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1993 SURVEY OF THE GEOTHERMAL ELECTRICITY INDUSTRY

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ABSTRACT

A survey of the geothermal electricity industry followed up on the eleven annual EPRI electric utility surveys of 1977 to 1987 with two objectives: (1) to ascertain how well the electric utilities were able to forecast future-year installed geothermal capacity and (2) to redo the survey taking into account the influence of independent power producers in stimulating development of geothermal resources. The survey was successfully carried out with the assistance of the Geothermal Resources Council; more than 50 responses have been received. The results for actual installed capacity for 1992 and estimated capacity for 1995, 2000, and 2005 at three levels of confidence are summarized.

INTRODUCTION

From 1977 through 1987, the Electric Power Research Institute conducted an annual survey of the electric utilities to estimate the potential growth of geothermal produced electricity over the next twenty years. The surveys included the electric utilities in the United States and interlinked western zones of Canada and Mexico. The last of the EPRI surveys (Kruger, 1989), based on responses from 26 electric utilities, provided data on existing installed geothermal capacity and estimates of future geothermal power-plant capacity over five-year periods through 2005 at three levels of confidence: (1) announced, either publicly or through PUC-type reports; (2) probable, based on successful demonstration of technology for economic utilization of moderate temperature hydrothermal resources; and (3) possible, based additionally on anticipated growth of electric power and a favorable regulatory environment.

Data from the eleven EPRI surveys showed a continuous growth rate in installed capacity of about 15% per annum from 1977 through 1987 and indicated a range of forecasts of 2600 to 3500 MW for 1990, 4300 to 4900 MW for 1995, and 8100 to 9500 MW for 2000. Extrapolation by linear regression of the actual installed capacity indicated 2600 MW for 1990, 3400 MW for 1995, and 4200 MW for 2000. The more optimistic extrapolation by exponential growth regression of the same observed data gave forecasts of 3900 MW for 1990, 8600 MW for 1995, and 18,700 MW for 2000.

In 1992, EPRI examined how well the electric utilities were able to predict the growth of installed geothermal power-plant installation. The comparison of pre-1985 forecasts for 1985 to actual for 1985 and pre-1990 forecasts for 1990 to actual for 1990 are shown in Table 1. It is noted that the asymptotic forecast for 1985 after 1981 underestimated the actual installed capacity of 1950 MW. On the other hand, for 1990, the forecasts from 1985 on were in good agreement with the 1990 actual of 2827 MW.

Table 1 also shows the forecasts for 1995. The announced and probable values of 3058 MW and 3423 MW could be rather accurate in spite of the unforeseen decline at The Geysers. The desire to compare the 1995 forecasts with actual and to compile current expectations for the next 20 years stimulated the 1993 survey. However, in the interim period, profound changes have occurred in the electric utility industry with respect to determining future growth in new electric power plant installation. This has been especially true for geothermal energy since passage of PURPA in 1978 and its growing influence in the electric utility industry. In the 1987 EPRI survey, it was noted that of the 973 MW of additional capacity reported for the period 1986-1995 (NERC, 1986), 368 MW were expected from non-utility generation (NUG). Short (1991) in his analysis of trends in the U.S. geothermal energy industry emphasized the change in the 1980s from essentially a handful of oil company subsidiaries selling steam at The Geysers to utilities in northern California to the 1990s where many independent power producers are selling electricity to utilities in several western states.

Thus, for conducting an EPRI-type survey of geothermal electricity expectations, it seemed necessary to include the independent power producer (IPP) sector of the industry as well as the utility sector. This has been accomplished by enlisting the cooperation of the Geothermal Resources Council who identified the many IPPs and carried out a mailing of the survey forms to both IPPs and utilities. The results were encouraging, more than 50 responses were received. Tabulation of the data in the prior EPRI format constitutes the survey portion of this report. In addition, data

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Table 1
Comparison of the EPRI Geothermal Forecasts

Survey Year	Installed Capacity (MWe) at End of Year								
	1985 annc	1985 prob	1985 poss	1990 annc	1990 prob	1990 poss	1995 annc	1995 prob	1995 poss
1977	1178	2528	2528	1378	3258	4268	1678	4358	6268
1978	2019	2664	3374	3019	5414	7764	3619	7473	11323
1979	2057	2564	2999	2242	4577	6443	2512	6108	9188
1980	1574	1912	2177	2294	4216	5203	2599	5681	8106
1981	1865	1887	1887	3399	3849	4448	3920	5440	7390
1982	1540	1579	1610	2391	3353	3910	2615	4220	6722
1983	1623	1623	1623	2134	2968	3246	2158	3847	4508
1984	1780	1780	1780	2255	2659	3211	2441	3103	4944
1985	1917	--	--	3028	3040	3354	3153	3636	4984
1986				3450	3836	4474	3668	4706	6071
1987				2721	2824	3074	3058	3423	3814
Actual		1950			2827			??	

were solicited on the expected useful sizes of future powerplants and the potential for wellhead or portable units in accelerating the development of new fields. Further data for the forecast were available from the North American Electricity Reliability Council (NERC), primarily from the Western Systems Coordinating Council (WSCC). WSCC comprises 68 member utilities and affiliates in 13 contiguous western states, including British Columbia and Alberta in western Canada and northern Baja California in Mexico. Forecasts of geothermal capacity in Mexico by the Comision Federal de Electricidad are also included in the EPRI surveys.

NERC DATA

An important source for estimating future geothermal electrical energy growth has been the 10-year forecast of electrical supply and demand published annually by NERC for the 9 subregions of the contiguous U.S. including tie-ins to Canada and Mexico. In its reliability assessment for 1992-2000, NERC (1992) noted the effects on projected peak demand resulting from the emphasis on utility demand-side management (DSM) programs. Expectations for growth of peak demand for the period up to 2001 are at a growth rate of 1.8 %/yr. The total capacity projections for U.S. summer 2000 decreased 5.1 % from 774.1 GW forecast in 1991 to 769.0 GW forecast in 1992. These values included a 5.7 % decrease in Other utility generation (which includes geothermal) from 29.9 GW to 24.2 GW and a 7.0 % increase in NUG generation from 35.4 GW to 42.4 GW. A summary of the 1992-2001 forecast (NERC, 1992) by generator units is given in Table 2. Geothermal units are included in both Other and NUGs. It is noted that the forecasted retirement of 5000 MW of presently installed capacity over the 10-year period is 25 times greater than the added geothermal capacity, reflecting a geothermal growth rate essentially independent of the national electrical energy demand growth rate.

Greater details of NERC geothermal growth is given in the 10-year Plan of the Western Systems Coordinating Council (WSCC, 1991) which includes essentially all geothermal capacity in the United States. Table 3 shows the 10-year forecast for generating capacity from 1991 to 2000 by fuel type. The increase of 250 MW over the 10-year period has a mean annual growth rate of 0.78 %/a from the 1991 installed capacity of 3.1 GW. The almost constant level represents only 2 % of the electrical energy consumed in the western United States. The value also includes a major fraction of the 620 MW generated at Cerro Prieto (Suarez, 1991) as the Mexican tie-in from Baja California to WSCC.

THE 1993 SURVEY

The results of the 1993 survey are given in Table 4 grouped by regional energy pools. The northwest states include Alaska, Idaho. Oregon, Washington, and British Columbia in Canada. The southwest states include Arizona, Colorado, Nevada, New Mexico, and Utah. Data for Hawaii are combined with the data for California. Data from the Mexican Federal Energy Commission are given separately in Table 5 although the CA/HI values include the interlinked transfer of electricity from northern Baja California, Mexico. Data for the Gulf states, which comprise the south-central states with potential resources of geopressured thermal water and methane gas deposits, are not included in the 1993 survey as they were in the prior EPRI surveys.

Table 4 shows that the northwest states do not anticipate development of geothermal resources until the end of the century. However, the region forecasted possible rapid growth in capacity following successful demonstration of electricity generation from moderate temperature hydrothermal resources. For the southwest states, the announced capacity data indicates a mean annual growth rate of 2.5 %/a over the 10-year period from 1991 and a possible growth rate of 11.8 %/a. A surprising result from the CA/HI data is the growth in announced capacity of only 148 MW over the 14-year survey period. The mean annual growth rate for the probable 3730 MW in 2005 is 2.3 %/a and the possible 4220 MW is 3.2 %/a. Clearly, geothermal energy does not appear to be favorably anticipated by the geothermal industry over the next decade.

Table 2
Generator Units Additions, Changes, and Retirements (1992-2001 Forecast)**

Fuel Type	United States (GW)	(%)	NERC-Total* (GW)	(%)
Nuclear	5.9	7.5	8.5	8.4
Coal	8.0	10.2	10.6	10.3
Hydro	0.8	1.0	11.6	11.4
Oil/Gas	36.8	46.7	37.7	37.1
Pump Stor.	1.3	1.6	1.3	1.2
Other(Util)	7.0	8.8	8.3	8.1
NUGa (net)	19.1	24.2	23.9	23.5
Additions	78.9		101.9	
Changes	17.2		17.5	
Retirements	-5.0		-5.7	
Net Total	91.1		113.7	

* Includes Canada and WSCC-Mexico
** adapted from NERC, 1992.

Table 3
WSCC Generating Capacity by Fuel Type**
(in GWe)

	Existing 1991	(%)	Additions '91-00	(%)	Forecast 2000	(%)
Hydro	63.3	41.8	2.05	14.2	65.3	39.4
Coal	35.6	23.4	1.65	11.4	37.3	22.4
Oil & Gas	25.0	16.5	1.78	12.3	26.8	16.1
Nuclear	10.8	7.1	0.00	0.0	10.8	6.5
Comb.Turb.	5.5	3.6	0.84	5.8	6.3	3.8
Geothermal	3.1	2.1	0.25	1.8	3.4	2.0
Other*	8.5	5.5	7.87	38.3	16.4	9.8
Total	151.8		14.44		166.3	

* includes internal combustion, combined cycle, and cogeneration.
** from WSCC (1991).

The data for Mexico in Table 5 show a similar expectation of growth in geothermal electricity capacity. The mean annual growth rate for the 10-year forecast of announced capacity is 2.4 %/a and for the 10 years of possible capacity, it is 4.0 %/a.

The 1993 survey also compiled data on expectations of future unit power-plant size and the potential for initiating new fields with portable or wellhead generators. The response to this section of the survey was rather sparse, 15 responses were received of which only three considered use of portable or wellhead generating units. To date, 5-MWe portable units have been used successfully in Mexico and several small binary-cycle units are operating in the United States. The responses for expected size of future central power plants showed a bimodal distribution with a range from 1.2 to 150 MW and means of between 20-30 MW (8 responses) and 50-65 MW (5 responses).

Figure 1 shows the annual survey data for actual and announced for the year 1995. The trend lines for the two data sets seem to converge in 1995 at about 3000 MW about midway between the values for the announced and probable levels of confidence. Figure 2 shows the annual data for actual, announced, and probable for the year 2000. Here it is noted that the announced trend line meets the actual trend line at 1995, and level extrapolation of the 1993 probable value meets the linear growth line at about 4000 MW, consistent with the 1993 forecast.

The cumulative data through 1995 for the survey years 1977 through 1987 were given in Table 1. Table 6 lists the cumulative data for prior-year actual and the forecasts for 2000 and 2005. Trends for the data for year 2005 are not yet well established. Figure 3 shows the extrapolation of the actual installed capacity by survey year to the year 2005 for the two generally limiting cases, linear regression and exponential regression. The linear regression model,

Table 4
1993 GEOTHERMAL ELECTRICITY SURVEY

	Capacity (MWe) at Year End 1991 Actl	1992 Firm	1993 Expd	1995 Estd	2000 Estd	2005 Estd
Announced						
NW States	0	0	0	0	90	90
SW States	186	231	231	239	239	239
CA/HI	2703	2650	2703	2633	2818	2851
Total	2889	2881	2934	2872	3147	3180
Probable						
NW States				72	312	382
SW States				333	548	618
CA/HI				2814	3424	3730
Total				3219	4284	4730
Possible						
NW States				125	525	865
SW States				389	608	798
CA/HI				2919	3786	4220
Total				3433	4919	5883

Table 5
1993 GEOTHERMAL ELECTRICITY SURVEY
Mexico's Electric Utilities

	Capacity (MWe) at Year End 1991 Actl	1992 Firm	1993 Expd	1995 Estd	2000 Estd	2005 Estd
Announced	720	740	753	813	913	913
Probable				813	1043	1103
Possible				813	1073	1223

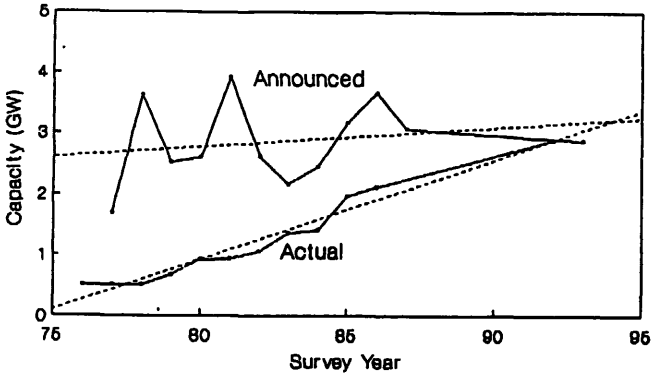

Fig.1 Actual and announced installed capacity for the twelve EPRI-GRC geothermal surveys for the year 1995.

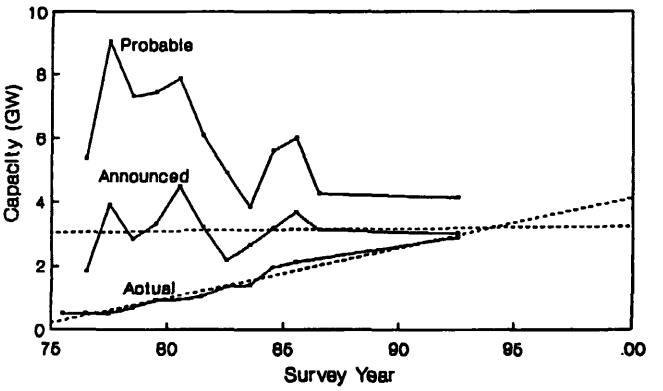

Fig.2 Actual, announced, and probable installed capacity for the twelve EPRI-GRC geothermal surveys for the year 2000.

Table 6
EPRI Geothermal Forecasts to 2005

Survey	Installed Capacity (MW) at End of Year					
	2000	2000	2000	2005	2005	2005
Year	Actu	annc	prob	poss	annc	prob	poss
1976	502						
1977	502	1828	5358	8868	--	--	--
1978	502	3919	9023	14723	--	--	--
1979	663	2832	7288	10888	--	--	--
1980	918	3299	7416	10761	--	--	--
1981	928	4481	7851	10811	--	--	--
1982	1047	3215	6087	9354	--	--	--
1983	1351	2158	4901	6525	--	--	--
1984	1397	2640	3823	6828	2640	4512	8007
1985	1950	3153	5581	7587	3153	6533	9624
1986	2112	3668	5973	8463	3668	6793	10068
1987		3125	4244	5316	3145	4953	6735
1992	2881						
1993		2997	4134	4769	3030	4480	5633

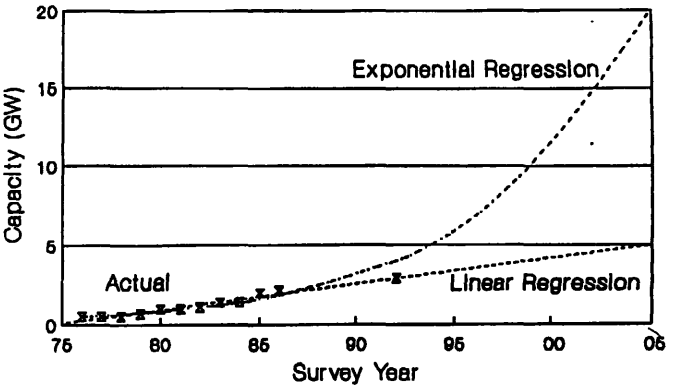

Fig.3 Actual geothermal installed capacity extrapolated to the year 2005 by linear and exponential regressions.

The linear regression equation is

$$C(t) = a + bt$$

where a = the initial value for the starting year (MW)
b = the growth rate (MW/a).

Using 1975 as the starting year, $C(t) = 178 + 164*t$.
The expectation value for year 2000 is 4278 MW, which compares with the probable value of 4284 in the 1993 survey.

The exponential regression equation is

$$C(t) = a*e^{it}$$

where i = mean annual growth rate (%/a).

For the same starting year, $C(t) = 457*e^{0.129t}$.
The mean annual growth rate of 12.9 %/a for the Actual record following the 1993 survey compares to 14.8 %/a following the 1987 survey. Even this smaller exponential growth extrapolated to the year 2005 shows a possible installed capacity of 20,000 MW. The 1993 survey value for Actual falls on the linear regression line and indicates, perhaps at best, an installed geothermal electricity capacity in the year 2005 of about 5000 MW.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the great assistance of Dave Anderson, Graciela Mata, and Cherri Simpson of the Geothermal Resources Council in making the 1993 survey possible.

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