researchers, stress the importance of re-investment in agricultural extension programs operated by land-grant universities. These programs, which represent one component of outreach, employ staff familiar with geothermal resource development and can be a resource for farmers and ranchers. Outreach is an overall issue that must be addressed in order to create a successful market for direct-use applications. Those working in agricultural industries assert that proactive outreach to groups who might benefit from geothermal development does not generally take place. In order to spend money developing new projects, awareness of where projects can have the greatest immediate benefit -- in terms of jobs, revenues, and marketability -- is necessary. Several sources, including the Strategic Plan, emphasized this effort not only for agricultural communities, but also for tribal communities.

According to suggestions included in the Strategic Plan, state facilities and buildings should be given guidelines to consider geothermal direct-use applications where feasible and direct-use applications should be integrated into the Rebuild New Mexico Program[45]. For communities, the Strategic Plan emphasized the expansion of geothermal district heating systems where economically feasible. The New Mexico Institute of Mining and Technology (New Mexico Tech) near the Socorro Peak KGRA and NMSU in Las Cruces have both received funding to study their district heating systems. Currently, NMSU has a geothermal-heated district heating system that provides domestic hot water and space heating to dorms, athletic facilities, and academic buildings on the eastern part of campus; however the system is in need of maintenance and much of it is currently idle.

Several interviewees pointed out that state regulation play a part in establishing markets. For instance, state regulations affect the availability and cost of water rights, and although most agree that state regulation for direct-use applications are not a significant impediment to development, there is a consensus that such projects should be streamlined and given priority, especially considering how some of these projects can produce significant economic development (such as greenhouses at Lightning Dock and Masson Radium Springs).

Need to close the information gap

The prospect of developing direct-use facilities is lost when not considered in the first place. When new communities and new businesses are created in New Mexico, there is often little discussion about how to plan energy usage, especially since energy prices have only begun to rise to significant levels.

Several communities in New Mexico have been identified that could potentially utilize geothermal energy for district heating and other applications, including Albuquerque and Las Cruces. While many communities throughout New Mexico could potentially benefit from the utilization of direct-use applications, there is a general concern that these applications are not being considered and community leaders would not understand how to pursue a direct-use project even if they were interested.

Although New Mexico is generally considered an area of the country with a warm climate, the aridity and high elevation of many parts of New Mexico create significant heating loads on cold winter nights[46]. For example, the average low for New Mexico's largest city, Albuquerque (4955 feet above sea level) is below freezing from November through February. The average low is below freezing in Las Cruces (at 3908 feet) from December through February. In the State Capital of Santa Fe (at 6989 feet), the average low is below freezing from November through March. Altogether, nearly 50% of New Mexico's population lives in these cities and their surrounding metro areas, and researchers suggest that all three cities could potentially benefit from direct-use heating applications[47].

There is a general consensus that in order to bring more of these types of projects into the mainstream, state and federal agencies should be reaching out to those who have successfully developed these projects before—including businesses, companies, consultants, and contractors—and encouraging them to share their knowledge. Experienced entities could be encouraged to report on geothermal direct-use projects in industry trade magazines, such as greenhouse and aquaculture industry publications, that provide visibility about geothermal technology to a broader audience. The Strategic Plan, suggests exploring mechanisms that encourage commercial geothermal development, such as enterprise zones and municipal financing or bonds[48].

Also suggested in the Strategic Plan is to increase state efforts to use the internet, speaker's bureaus, and fact sheets that can be disseminated to the public. Furthermore, the Strategic Plan suggested that the state should, "sponsor, initiate, and coordinate educational programs such as workshops and symposiums to promote the uses of geothermal energy to various groups, including businesses, developers, New Mexico and local government departments, lawmakers, financial organizations, regulators, planners, engineers, geologists, utilities, city and county economic development organizations and forums"[49]. Among the primary emphases included in the Strategic Plan is education. Education is emphasized as a general concept in the Strategic Plan for both power production and direct-use applications (although direct-use applications are

the primary focus) and includes discussing the advantages of geothermal to the public, potential users, regulators, legislators, government policy makers, financial institutions and advisors.

However, before such information is dispensed, there is urging by the research community that information on these resources needs to be updated. This includes the need to perform a reconnaissance on all of New Mexico's direct-use installations that were identified in the past, and an update on any new installations installed since the last comprehensive update (circa 1996)[50]. Such an update may include traveling to the locations themselves, and/or checking with regulators and local chambers of commerce to get updated information.

Web Resources with more information for New Mexico

Battocletti, Liz. *The Economic, Environmental, and Social Benefits of Geothermal Use in New Mexico*. Bob Lawrence and Associates (May 2006): http://www.geothermal-biz.com/Docs/NM.pdf

Database of State Incentives for Renewable Energy (DSIRE) – New Mexico Incentives for Renewables and Efficiency: http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=NM&RE=1&EE=1

Energyatlas.org: New Mexico Renewable Energy Resources: http://www.energyatlas.org/PDFs/atlas_state_NM.pdf (Page 53)

Geo-Heat Center at the Oregon Institute of Technology (OIT): Quarterly Bulletin (December 2002): http://geoheat.oit.edu/bulletin/bull23-4/bull23-4.pdf

GeoPowering the West (GPW) – New Mexico State Fact Sheet: http://www.eere.energy.gov/geothermal/gpw/pdfs/29219.pdf

Idaho National Laboratory New Mexico Geothermal Resources (Geothermal Energy Map): http://geothermal.inel.gov/maps/nm.pdf

National Renewable Energy Lab (NREL) – "Opportunities for Near-Term Geothermal Development in the Western United States":

www.nrel.gov/docs/fy03osti/33105.pdf

New Mexico Bureau of Geology and Mineral Resources – "Geothermal Energy in New Mexico". Earth Matters (Summer 2006): http://geoinfo.nmt.edu/publications/periodicals/earthmatters/EMV6n2.pdf

New Mexico Energy, Minerals and Natural Resources Department (EMNRD). "Strategic Plan for New Mexico Geothermal Resources Development". Prepared by James C. Witcher 8/31/2004: http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/documents/NMGeothermalStrategicPlan.pdf

New Mexico Geothermal Energy Working Group: http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/Geothermal.htm

New Mexico State University – Southwest Technology Development Institute (SWTDI): http://www.nmsu.edu/~tdi/Geothermal-Energy/GeoEnergy.html

New Mexico State University – Southwest Technology Development Institute (SWTDI) – Geothermal databases:

http://www.nmsu.edu/%7Etdi/Geothermal-Energy/NMgeo-databases/NM-Geo-Databases.html

New Mexico State University – Southwest Technology Development Institute (SWTDI) – Geothermal Sites and Location Data Tables: http://www.nmsu.edu/~tdi/pdf-resources/appendix1.PDF

Witcher, James C. "Geothermal Resource Data Base, New Mexico". Southwest Technology Development Institute, New Mexico State University: July 1995: http://www.nmsu.edu/~tdi/pdf-resources/report.pdf

Endnotes

[1]EIA: http://www.eia.doe.gov/cneaf/electricity/st_profiles/new_mexico.pdf (page 151) - based on generation. By 2006, wind capacity had nearly doubled, and estimates for 2006 wind production, along with other renewables, are over 4%.

[2]See Geo-Powering the West: http://www.eere.energy.gov/geothermal/gpw/pdfs/29219.pdf & Geo-Heat Center: http://geoheat.oit.edu/bulletin/bull23-4/art2.pdf

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

[4]According to Jim Witcher in the Geo-Heat Center Bulletin (December 2002), "the Colorado Plateau (CPP) has elevated heat flow, and many deep-seated and confined aquifers that can provide mostly low-temperature 'conductive' geothermal resources. The Basin and Range (BRP) and Southern Rocky Mountains Provinces (SRMP) also have elevated heat flow and youthful faulting and volcanism. The Rio Grande Rift (RGR) is a subset of these two provinces. Low-to-intermediate temperature 'convective' resources are currently utilized in BRP and SRMP, especially in south-western New Mexico. In north-central New Mexico, a large Pleistocene rhyolitic volcanic complex straddling the rift in the Jemez Mountains has the only known high-temperature 'convective' resource in New Mexico. The Great Plains Province (GPP) generally has normal or low heat flow that is typical of a stable continental setting and only has limited potential for deep-seated low-temperature geothermal resources." SOURCE: Geo-Heat Center at the Oregon Institute of Technology (OIT): http://geoheat.oit.edu/bulletin/bull23-4/art2.pdf

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

[6]See USGS Circular 790 (1978) – page 55

[7]Goff, Fraser. "Geothermal Potential of Valles Caldera, New Mexico". GHC Bulletin, Geo-heat Center, Oregon Institute of Technology (OIT), December 2002: http://geoheat.oit.edu/bulletin/bull23-4/art3.pdf &

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

[8]A private mineral owner holds the other 1/8th of the mineral rights to the resource. The challenge for the owner would likely be obtaining the NEPA permits for a power plant and transmission.

[9]Bowers, Roger L. and Cunniff, Roy A. "Final Technical Report. Geothermal Resource Evaluation and Definition (GRED) Program – Phases I, II and III for the Animas Valley, NM Geothermal Resource". U.S. Department of Energy and Lightning Dock Geothermal Inc., August 2005.
Sources for Lightning Dock/AmeriCulture/Animas Valley:
Gary Seawright; President, AmeriCulture, Inc.: gary@americulture.com
OIT: http://geoheat.oit.edu/bulletin/bull23-4/art8.pdf

[10]The plant would be 1.42 MW gross and 1 MW net. See Bloomquist, Gordon, "Integrating Small Power Plants into Agricultural Projects" – February 2006, pages 28-30: http://www.harvestcleanenergy.org/conference/HCE6/Bloomquist.pdf

[11]Witcher, James C. "Geothermal Resource Data Base, New Mexico". Southwest Technology Development Institute, New Mexico State University: July 1995: http://www.nmsu.edu/~tdi/pdf-resources/report.pdf (pages 20-21)
Radium Springs Drilling Report: http://www.osti.gov/bridge/servlets/purl/791568-kTtzv4/native/791568.pdf
OIT: http://geoheat.oit.edu/bulletin/bull23-4/art13.pdf & http://geoheat.oit.edu/bulletin/bull23-4/art9.pdf
Alexander Masson, of Alex R. Masson, Inc.: ram@armasson.com

[12]I toured Rincon with Jim Witcher on May 17th, 2006. I also relied on his 1995 report: Witcher, James C. "Geothermal Resource Data Base, New Mexico". Southwest Technology Development Institute, New Mexico State University: July 1995: http://www.nmsu.edu/~tdi/pdf-resources/report.pdf (page 15)
[13]Witcher, James C. "Geothermal Resource Data Base, New Mexico". Southwest Technology Development Institute, New Mexico State University: July 1995: http://www.nmsu.edu/~tdi/pdf-resources/report.pdf (page 23)
[14]As of August 2006, the mine is currently inactive
[15]New Mexico Natural Gas and Oil production – Energy Information Agency (EIA)
EIA: http://tonto.eia.doe.gov/oog/info/state/nm.html &
http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_057.pdf
[16]New Mexico Bureau of Geology and Mineral Resources – "Geothermal Energy in New Mexico". Earth Matters (Summer 2006): http://geoinfo.nmt.edu/publications/periodicals/earthmatters/EMV6n2.pdf (p. 4)
[17]For more information see the USDOE: http://www.eere.energy.gov/geothermal/pdfs/egs.pdf
[18]Brown, Don & Duchane, Dave Duchane. "Hot Dry Rock (HDR) Geothermal Energy Research and Development at Fenton Hill, New Mexico." GHC Bulletin, Geo-heat Center, Oregon Institute of Technology (OIT), December 2002: http://geoheat.oit.edu/bulletin/bull23-4/art4.pdf
[19]I toured part of the Las Cruces East Mesa with Jim Witcher on May 17th, 2006. I also relied on his 1995 report: Witcher, James C. "Geothermal Resource Data Base, New Mexico". Southwest Technology Development Institute, New Mexico State University: July 1995: http://www.nmsu.edu/~tdi/pdf-resources/report.pdf (pages 18-19)
[20]Source: Barroll, M.W. and Reiter,M. (1990), "Analysis of the Socorro hydrogeothermal system: Central New Mexico," J. Geophys. Res., 95, 21,949-21,963.
The $1.2 million in savings was estimated due to expectations of rising natural gas costs for the winters of 2005 and 2006. According to researchers at NM Tech, the initial estimates for those years were lower than anticipated due to warmer than expected winter temperatures. However, it is likely that natural gas prices will increase to these numbers based on rising costs and considering the life of the project.
[21]Source – U.S. Department of Energy Tribal Energy Program (April 2004):
http://www.eere.energy.gov/tribalenergy/pdfs/jemezpueblo05final.pdf
[22]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)
[23]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.
[24]Source: Gary Seawright; President, AmeriCulture, Inc.: gary@americulture.com
[25]See Idaho National Laboratory (INL) Map: http://geothermal.inel.gov/maps/nm.pdf
[26]The 46.3% comes from the BLM (2002): Mineral and Surface Acres Administered by the Bureau of Land Management: http://www.blm.gov/natacq/pls02/pls1-3_02.pdf#search=%22MINERAL%20AND%20SURFACE%20ACRES%20ADMINISTERED%20BY%20%22
The reason that BLM owns more mineral rights in New Mexico is due to the interpretation of the Stock-Raising Homestead Act of 1916. The law says that even when land was sold to Homesteaders by the federal government, the mineral rights could be retained if the minerals in the land were considered prospectively valuable. This was later interpreted to include geothermal resources.
Source: Jay Spielman: jspielma@nm.blm.gov
[27]*SOURCES: University of Nevada-Reno, University Center for Economic (1999):*
http://www.unce.unr.edu/publications/FS01/FS0132.pdf
Source: Jay Spielman – NM BLM: : jspielma@nm.blm.gov
[28]For more information on new regulations see the U.S. Department of Interior:
http://www.doi.gov/iepa/2005_results.pdf (Section 222-224)
[29]For more information on the CREB program, see the Environmental Law & Policy Center (ELPC) Clean Renewable Energy Bonds: http://www.elpc.org/energy/farm/crebs.php

[30]**Large Investor-owned Utilities that qualify for the RPS**
PNM Resources – In 2004, PNM provided approximately 43.1% of the electricity for New Mexico residents. They later combined with Texas-New Mexico Power Company, who is included in the 43%.
SW Public Service Company (Xcel Energy) – In 2004, SW Public Service Co. provided approximately 17.8% of the electricity for New Mexico residents.
El Paso Electric Company – In 2004, El Paso Electric Co. provided approximately 7.2% of the electricity for New Mexico residents. Source – Energy Information Agency (EIA): http://www.eia.doe.gov/cneaf/electricity/st_profiles/new_mexico.pdf

[31]This system also encourages solar, biomass, landfill gas, and fuel cells. One kWh of electricity generated by biomass, geothermal, landfill gas or a fuel cell is worth two kWh toward the RPS and one kWh of electricity generated by solar resources is worth three kWh toward the RPS.
Info on the NM RPS: http://www.geocollaborative.org/publications/RPS.pdf (pgs. 49-50, 96)
The Database of State Incentives for Renewable Energy (DSIRE): http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NM05R&state=NM&CurrentPageID=1&RE=1&EE=1

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

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

[34]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. PURPA requirements in New Mexico have placed no specific limits on plant size.
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

[35]Information on the State Renewable Energy Production Tax Credit – The Database of State Incentives for Renewable Energy (DSIRE): http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NM02F&state=NM&CurrentPageID=1&RE=1&EE=1 & Michael McDiarmid, New Mexico Energy, Minerals and Natural Resources Department (EMNRD): michael.mcdiarmid@state.nm.us

[36]The program has been used for geothermal heat pumps. See the Database of State Incentives for Renewable Energy (DSIRE) – Energy Efficiency & Renewable Energy Bond Program: http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NM07F&state=NM&CurrentPageID=1&RE=1&EE=1

[37]The bullet points below are included in multiple locations within the analysis of the Strategic Plan. Source: New Mexico Energy, Minerals and Natural Resources Department (EMNRD). "Strategic Plan for New Mexico Geothermal Resources Development". Prepared by James C. Witcher 8/31/2004: http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/documents/NMGeothermalStrategicPlan.pdf

[38]New Mexico Energy, Minerals and Natural Resources Department (EMNRD). "Strategic Plan for New Mexico Geothermal Resources Development". Prepared by James C. Witcher 8/31/2004: http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/documents/NMGeothermalStrategicPlan.pdf (page 17 of 28)

[39]Battocletti, Liz. *The Economic, Environmental, and Social Benefits of Geothermal Use in New Mexico.* Bob Lawrence and Associates (May 2006): http://www.geothermal-biz.com/Docs/NM.pdf (page 4)

[40]"In New Mexico all geothermal resources with temperatures of 250°F or less fall under New Mexico water law and require permitting with the New Mexico State Engineers Office (NMSEO). There are two areas in New Mexico with leases for geothermal resources under 250°F, and both pay small royalties (no more than $10,000) to the State Lands Department. All geothermal use from Federal land is also subject to leasing and royalty requirements of the U. S. Bureau of Land Management (BLM) and the U. S. Minerals Management Service (MMS). Geothermal resources greater than 250°F on State lands are subject to leasing and royalties with the State Lands Department and they also require drilling and production permits from EMNRD's Oil Conservation Division (OCD) and the NMSEO." *See* New Mexico Energy, Minerals and Natural Resources Department (EMNRD). "Strategic Plan for New Mexico Geothermal Resources Development". Prepared by James C. Witcher 8/31/2004: http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/documents/NMGeothermalStrategicPlan.pdf (page 7 of 28)

[41] Unemployment rates (2005): ftp://ftp.bls.gov/pub/special.requests/la/laucnty05.txt

[42]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

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

[44]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)

[45]Rebuild New Mexico is a public-private partnership with support from the state and federal government that relies on grants towards energy-efficiency and renewable energy projects. New Mexico has used grants to promote updated Codes and Standards to the construction industry and to provide broad educational programs and workshops on energy efficiency
Source: http://www.rebuildnewmexico.org/

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

[47]**Weather Statistics**
Las Cruces: http://www.weather.com/weather/wxclimatology/monthly/graph/USNM0169?from=search
Santa Fe: http://www.weather.com/weather/wxclimatology/monthly/graph/USNM0292?from=search
Albuquerque: http://www.weather.com/weather/wxclimatology/monthly/graph/USNM0004?from=search

[48]New Mexico Energy, Minerals and Natural Resources Department (EMNRD). "Strategic Plan for New Mexico Geothermal Resources Development". Prepared by James C. Witcher 8/31/2004: http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/documents/NMGeothermalStrategicPlan.pdf (page 20 of 28)

[49]New Mexico Energy, Minerals and Natural Resources Department (EMNRD). "Strategic Plan for New Mexico Geothermal Resources Development". Prepared by James C. Witcher 8/31/2004: http://www.emnrd.state.nm.us/emnrd/ecmd/Geothermal/documents/NMGeothermalStrategicPlan.pdf (page 20 of 28)

[50]This refers to research performed by the Geo-Heat Center at the Oregon Institute of Technology (OIT): http://geoheat.oit.edu/state/nm/all.htm