Distribution of High-Temperature (>150 ¡C) Geothermal Resources In California

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California contains, by far, the greatest geothermal generating capacity in the United States, and with the possible exception of Alaska, the greatest potential for the development of additional resources. California has nearly 2/3 of the US geothermal electrical installed capacity of over 3,000 MW. Depending on assumptions regarding reservoir characteristics and future market conditions, additional resources of between 2,000 and 10,000 MW_e might be developed (see e.g., Muffler, 1979).

The high-temperature resources are distributed unevenly over the state. In figure 1, we plot the locations of existing power plants (solid stars) and projected or planned developments (open stars), together with those areas characterized by heat flow greater than 100 mW m^{-2} (red areas). See Williams (2001) for detailed database. Regions characterized by these high heat flows are more likely to contain those rare areas where temperatures of 150¡ C or more can be reached at depths that can be drilled economically (currently about 3 kilometers, or 10,000 ft). .According to the California Energy Commission s 2001 listing of California Power Plants, http://www.energy.ca.gov/database/index.html#powerplants, California has 46 geo-thermal plants with a total installed electrical capacity of 2,561 MW (Table 1). Most power plants are associated with areas of young-to-contemporary igneous activity (1 million years or younger).

Geothermal developers typically aim for a working life of between 20 and 30 years for a given geothermal system. Some plants are early in this cycle, whereas others are suffering declines in temperature and pressure. The productivity and longevity of most existing plants can be increased through the application of Enhanced Geothermal Systems (EGS) technology. Components of this technology include: improved conversion technology, directional drilling and targeted hydrofracture based on studies of regional and local stress fields, targeted injection using available surface water (including reclaimed wasted water) and groundwater, and chemical treatment of dissolved solids to mitigate the effects of scaling and corrosion.

The red areas that are not presently exploited for geothermal power provide good candidates for further evaluation. Some, in environmentally sensitive areas (e.g. Lassen, Death Valley) will probably never be developed. Probably the greatest potential for augmenting resources lies in applying EGS techniques to currently producing fields, an option that is being pursued vigorously at the Geysers, and is the subject of a systematic study at Coso.

References

Muffler, L.J.P., (editor), Assessment of Geothermal Resources of the United States-1978, U.S Geological Survey Circular 790, 1979.

Williams, Colin, 2001, USGS Heat Flow Data Base for California, http://proto-dev.wr.usgs.gov/heatflow/index.html

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Table 1. Installed Capacity (MW_e) of California Geothermal Areas.

Area	No. of Plants	Capacity (MW_e)
Amedee/Wineagle (AL)	2	2.3
The Geysers	21	1807.6
Long Valley (LV)	4	37.0
Coso	3	240.0
Imperial Valley	16	474.8
TOTALS	**46**	**2561.7**

Figure 1. Shaded relief map of California showing major physiographic-tectonic provinces, Locations of geothermal power plants, and zones of elevated heat flow (>100 mW m^{-2}) in red.