Nevada Geothermal Resource Use — 1993 Update

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Geology

Nevada is well-endowed with both high- and low-temperature geothermal resources. Over 40 percent of the state is believed to have potential for the discovery of high-temperature (>90°C) geothermal resources, and another 50 percent has potential for low- to moderate-temperature (<°90C) resources (see Figure 1). Surface and subsurface indications of these resources are the more than 1,000 thermal springs and wells in the state. Realistically, this number of individual springs and wells represents several hundred resource areas.

Geothermal reservoirs in the northwestern part of the state have generally higher temperatures; these reservoirs are usually interpreted as being related to circulation of groundwater along faults to deep levels in a region of higher-than-average heat flow. In east-central and southern Nevada, the low- to moderate-temperature geothermal resources are generally believed to be related to regional groundwater circulation in fractured carbonate-rock aquifers. Discharge areas (for example, warm springs) may be up to several hundred kilometers from the area of recharge, and the waters may have circulated for dozens to hundreds of years to depths of several kilometers. Maximum temperatures attained during this journey could be 100°C or higher, but spring temperatures at discharge points are generally less than 65°C.

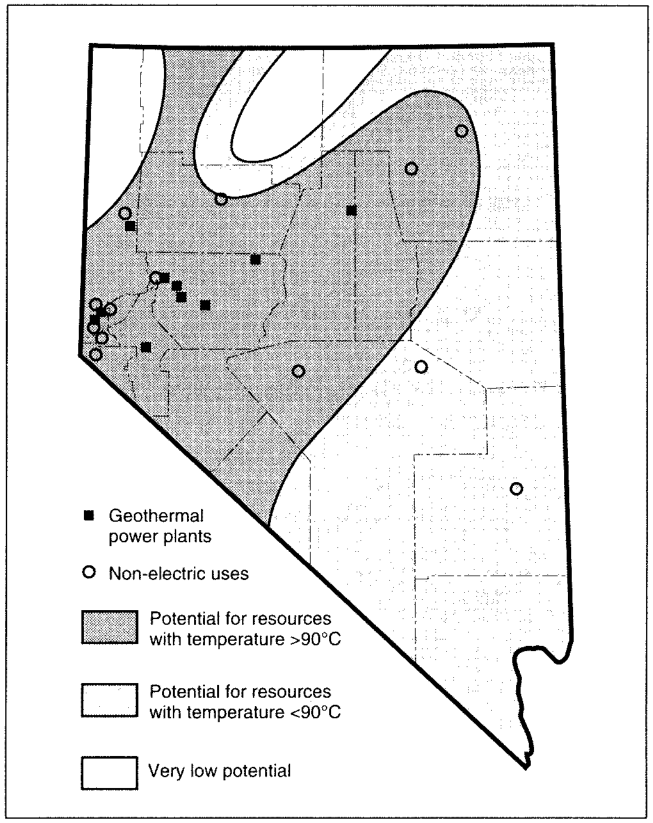

Figure 1. Generalized locations for Nevada's geothermal resources.

Exploration and Development

Two hundred and eighteen geothermal well permits were issued from 1988 through 1993 by the Nevada Division of Minerals. They include 58 industrial-class production wells, 30 domestic class, 88 observation or gradient wells, 10 commercial-class, and 25 injection wells. During this same period 109 geothermal wells are reported to have been drilled, with a total amount drilled of approximately 86,500 m. Forty-five of the wells drilled were production wells, with a total amount drilled of approximately 44,800 m. Figure 2 and Table 1 illustrate the number of power generating wells and pace of drilling since 1980.

From 1989 through 1992 noncompetitive and competitive federal geothermal leases in Nevada generated $1,699,282 in rental fees, $849,641 of which was returned to the State of Nevada. Federal production royalties during the same period generated $7,485,000, of which $3,742,500 was returned to the State. Geothermal lease returns ($849,641) and royalty returns ($3,742,500) to Nevada totaled $4,592,141. By regulation, half of all funds collected by the Bureau of Land Management from federal geothermal leases and production royalties is returned to the state.

Geothermal Electric Power Generation

Electric power is generated using geothermal resources at 10 plants in northern Nevada (Table 2, Figure 1). The state's

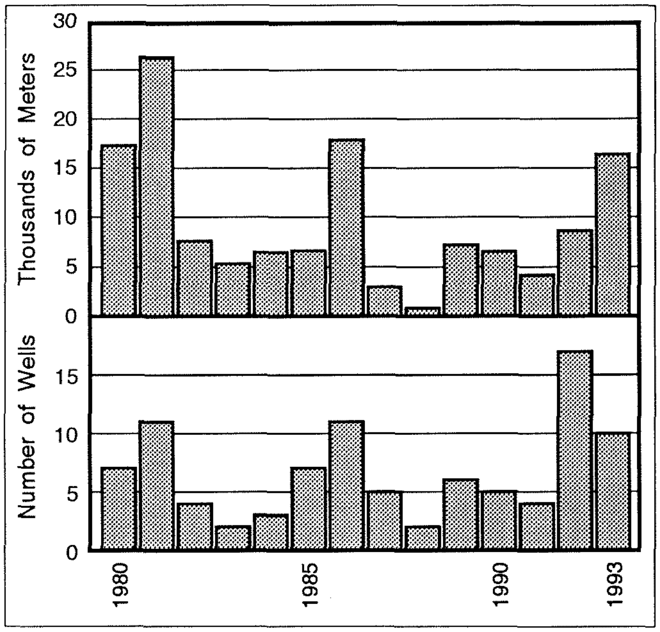

Figure 2. Industrial-class (power generating) wells drilled in Nevada, 1980-1993.

total installed geothermal generating capacity is second only to California.

In 1993 the state-wide peak power demand was 3,755 MW; the total installed generating capacity of Nevada's two major utilities (which supply most of the state's customers) is nearly 2,600 MW (Public Service Commission of Nevada). Thus, geothermal energy provides about 7 percent of the total electricity generated within Nevada (although only about 3 percent of the peak load). Over 40 percent of Nevada's geothermal electric power is exported to California.

From 1989 to 1992, total Nevada geothermal electrical production was 4,076,616 megawatt-hours with an approximate sales value of $307,410,000. Production capacity in 1988 from eight geothermal power plants was 115.8 MW (gross) while current power production from 10 existing geothermal power plants in Nevada is 191.7 MW gross (Table 1). These values represent a 17 percent increase in sales value of the power sold from 1988 to 1992 and an increase in installed gross power production capacity of 60 percent over 1988.

It is important to note that in 1988 Nevada had nearly a threefold increase over 1987 in the amount of online geothermal generating capacity (Figure 3). The primary reason for this increase was the Dixie Valley 60 MW Oxbow Geothermal plant being put online. The OESI plants at Empire (4.8 MW) and Soda Lake No. 1 (3.6 MW) were also brought online during this period.

According to a 1991 Department of Energy estimate, under stable market conditions and with continuing technologic advancements in the geothermal industry, Nevada's projected electrical production capacity from known geothermal resources by the year 2010 should be at least 600 MW (Energy Information Administration, 1991). It is estimated that, for the Basin and Range province as a whole, aggressive exploration activity and continued rapid geothermal technologic advancements could add up to 2,000 MW of production capacity from known resources and new discoveries over the next 10 to 20 years (Wright, 1992). These relatively optimistic future scenarios should be tempered by today's reality of low-priced natural gas, increases in efficiency of fossil fuel generating equipment, and anticipated changes in power sales contracts. The future is bright for Nevada's high-temperature resources, but the pace of development will depend on many factors not related to the viability of the geothermal resource.

Table 1. 1992 directory of Nevada geothermal power plants.

Year	Total # drilled	Total depth(m)	No. industrial wells drilled	Total depth(m)
1988	11	4,268	3	1,098
1989	15	14,817	6	7,317
1990	12	11,280	5	6,707
1991	14	12,561	4	4,268
1992	36	17,988	17	8,841
1993	21	25,596	10	16,686
TOTAL	109	86,510	45	44,917

Beowawe

The **Oxbow/Beowawe Geothermal Power Co., Beowawe** plant came online in 1988. It is a 16 MW (gross), dual-flash plant, which uses geothermal fluids from three wells with a resource temperature of 221°C.

Brady Hot Springs

The **Brady Hot Springs** geothermal power plant (Figure 4) came online in July 1992. Plant operation and maintenance is being performed by **Oxbow Power Services, Inc.**

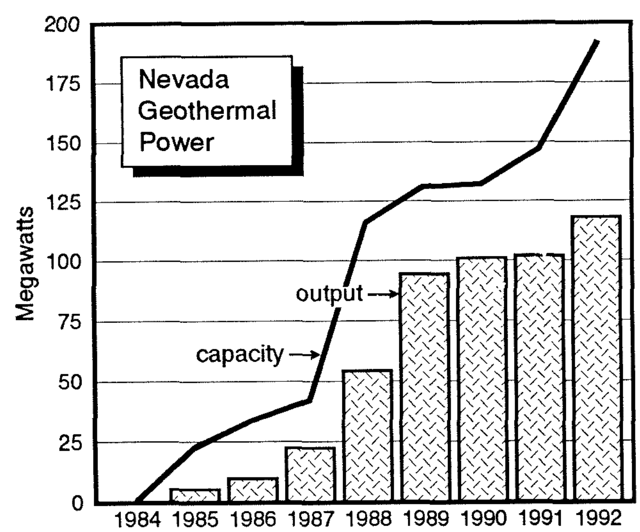

Figure 3. Rated capacity and average net output of Nevada geothermal plants, 1984-1992. Average net output is annual sales in megawatt-hours divided by the number of hours in a year (8,760).

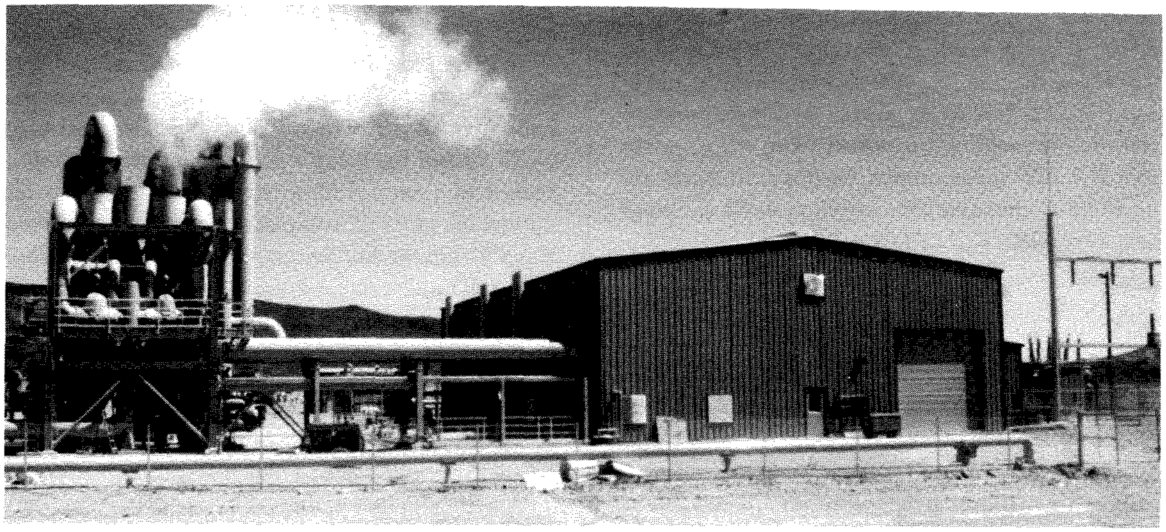

Figure 4. Steam separators and power house at Brady Hot Springs plant (Brady Power Partners), Churchill County, NV. *Larry Green photo.*

Table 2. Total number of all classes of geothermal wells drilled and number of industrial-class geothermal wells drilled by year, 1988 through 1993. Source: Hess, 1993; Nevada Division of Minerals, 1993.

Plant name (year on line)	Production capacity[1] (MW)	1992 Production (MWh)		Location	Operator
		Gross	Net (sales)		
Beowawe (1985)	16.0	138,196	104,415	S13,T31N,R47E	Oxbow/Beowawe Geothermal Power Co. P.O. Box 6 Beowawe, NV 89821
Bradys Hot Springs (1992)	21.1	69,999	54,563	S12,T22N,R26E	Oxbow Power Services, Inc. P.O. Box 649 Fernley, NV 89408
Desert Peak (1985)	8.7	85,364	76,906	S21,T22N,R27E	Western States Geothermal Co. P.O. Box 2627 Sparks, NV 89432-2627
Dixie Valley[2] (1988)	66.0	535,220	483,307	S7,T24N,R37E S33,T25N,R37E	Oxbow Geothermal Corp. 5250 South Virginia St. Suite 304 Reno, NV 89502
Empire (1987)	3.6	17,783	12,752	S21,T29N,R23E	OESI/AMOR II P.O. Box 1650 Fallon, NV 89407
Soda Lake No. 1 (1987) and Soda Lake No. 2 (1991)	16.6	107,315	84,419	S33,T20N,R28E	OESI/AMOR III P.O. Box 1650 Fallon, NV 89407
Steamboat I, I-A (1986) and Steamboat II, III (1992)	31.1	104,574	79,790	S29,T18N,R20E	S.B. Geo, Inc. P.O. Box 18087 Reno, NV 89511
Stillwater (1989)	13.0	72,707	59,692	S1,T19N,R30E S6,T19N,R31E	OESI/AMOR IV P.O. Box 1650 Fallon, NV 89407
Wabuska (1984)	1.2	6,262	3,860	S15,16,T15N, R25E	Tad's 10 Julian Lane Yerington, NV 89447
Yankee Caithness (1988)	14.4	82,280	76,096	S5,6,T17N,R20E	Yankee Caithness J.V.L.P. P.O. Box 18160 Reno, NV 89511
TOTAL	191.7	1,219,700	1,035,800		

[1]Production capacity from currently developed geothermal resources.
[2]Gross output of the Dixie Valley plant occasionally exceeds 66 MW.
Source: Hess (1993).

The plant uses 5.4 million pounds of brine per hour produced from six of eight production wells. The production zone is 300 to 425 m deep with a resource temperature of between 172 and 182°C. The wells supply two high pressure turbines and one low pressure turbine in a two stage system that produces 21.1 MW gross output. Geothermal fluids are injected into three of five available injection wells (Ettinger and Brugman, 1992; GRC *BULLETIN*, v. 21, no.1).

Desert Peak

The **Western States Geothermal Co., Desert Peak** plant went online in 1985. It was designed by Phillips Petroleum Co. and uses a biphase turbine built by TransAmerica Corp. Production capacity from the currently developed resource is 8.7 MW. The resource temperature is approximately 205°C and wellhead temperature is 165°C.

Dixie Valley

The largest single geothermal power plant in Nevada, **Oxbow Geothermal Corp. Dixie Valley** plant, came online in 1988 producing 55-59 MW (net). (Gross output sometimes exceeds 66 MW, as listed on Table 2.) The power is produced in a double-flash turbine generator and purchased by Southern California Edison Co. Oxbow estimates a geothermal energy reserve in Dixie Valley sufficient to supply 200 MW for 30 to 60 years (GRC *BULLETIN*, June 1987; *Reno Gazette-Journal*, August 6, 1988).

Empire/San Emidio Desert

The **OESI/AMOR II Empire** plant came online in 1987 and consists of four Ormat Energy Converter Modules with a gross output of 3.6 MW from currently developed geothermal resources. Production is from a liquid-dominated geothermal source at 129 to 137°C. **San Emidio Resources** continued their geothermal program in the **San Emidio Desert** near Gerlach, Nevada. Early in 1991 San Emidio Resources signed a 5 MW, 30-year geothermal power supply contract, effective 1992, and a 20 MW, 30-year geothermal power supply contract, effective 1995, both with Sierra Pacific Power Co. (GRC *BULLETIN*, February 1991). The initial price paid for produced electricity under the long-term contracts is reported to be approximately 5 cents per kWh. At that time plans called for construction of a 6.5 MW binary plant to be online by November 1992. Since then San Emidio Resources requested and was granted a suspension of the 5 MW project in order for Sierra Pacific Power Co. and San Emidio Resources to determine the feasibility of combining the 5 and 20 MW projects into one project. In July 1993, Sierra Pacific Power Co. executed an amendment to the long-term power purchase agreement with San Emidio Resources. The agreement now calls for a 30 MW geothermal power plant to be online by November 1, 1995 (Public Service Commission of Nevada).

Fallon

In early 1992 the **U.S. Navy** issued a request for proposal to construct an 80 to 90 MW geothermal power plant at the Fallon Naval Air Station. If this plant is constructed, it will be Phase I of the Navy's geothermal program. Phase II will consist of a second 80 to 90 MW facility to be constructed within 10 years of completion of the Phase I project. The Navy estimates that the potential geothermal resource in the area will be able to produce 300 to 500 MW. The exploration drilling and reservoir testing performed during the initial phase of this project will be used to better define the geothermal potential of this area. Based on previous exploration information it is expected that the resource will be in the 175 to 205°C range.

Fish Lake Valley

Fish Lake Power Co. continued their extensive drilling efforts to develop a geothermal resource in the Fish Lake Valley area of Esmeralda County. If a geothermal generating facility is built, the electricity would be delivered to California under a Standard Offer No. 4 Contract.

Hot Sulfur Springs

Earth Power Energy and Minerals has requested an avoided-cost purchase contract agreement with Idaho Power Co. If a contract were obtained, a 9.9 MW geothermal power plant could be constructed at Hot Sulfur Springs, Elko County, Nevada (*Reno Gazette-Journal*, October 10, 1993).

Rye Patch

The **Rye Patch Limited Partnership (OESI)** is currently nearing completion of a 12.5 MW binary generating plant at their site near **Rye Patch** reservoir. The company has a signed purchase agreement with Sierra Pacific Power Company with an anticipated plant online date of November 30, 1993. This has been delayed while the company continues to develop sufficient and continuous geothermal resources to fuel the plant.

Soda Lake

On August 19, 1991, the 13 MW **OESI/AMOR III Soda Lake No. 2** geothermal power plant completed commercial operations testing and went online. This plant is adjacent to the 3.6 MW OESI **Soda Lake No. 1** plant that came online during 1987 (GRC *BULLETIN*, October 1991). Both plants are producing from a liquid-dominated geothermal source at 160°C.

Steamboat Springs

Two 12 MW, air-cooled, binary geothermal power plants, **Steamboat II and III,** operated by **S.B. Geo, Inc.,** were brought online in December 1992, adding 24 MW of production to the existing 7.1 MW **S.B. Geo Steamboat** plant, for a combined gross production capacity of 31.1 MW.

The geothermal fluid cycle at the new plants is completely contained and the fluids are injected back into the ground (closed binary-cycle system). The existing resource is expected to last 30 years or more and can support an additional 36 MW of production capacity. Based on this, plans are currently being formulated to determine the feasibility of installing an additional 24 MW facility in the near future. In December 1993, S.B.Geo, Inc. received a $7.2 million grant from the U.S. Department of Energy to develop a pilot project known as the Kalina Pilot Plant. The purpose of the project is to increase the efficiency of extracting heat from hot geothermal fluids.

Yankee Caithness J.V.L.P. operates a 14.4 MW (gross) flash turbine system producing from a 170°C resource. The **Yankee Caithness Steamboat** plant came online in 1988, and the produced power is purchased by Sierra Pacific Power Co. on a 30 year contract.

Stillwater

OESI/AMOR IV, Stillwater Geothermal plant came online in April 1989. Total project cost was $36 million. The air-cooled plant consists of 14 Ormat Energy Converters that have a combined gross generating capacity of 13 MW. The plant uses a liquid-dominated geothermal source ranging in temperature from 155 to 170°C. The plant operates on a closed system; all geothermal liquids are injected (Ormat Fact Sheet, 1989; Geo-Heat Center, Fall 1989).

Wabuska

Tad's Wabuska plant came online in 1984. Current production capacity is 1.2 MW produced from two Ormat Energy Converter modules. The plant operates on fluids at 107°C. produced from a depth of 107 m (GRC *BULLETIN*, July, 1987).

Non-Electric Low- and Moderate-Temperature Applications

The majority of Nevada's population is concentrated in two areas, Reno-Carson City and Las Vegas. Many of the state's geothermal resources are remote from any population centers, thus limiting some potential applications. Although 50 or more small-to-large communities are located within 8 km of geothermal resources, only a few of these areas have been able to use these resources effectively. The reasons for this under-utilization are varied. Although some reasons relate to technical and engineering problems (resource size and temperature, heat loss during transport, etc.), many more are economic (high capital outlays, long payout, under-capitalization of projects) and perceptual (unconventional *vs.* conventional technology, short *vs.* long-term cost evaluations, uncertainties about long-term economic risks).

There have been attempts to use Nevada's low- and moderate-temperature geothermal resources in more than 20 areas, mainly in the past 5-10 years. Additionally, economic and/or technical appraisals of more areas have been conducted, but for a variety of reasons projects were not completed.

Moana Geothermal Area

Moana Hot Springs, located in the southwestern part of Reno, have not flowed at the surface for at least 15 years. The springs were the discharge point for an area of thermal groundwater that has been used for a spa, swimming pool, and home heating for nearly 100 years. Recent use for home space heating began in the 1960s. The area today is predominantly residential. We estimate that the area of thermal groundwater encompasses at least 9 km^2. In this area there are more than 300 homes that use geothermal fluids for space heating. One hundred and thirty of these homes are part of a district heating system, while most of the rest use downhole heat exchangers in individual wells. A smaller district heating system has retrofitted 12 homes for geothermal heat, and plans to add another four in the spring of 1994. A large hotel, a motel, about three apartment or townhouse complexes, five churches, and a county swimming pool also use the resource. The Veterans Administration Hospital, located about 2 km northeast of the geothermal area, drilled a deep well several years ago and encountered approximately 43°C water. The well was plugged and abandoned.

Steamboat Hot Springs

The Steamboat geothermal area consists of a deep, high-temperature (215 to 240°C) geothermal system, a shallower, moderate-temperature (160 to180°C) system, and a number of shallow, low-temperature (30 to 80°C) subsystems (Goranson and others, 1991). The higher temperature systems are used for electric-power generation (see the preceding section). A number of low-temperature thermal groundwater anomalies are in an area of approximately 30 km^2 centered on the hot spring area (Goranson and others, 1991), but these thermal areas are not well known and are little used. A few homes in the Steamboat area have used low-temperature fluids for over 40 years, and one or more spas have been active in the springs area since the 1860s. Presently probably less than a dozen homes use the low-temperature geothermal fluids for space heating or domestic hot water (including swimming pools). About one domestic geothermal well permit has been issued per year over the last 5 to 7 years.

Bower's Hot Springs

A large outdoor swimming pool and smaller children's pool at the Washoe County Park at Bower's Mansion (located between Reno and Carson City), are supplied with warm water from a geothermal well located near the spring.

Carson City Area

Water from a well at the site of Carson Hot Springs in northern Carson City is used directly in a swimming pool. In southeast Carson City, thermal groundwater is found in the State Prison/Pinyon Hills area. In the past, there have been a few attempts to use the thermal groundwater from domestic wells in that area for space heating. Geothermal space heating has been considered, but not implemented, for at least two schools in the area.

Saratoga Hot Springs

A California company, Lobsters West, has proposed raising lobsters near the warm springs located about 15 km southeast of Carson City. The geothermal fluids would be used to heat tanks in which the lobsters would grow to full size. The experimental study is proposed to last 4 years; live lobsters would be shipped twice a month to local markets (*Reno Gazette-Journal*, November 4, 1993).

Hobo Hot Springs

These hot springs, located about 15 km south of Carson City, were used to raise tropical fish and Malaysian prawns in the late 1980s. Lobster raising was also considered. The water temperature is slightly over 40°C. The site is presently inactive.

Walley's Hot Springs

Walley's Hot Springs, located near Genoa, about 20 km south of Carson City, was the site of a large spa in the late 1800s and early 1900s (Garside and Schilling, 1979). A modern spa was built on the site in the early 1980s. In addition to use of the geothermal fluids for bathing and domestic hot water, the buildings are heated with geothermal energy (Lienau and others, 1988).

Gerlach

Hot springs located just west of the town of Gerlach (Great Boiling Springs) have been used for bathing for many years. The Gerlach General Improvement District built a bath house using geothermal fluids in 1989. The facility was planned for use by tourists and local residents. The facility has been unable to obtain a permit from the health department because sediment from the well plugged water filters. Future plans are for a geothermal heat exchanger system to heat city water for the spa. Geothermal groundwater apparently extends under at least part of the town, as at least two Gerlach homes use geothermal wells for space heating. The water in one well is reported to be 35 to 36°C (unpublished data, Nevada Division of Minerals).

San Emidio Desert

A vegetable dehydration plant is under construction in the San Emidio Desert area southwest of Gerlach (Figure 5). The plant is a few kilometers north of the Empire (OESI/AMOR II) Electric-Power plant. Integrated Ingredients (Spice Islands, Fleischmann's, and other brands), part of international food manufacturer Burns Philp, is contracting for the construction of the facility, which will employ about 25 persons when completed in early 1994. The number of employees may increase to about 65 after 18 months. Onions and garlic will be dehydrated and stored at the plant (*Reno Gazette-Journal*, August 31 1993). The plant will use approximately 150°C geothermal fluid.

Brady Hot Springs

A geothermal vegetable dehydration plant has been operated at this site, about 80 km northeast of Reno, since 1978. The facility uses a moderate-temperature (132°C) geothermal well on site. Since 1993, additional geothermal fluid has been supplied by the nearby Brady Power Partners electric power generation plant, operated by Oxbow Power Services, Inc.

Wabuska Hot Springs

In addition to the rather low-temperature electric-power generation plant operated at Wabuska by Tad's Enterprises, several non-electric applications have been located in the area, but none are active today. A hydroponic geothermal greenhouse operation (tomatoes, cucumbers, etc.) was built on the site in the early 1970s, but few vegetables were grown. Tad's Enterprises has in the past operated a geothermal ethanol facility, a plant to grow algae (*Spirulina*) for human consumption, and facilities to raise Malaysian prawns, catfish, and tropical aquarium fish. Some of these were pilot facilities, rather than actual production facilities.

Rye Patch Geothermal Area

Florida Canyon Mining Co. operates a large open-pit gold mine and heap-leach gold recovery facility about 50 km northeast of Lovelock, and 7 km north of the area presently under development by Rye Patch Limited Partnership for geothermal electric power production. A 180 m well produces fluids at approximately 100°C; these fluids provide makeup water for the cyanide extraction solutions. Heat from heat exchangers is also extracted to heat the solutions. The heating of cyanide solutions aids extraction during cold weather, and may somewhat enhance total gold recovery.

Darrough's Hot Springs Area

Round Mountain Gold Corp. operates a large open-pit gold mine and heap-leach gold recovery facility near the Darrough's Hot Springs geothermal area in Nye County. Geothermal fluids from shallow (approximately 300 m)

Figure 5. Vegetable-dehydration plant under construction in the San Emidio Desert. *Larry Green photo.*

wells are used in a heat exchanger to transfer heat to cyanide heap-leach solutions (Trexler and others, 1990).

Carlin

Carlin Hot Springs, located near the Humboldt River southwest of the town, have a reported temperature of 80°C (Trexler and others, 1982). The Carlin High School used 31°C geothermal fluid from 280 m well from 1986 to 1992 in a closed-loop space heating system. The well was abandoned in 1992, apparently in part because of scaling problems with iron and manganese.

Elko Area

Hot springs south of the town of Elko were first used in a bath house in the 1860s (Garside and Schilling, 1979). Thermal groundwater was known to exist to the north of the springs under a part of the town, but no use was made of it until the Elko Heat Company began supplying geothermal fluid for space heating to several downtown buildings in 1982 (Rafferty, 1988). The company has continued to grow; in 1993 it served 16 commercial customers and two residential customers (Mike Lattin, oral commun., 1994).

The Elko County School District, in conjunction with the Elko General Hospital, developed a district geothermal heating system in 1986. The system supplies heat to eight buildings (two schools, a municipal swimming pool complex, a gym, a convention center, a hospital, a city hall, and a school administration building). In 1988 the estimated combined savings to all users was $300,000 per year (Rafferty, 1988; Richard Harris, oral communication, 1994).

Jackpot Area

Two wells drilled in 1988 at the Y3 Ranch about 7 km southeast of Jackpot, were used for raising catfish. The maximum reported well temperature was 40°C (Lund and others, 1990). The catfish-raising operation was not active in late 1993, reportedly due to insufficient geothermal fluid.

Wells Area

Warm springs about 1.5 km north of the present town of Wells were referred to by travelers on the emigrant trail in the 1850s as Humboldt Wells (from which the town name is derived). Thermal (32 to 34°C) groundwater is used by an elementary school and the Wells Rural Electric Co. in heat pump applications for space heating.

Duckwater (Big Warm) Springs

A geothermal catfish-growing facility has been operated at this site since 1982. The facility was purchased in 1992 by Robert and Jeff King (Valley Fish) of Preston, Idaho. The facility, located about 110 km west of Ely, produces over 300,000 pounds of prime 8-ounce catfish filets per year that are shipped to Idaho for sale (*Geo-Heat Center Quarterly Bulletin*, December 1992).

Caliente Hot Springs

The town of Caliente in Lincoln County derives its name from the local hot springs. A number of wells in the area have reported temperatures from 40 to 80°C (Garside and Schilling, 1979; Lienau and others, 1988). A motel supplies geothermal well water to bathing pools and individual room whirlpool baths, and a trailer park supplies hot water to individual mobile homes. The Lincoln County Hospital (20 beds) was heated using 39°C water from a well on the site, but reduced temperatures (to 28°C) forced reliance on electric resistance heating. The hospital plans to use the lower-temperature fluids from its well for heating and cooling using heat-pump technology. The city swimming pool used geothermal heat in the past, but was damaged during the winter of 1992 and will probably be replaced. The City of Caliente has a grant from the Rural Development Administration to use the local geothermal resources. A nearby perlite processing plant may be the first user of plant process heat. If more funding is found, the city plans to provide heat to the hospital, swimming pool, and eventually an elementary school and youth training facility (Glen Van Roekel, oral communication, 1994).

Ash Springs

Thermal waters (31 to 36°C) at Ash Springs, located about 10 km north of Alamo, in Lincoln County, have been used in the past at a spa on the site. The facility is presently closed.

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