Geothermal Inventory

New Study Highlights Geothermal Resources Available for Development in California and Nevada

By Jim Lovekin – Manager of Field Operations, GeothermEx, Inc.

The California Energy Commission recently released a study of geothermal resources available for development in California and western Nevada. Funded by the CEC's Public Interest Energy Research (PIER) program, the study was prepared by GeothermEx, Inc. (Richmond, CA) under a contract with the Hetch Hetchy Water and Power Division of the San Francisco Public Utilities Commission.

New Geothermal Site Identification and Qualification describes a portfolio of well-characterized geothermal resources that could supply additional power to electrical markets in the western United States. In preparing the study, GeothermEx relied on information in the public domain and from private geothermal developers. For each geothermal resource with sufficient information available, the study presents estimates of generation capacity (minimum and most-likely values) and total development costs.

A principal outcome of the study has been the creation of the PIER Geothermal Database in MS Access©, which allows review of supporting documentation on a field-by-field basis. The database includes information about the resource characteristics of 155 separate geothermal projects at 83 resource areas. It also includes embedded documents describing study methodology, as well as tables that summarize results.

To establish a quick way of ranking geothermal projects at varying stages of maturity, the study defines four development categories:

A – Existing power plant in operation.

B – One or more wells tested with a potential greater than or equal to (≥) 1 MW, but no power plant in operation.

C – Minimum 212° F temperature logged downhole, but no well tests at ≥ 1 MW.

D – Other exploration data and information available (≥ 212° F not proven).

To facilitate consideration of options for transmission of power to the California electricity market, the study also classifies geothermal projects geographically into four areas:

Area 1 – Greater Reno, Nevada (outlined in Fig. 1).

Area 2 – The Dixie Corridor (outlined in Fig. 1).

Area 3 – Other locations in western Nevada.

Area 4 – All California locations (excluding those in the Greater Reno, Nevada area).

Minimum and most-likely estimates of electrical generation capacity were calculated for 58 geothermal resource areas with sufficient information in the public domain. The estimates are based on a methodology that GeothermEx has used over the past two decades. This methodology is a volumetric reserve-estimation approach introduced by the U. S. Geological Survey, modified to account for uncertainties in some input parameters using a probabilistic basis (Monte Carlo simulation). Estimates of geothermal generation capacity (both total and incremental) are included on the map in Figure 1, and are presented in greater detail in Table 1.

Based on reserve estimates of the study, electrical generation capacity available from geothermal sources in California and western Nevada has a minimum value of about 4,700 gross megawatts (MW), and a most-likely value of about 6,200 gross MW. After allowances for generation capacity already online, incremental generation capacity available from geothermal resources in both states has a minimum value of about 2,800 gross MW, and a most-likely value of about 4,300 gross MW. These estimates may be conservative to the extent that they do not take into account resources about which little or no public-domain information is available.

Generation capacity available from geothermal fields within California alone has a minimum value of about 3,700 gross MW, and a most-likely value of about 4,700 gross MW. Incremental generation capacity available from geothermal fields within California alone has a minimum value of about 2,000 gross MW, and a most-likely value of about 3,000 gross MW. Geothermal sites in California alone account for about 70 percent of the combined incremental generation capacity available from both states. Within California, 90 percent of the incremental generation capacity identified in the study comes from three areas: the Imperial Valley, The Geysers, and Medicine Lake. The Imperial Valley alone accounts for about 65 percent of incremental capacity available in California.

For geothermal sites in both states, the capital cost of incremental generation capacity averaged about $3,100 per installed kilowatt (kW) (Table 2). For California sites alone, the average capital cost of incremental generation capacity was somewhat lower, at about $2,950 per installed kW. These cost estimates include the following components:

- Exploration (up to siting of the first deep, commercial-diameter well).
- Confirmation drilling (up to achieving 25% of required capacity at the wellhead).
- Development drilling (up to achieving 105% of required capacity at the wellhead).
- Construction of the power plant (including ancillary site facilities).
- Transmission-line costs.

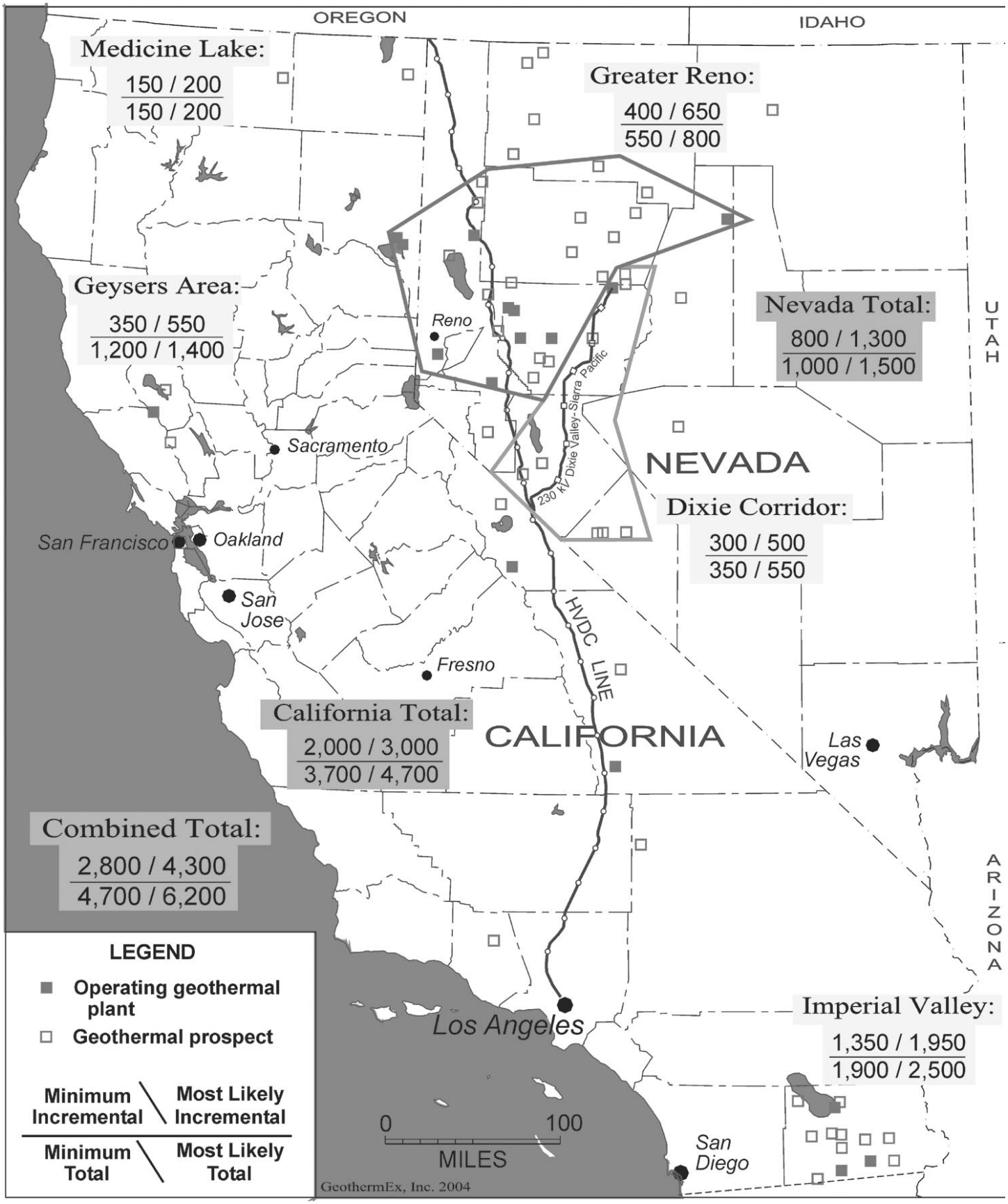

Figure 1 – Generation capacities of major geothermal resource areas in California and western Nevada (Gross MW).

Table 1 – Geothermal Generation Capacities in California and Western Nevada

Area	Total Capacity Minimum (Gross MW)	Total Capacity Most-likely (Gross MW)	Capacity In Use (Gross MW)	Incremental Capacity Minimum (Gross MW)	Incremental Capacity Most-likely (Gross MW)	Most-likely Incremental As % of State Total	Most-likely Incremental As % of State Total
California							
Imperial Valley	1,900	2,500	550	1,350	1,950	65%	45%
The Geysers	1,200	1,400	850	350	550	18%	13%
Medicine Lake	150	200	0	150	200	7%	5%
Other	450	600	300	150	300	10%	7%
California Total	**3,700**	**4,700**	**1,700**	**2,000**	**3,000**	**100%**	**70%**
Western Nevada							
Greater Reno	550	800	150	400	650	50%	15%
Dixie Corridor	350	550	50	300	500	38%	12%
Other	100	150	0	100	150	12%	3%
W. Nevada Total	**1,000**	**1,500**	**200**	**800**	**1,300**	**100%**	**30%**
Grand Total	**4,700**	**6,200**	**1,300**	**2,800**	**4,300**	**-**	**100%**

Table 2 – Estimated Geothermal Development Costs by Area

Area	Most Likely Incremental Capacity (Gross MW)	Average Development Cost Per kW Installed
California	3,000	$2,950
Western Nevada	1,300	$3,450
Total	**4,300**	**$3,100**

Capital cost estimates are only approximate, because each developer would bring its own experience, bias, and opportunities to the development process. Nonetheless, GeothermEx believes that the overall costs per project estimated in the study are reasonable, based on available information.

The capital cost for specific geothermal projects ranged from about $1,000 per kW (for a small expansion at an existing project), to values in excess of $6,000 per kW (for deep, low-temperature resources at remote locations). Of the 4,300 gross MW of most-likely incremental capacity available from both California and Nevada, about 2,500 gross MW is available at a capital cost less than the average of $3,100 per kW. Considering geothermal fields only within California, about 2,000 gross MW of incremental generating capacity is available at a capital cost below the average of $2,950 per kW.

For the purposes of the study, a capital cost of $2,400 per kW or less is considered competitive with other renewable resources. The amount of incremental geothermal capacity available at or below $2,400 per kW is about 1,700 gross MW. Such available capacity represents a significant opportunity for commercial geothermal energy development to meet the needs electricity markets in the western United States. Resources with higher estimated costs may also be attractive, depending on market conditions and mechanisms for implementing Renewable Energy Credits and Renewable Portfolio Standards in various states.

The California Energy Commission and GeothermEx hope the study will help make possible a significant new phase of geothermal resources development in the Western United States, and increase the number of entities participating in geothermal projects. The study helps make reliable information about geothermal resources in California and western Nevada more easily accessible to entities interested in developing or purchasing geothermal power, including municipal power agencies and investor-owned utilities. It is anticipated that the portfolio of geothermal projects described in the study will be evaluated with other potential energy sources in the same geographic areas, to seek options for the collocation of power plants with shared transmission facilities and coordinated base-load and peaking power generation. This should facilitate aggregation of undeveloped renewable resources for achievement of greater economies of scale.

New Geothermal Site Identification and Qualification (CEC Publication No. P500-04-051, April 2004) is available at the GeothermEx website at: www.geothermex.com. It is a 264-page document in Adobe Acrobat© (4.2-megabyte download). To obtain it, click on the icon, "CEC-PIER Reports," then on the icon, "New Geothermal Site Identification and Qualification." Also available on the GeothermEx website is the PIER Geothermal Database (45.1-megabyte download). The database requires MS Access© to run, but includes an icon-driven interface that allows use with no prior software familiarity.

Readers with updates or corrections to the GeothermEx study or to the PIER Geothermal Database should contact Jim Lovekin by email at: mw@geothermex.com. GeothermEx is currently working on a second PIER-funded study about potential improvements at existing geothermal power plants in California. It is scheduled for completion in the spring of 2005. To the extent allowed by the budget for this work, GeothermEx intends to incorporate any new technical information into an updated version of the first study and its associated database. ■

Jim Lovekin is manager of field operations for GeothermEx, Inc. He is a registered professional engineer in petroleum engineering in California. Contact him at: GeothermEx, Inc., 5221 Central Ave., Suite 201, Richmond, CA 94804. Phone: (510) 527-9876. Fax: (510) 527-8164. Email: mw@gemthermex.com. Website: www.geothermex.com.