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Status of Nevada Geothermal Resource Development – Spring 2011

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ABSTRACT

Recent increases in geothermal exploration and power plant construction in Nevada are the first significant activities since the Steamboat II/III and Brady plants came on line in 1992. Exploration activity on existing projects grew between 2005 and 2010, culminating in the construction of several new power plants. The BLM's 2007 lease auction (first since the 2005 Energy Policy Act revisions) opened the door to exploration on greenfield properties. The number of wells permitted and drilled remained low from 1994 through 2003, but rose sharply to peak in 2009. However, over 760,000 acres were leased between 2007 and 2010, with numbers of acres, price per acre, and number of wells drilled declining in 2010 as the activity appeared to level off as previously leased parcels were evaluated with thermal gradient holes and other assessment methods. This decline in leasing in 2010 could be attributed to the companies focusing on advanced stage projects to take advantage of the production tax credit by 2013. In addition, markets remained reluctant to fund early stage exploration companies and projects.

Introduction

The most recent update of geothermal activities in Nevada was published in 2002 (Garside et al., 2002; GRC Transactions), and considerable exploration and development has occurred since that last summary. Currently, there are 439.5 MW of installed capacity in Nevada as of the completion of the Jersey Valley power plant in early 2011. The first power plant to be constructed after 13 years of inactivity was the Galena 1 unit (30 MW) at Steamboat Hills in 2005. Subsequent units were constructed at Steamboat in 2007 (Galena 2, 13.5 MW) and 2008 (Galena 3, 30 MW), bringing the total nameplate capacity (reported to the Nevada Division of Minerals) to approximately 147 MW. After the renewed interest in geothermal plant construction in 2005, the next plant to be built was the Desert Peak II in 2006, which is a new binary power plant that was built to replace the original steam turbine power plant at Desert Peak. The original Desert Peak unit was permanently shut down on May 1, 2006. The new power plant came online on August 1, 2006 with a generation capacity of 23 MW, more than twice that of the original power plant. Then in 2009 two new plants were constructed in new geothermal areas not previously exploited: Blue Mountain (49.5 MW) and Salt Wells (47.2 MW). These were the first new geothermal developments since 1992 that were not expansions of existing resources, a 17 year hiatus in new geothermal development. Jersey Valley completed construction in early 2011, and plants are being built at Patua and McGuiness Hills. More new plant construction is anticipated in the near future as over 70 properties have active exploration programs, many of which are briefly discussed in a companion paper (Shevenell and Zehner, this volume).

Historical View of Geothermal in Nevada

Prior to 2005, BLM lands were leased non-competitively in Known Geothermal Resource Areas. In response to provisions to the 2005 Energy Policy Act, BLM geothermal leasing rules were significantly modified. No leases were issued in 2005 and 2006 while the new rules were being written, and the first totally

Table 1. Geothermal leasing activity in Nevada, 2007-2010.

Year	Parcels		Acres	Total receipts	Average per acre
	offered	sold			
2007	43	43	122,849	$11,669,821	$95
2008	35	35	105,212	$28,207,806	$268
2009	108	82	323,223	$8,909,445	$28
2010	114	75	212,370	$2,762,292	$13
2011	51	17	42,627	$456,353	$11
Totals:	351	252	806,281	$52,005,717	$83

Source: http://www.blm.gov/nv/st/en/prog/minerals/leasable_minerals/geothermal0/ggeothermal_leasing.html

competitive lease sale was conducted on August 14, 2007. Results of these competitive sales are noted in the following table and figure. The total dollar amount generated from BLM lease sales peaked in 2008, yet the most parcels and acres were sold in 2009, with 2010 and 2011 showing a significant decline in prices paid per acre as companies are busy developing properties acquired in previous lease sales. All parcels offered were sold in 2007 and 2008, yet only 66 and 33% of the parcels offered were sold in 2010 and 2011, respectively (see Table 1 and Figure 1).

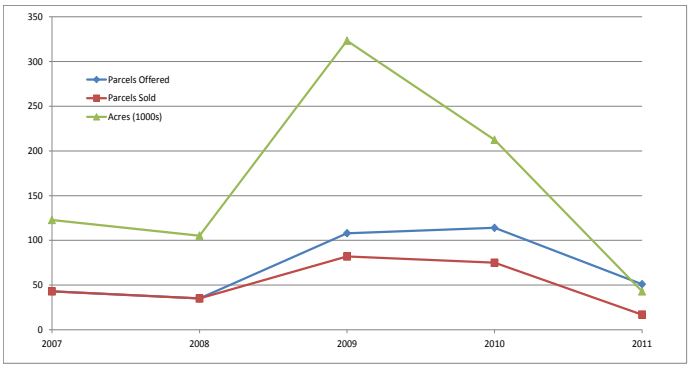

Figure 1. Trends in geothermal leasing on BLM lands in Nevada. Note that acres are in 1000's in order to show the data from Table 1 on one graph.

Table 2. Nevada geothermal power plants, 2011.

Plant name (year on line)	Nameplate Capacity (MW)	Location	Operator
Beowawe (1985)	16.6	S13,T31N,R47E	TerraGen Power, LLC
Blue Mountain (2009)	49.5	S14,T34N, R34E	Nevada Geothermal Power
Bradys (1992)	26.1	S12,T22N,R26E	Ormat Nevada
Desert Peak (1985) Desert Peak II (2006)[2]	Decommis-sioned 23.0	S21,T22N,R27E	Ormat Nevada
Dixie Valley (1988)[3]	62.0	S7,T24N,R37E S33,T25N,R37E	TerraGen Power, LLC
Empire (1987)	4.8	S21,T29N,R23E	USG Nevada LLC
Jersey Valley (2011)	15.0	S28,T27N,R40E	Ormat Nevada
Salt Wells (2009)	18.0	S36,T17N,R30E	Enel North America
Soda Lake No. 1 (1987) Soda Lake No. 2 (1991)	5.1 21.0	S33,T20N,R28E S33,T20N,R28E	Magma Energy Corp
Steamboat I (1986)[1] Steamboat I-A (1986) Steamboat II (1992) Steamboat III (1992) Galena (2005) Galena 2 (2007) Galena 3 (2008) Steamboat Hills (1988, formerly Yankee Caithness) Total MW at Steamboat	7.4 2.4 25.6 25.6 30.0 13.5 30.0 20.1 147.2	S29,T18N,R20E S29,T18N,R20E S5,6,T17N,R20E	Ormat Nevada
Stillwater (1989) isolated from the grid; shut down mid-January Stillwater 2 (2009)	47.2	S1,T19N,R30E S6,T19N,R31E	Enel Stillwater
Wabuska (1984)	2.4	S15,16,T15N,R25E	Homestretch
Total:	437.9		Geothermal

[1] *Ormat decommissioned the Steamboat I plant.*

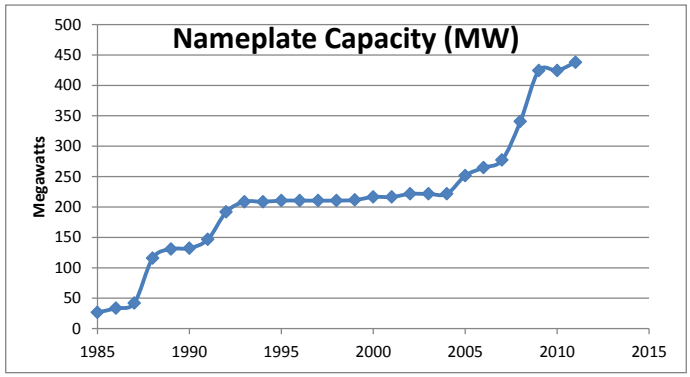

Figure 2. Nameplate generating capacity (MW) of all Nevada power plants in operation by year.

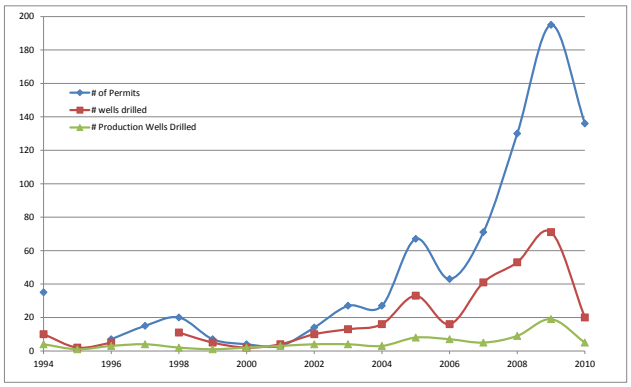

Figure 3. Number of permits issued by the Nevada Division of Minerals and number of wells drilled.

Figure 2 shows the steady growth in MW capacity in the late 1980's and early 1990's, with flattening of the trend for a 13 year period. As noted in the introduction, new power plants started to come on line in 2005, and as such Nevada has experienced a new jump in on-line generating capacity, although a relatively modest increase in actual generation.The statistics used to construct the next four plots were compiled from the annual report published by the Nevada Bureau of Mines and Geology, "The Nevada Mineral Industry" (http://www.nbmg.unr.edu/dox/mi/09.pdf).

Figure 3 shows the total number of permits issued by the Nevada Division of Minerals (NDOM) and the total number of wells (gradient, injection, production), and total number of production wells drilled by year based on record from NDOM. For most years, particularly more recent ones, there have been far more permits issues than wells drilled. In 2010, there were five new production wells drilled (with none of those having been permitted in 2010), with slightly over half of the 30 wells that were drilled having been thermal gradient wells.

With data compiled from the department of taxation and the annual Nevada Mineral Industry report, Figure 4 was constructed showing the variation in annual revenue that the geothermal industry generated along with the variation in average price (for all power sold

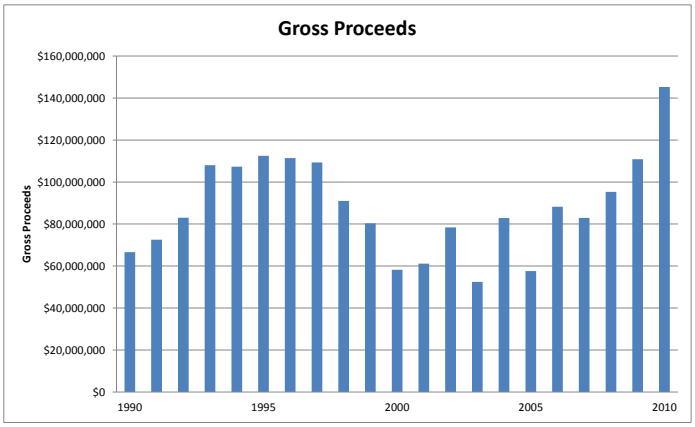

Figure 4. Total gross proceeds of the Nevada geothermal industry by year.

regardless of source) noted in www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html. The exact price paid by the utilities for geothermal power varies by contract, with these values being held confidential as part of the contract.he price variations noted at the above web site for 2010 of 9.39 cents is the average of power paid by residential, commercial, industrial, transportation and other sectors all combined for all power sources. The cost of power from geothermal alone cannot be determined.

Existing Power Plants

Current capacity for the existing power plants is listed in Table 2. Locations of these power plants is illustrated in Figure 5.

The MW numbers quoted above are nameplate capacities (likely the maxima), which are relatively elusive numbers. Nameplate capacity is the manufacture's rating of equipment output capacity as reported to the Nevada Division of Minerals by the

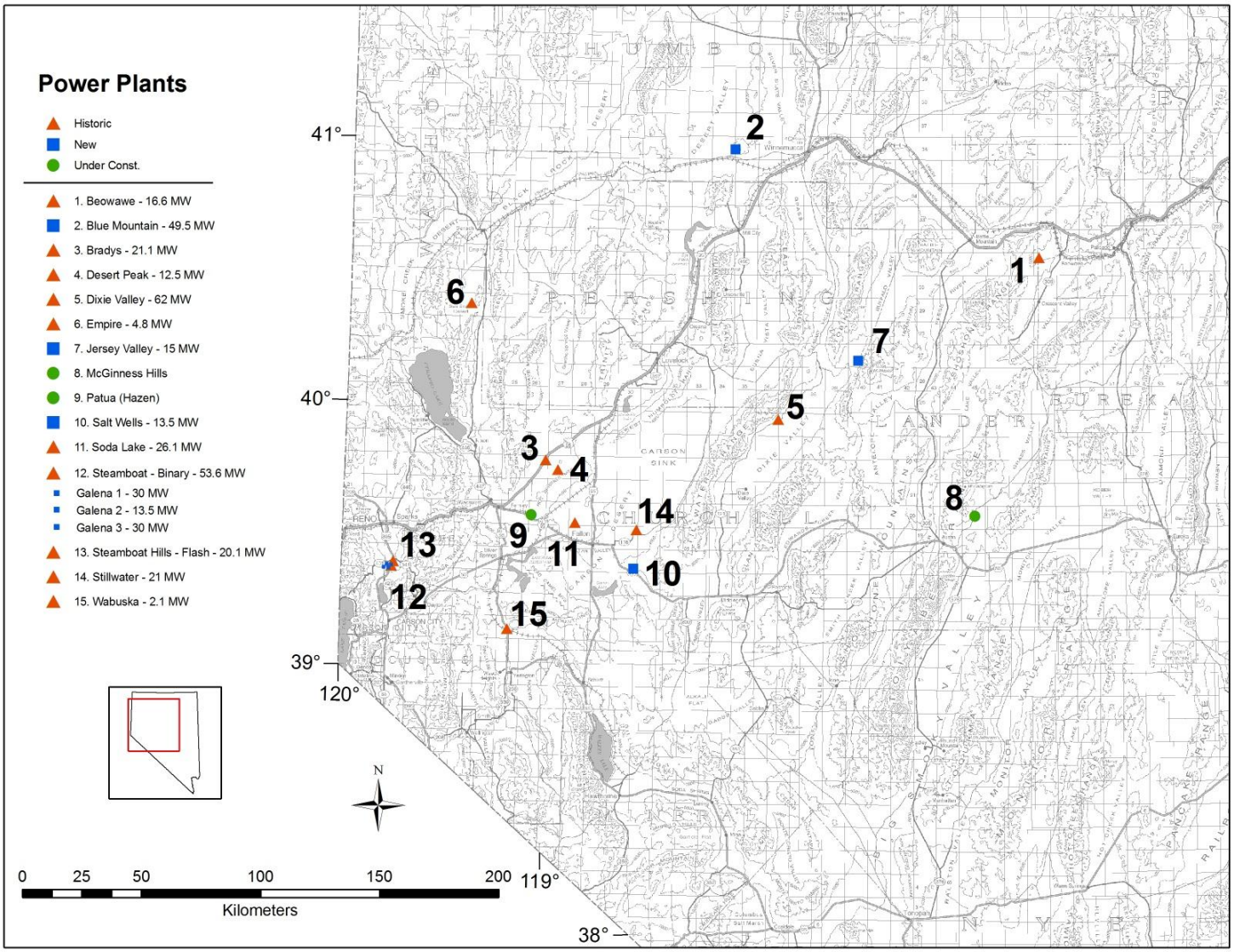

Figure 5. Location of existing and planned power plants in Nevada. Steamboat-binary consists of 6 separate power plants that have a combined generating capacity of 127 MW. Only the three new plants constructed since 1992 are listed separately under the binary category. "Historic" plants were constructed prior to 2005.

plant operators (as of February, 2011) and does not necessarily reflect the capability of the currently developed resource. These nameplate capacities are estimates, and several different values can be found in the literature. Generator nameplate capacity actually refers to how big the actual generator is but not the turbines or the actual capacity of the power plant. There are no public documents breaking down nameplate capacity of the turbines or gross power so these numbers may not adequately reflect actual generation (Dan Fleischmann, pers. comm., June 1010). In service (MW) is the MW reported by NV Energy (2010) as in service in 2009.

New Power Plants since 1992

A brief description of each of the new power plants constructed beginning in 2005 follows.

Blue Mountain (Faulkner 1)

The Nevada Geothermal Power, Inc. (NGP)Blue Mountain project area covers approximately 17.4 square miles (45 km^2) in Humboldt County in T36N, R34E, Nevada above a blind geothermal system with no visible hydrothermal features at the surface. This geothermal area was located during gold exploration drilling that encountered high temperature water (up to 88°C) in the early 1990s (Parr and Percival, 1991). Later temperature logging of drill holes found temperatures up to 81°C in a 108-m drill hole (Fairbank and Ross, 1999) No hot springs or spring deposits were known in the area, which is mostly covered by Quaternary alluvium.The hot fluids probably circulate along numerous north-striking normal faults in Triassic metasedimentary rocks present in the subsurface along the west flank of Blue Mountain, which is controlled by a northeast-striking range fault in this area.

NGP signed a fixed-price, date-certain engineering, procurement, and construction (EPC) contract with Ormat Nevada, a subsidiary of Ormat Technologies Inc., toconstruct the Blue Mountain Faulkner 1 binary cycle geothermal power plant by December 31, 2009. Maximum temperatures encountered at the site are 188°C (370.4°F) at approximately 2,000 ft (610 m) (Niggeman et al., 2009). Ormat completed construction of the plant approximately four months ahead of schedule, and NGP brought the plant on line in September 2009, and held the official dedication ceremony on October 22, 2009. NGP estimates that the Blue Mountain geothermal resource should be able to eventually support power production at the level of 49.5 MW gross, 39.5 net. As of November 2009, Blue Mountain was producing power at a sustainable rate of 27 megawatts (MW) net as plant output was limited by deep injection capacity. Three additional deep wells were planned to bring the plant up to a capacity of greater than 40 MW (net). Capacity by the end of 2009 was up to 30.5 MW (net). The company reported that Department of Treasury grant funds ($57.9 million awarded) will be used to complete additional drilling and pipeline connection. They were the first geothermal developer to receive an investment tax credit (ITC) for development of a property. Early production wells 14-14, 15-14 and 17-14 have production capacities between 7 and 7.5 MW (net) each, similar to the three original wells drilled (23-14, 25-14, 26A-14 (3/9/09 company press release). The resource is an artesian reservoir at or below an elevation of about 1,100 ft (about 335 m), and geothermometers predict reservoir temperatures of 250°C (about 482°F) at depth. Waters produced are oversaturated with respect to silica, causing a potential for scaling, which is being mitigated by chemical inhibition (Casteel et al., 2009). NGP completed construction of a 20-mile-long 120 kV overhead transmission line that connects to the electric grid just north of Mill City with an approved capacity of 75 MW. The path of the transmission line traverses a checkerboard of land ownership that is approximately 50% private land and 50% public land administered by the Bureau of Land Management. Due to the checkerboard nature of the property, NGP acquired the mineral rights to Blue Mountain from Gryphon Gold Corp in order to protect access to the geothermal resources. Additionally, NGP hired GeothermEx to conduct reservoir modeling and evaluate its power production potential over the long term. A preliminary conceptual model of the Blue Mountain area is presented in Casteel et al. (2009). http://www.nevadageothermal.com/s/Home.asp).

Jersey Valley

The Jersey Valley geothermal area is located at the base of the western flank of the Fish Creek Range in Pershing County (T27N, R40E), likely along a projection of a mountain-front fault shown by Stewart and Carlson (1976) Early temperature estimates using silica and Na-K-Ca geothermometers indicated reservoir temperatures of 142°**C**and 182°C, respectively (Mariner and others, 1974). Ormat Nevada Inc. began drilling in this area in 2007, encountering valley fill and metasediments of the Fish Creek Range. A 20-year power purchase agreement (PPA) between Ormat Technologies Inc. and NV Energy was established. Construction of a 30 to 35 MW nameplate-capacity generation facility began in mid-2010, with initial power generation of approximately 15 MW. As of February 3, 2011 ORMAT's 15 MW Jersey Valley power plant is built and in commissioning, operating at partial capacity with final completion planned for the second quarter of 2011. The Jersey Valley power plant was the only geothermal power plant built in Nevada in 2010.

Soda Lake

Geothermal activity was apparently unknown or very poorly known in the area until a well drilled in 1903 to supply water for a topographic survey camp for the Truckee-Carson Irrigation Project hit boiling water at about 18 m, and the well was still emitting hot steam in 1974. Alteration in Quaternary sediments exposed at the surface probably indicates shallow subsurface boiling (Olmstead and others, 1975); a hot spring may have discharged at this site through the end of the 19th century (Hill and others, 1979).

At Soda Lake, several hundred to more than 1,000 m of Quaternary and Tertiary sedimentary and volcanic rocks overlie a Mesozoic metamorphic basement. Geothermal fluids in the Soda Lake area are believed to originate deep within the Carson basin to the east and northeast, and migrate up dip along permeable beds in a late Tertiary sedimentary unit. A northeast-striking(?) fault is thought to allow vertical fluid migration between offset portions of a permeable pumice tuff unit that makes up the reservoir (McNitt, 1990). A power plant was built in 1987 at Soda Lake.

When Magma Energy (US) Corp. acquired the Soda Lake power plant from Constellation Energy in 2008, it was not operating at its full name-plate capacity and they decided to restore the

plant to full capacity, then increase power production by drilling more wells and stepping out beyond the existing, known field (Van Gundy et al., 2010). In 2009, Magma acquired additional leases adjacent to their Soda Lake property and completed two drill holes to depths of 4,468 feet (1361.8 meters) and 8,995 (2741.7 meters) feet to determine the distribution of permeability and heat in hope of doubling the plant's gross generating capacity from 11 to 23 MW. Maximum temperatures attained in these two wells were 201.67 and 207.22°C (395 and 405ºF) (http://www.magmaenergycorp.com).

Magma received a $5 M DOE grant to perform sophisticated 3D seismic surveys on the property. Production hole 45A-33, drilled in 2009, has been stimulated to produce 3 MW net of geothermal power. In 2010 Magma applied for permits to drill 7 temperature gradient wells and 3 production holes on the property. Magma reported this upgrade and expansion project is expected to produce 12 MW (Jennejohn, 2010).

Steamboat Hot Springs

Steamboat Hot Springs (T18N, R20E) has been long know and is one of the most studied geothermal systems in the state. The springs have a long history as a resort and health spa and they were first located in 1860, with the first power plants built there in 1986. See http://www.nbmg.unr.edu/Geothermal/site.php?sid=Steamboat Hot Springs for an extensive list of reference and overview of the history and geology.

Ormat Nevada Inc. (ORMAT) brought the Richard Burdette Power Plant online in 2005, which is part of the Galena Geothermal Project. This plant was formerly known as the Galena 1 project was been renamed in honor of former Governor Kenny Guinn's late energy advisor Richard Burdette Jr. The state-of-the-art 30-MW (nameplate capacity) power plant was completed on November 14, 2005 only 8 months after the ground breaking ceremony. This was the first power plant constructed in Nevada under the Nevada Renewable Portfolio Standard (RPS) legislation from 1997. It is a binary, air-cooled power plant with a closed fluid production cycle that allows 100% of geothermal fluids to be re-injected. (Nevada Geothermal Update, April 2006, Nevada Division of Minerals). Galena 2 is a 13.5 MW binary plant constructed in 2007. The third in this sequence, which was also constructed in 2007 was the Galena No. 3 plant, Ormat's newest binary geothermal power plant at Steamboat Hot Springs. The addition of this new plant brings the gross power production from the Steamboat Hot Springs area up to approximately 147 MW. Sierra Pacific Power Co., Sierra Pacific Resources northern Nevada utility (now NV Energy), and ORNI 14 LLC, a subsidiary of ORMAT Nevada, Inc., signed a 20-year 20-MW PPA for the Galena No. 3 project. Ormatdecommissioned the original 7.4 MW Steamboat I power plant, which was brought on line in 1986. At present, there are no new power plants planned for the Steamboat geothermal area.

Future Electric-Power Developments

Patua (Hazen)

Numerous springs and seeps (including cold seeps) occur in a large swampy area, and temperatures of the thermal waters ranged from 28 to 95.5°C, measured in 13 discrete springs. These springs were visited in May 2002 by NBMG personnel and samples collected. Three samples were collected in 2002. The chalcedony geothermometer temperature is 130°C, whereas the Na-K-Ca geothermometer indicates 178°C.

Vulcan Power (now Gradient Resources) acquired land positions during BLM lease sales. Several production drill rigs were observed on the ground controlled by Gradient in 2009 and on into 2010. A GeoVision airborne survey identifying thermal anomalies, a 50 station MT survey, and a 2-D seismic reflection survey were all completed in 2009-2010 on the property. The Company applied to drill 4 observation and 6 production holes on the property.

Several exploration drill rigs were observed on ground controlled by Gradient Resources in 2009. Vulcan has drilled seven production wells and eight observation wells at Patua so far. On February 11, 2010, Vulcan announced plans to begin construction of the 60 MW power plant immediately, with plant completion expected in 2012. Rumors have surfaced that construction of this 60 MW power plant that is scheduled to begin in early 2011.

The project is located about 38 miles (about 61 kilometers) east of Reno, 10 miles (16.1 kilometers) east of Fernley. Vulcan has been conducting an extensive exploration program including well drilling and core drilling, geological, geochemical and geophysical surveys and well discharge testing. In 1962, Magma Power drilled three wells from 300 to 750 ft (91 to 230 m), recoding a maximum temperature of 132.22°C (270ºF) (http://www.vulcanpower.com/Pages/Patua.html).

McGuiness Hills

Surface sinter is exposed in this former gold exploration property in Lander County. Drilling of 300-meter-deep exploration holes through the sinter cap (Figure 4, Casaceli and others, 1986) by Newcrest Resources, Inc. in 2004 intercepted near boiling waters (up to 88°C) with some geysering action observed in one hole. Recognizing the significance of the discovery for geothermal exploration, Newcrest geologists had samples of artesian hot water collected from two drill holes, which yielded quartz geothermometer temperatures of 151° and 193°C and Na-K-Ca, Mg corrected geothermometer temperatures of 209° and 214°C (Coolbaugh and others., 2006,). Subsequent work by Ormat led to a November 2009 announcement of a 30 MW PPA to furnish power to NV Energy from the McGuiness Hills Geothermal project. Drilling is ongoing and the project is in an advanced stage of equipment manufacturing as of early 2011.

Current Exploration Projects

There are approximately 70 properties in Nevada under various stages of exploration and development.See Shevenell and Zehner (this volume; 2011) for locations and brief descriptions of each.

New Non-Electric Low-Temperature Application

Peppermill Resort Casino

The Peppermill Resort Casino is located within the Moana geothermal area and is the only hotel in the country that uses geothermal energy for heating. The resort drilled a new 4,400 ft (1,340 m) deep well that produces 170°F (77°C) water at 1,200 gallons per minute. With this new well and a complete overhaul

of the existing geothermal system, the resort invested $9.7 million to offset their use of natural gas for heating. The Peppermill is harnessing the geothermal energy, which now heats 100% of the resort's domestic water and is heating the entire 2.1-million-square-foot facility 24 hours per day. The conversion to geothermal heating is expected to save the resort millions of dollars by offsetting natural gas use.

Summary

After an approximately 13 year hiatus in no new geothermal power plants having been built, Galena 1 power plant was constructed in 2005, with several others to follow up until the newly constructed Jersey Valley plant in early 2011 when total, state-wide plant capacity had nearly doubled compared to pre-2005 values. There are currently 12 properties (all of Steamboat is considered as one property) in Nevada with operating power plants, with two under construction and approximately 70 under various stages of development. All existing or planned power plants are in northern Nevada, all north of latitude 39°. Nevada experienced a significant boom in geothermal leasing on BLM lands since 2007, with a peak in revenues in 2008, but a peak in acres leased in 2009 and number of wells permitted by the Nevada Division of Minerals. By 2010 and 2011, leasing activity declined significantly, yet existing leased properties are being evaluated and developed.

Annual gross proceeds from geothermal power production have varied, somewhat erratically in response to changes in price per kW-hr, ranging from a low of approximately $52 M in 2003 to a maximum of $145 M in 2010 as capacity and price increased.

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