DEVELOPMENT OF LOW-TEMPERATURE GEOTHERMAL RESERVOIRS FOR COMMERCIAL POWER - THE U.S. EXPERIENCE

by

S.K. Sanyal, J.B. Koenig, A. Robertson-Tait and A.J. Menzies
GeothermEx, Inc.
Richmond, California
(USA)

Low-temperature geothermal resources are defined herein as those with reservoir temperatures less than 200°C. This paper reviews the experience of the U.S. geothermal industry in the development of 19 electrical power projects in 13 different geothermal systems in the western United States with particular reference to geologic setting, reservoir temperature, generation technology and installed capacity (table 1).

While low-temperature geothermal systems are found in diverse geologic settings worldwide, those which have been developed for electric power generation in the U.S. are found within two physiographic provinces: the Basin and Range in Nevada and Utah and the Salton Trough in California. Magmatic heat sources are not directly associated with the majority of these systems; instead, they are found in areas devoid of Quaternary magmatism but with elevated crustal heat flow. The low-

temperature geothermal system within the Long Valley caldera in California is an exception.

The low-temperature systems of the Basin and Range province exist primarily within fault zones which bound or transect a mountain range or an intermontane valley. These systems are characterized by high fracture permeability and limited areal extent. The low temperature systems in the Salton Trough exist within relatively shallow sedimentary rocks, sometimes representing outflow from deeper, hotter geothermal systems. They are characterized by variable intergranular permeability and large areal extent. The Long Valley geothermal system is found within an extensive ash-flow tuff unit.

Temperatures in these systems range from approximately 105°C (Wendel and Amedee, California) to a high of 200°C (Steamboat Springs, Nevada). Fluids within most of this range of temperature are typically used in binary cycle geothermal power plants; however, four of the systems support flash steam generation and one system supports rotary two-phase turbine generation. All of the projects are fully commercial and were developed by private financing.

Three of the flash plants produce from resources which are also used to supply nearby binary plants. This type of dual development is applicable where the same geothermal area contains two distinct regions which are separated vertically or laterally. For example, wells drilled into an upflow zone can supply a flash steam power plant, and wells drilled into the outflow zone of the same system may be better suited to binary technology. Carefully developed, these systems can be used to maximum efficiency by using both types of generation schemes.

The systems which are used for binary generation have a large range in temperature (104° to 182°C). Wells drilled into these systems are typically shallow (200m to 1,800m) and downhole pumps are often used to maintain a suitable flow rate and enthalpy at the wellhead. Modular binary generating units are used for many of the projects; this allows for both rapid construction and easy addition of further generating capacity.

A total of approximately 260 MWe of power capacity based on low temperature geothermal systems is on-line or under construction in the United States, and the estimated undeveloped capacity is several thousand MWe. These low-temperature geothermal systems have proven to be commercially attractive for power generation because of their widespread occurrence, relatively shallow depth and suitability for small, modular developments.

Table 1. Low-Temperature Geothermal Projects in the United States

Field	Approximate Temperature (°C)	Plant Type	Plant Capacity (MWe)
East Mesa, California (ORMESA I)	157	Binary	20
East Mesa, California (ORMESA IE)	146	Binary	10
East Mesa, California (ORMESA II)	168	Binary	16
East Mesa, California (Magma)	172	Binary	9

Field	Plant Approximate Temperature (°C)	Plant Type	Capacity (MWe)
East Mesa, California (GEO)*	177	Double Flash	37
Heber, California (Dravo)	182	Double Flash	47
Heber, California (S.D.G & E.)	182	Binary	45
Long Valley, California	171	Binary	7
Desert Peak, Nevada	190	Rotary Biphase Turbine	9
Beowawe, Nevada	190	Flash	15
Cove Fort, Utah	180	Binary	3
Wabuska, Nevada	104	Binary	0.3
Steamboat Springs, Nevada	171	Binary	6
Steamboat Springs, Nevada	200	Flash	12
Soda Lake, Nevada*	171	Binary	3
Stillwater, Nevada*	?	Binary	15
Wendel, California	105	Binary	0.6
Amedee, California*	105	Binary	3
Empire, Nevada*	127	Binary	5

*Under construction