Proceedings World Geothermal Congress 2000
Kyushu - Tohoku, Japan, May 28 - June 10, 2000

POTENTIAL SITES AND EXPERIMENTS FOR ENHANCED GEOTHERMAL SYSTEMS IN THE WESTERN UNITED STATES

Ann Robertson-Tait and James Lovekin
GeothermEx, Inc., 5221 Central Avenue, Suite 201, Richmond, California 94804-5829 USA

Key Words: EGS, stimulation, enhancement, augmented injection, HDR, Hot Dry Rock

ABSTRACT

The Department of Energy's EGS Strategic Plan anticipates that EGS experimentation in the United States will be underway by 2004 in areas within or adjacent to commercially developed hydrothermal fields, and that an EGS demonstration plant will begin operating in 2008. Criteria for selecting sites for EGS experimentation focus on enhancing energy recovery at producing fields while advancing the EGS knowledge base incrementally towards a demonstration project. With input from field operators, basic characteristics and information on the type of EGS work that may be undertaken are presented for 15 producing fields and 2 unexploited fields. Six producing fields meet 90 - 100% of the site selection criteria and 9 meet 60 - 70%. The use of EGS techniques to supply an existing facility has the advantages of low cost, support from the geothermal industry and demonstration of applicability to a variety of conversion technologies. This approach seeks to reduce EGS risk and uncertainty, promoting the transition from research to commercial development.

1. INTRODUCTION

The Department of Energy's Strategic Plan for Enhanced Geothermal Systems calls for the selection of EGS sites by 2004 and the development of a demonstration project by 2008. First, field experiments to enhance permeability and/or fluid content will be undertaken in areas within or adjacent to commercially developed hydrothermal fields, using EGS technology to increase energy recovery. A portfolio of potential EGS projects is to be developed to assist DOE in both accommodating as wide a range of EGS project types as possible, and prioritizing potential projects. It is anticipated that a series of small-scale experiments will define realistically what may be achieved in the near future, thus setting the stage for a successful pilot demonstration. As a follow-up to Sass and Robertson-Tait (1998), this paper uses input from field operators to identify potential locations, types and benefits of EGS projects in the United States.

2. CRITERIA FOR SELECTING EGS SITES

EGS site-selection criteria were initially defined at the April 1998 DOE Geothermal Program Review by a group from the geothermal industry, academia, the USGS and the National Laboratories. Focusing on both industry participation and the modest level of anticipated funding, criteria were developed with respect to the geothermal resource, the infrastructure that supports its development, and social issues. The most important social issue discussed was support not only from the geothermal industry but also from the public at large, so that the societal benefit can be realized.

The site-selection criteria related to infrastructure issues include:

<u>Proximity to a developed hydrothermal resource</u> to take advantage of existing access and facilities for electricity generation and transmission. Transmission costs aside, more than twice the current market price of electricity is required to support the development of a new project supplied by a hydrothermal resource, and the cost to develop a stand-alone EGS project would be higher. However, additional EGS-derived power could be immediately useful and marketable at an existing development.

<u>Economic advantage.</u> The EGS project could either sustain the ability of the power plant to meets its capacity requirements under existing power sales agreements, or increase power sales from the existing facility under the terms of a new agreement. EGS projects that sustain or increase output, reduce operating costs and/or increase the profitability of existing contracts would be favored.

The resource-related site selection criteria include:

<u>Low permeability or water content, or both.</u> This follows the essential definition of EGS: systems in which permeability is too low for commercial exploitation by conventional methods and/or the reservoir is fluid-deficient. While fluid-deficiency is a natural consequence of low permeability, it could also be caused by long-term production.

<u>Water available for injection.</u> Injection of water is likely to be the mechanism of heat recovery. Therefore, all other criteria being equal, a site with available water at a reasonable cost would be preferable.

<u>Existing wells available for EGS work.</u> This criterion is the direct result of economic considerations, because it is unlikely that initially limited R&D funds would support the drilling of new, dedicated EGS wells.

<u>A well characterized reservoir</u> in terms of its geology and hydrology, boundaries, stress regime and permeability characteristics, so that a meaningful assessment of the results of the EGS work can be made.

<u>An extensional stress regime</u> to provide favorable formation breakdown and fluid injection pressures. Fortunately, most known geothermal fields lie in regions of tectonic extension.

3. DESCRIPTION OF POTENTIAL EGS SITES

The most likely near-term candidates for EGS work will be geothermal fields with existing and sometimes under-utilized generation facilities. A second tier of candidates would consist of those for which wells have been drilled but no generation facilities currently exist. A preliminary review of sites with significant EGS potential (Figure 1) has been performed, using publicly available information and additional data provided by field operators. For each site, the information has been reviewed with the current field operator for accuracy and consent to publish.

Coso, California. The Coso reservoir occurs in granitic rock in extensional terrane at the western margin of the Basin and Range province and has temperatures up to 340°C. The field has 270 MW of installed plant capacity and historically has maintained a high capacity factor. Two conditions make Coso a good candidate for EGS work: the existence of low-permeability wells in and around the field; and a degree of fluid depletion as a result of sustained production. Addressing these conditions has the potential to significantly improve the field's ability to sustain its current level of power output. The field operator already has had some success in thermally stimulating some wells, and there have been preliminary discussions about hydraulically stimulating a deep injection well.

Separated brine could be used for EGS work. Also, shallow groundwater is potentially available from several sources, including wells located east of the field. The field operator has been considering installation of a 16-km pipeline to bring about 40 l/s from this area into the field for injection. There is one other existing shallow groundwater well and the potential for others to be drilled near the developed area.

East Mesa, California. Production at East Mesa is derived from sandstones and siltstones on the eastern margin of the Salton Trough. To supply 105 MW of binary and flash generation, all of the production wells are pumped. Injection wells are located both in-field and at the field margins, and reservoir cooling from injection breakthrough has occurred. The field has potential to benefit from EGS work to stimulate certain deep injection wells on the periphery of the field that encountered high temperatures but relatively low permeability. Brine from the production separators could be used to stimulate these wells.

In addition, there may be potential to stimulate strata underlying the zones in which most production wells are completed. As indicated in the discovery well (6-1), these underlying beds locally are productive in the vicinity of deep fractures. Although well 6-1 is not mechanically suitable for deepening or fracture stimulation, other deep wells could be used for EGS experiments.

The Geysers, California. Owing to its fluid deficiency, The Geysers is by definition an EGS. Augmented injection has been used to maintain reservoir pressure and increase heat recovery. In September 1997, the Southeast Geysers Effluent Pipeline (SEGEP) began operating, providing about 350 l/s of treated sewage effluent and Clear Lake water to the southeastern part of the field. This project has increased the injection fraction (the ratio of total injection to total production) from 25 - 30% to more than 60%. Heat recovery could be enhanced in areas with little or no access to the water from the SEGEP or from pumping of surface waters, including the central and northern areas of the field, which have been greatly depleted. This area will be the target for injection from the Santa Rosa effluent pipeline (now underway). Providing 470 l/s, this will increase the injection fraction in these areas to more than 60%, and to about 90% field-wide.

Certain areas cannot be supplied by the effluent pipeline(s). Some surface water is extracted in these areas during the rainy season and property owners can drill and produce groundwater wells, provided that the water is not produced from an aquifer that has other users. These two sources have a seasonal low in productivity; because of this, water storage methods may be sought to maintain a more constant level of augmented injection in some areas.

There are a number of idle wells that could be used for injection, pending suitable agreements with land owners. Numerous wells of opportunity are available for stimulation of permeability, both within the wellfield and in peripheral areas. If stimulation efforts are successful, the enhanced wells could be considered for either production or injection, depending on the injection strategy for the area in which they are located. A side benefit to heat mining by injection would be management of corrosion and non-condensable gases in affected areas.

Heber, California. Like East Mesa, the Heber field has both flash and binary plants. The flash plant is supplied by deep, closely spaced, self-flowing wells drilled into the hottest portion of the reservoir, while the binary plant uses shallower, more widely spread pumped wells. Injection and production are delicately balanced to maintain pressure while minimizing cooling from injection breakthrough. The field operator is presently focusing on decreasing the injection pumping requirements to maximize net output. There is a relatively deep, tight well in the southern part of the field (GTW-6A) that could be the focus of stimulation work. Water from the Highline Canal, which runs along the southern side of the developed area, could be purchased and used for stimulation. If significant permeability could be developed in GTW-6A or other peripheral wells, peripheral injection could be developed to both sweep more heat from the reservoir and lower the injection pumping requirements.

Glass Mountain, California. The geothermal resource at Glass Mountain has temperatures of up to 290°C, hosted in young volcanic rocks at depths in the range of 600 to 2,800 m. A number of temperature gradient holes and full-diameter deep wells have been drilled. Two developers are each proposing 50 MW projects; both are currently undergoing regulatory review. Transmission line routes for these projects are on the order of 32 km long. Well test results to date suggest that Glass Mountain could benefit from EGS work to stimulate formation permeability. Several sources of water, including shallow water wells and brine from the geothermal reservoir, could be used to supply water for hydraulic fracturing operations. An EGS program to demonstrate effective stimulation methods in young volcanic rocks could have significant economic benefits, not just at Glass Mountain, but at a large number of geothermal fields in similar geologic settings worldwide.

Salton Sea, California. The Salton Sea field is one of the hottest in the world, with measured temperatures in excess of 370°C. The reservoir is hosted in sandstones and siltstones at depths ranging from 450 to 4,500 m. Existing electrical generation plants have a capacity of 268 MW, and an additional 59 MW of capacity is scheduled to go on line in

2000. A facility to recover approximately 34,000 tonnes per year of zinc from produced geothermal brine is under construction and is also scheduled to start operation in 2000. Permeabilities in the geothermal field are generally high, and the reservoir appears to receive sufficient pressure support from injection and natural recharge to assure stable long-term operations. However, there are areas with significantly lower permeability on the periphery of the region of active production and injection. A number of idle wells exist that could be stimulated as part of an EGS project.

The Salton Sea is experiencing rising water levels and increasing salinity; mitigation of these trends could be a significant collateral benefit of an EGS project. Expensive proposals for long pipelines and desalination plants are being evaluated by governmental authorities to lower both the water level and the salinity of the Salton Sea. An EGS program to stimulate permeability underground on the periphery of the Salton Sea geothermal field and to simultaneously dispose of significant volumes of Salton Sea water could attract funding from a variety of governmental and private sources. It may be possible to process Salton Sea water so as to yield two outflow streams: 1) a stream of water suitable for agricultural use; and 2) a stream of concentrated brine suitable for injection (including a chemical inhibitor to prevent mineral precipitation). Another potential benefit of such a project would be to provide an economical source of water for end users such as the zinc recovery project, which currently plans to purchase water at an industrial rate.

Puna, Hawaii. The Puna geothermal reservoir has temperatures in excess of 360°C and presently supports a hybrid (flash-binary) power plant with an installed capacity of 30 MW. Zones of high productivity are closely associated with intrusions from the 1955 fissure eruption. There is potential for an EGS program to increase the recovery of heat from the reservoir by stimulating low-permeability wells drilled on the margins of the fissure eruptions, which could play a significant role in sustaining the long-term output of the field. The project currently has adequate injection capacity, but this could change if the production well currently being drilled yields fluid with a high liquid fraction. Thus, there is potential for a significant near-term economic advantage from an EGS program to develop additional injection capacity.

Bradys Hot Springs, Nevada.

The Bradys Hot Springs field produces from wells on the down-thrown side of the Bradys Fault. Production is primarily from permeable zones developed in Tertiary volcanics in the hanging wall of this fault, and initial measured temperatures in this permeable zone were in the range of 170 to 180°C. The depth of the producing zone ranges from about 300 to 1,800 m, depending on the position of the well relative to the northwest-dipping fault surface. Wells on the foot wall side of the fault have encountered temperatures of up to 210°C in metamorphic basement rocks, but the permeability of wells in the foot wall block has generally been low. The field has dual-flash power plant with a capacity of 26 MW gross (21 MW net). Several wells completed in the foot wall are currently open, and brine from the active production wells could be used for stimulation work. The current power output at Bradys is below the plant capacity due to gradual reservoir cooling, so an EGS program that could expand the volume of the productive reservoir and increase the temperature of produced fluids would have an immediate economic benefit.

Desert Peak, Nevada. The Desert Peak field produces from metamorphosed sedimentary and igneous rocks of Mesozoic age at depths in the range of 300 to 2,100 m (Faulder and Johnson, 1987) and temperatures ranging from 200 to 220°C. A 9 MW plant has been operating since December 1995, with production from two wells and injection into a third. Several other wells exist which have encountered potentially commercial temperatures but low permeability. EGS stimulation work could be undertaken in at least one existing well: a sidetrack of 22-22, which has the highest recorded temperature in the field. Other wells may also be suitable for stimulation, depending on their current mechanical condition. Under the current contractual arrangements for selling power from Desert Peak, there is little financial incentive for the operator to develop additional production capacity. Still, the field does present an opportunity to demonstrate EGS stimulation techniques in a moderate-temperature reservoir hosted in metamorphic rocks. A successful program could have significant long-term economic benefits at Desert Peak and at a number of other Basin and Range fields in similar geologic settings.

Dixie Valley, Nevada. A 62 MW dual-flash plant has been operating here since 1988. Dixie Valley is a classic Basin and Range geothermal system, with a reservoir associated with a major range-bounding normal fault. Wells drilled to intercept the range-bounding fault zone at Dixie Valley have had a reasonable success rate, but a number of dry holes exist (Benoit, 1997). A number of wells with high temperatures but low permeability are located within and outside the area of known production. These could be the target of stimulation experiments; such work would be highly useful for characterizing the behavior of enhanced Basin and Range systems, and would set the stage for other, similar stimulation work in fault-controlled geothermal systems. Considerable DOE-supported field work to characterize the stress field at Dixie Valley has already been performed (Hickman *et al.*, 1998).

The field operator has initiated a program of augmented injection to maintain reservoir pressure, and continues to modify its injection scheme to maximize heat recovery while minimizing the potential for injection breakthrough. An EGS program to further optimize injection augmentation at Dixie Valley could be of great value as a case study in effectively compensating for fluid deficiency in a Basin and Range system. A shallow groundwater well can currently produce up to 130 l/s for augmentation and more groundwater could be developed.

Soda Lake, Nevada. The Soda Lake field has binary generating units with a total capacity of approximately 24 MW gross (19 MW net), and the pumped production wells tap a 180°C reservoir. The field supplies enough fluid to run the plant at about 70% of its full capacity. Productivity in the geothermal system is controlled by a combination of stratigraphic and structural features (McNitt, 1990), with fluid flowing up-dip in a coarse, pumice tuff unit into a structural and gravity high, where it is intercepted by the production wells. Successful and unsuccessful wells are interspersed in the field. To increase productivity, either the Mesozoic basement rock beneath the producing reservoir or the pumice tuff zone could be hydraulically stimulated. Injection water could be made available for such stimulation work. Wells of opportunity would need to be carefully chosen to avoid detrimental interference with existing producers.

Steamboat, Nevada. There are two developments at Steamboat: the upper, high-temperature area, where a 13 MW flash plant is supported; and the lower Steamboat area, where a 45-MW binary plant is installed. Commercial permeability is found both in basement (granitic and metamorphic rocks) and in Tertiary volcanic units. At Upper Steamboat, there is potential for EGS work both to stimulate permeability and to mitigate a fluid deficiency by improving the injection configuration. Production is associated with a zone of naturally high permeability in basement rocks along a normal fault. Three wells located within a few hundred feet of active producers penetrated this fault but were not commercially productive. If their permeability could be enhanced, only modest pipeline modifications are required to tie them into the gathering system. Alternatively, one of the stimulated wells could be used for injection, thus improving pressure support to the production wells. No outside source of injection water for augmented injection is available. As the plant is currently operating about 4 MW below capacity, there is good potential for near-term economic advantage.

At Lower Steamboat, enhancing permeability in an idle injection well completed in granodiorite would allow better distribution of injection and would alleviate cooling due to injection breakthrough. The temperatures of existing producers could potentially be increased. In addition, the net power output of the facility could be increased by shutting in one of the lower-temperature producers (saving the electricity needed to run its pump) and forestalling the installation of booster pumps that might otherwise be needed to accommodate increased brine flow at cooler temperatures.

Stillwater, Nevada. Production is obtained from a combination of artesian and pumped wells, and the field has binary generating capacity totaling approximately 21 MW gross (16 MW net). Recent electrical output has been about 70% of plant capacity. An EGS stimulation program to improve the permeability of injection wells has the potential for an immediate economic benefit by decreasing the parasitic load required to run injection pumps.

Newberry, Oregon. Two core holes and two deep, full-diameter wells were drilled in 1995 on the western flank of Newberry Crater (Spielman and Finger, 1998). The deep wells penetrated several hundred feet of pre-Tertiary granitic basement below depths of about 2,700 m. All had relatively low permeability (~0.3 millidarcy) and high temperatures (up to 320°C). One of the deep wells would be an ideal candidate for EGS stimulation work. A shallow water well could be used to supply water for hydraulic fracturing. Newberry has no existing power plant, and the wells are approximately 18 km from the nearest transmission line access. Therefore, EGS work at Newberry is unlikely to have a direct economic benefit in the near term. However, as at Glass Mountain, demonstration of an effective stimulation technique at Newberry would provide useful information that might be applicable to a large number of geothermal resources hosted in young volcanic rocks worldwide, and could provide significant economic benefits in the long term.

Cove Fort, Utah. The Bonnett Geothermal Plant at Cove Fort has an existing capacity of 11.5 MW, comprising 3 MW of binary units and an 8.5-MW flash-steam unit. Production began in 1984. The plant is supplied by several wells producing from a steam zone in a Paleozoic sandstone and one pumped well producing from an underlying liquid-dominated zone in a Paleozoic carbonate unit (Huttrer, 1992). This field has near-term potential for an EGS program to mitigate a fluid deficiency that has caused pressure and productivity declines in a producing steam zone; an idle well completed at the bottom of the steam zone presents the possibility of injecting brine to extract additional heat from and supplement the recharge to the steam zone. Low steam-zone pressures have reduced output to about 50% of capacity. Thus, there is potential for a significant economic benefit. Long-term potential also exists for stimulation of permeability in an underlying body of crystalline rock (quartz monzonite) that has been penetrated by one active production well.

Roosevelt Hot Springs, Utah. A 25 MW flash plant (the Blundell Plant) has been operating at Roosevelt Hot Springs since 1984, supplied by wells drilled into fractured Tertiary volcanic and Precambrian metamorphic rocks in the hanging wall of a major fault. As indicated in well 9-1, commercial temperatures (227°C) exist in the foot wall, but permeability is limited to the zone immediately adjacent to the fault. Well 9-1 has some pressure communication with the reservoir. An EGS program at Roosevelt to stimulate well 9-1 and use if for injection would allow some of the heat in the foot wall to be recovered. Water for this stimulation work could be supplied by separated brine. Because, existing wells currently have a surplus of steam, there is no immediate economic incentive for an EGS program here.

4. DISCUSSION

Table 1 presents a ranking of the sites discussed, prioritized based on a "yes-or-no" approach to the infrastructure and resource criteria described above. The criterion of "proximity to a developed hydrothermal resource" was assessed based on the presence (or lack thereof) of an existing power plant and the availability of transmission-line capacity. The "prospect for economic advantage" was judged based on the current capacity and market potential of an existing plant to sell additional power. For both EGS categories (enhancement of permeability and fluid content), the ranking considered the availability of suitable wells of opportunity and the availability of water. Finally, the sites were assessed according to whether they occurred in extensional stress regimes. Because all the sites considered have been studied fairly thoroughly, the criterion that the resource be "well-characterized" was not addressed separately; however, it is likely that characterization of the stress field (at least) would be required at many fields prior to any hydraulic stimulation work. A few producing fields were not discussed because of either their relatively small size (Amedee and Wabuska) or the lack of benefit perceived by the operator (Mammoth and Beowawe).

Six fields (Coso, The Geysers, Cove Fort, Dixie Valley, Salton Sea and Upper Steamboat) meet 90% or more of the selection criteria. Nine fields meet 60 to 70%, and two (Glass Mountain and Newberry) ranked fairly low owing to the lack of infrastructure and potential for near-term economic advantage. The prioritization in Table 1 is qualitative and is based on a preliminary review. Any specific EGS proposal would need to be considered on its own merits, and fields with lower priorities in Table 1 could easily prove to be attractive prospects for EGS experimentation. The purpose of undertaking EGS work at any of these fields is to reduce the risk and uncertainty associated with EGS development, thus setting the stage for moving forward from research projects to demonstration projects and ultimately to commercial development.

An EGS demonstration project could be: 1) a project that supplies an existing geothermal power plant with additional generating capacity using EGS techniques; 2) a separate generating facility adjacent to an existing geothermal development supplied by an EGS injection and production system; or 3) a stand-alone EGS demonstration plant in an area with no existing geothermal development. The use of EGS techniques to supply an existing facility would have the following advantages:

- it is a low-cost option that could use wells of opportunity to develop and demonstrate EGS techniques; no new power plant construction would be required;

- it would be popular with the US geothermal industry, because today's low power prices make mitigation of capacity decline uneconomic in many fields, and operators are seeking ways to maintain capacity at affordable cost; and

- depending on the fields chosen, a variety of conversion technologies (*e.g.*, single- and dual-stage flash, water-cooled binary, air-cooled binary and hybrid) could be supported, which would show a broad applicability of EGS techniques.

Development costs could span a wide range, and would be likely to include those associated with well re-completion, well stimulation, development of water sources for augmented injection (such as pipelines and groundwater wells) and increasing the pumping capacity to enable more water to be moved through the system. In a demonstration of augmented injection, the location and rate of injection would need to be carefully chosen to avoid premature breakthrough of injected water, and to enable the maximum possible benefit. The challenge of demonstrating permeability enhancement will be to design and conduct the most effective stimulation program. In any EGS development supplying an existing facility, the improvement associated with the EGS project would need to be quantified, and a way of disseminating information from the project to other interested parties would need to be devised.

ACKNOWLEDGEMENTS

The authors are very grateful for the support from the United States Department of Energy, and for the cooperation of the geothermal field operators in undertaking this work.

REFERENCES

Benoit, D., 1997. Dixie Valley Research Introductory Comments and Overview. Proceedings, 21st Workshop on Geothermal Reservoir Engineering, Stanford University, January 1997, pp. 121 - 122..

Faulder, D.D., and S.D. Johnson, 1987. Desert Peak geothermal field performance. Transactions, Geothermal Resources Council, Vol. 11, pp. 527-533.

Hickman, S., J. Sass, C. Williams, R. Morin, C. Barton, M. Zoback and D. Benoit, 1998. Fracture permeability and in situ stress in the Dixie Valley, Nevada, geothermal reservoir. Federal Geothermal Research Program Update, Fiscal Year 1997, March 1998, pp. 4 -189 to 4 -196.

Huttrer, G.W., 1992. Geothermal exploration at Cove Fort - Sulphurdale, Utah, 1972 - 1992. Transactions, Geothermal Resources Council, Vol. 16, pp. 89 - 95.

McNitt, J.R., 1990. Stratigraphic and structural controls of the occurrence of thermal fluid at the Soda Lakes geothermal field, Nevada. Transactions, Geothermal Resources Council, Vol. 14, pp. 1,507 - 1,512.

Sass, J.H., and A. Robertson-Tait, 1998. Potential for "Enhanced Geothermal Systems" in the western United States. Proceedings of the 4th International HDR Forum, Strasbourg, France, September 28 - 30, 1998.

Spielman, P.B., and J.T. Finger, 1998. Well test results of exploration drilling at Newberry Crater, Oregon in 1995. Proceedings, 23rd Workshop on Geothermal Reservoir Engineering, Stanford University, January 1998.

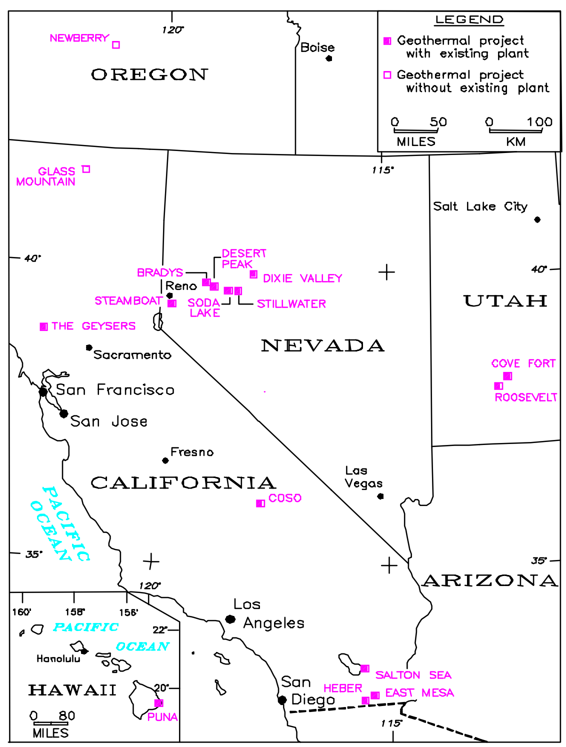

Figure 1: Location of geothermal projects discussed in the text

Table 1: Ranking of Potential EGS Sites

Field	Existing Plant	Transmission Capacity	Economic Advantage	Areas of Low Permeability	Wells Available for Stimulation	Water Available for Stimulation	Fluid Deficiency	Wells Available for Augmented Injection	Water Available for Augmented Injection	Extensional Regime	**Ranking** (10 = Highest)
Coso	X	X	X	X	X	X	X	X	X	X	10
The Geysers	X	X	X	X	X	X	X	X	X	X	10
Cove Fort	X	X	X	X		X	X	X	X	X	9
Dixie Valley	X	X		X	X	X	X	X	X	X	9
Salton Sea	X	X	X	X	X	X		X	X	X	9
Upper Steamboat	X	X	X	X	X	X	X	X		X	9
Bradys Hot Springs	X	X	X	X	X	X				X	7
East Mesa	X	X	X	X	X	X				X	7
Heber	X	X	X	X	X	X				X	7
Lower Steamboat	X	X	X	X	X	X				X	7
Stillwater	X	X	X	X	X	X				X	7
Desert Peak	X	X		X	X	X				X	6
Puna	X	X		X	X	X				X	6
Roosevelt Hot Springs	X	X		X	X	X				X	6
Soda Lake	X	X	X	X		X				X	6
Glass Mountain				X	X	X					3
Newberry				X	X	X					3