GEOTHERMAL ENERGY IN NEW MEXICO

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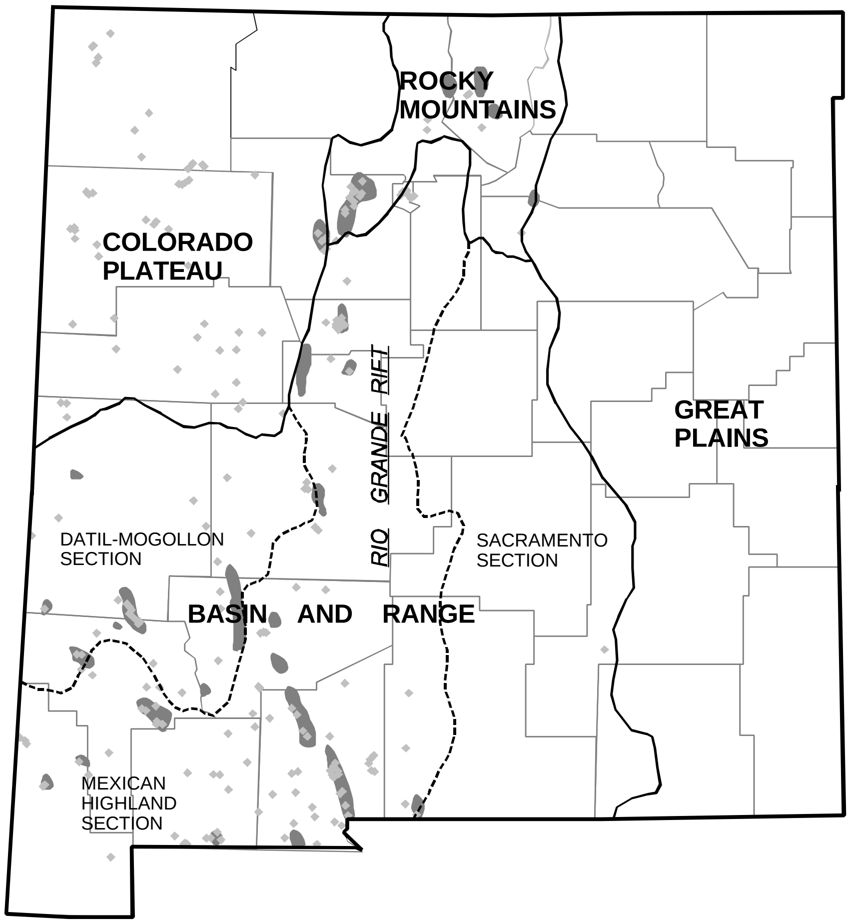

Figure 1. Physiographic provinces and major geothermal fields in New Mexico (Witcher, 1995).

INTRODUCTION

Important economic growth in New Mexico has occurred during the last decade and a half with direct-use of geothermal energy. New Mexico has taken the nation's lead in geothermal greenhouse acreage with more than half of the state's acreage now heated by geothermal. In some recent years, geothermal greenhouse gross receipts have exceeded those of field grown chile and ranked as high as fifth in over all agriculture sector gross receipts. New Mexico is appealing to the greenhouse industry for several reasons, including a good climate, inexpensive land, a good agricultural labor force, and the availability of low-cost geothermal heat. More than half of this geothermal development is directly-tied to the geothermal program at the Southwest Technology Development Institute (SWTDI) at New Mexico State University (NMSU) in Las Cruces.

GEOTHERMAL PROGRAM AT NEW MEXICO STATE UNIVERSITY

The geothermal program at Southwest Technology Development Institute at New Mexico State University in Las Cruces has actively recruited out-of-state greenhouse businesses in past years, and has stimulated the creation of entirely new businesses and assisted existing businesses through an integrated program of geological studies, engineering, and marketing assistance that is centered around business incubator facilities, the NMSU Geothermal Research Greenhouse (GRG) and NMSU Geothermal Aquaculture Center (GAC). During the last 15 years, five clients have leased the GRG. Of the five, three were new business startups; while, two were out-of-state businesses, interested in moving operations to New Mexico. With the large geothermal resource base in the state, future economic benefits may be enormous.

RESOURCE BASE

Many types of geothermal resources occur in New Mexico. This is largely due to the geologic and physiographic diversity of the state. Four major physiographic provinces are found in the state and each has unique geologic heritage, geothermal characteristics, hydrogeology, demographics and therefore, potential (Figure 1). 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.

The only known high-temperature geothermal system in New Mexico is found on the southwest side of Redondo Peak, a resurgent dome in the Valles Caldera (Goff, this Bulletin). The Valles reservoir is under pressured and liquid-dominated with a base temperature in excess of 260ºC (500ºF). Locally, small vapor-dominated systems overlie the liquid dominated system; where, boiling and permeability is lower. In the 1970s and early-1980s, the Baca Land and Cattle Company and UNOCAL Geothermal performed exploration and drilling on the Valles geothermal system. In 1977, a 50-MWe power plant was proposed as a part of collaboration of UNOCAL Geothermal, Public Service Company of New Mexico (PNM), and the U.S. Department of Energy (USDOE). In 1982, the project was terminated due to a failure to obtain the necessary fluid production from drilling and from various disputes over land and water use. Since 1982, strategic parts of the Valles system were drilled as a part of the Continental Scientific Drilling Program (CSDP)(Gardner, et al., 1989). Also, of note, the national Hot Dry Rock (HDR) program used a site at Fenton Hill, just outside of the Valles Caldera on the caldera rim and west of the Valles geothermal system beneath Redondo Creek and Sulfur Creek (Duchane & Brown, this Bulletin. Most recently, the Baca Land Grant portion (Baca Land and Cattle Company lands) of the Valles Caldera has been sold to the federal government for $101 million and designated the Valles Caldera National Preserve by the U S. Congress and signed into law by President Clinton in July 2000. Any near-future geothermal development of the Valles geothermal system is uncertain at this time. However, based upon the results of exploration and drilling in the 1970s and 1980s, at least 20 to 30 MWe of geothermal power potential is probably present. On the other hand, the outflow plume of the Valles geothermal system has much potential for low-temperature direct-use heating as far south as Jemez Pueblo. Carbonate (calcite and aragonite) scaling potential and hydrogen sulfide corrosion potential is high at all potential sites along the south-flowing outflow plume beneath San Diego Canyon of the Jemez River.

Current space heating and geothermal greenhouse and aquaculture development in New Mexico is in the BRP and RGR with wells less than 980 ft depth. The currently used resource represents discharge from deeply-penetrating, large-scale, regional groundwater flow systems in fractured bedrock which sweeps up heat at depth and concentrates it in the near surface, and structurally-controlled upflows and associated shallow lateral outflow plumes. All of these systems are found in structurally high terrane in normal fault footwalls or horst blocks, and are preferentially associated with extensional fault accommodation or transfer zones. The higher temperature systems are always associated with the vergent boundaries of northwest-trending pre-rift basement-cored Laramide orogeny compressional uplifts that are broken by north-trending extensional faulting. Maximum temperatures of these geothermal systems are probably limited to 300 and 350ºF at depths less than 3,000 to 4,000 ft. Water quality of the systems is generally between 1,000 and 3,500 mg/L total dissolved solids (TDS) and usually represents a sodium chloride to chloride-sulfate-bicarbonate chemistry, depending upon the bedrock host rocks. Hydrogen sulfide is only present in trace amounts at a few sites and carbonate scaling potential varies from site to site.

CURRENT GEOTHERMAL USE

Electric Power

Geothermal electrical power production is currently done in conjunction with the large 30-acre Burgett Geothermal Greenhouse in the Animas Valley near Cotton City (Figure 2). The Burgett power plant provides a model for how geothermal electrical power may best be accomplished in New Mexico. The Burgett facility has evolved into a cascaded system; where, 230ºF well production is fed into the power plant heat exchangers at a rate of 1,200 gallons per minute (gpm) and the 185ºF outflow from the power plant is used for space heating of the greenhouses. The Burgett power plant applies binary power technology. A heat exchanger allows the geothermal water to heat a low boiling-point working fluid that is isolated in a closed loop across the turbine, condenser, and heat exchanger. The Burgett power plant consists of three modular 0.3 MWe units that use isopentane, a hydrocarbon working fluid. Power produced by the plant is used on location at the greenhouse.

Geothermal Aquaculture

The AmeriCulture Fish Farm at Cotton City in southwest New Mexico (Figure 2) raises tilapia from eggs produced on site. AmeriCulture markets and sells a disease-free Tilapia fry to growers and researchers nationwide for grow out to full size. Tilapia is a fish that is growing in popularity for its taste. In recent years, local Red Lobster seafood restaurants have added Tilapia to the menu.

Geothermal offers several advantages for fish culture. For instance, AmeriCulture is heated at much lower costs than fossil fuels with a downhole heat exchanger installed in a 400-ft depth well. Many species have accelerated growth rates in

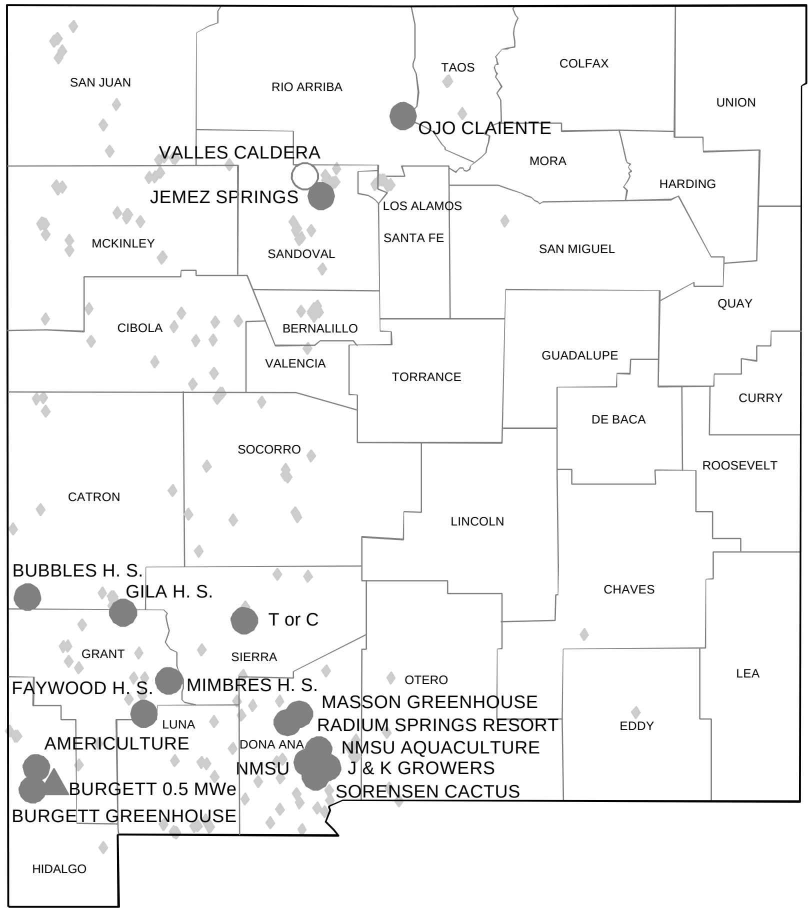

Figure 2. Location of hot springs and geothermal wells (diamonds), and geothermal utilization in New Mexico (Withcer, 1995).

warm water. In addition, the geothermal water can be used as a growth medium; thereby, adding to the agriculture receipts in the state without consumptive use of valuable freshwater supply.

Geothermal Space and District Heating

The aridity and high elevation of New Mexico creates significant heating loads on winter nights. Where shallow geothermal resources are collocated with large heating demands, space and district heating is favorable and can compete with fossil fuel costs. Many of these sites are also favorable for spas.

In operation since 1982, a district geothermal heating system on the NMSU campus in Las Cruces uses up to 260 gpm of 143ºF water that is produced from less than 980 ft depth. Geothermal water is passed through a heat exchanger to heat freshwater that is fed as needed into space and domestic hot water loops on campus. The geothermal water with heat removed is injected into the reservoir margin beneath the NMSU golf course. Geothermal heating is used in the dorms, academic buildings, and athletic facilities on the eastern third of the campus. Geothermal heat also provides domestic hot water for showers in the dorms and athletic facilities.

At Gila Hot Springs, geothermal space and district heating is applied to a trailer court, rental cabins, a store, and several homes. A 300 ft depth flowing well provides 165ºF water for heating.

Geothermal Spa and Pool Heating

There are a number of resorts and spas that use geothermal fluids for heating the various soaking tubs and swimming pools throughout the state. These include three in Grant County at Faywood Hot Springs, Mimbres Hot Springs and Gila Hot Springs; one each in Rio Arriba County at Ojo Caliente; Sandoval County at Jemez Springs; Dona Ana County at Radium, and several in Truth or Consequences. This latter location has approximately eight spas using the geothermal water in thermal baths and swimming pools at slightly over 100ºF. A recent reference on New Mexico Hot Springs gives additional details on this natural resource (Bischoff, 2001).

Geothermal Greenhousing

The most important geothermal use in New Mexico is for greenhouses (Figure 2). Geothermal greenhousing accounts for more than half of the greenhouse acreage in the state. In fact, New Mexico leads the nation in geothermal greenhouse acreage. Table 1 lists the geothermal development in New Mexico.

The success and growth in the geothermal greenhouse industry in New Mexico can be attributed to several factors including a good climate with abundant sunshine and low humidity, inexpensive land, collocation of geothermal resources with a supply of freshwater, a good agricultural labor force, and the availability of favorable shallow geothermal resources. Current geothermal green-houses use wells less than 1,000 ft depth with resource temperatures ranging from 143 to 240°F.

ECONOMIC IMPACT

A measure of the importance of geothermal greenhousing is found in Table 2. Altogether, a total of 52 acres are heated with geothermal and represent a capital investment of over $18 million, a payroll of more than $4 million, and gross receipts exceeding $12 million. This places geothermal greenhouse sales among the top 10 agriculture sectors in the state. The Burgett Geothermal Greenhouse near Cotton City is the largest employer and business in Hidalgo County. The Masson Radium Springs Farm geothermal greenhouse is the largest employer in northern Dona Ana County.

POLICY AND FUTURE DEVELOPMENT

Over the last 25 years or more, the geothermal policy at the federal level and in most of the geothermal industry has predominantly focused on electrical power generation. When one looks at the resource base and success that has accrued to regions like California and Nevada, this is an attractive and seductive approach to developing policy and committing resource exploration and development budgets. However, in New Mexico more than 5,000 MWe is produced by traditional fossil fuels and only about 40 to 45 percent of this electric power is used in state. The Valles geothermal resource in the Jemez Mountains is the only resource with proven reserves that exceed 20 MWe. This is the only resource in the state with a probable magma heat source. Development of this site by industry is tentative due to its designation as a national preserve. However, this site could provide a politically-attractive opportunity for the Pueblos of northern New Mexico to be energy self-sufficient and at the same time proactively protect tradition interests, cultural sites, and water rights in the Jemez Mountains, and generate income for the tribes and for the management of the preserve.

Inferred reserves at other sites in New Mexico are all probably less than 5 MWe. Small-scale geothermal electric power at these sites only makes good sense if it is done in conjunction with cascaded direct-use and the generated power is used on site to assist or augment a direct-use operation. For comparison, the gross receipts or cash flow of an acre of greenhouse that grows potted plants is equivalent to 1 to 2 MWe of electric power generation with wholesale energy sales of $0.10 per kilowatt-hour. Federal and state geothermal policy should emphasize direct-use geothermal endeavors in New Mexico over standalone electric power generation. Federal royalty rules for direct-use and regulatory requirements for low- and intermediate-temperature drilling on federal lands are impeding geothermal development in the state and should be modified to provide a realistic framework for development. Currently, all geothermal direct-use is done on private and state mineral properties except for a small 2-acre geothermal greenhouse east of Las Cruces. In addition, the BLM has designated the Las Cruces East Mesa as a Known Geothermal Resource Area (KGRA). A KGRA designation, coupled with current minimum acreage lease application requirements, certainly puts a chill on long-range land use planning for geothermal and any large-scale district heating endeavors as Las Cruces grows across the resource which it is poised to do in the next 5 to 10 years. Developers have enough permitting issues with city, county, and state governments.

CONCLUSIONS AND FUTURE POTENTIAL

Geothermal is more than energy. Geothermal is a potentially powerful vehicle for important rural economic development. The future of direct-use geothermal in New Mexico may include chile and onion drying, cheese and milk processing, additional aquaculture, greenhouses and district heating. Small-scale electric power generation is very likely to occur in a cascaded mode with direct-use development. The accessible geothermal resource base is vast and the options for economic utilization are many. However, oppressive federal royalty and leasing rules are stalling use of the federal geothermal resource of direct-use applications and much needed economic development in rural areas.

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Table 1. Geothermal Utilization in New Mexico

Site	Max. T (°F)	Peak Flow (GPM)	Energy 10^9Btu/yr	Capacity MWt	Application
Catron County	120	50	1	0.2	Resort & Spa - Bubbles Hot Springs near Glenwood (Lower Frisco Hot Springs)
Dona Ana County	148	250	36	6.0	District Heating (NMSU)
Las Cruces area	148	60	3	0.3	Greenhouse - STDI (NMSU)
	135	25	<1	<0.1	Aquaculture - STDI (NMSU)
Radium Springs	145	200	10	3.1	Greenhouse - J & K Growers
	170	1,000	77	12.9	Greenhouse - 2nd largest nationally, Masson Radium Springs Farm
	112	10	1	0.1	Baths - Radium Hot Springs Resort
Grant County	130	50	1	0.2	Resort & Spa - Faywood Hot Springs
	135	50	1	0.2	Resort & Spa - Mimbres Hot Springs
	165	75	3	0.4	District Heating / Resort & SpaGila Hot Springs
Hidalgo County	230	2,000	184	19.0	Greenhouse - Largest nationally, Burgett Geothermal Greenhouses
Cotton City	185	200	11	0.7	Aquaculture - AmeriCulture Inc.
Rio Arriba County	115	60	1	0.2	Resort & Spa - Ojo Caliente
Sandoval County	155	50	1	0.2	Resort & Spa - Jemez Springs Bathhouse
Sierra County	110	1,000	8	0.7	Resort & Spa - Several spas in Truth or Consequences
	Total		**339**	**44.3**	**Note: Energy use is estimated.**

Table 2. Details of Geothermal Greenhouses

Site	Location	Product	Size	Employees/ Jobs	Payroll	Capital Investment	Sales Gross	Energy Use	Energy Savings
			Acres	Persons	1000 $/yr	1000$	1000 $/yr	10^9Btu/yr	1000 $/yr
Burgett Geothermal	Animas/ Cotton City	Cut Roses	32	90	2,080	11,200	4,000	184	736
Masson Radium Springs	Radium Springs	Potted Plants and Flowers	16	136	1,988	5,600	7,395	77	308
J & K Growers	Las Cruces	Potted Plants and Flowers	2	16	234	700	870	10	40
Sorensen Cactus	Las Cruces	Decorative Cactus	1	8	117	350	435	4	16
		Totals	**51**	**250**	**4,419**	**17,850**	**12,700**	**275**	**1,100**