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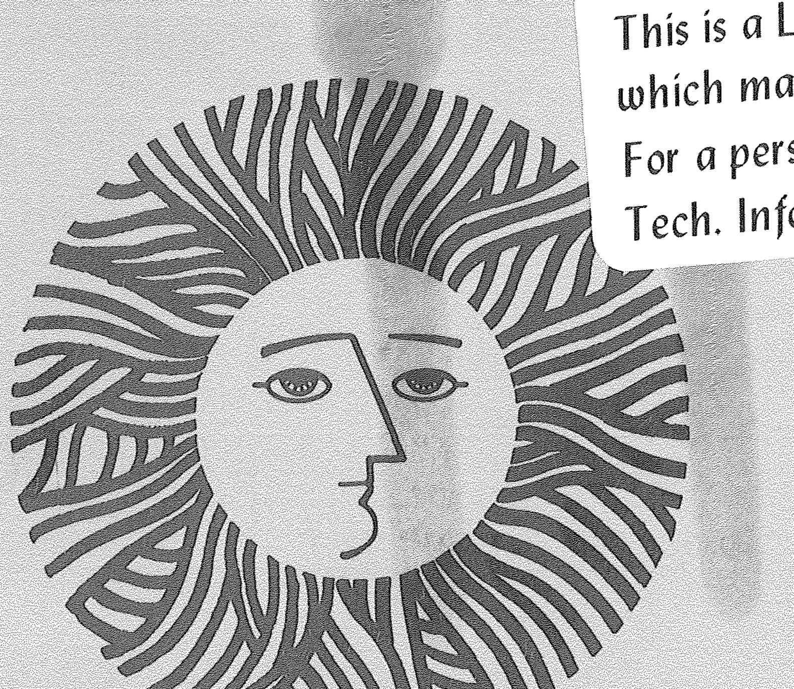

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LOCAL POPULATION IMPACTS OF GEOTHERMAL ENERGY DEVELOPMENT IN THE GEYSERS - CALISTOGA KGRA REGION

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ABSTRACT

The county-level population increase implications of two long-term geothermal development scenarios for the Geysers region in California are addressed. This region is defined to include the counties of Lake, Sonoma, Mendocino and Napa, all four in northern California. The development scenarios include two components: development for electrical energy production and direct use applications. Electrical production scenarios are derived by incorporating current development patterns into previous development scenarios by both industry and research organizations. The scenarios are made county-specific, specific to the type of geothernal system constructed, and are projected through the year 2000. Separate high growth rate and low growth rate scenarios are developed, based on a set of specified assumptions. Direct use scenarios are estimated from the nature of the available resource, existing local economic and demographic patterns, and available experience with various separate direct use options.

From the composite development scenarios, required numbers of direct and indirect employees and the resultant in-migration patterns are estimated. In-migration patterns are compared to current county level population and ongoing trends in county population change for each of the four counties. From this comparison, conclusions are drawn concerning the contribution of geothernal resource development to future population levels and the significance of geothermally induced population increase from a county planning perspective.

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I. INTRODUCTION

Regional Overview

The Geysers region is a subregion of northern California which contains large amounts of commercially attractive geothermal resources and the only known vapor dominated geothermal field in the United States, outside of national parks. The subregion includes The Geysers-Calistoga, Lovelady Ridge, Knoxville, Little Horse Mountain and Witter Springs Known Geothermal Resource Areas (KGRA)s and is located in portions of Colusa, Lake, Mendocino, Napa, Sonoma and Yolo counties north of San Francisco. The five KGRAs consist of about 420,000 acres of which nearly 90 percent (380,000 acres) is in the Geysers-Calistoga KGRA. Over 300,000 of these acres are state and private lands. Of the 40,000 acres associated with the four smaller outlying KGRAs, approximately 22,000 acres are under Bureau of Land Management (BLM) and Forest Service jurisdiction (Fredrickson, 1977).

The bulk of the region lies in Lake County, but most of the electric development to date has occurred in Sonoma County. Figure 1 shows the overall region and the individual KGRAs. While non-electric use of geothermal energy for spas was prevalent throughout the region as early as the late 1800's, that activity is now concentrated in northern Napa County and in parts of Sonoma County. Electric production efforts in the area began between 1921 and 1925 when eight steam wells were drilled for generating electricity. However, the project failed from lack of both nearby markets and of safe drilling technology. In 1955, Magma

Power Company began drilling for steam. In June 1960, Pacific Gas and Electric Company's first geothermal steam power plant went on line with 12.5 MW.

Since then, the addition of 12 generating units with total capacity of 608 MW* has made The Geysers the world's largest producer of power from geothermal energy. General lease patterns in the Geysers area are shown on Figure 2. Developed portions of the KGRA lie along the Sonoma County side of the Sonoma County - Lake County border through the Mayacmas Mountains. This is a sparsely populated area away from significant agricultural and recreational areas. Recent expansions into Lake County are approaching major recreational areas (e.g. Cobb Valley and Boggs Mountain) and more densely populated areas.

Lake County contains the largest area within the KGRA boundary. Because of the county's natural lakes and scenic mountains and its proximity to the San Francisco and Sacramento metropolitan areas, tourism has become one of the major economic activities. Extensive recreation development has occurred mainly in two areas, Cobb Mountain and Clear Lake (the largest natural lake in California). Commercial development and the utilization of the lake's recreation resources began over 100 years ago. The southern part of the lake is within The Geysers-Calistoga KGRA and the surrounding land is mostly in private ownership. Federal ownership within 4 to 5 miles of this portion of the lake is minimal and scattered. Potential geothermal leasing for such lands

*Since the compilation of this report, Unit 13 has come on line. However, the scenarios and calculations for this report were completed before this capacity addition and were based on a regional capacity of 608MW.

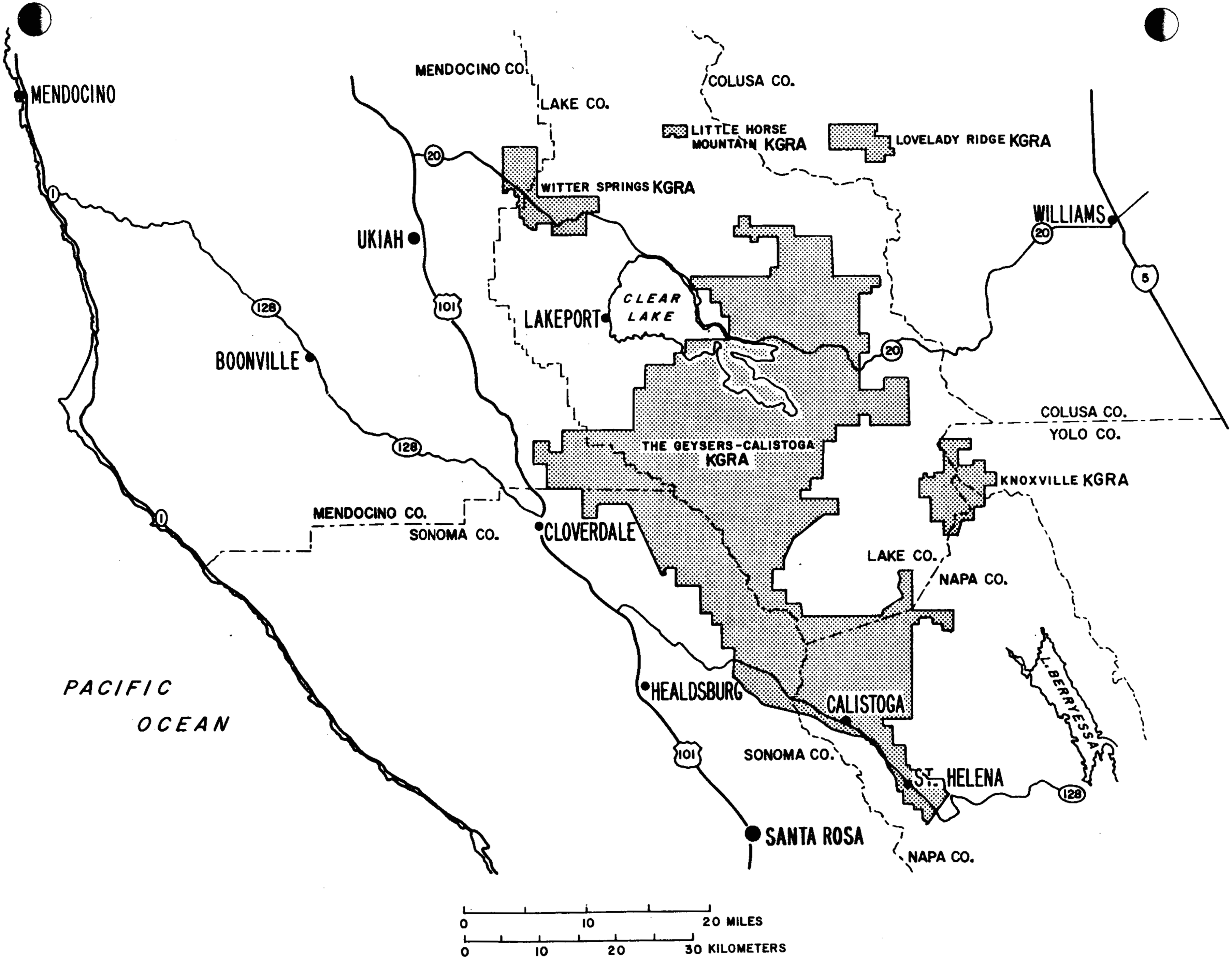

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Figure 1. Regional Overview and KGRA Locations

would, in most instances, have to be accomplished in conjunction with adjacent private lands. Although only 20 percent of the lake is in the KGRA, this portion contains about two-thirds of the lake's resorts, trailer parks, and related commercial facilities. Clear Lake State Park is located partially within the KGRA on the west side of the lake.

The forested Cobb Mountain area, near the center of the region, flourished as a resort area from 1870 to 1930. Adjacent to Cobb Mountain is the 3,300-acre Boggs Mountain State Forest which received 1870 recreation visitors in 1972. All of the State Forest and most of the adjacent Boggs Mountain area are within The Geysers-Calistoga KGRA. The scattered National Resource (BLM) lands, for the most part, do not have public access. The nearest urban centers to the KGRA are Santa Rosa (Sonoma County), Napa (Napa County) and Ukiah (Mendocino County).

<u>Recent Activity</u>

Active resource development has been underway for over 20 years, and over 300 geothermal wells have been drilled (Smith and Matlock, 1978). When the Pacific Gas and Electric Company's Unit 11 came on line in 1974, it raised the installed electrical capacity to 502 MWe making it the largest geothermal installation in the world. The company (with 608 MW currently on line) plans to add another 1000 MWe of capacity by 1985.

In recent years development at The Geysers has slowed. Unit 12, the first addition to be sought after the provisions of the California Environmental Quality Act (CEQA) went into effect, suffered considerable delays while the procedures and data requirements for the issuance of

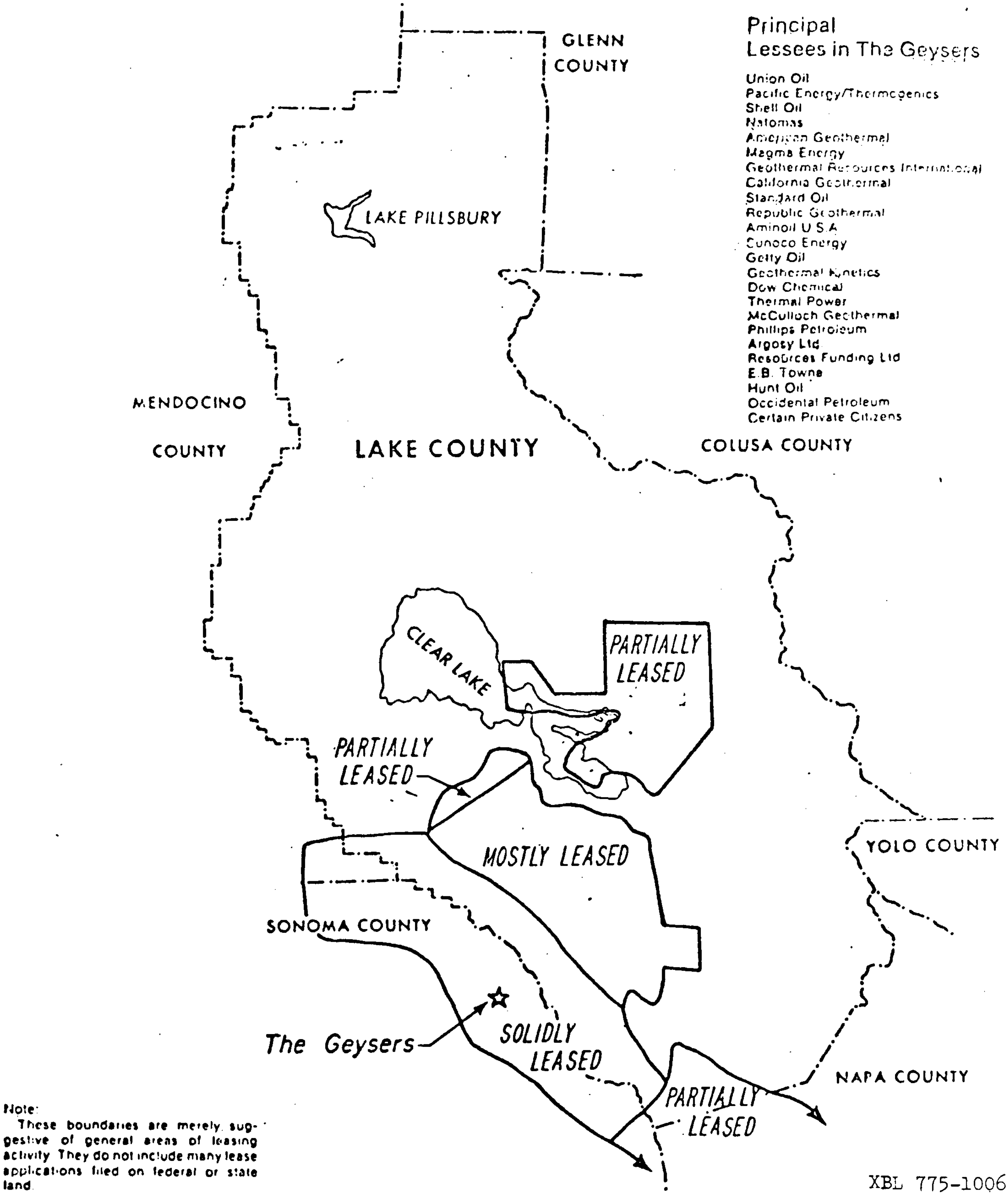

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Fig. 2. Areas of Major Leasing Interest

the necessary permits were being defined. In 1976 the development process was resumed and authority was granted to PG & E for units 13, 14 and 15. The last of these units approved, Unit 14, is expected to be on line in the early 1980's.

The California State Department of Water Resources, the Northern California Power Agency and Sacramento Municipal Utility District have lease holdings which may allow them to operate electric power plants in the Geysers region in the near future. There are also strong indications that hot-water resources are present in significant quantities under large portions of the region. The USGS (1978) lists numerous hot springs in the greater Geysers area. However, the extent of the hot water resources has yet to be demonstrated by deep drilling.

The KGRAs (The Resource)

A brief description of the location and basis for establishing each KGRA is presented here, based on work by the Jet Propulsion Laboratory (JPL, 1976) and USGS (1978). An estimate of the extent of the resource and its potential is provided in Table 1. Estimates by other researchers (e.g. Greider, 1977; or SRI, 1977) show similar potentials. No new assessment of the KGRAs has been made for this project and the reader is referred to the referenced sources for greater detail on the geophysical characteristics of the region.

The Geysers-Calistoga KGRA

The Geysers-Calistoga KGRA consists of 378,687 acres located in portions of Lake, Mendocino, Napa, and Sonoma Counties. This KGRA has evolved from additions to The Geysers and Calistoga KGRAs causing them

Table 1

Estimated Energy Potential, the Geysers Region KGRA's

Location/KGRA	Circular 790/726 Designation	Estimated Reservoir temperatures, °C	Wellhead Thermal Energy, x 10^{18}J
Geysers-Calistoga	The Geysers	240	9.3
	Clear Lake Volcanic Field	195	9.8
	Calistoga	141	0.6
	Sulfur Bank Mine	186	0.8
	Skagg's Hot Springs	95	0.22
	Wilbur Hot Springs	141	1.09
Knoxville	One Shot Mining	150	NA*
Little Horse Mtn.	Crabtree Hot Spring	150	NA
Lovelady Ridge	Cook Springs	140	NA
Witter Springs	Saratoga Springs	140	NA

*Not available.

From: USGS, 1978; D. Citron, et al., 1976; Brook, et al., 1979; and JPL, 1978.

to coalesce into a single large KGRA. The initial KGRAs were located in northeastern Sonoma County (The Geysers) and in the northern end of Napa Valley (Calistoga) between 60 and 70 miles north of San Francisco. An arm of the present KGRA extends some 9 miles southeastward and encompasses the towns of Calistoga and St. Helena.

Geological indicia led to establishment of The Geysers and Calistoga KGRAs on December 24, 1960. A review of the geology in the area between The Geysers and Calistoga KGRAs indicated that the two existing KGRAs should be consolidated and that lands southeast of the Calistoga KGRA should be added to the new KGRA. Thus, the addition to, and consolidation of, The Geysers-Calistoga KGRA was determined on the basis of (1) favorable geological data and (2) competitive interest.

Knoxville KGRA

The Knoxville KGRA contains 14,702 acres (of which 9,785 acres are National Resource Lands) and is located in the north coast ranges of California approximately 75 miles north of San Francisco and 10 miles east of the original Geysers KGRA. The KGRA includes sections of Lake, Napa, and Yolo Counties. A small population center (Knoxville) lies less than one mile east of the KGRA and is more or less a ghost town. The area is serviced by the Berryessa-Knoxville, or Morgan Valley, Road.

This KGRA is based on the filing of overlapping noncompetitive lease applications indicating competitive interest, and is supported by geologic indicia in the area.

Little Horse Mountain KGRA

The KGRA consists of 1,196 acres in Lake County, 12 miles north of the town of Lucerne on Clear Lake. The land of the KGRA includes two sections in an east-west alignment. Approximately 1 mile to the northwest is Crabtree Hot Springs with a surface temperature of 41 degrees Centigrade.

Overlapping geothermal lease applications filed in the vicinity of Little Horse Mountain, Lake County, in January, 1974, indicated that competitive interest in the area exists. Designation of the area as a KGRA is based solely on this competitive interest.

Lovelady Ridge KGRA

The Lovelady Ridge KGRA contains 6,879 acres in Colusa County and lies about 16 miles northeast of the Geysers-Calistoga KGRA and approximately 4 miles southwest of Lodoga. The dominate geographic feature in the KGRA is Lovelady Ridge, trending north to northeast.

Lovelady Ridge KGRA is based primarily on competitive interest. Geothermal indicia, such as dissolved silica in the waters of Cook Springs and Deadshot Spring in the KGRA which indicate water source temperatures of 120 degrees Centigrade and 100 degrees Centigrade respectively, also lend support to the designation.

Witter Springs KGRA

The Witter Springs KGRA contains 18,152 acres in portions of Lake and Mendocino Counties. It is located a few miles northwest of Clear Lake in Lake County. The City of Ukiah is approximately 12 miles to southwest.

Overlapping geothermal lease applications in the vicinty of Witter Springs filed during January 1974 indicated that competitive interest in the area exists. KGRA designation was based on these interests and upon geothermal indicia.

Geysers Socioeconomic Research Program

A series of previous studies have addressed geothermal development in the Geysers area. A majority of these have addressed the characteristics of the resource and its potential for generating electric power (e.g: Citron, et al., 1977; Leibowitz 1976 and 1977; SRI, 1976; Fredickson, 1978; Goff, et al., 1979; Freider, 1977; and so forth). A second series of studies (principally EIR/EIS and topical studies such as Vollentine, Kunin and Sathaye, 1977) have addressed in detail the environmental and socioeconomic impacts of the construction and operation of a single plant. However, little has been done to assess the cumulative potential effects associated with enactment of a long-term development scenario.

DOE is actively supporting commercialization of geothermal energy resources in the Geysers-Calistoga KGRA through a variety of research programs and the Geothermal Loan Guarantee Program. DOE therefore has assumed the function of assessing the probable environmental and socioeconomic consequences of geothermal energy development within the region. The program has been conducted through the San Francisco Regional DOE Office and Lawrence Livermore Laboratory (LLL), the lead laboratory for geothermal energy assessments.

Planning by LLL for socioeconomic research in the Geysers region began late in 1977 with an Overview Program. A major research program with the objective of long-term scenario assessment evolved from the DOE overview program. A small task force was convened on December 16, 1977 at Sonoma State College. The task force identified preliminary issues, data sources, constituent interest groups, information user groups and needs, and made research recommendations. This was followed by a workshop on June 9, 1978 at St. Helena (Napa County). A broad spectrum of major interests in the four county area was represented, including:

> County Board of Supervisors; Planning Commissions; planning, public works, social service, and assessor department heads; citizens; growers; vintners; energy industry; State Energy Commission; Bureau of Land Management; land owners; interest groups; State Department of Finance; school district representatives; consultants; and research organizations, as well as DOE officials.

The workshop devoted itself to a thorough examination of the issues of importance to the local communities. After an exhaustive listing and description of a wide range of issues, the workshop participants ranked over 160 specific issues. In broad categories, the most critical priorities were: land use, fiscal, demographic, and economic issues. Research recommendations, on the basis of this priority ranking, were made by a joint LLL-GRIPS overview staff. GRIPS, (Geothermal Research, Information and Planning Services) is an inter-county agency representing the counties of Lake, Sonoma, Mendocino and Napa and tasked with the coordination of information related to the development of geothermal resources in the area.

A socioeconomic research plan was developed by LLL to provide a comprehensive response to the issues identified by the socioeconomic overview program (Hall and Obanion, 1979). This multi-year study plan identified research tasks in all areas of socioeconomic concern and was presented to the GRIPS Technical Advisory Committee (TAC) by LLL on February 23, 1979. A revised plan was presented to a TAC meeting March 16, 1979 which outlined a program built on collaborative LLL/LBL efforts.

A feature especially designed with local land use management needs in mind is an iterative identification and evaluation of mitigating policy options to reduce significant adverse impacts. These policy options are designed for consideration by the counties and GRIPS as mechanisms to manage geothermal growth and related development through geothermal or energy elements to county comprehensive land use plans, area specific plans, use permit performance standards, or other policy implementing tools. This approach, in which local agencies participate in the design of and conduct of a major research program, is designed to encourage maximum local participation. The proposed research program was initiated in April 1979.

Study Objectives

The study reported here is one part of the entire assessment described in the LLL socioeconomic research plan. The goals of this study were to define probable development scenarios for electric and non-electric geothermal energy development in the Geysers region and to assess county level population impacts resulting from probable future (1979-2000) geothermal energy development paths.

We divided the study into three tasks. The first task was to define probable development scenarios for both electric and non-electric utilization of geothermal resources and to define the employment impacts of these scenarios. The second was to assess available baseline data for county level population characteristics and for recent trends in population shift and county in-migration. The third step was to use the baseline and scenario data to drive a cohort-survival population model in order to assess long-term county level population impacts of alternate levels of geothermal activity.

Subsequent sections in this report present the specific methodology used in, and results obtained from, each of these tasks. Conclusions concerning geothermal development impacts on county population are presented in the final section.

It is important to view this study within the context of the overall LLL research plan. All studies undertaken during FY 79 were designed to build a body of basic information. Ongoing studies include fiscal characterizations, land use assessments and economic assessments as well as the demographic work reported here. From these studies, subsequent efforts (FY 80 and 81) will evaluate the impacts of alternate local policy options on the projections developed during FY79 and will address detailed sub-county issues arising from the basic studies. As a result, the current study is limited in several ways. First, this is a county level study. A major conclusion of the study, however, is that demographic impacts will be most strongly felt at a sub-county level. Second, as a base case analysis, the study must exclude the effect of any policy options which might be exercised by various levels of government. These, too, are to be addressed in subsequent efforts.

While it may appear that little room is left for analysis, we found that such was not the case. Much innovative work was performed for this study in the areas of direct use of geothermal energy and in evaluating the employment and in-migration implications of geothermal energy. In those regards the study can stand alone. However, it should be remembered that this study is designed as one part of a much larger socioeconomic assessment.

II. ELECTRICAL ENERGY DEVELOPMENT SCENARIOS

Basis for Scenario Development

Scenarios forecasting the future path of electrical generation from geothermal energy in the Geysers area have been prepared by JPL (Leibowitz, 1976; Fredrickson, 1977), by Greider (1977), by SRI (1977), and more recently by the California Energy Commission (Hill, 1979). These forecasts were used as a starting point for this study. Revision of the existing forecasts was required for several reasons. First, recent analysis (Hill, 1979) indicates a general delay in meeting the near term (1980-1985) goals listed in JPL and other scenarios. Second, our study required the identification of plant type (e.g. steam, hot water binary, etc.) for all plants included in a forecast in order to calculate associated construction labor force. This could not be done at a county level from existing scenarios. Third, existing scenarios assume a set of state and county institutional policies and actions, and include the influences of these policies in the final scenarios. As defined by the LLL socioeconomic research plan, our scenarios must discount county or local policy options and concentrate on technical, economic and geophysical feasibility. As a result, the effects of various policy options had to be removed from existing scenarios.

Scenarios developed here were conceived in a top down manner. Regional electric production goals were forecast based upon previous analyses and the set of scenario assumptions described later in this section. Resulting totals were apportioned to counties as a function of

KGRA potential (from USGS 1979 and Goff, et al. 1977) and of existing development and drilling patterns. Assumptions were made concerning the future shares of the total regional capacity for steam, flash hot water and binary hot water plants. Steam plants were limited to Lake and Sonoma Counties in the area of the existing steam field. Finally, county capacities were allotted to the three plant types and associated drilling and construction schedules were defined.

All scenarios recognize ongoing development activities (see Table 2 and Table 3). While some of the later plant-on-line dates shown in Table 2 were allowed to slip under a low growth scenario, the plants shown were all eventually included in each scenario.

Scenario Assumptions

Two types of assumptions were identified for consideration in developing scenarios for this study. There were assumptions which limit the magnitude of development, and assumptions which affect the timing of development. Areas for consideration were limited to physical resource characteristics, engineering considerations, economic considerations, energy demand/supply relationships, and environmental control technology. As previously mentioned, sociopolitical and institutional areas were not considered. The assumption areas and their implication for geothermal development are:

1. Size of Steam Field: For previous analyses the boundary of the current field has been accepted as the ultimate boundary of the steam field (see Goff, et al., 1977). Recent measurements by USGS (Iyer et al., 1979) indicate a higher temperature anomaly than previously suspected northeast of the current field of operation as far as the Mt. Hannah area. This does not establish the existence of an expanded steam field. However, since we lack detailed proprietary data on test drilling results in that area, the possibility of a larger steam field and its effect on development rates

Table 2

On-Going Geothermal Power Plant Activity in the Geysers Region
(as of Sept 79)

Utility	Unit	Developer	Capacity (MWe)	Scheduled Date on Line	Status
1. PLANTS ON LINE					
PGE	1-12		608	---	---
2. PLANTS UNDER CONSTRUCTION					
PGE	15	Thermogenics	55	Fall 1979	under construc.
PGE	13	Aminoil	135	2/80	"
PGE	14	Union	110	6/80	"
3. PLANTS SITED, PLANNED AND ANNOUNCED					
PGE	17	Union	110	1981	AFC accepted
PGE	16	Aminoil	110	1982	NOI decision due late 79 (Powerline routing problems exist)
NCPA	2	Shell	2ea 55MW units	1981/1982	AFC in to Energy Comm.
DWR	Bottle-rock	McCulloch	55	1983	Prelim. report by Energy Comm. 3/79
PGE	18	Aminoil	110	1983	NOI/AFC to Energy Comm. 5/79
NCPA	1	Resources Funding Limited	2ea. 33MW units	1983	
PGE	19	Aminoil	110	1984/85	Test well problems-more test drilling scheduled in 1980
DWR	Rora-baugh	Geo. Kine-tics	55	1984	
SMUD	1	Aminoil	55	1984	NOI due late 1979

Table 2

On-Going Geothermal Power Plant Activity in the Geysers Region
(as of Sept 79)

(continued)

Utility	Unit	Developer	Capacity(MWe)	Scheduled Date on Line	Status
4. PLANTS PLANNED BUT NO ACTION TAKEN					
DWR	New-field	McCulloch	55	?	Problems with county acceptance of exploratory well permit.
PGE	20	Union	110	?	Siting uncert. Tests in Cobb Mountain area did not produce proven resource.
PGE	21	?	55	?	Currently negotiating steam supply

Source: D. Hill, 1978, 1979

Table 3

On-Going Drilling Activity in The Geysers Area (Sept. 1979)

1. Existing Exploratory Step-out Projects

Thermogenics - Rorabaugh and others, Sonoma County
30 wells; 24 production wells completed for Unit 15.

Aminoil - Wildhorse, Sonoma County
4 wells; none yet producing commercial quantity of steam.

Aminoil - Castle Rock Springs, Lake County
25 wells (one in Sonoma Co.); 19 productive for Unit 13; drilling in progress.

Shell Oil - BLM/Bounsall, Lake County
3 wells; 2 productive (drilling in progress)

2. Exploratory Permits Granted and/or Drilling in Progress

McCulloch Oil - Francisco (High Valley Cr.), Lake County
2 wells; one completed and productive.

Aminoil/Gulf Oil - BJ, Maguire Peak, Lake County
drilling in progress; Negative Declaration granted by Planning Commission.

Republic Geothermal - Howard Hot Springs, Lake County
2 exploratory wells.

Union Oil - Binkley, Lake County
site prepared; no drilling yet.

Union Oil - Phelps, Lake County, site preparation in progress;
EIR and permit held in court for two years.

Magma Energy - Watson, (Mt. Konocti), Lake County
2 wells; no drilling yet. Negative Declaration denied by Planning Commission. Use permit denied by Planning Commission. Use permit denial overturned by Board of Supervisors.

3. Exploratory Drilling Projects Seeking Approval

Phillips Petroleum - Borax Lake, Lake County
1 exploratory well.

Union Oil - Thurston Lake, Lake County
exploratory well(s).

Chevron Oil - Dry Creek, Lake County
3 exploratory wells; Negative Declaration sought

Table 3

On-Going Drilling Activity in The Geysers Area (Sept. 1979)

4. <u>Partial Action or Informal Discussion Stage Projects</u>

Resources Funding Limited/Northern California Power Association - Boggs Lake, Lake County
exploratory drilling, field development for up to four 55 MWe plants

State Lands Commission/Lawrence Berkeley Lab - Clear Lake, Lake County
conducted tests of heat probes and temperature gradients of Lake bottom

Bureau of Land Management (Ukiah District Office) - 93,000 acres in Lake, Sonoma, Mendocino, and Colusa Counties (75,000 in Lake)

a) Cow Mountain, Lake and Mendocino Counties' draft completed
b) Witter Springs, Lake County; draft completed
c) Bartlett Springs/Walker Ridge, Lake and Colusa Counties' study underway
d) Lovelady Ridge, Lake County; study planned

should be explored. Therefore, under the high growth scenario an additional 5000 acres of steam field (500 MWe) are assumed to be available for development by 1985.

2. Energy Price and Demand: The rate of development of geothermal energy is dependent upon the price of alternate sources of energy and upon the regional demand for electricity. As the price of alternate sources (oil) rise, the capital investment necessary to construct a geothermal plant becomes more attractive. Thus the rate of geothermal development and oil prices are directly related. If world oil prices continue to climb at current rates (5 percent-6 percent real growth per year) both geothermal steam systems (already economically attractive) and hot water systems will be attractive by the early 1980's. However, the electricity produced from geothermal energy must also be in demand before plant construction is warranted. PG&E service area growth has been below 3 percent per year for the past several years (CEC, 1978). With other major facilities due on line during the scenario period (e.g. Diablo Canyon, Pittsburg 8 and 9, and Fossil I) and with California Energy Commission forecasts predicting continued low growth rate, investment in geothermal development above the high growth rate scenario used here does not appear to be likely. Statewide conservation efforts or other demand reducing forces (increased off-peak power utilization for example) could easily reduce future demand sufficiently to delay scheduled geothermal investment plans (low growth scenario).

3. Hot Water Development: System development of hot water resources will depend upon success of the Imperial Valley demonstration and prototype plants even though such systems have been forecast to first come on line in the Geysers in 1985 (Fredrickson, 1977) and in the mid to late 1980's by the CEC (Hill, 1979). The first Imperial Valley 10 MW demonstration plant (Niland) went on line in 1976. Progress since then has been slower than originally forecast. However, test facilities (e.g. LLL's total flow system) and more than 10 operating plants are expected to be on line by the mid 1980's (date provided by D. Layton, LLL, 1979). If the operation of these plants demonstrates that hot water brines can be managed within the plant and that high plant capacity factors can be maintained, capital will become available to develop hot water resources in the Geysers area (high growth scenario). If however, the existing system designs do not prove feasible in Imperial Valley, development of hot water in The Geysers will be stalled until new engineering designs have been developed and tested or until federal demonstration grants are made available to Geysers development (low growth scenario).

4. Binary System Development: Initial hot water development will favor binary systems over flash systems. At lower brine temperatures (150 degrees Centigrade to 250 degrees Centigrade), a binary system has well-head efficiencies 1.5 to 2 times those of a flash system (SDGE, 1977; Goldsmith 1976; Ramachandran et al., 1977). This means a flash system (assumed to be a 2-stage flash for these calculations) will require 1.5 to 2 times as much incoming brine

(i.e. 1.5 to 2 times as many wells) to produce the same output power. Further, binary systems do not produce the large quantities of gaseous emissions that flash systems will produce. Binary plants do cost approximately 7 percent more than flash for the same power output (SRI, 1977; MITRE, 1979). However, this extra plant cost is far outweighed by the field development and steam cost savings of the binary system. Finally, current Imperial Valley plant designs (assumed prototype for initial Geysers plants) favor binary systems. Thus binary plants should be the "system-of-choice" when hot water resources are first developed. The limiting factor for binary system development will be that, unlike flash systems, external cooling water will be required (see #5 below).

5. Cooling Water Supply: Lack of cooling water supplies will limit binary system development in Lake County. Both USBR (1979) and the California DWR (1971) project water supply and demand for Lake County to 2020. Depending upon the growth scenario analyzed, county water demand that year is forecast to be in the 68,000 to 95,000 acre-ft/yr range. This entire range of possible 2020 demands exceeds the available in-basin supplies (USBR, 1979) and water imports will be required to support the future population. The allocation of cooling water to binary systems will therefore mean an increase in the amount of imported water required. Binary systems typically consume 40 acre-ft/yr/MW (MITRE, 1978). Thus a 55 MW plant will require 2200 acre-ft of water per year. Firm limits on the amount of imported water which could be made available to Lake County cannot be established; however a 25 percent increase above the supply forecast by the USBR plan appears to be a reasonable upper limit for the county for cooling water allocation. Thus, the high growth scenario provides a maximum of 23,000 acre-ft in 2000 for energy development (or 585 MW of binary systems) in Lake County. The low geothermal growth scenario assumes no additional major water supplies will be made available. In this case a portion of the USBR and DWR forecasted industrial water use is assumed to support geothermal activity. It is estimated that 8500 acre-ft/yr could thus be made available and could support 210 MWe of binary systems in Lake County.

6. H_2S Abatement: H_2S abatement technology effectiveness will substantially influence the allowable limit of steam and flashed steam plants. H_2S abatement technology has been significantly advanced in recent years. If the new generation of systems proves effective, H_2S should not be a limiting factor in future geothermal expansion (high growth). If ambient levels of H_2S remain significant, future (post 1985) development will be curtailed until effective abatement technology is available (low growth scenario).

7. Capital Availability: Capital will be available to finance steam field and plant development. Investor confidence in steam systems has been established. However, some members of the financial investment community have expressed personal reservation at hot water systems until the technology has been proved within the United States. Until then, potential returns do not justify the perceived level of risk. Under a high growth scenario, Imperial

Valley plant experience is assumed to be sufficient to ensure an adequate supply of capital for all geothermal development.

8. New Technology: It is assumed that no new geothermal technologies or basic system configurations will be developed before 2000.

9. Resource Limits: It is assumed that existing resource characterizations have accurately depicted both the physical limits and capacity of the geothermal resource except as previously noted (see assumption 1).

Not all of the above assumptions act in consort to promote or restrict geothermal development. Rather, several act as counter balances. For example, an expanded steam field reduces hot water development. The assumptions which ultimately acted as primary limiting factors in the scenario development for this study were steam field size, energy demand growth rate, hot water technology development, and cooling water availability for binary systems.

Electric Energy Scenarios

The assumptions were applied to the regional goals obtained from the previously described studies. Table 4 shows the resultant regional and county level capacity totals for the high and low growth scenarios. This information is displayed graphically on Figures 3 and 4. Figure 5 shows year-by-year region capacity by system type for each scenario. Table 5 shows the required new plants on line for each five year time period. This information is presented graphically in Figures 6, 7, and 8.

Table 6 lists the capacity difference in electric power production between high growth and low growth scenarios. No difference exists until 1985 but, on a regional basis, grows steadily thereafter until 2000. Regional capacity additions for the high growth scenario peak in

Table 4

Electric Energy Scenario by County

1. High Growth Scenario

COUNTY / YEAR:	PRESENT Capacity (MWe)	1980	1985	1990	1995	2000
Sonoma	608	773	938	1253	1405	1603
Lake	0	135	751	1381	2011	2411
Mendocino	0	0	0	50	150	400
Napa	0	0	0	0	50	100
TOTAL	608	908	1689	2634	3654	4514

2. Low Growth Scenario

COUNTY / YEAR:	PRESENT Capacity (MWe)	1980	1985	1990	1995	2000
Sonoma	608	773	938	1071	1093	1093
Lake	0	135	751	1043	1226	1376
Mendocino	0	0	0	0	0	50
Napa	0	0	0	0	0	0
TOTAL	608	908	1689	2114	2316	2519

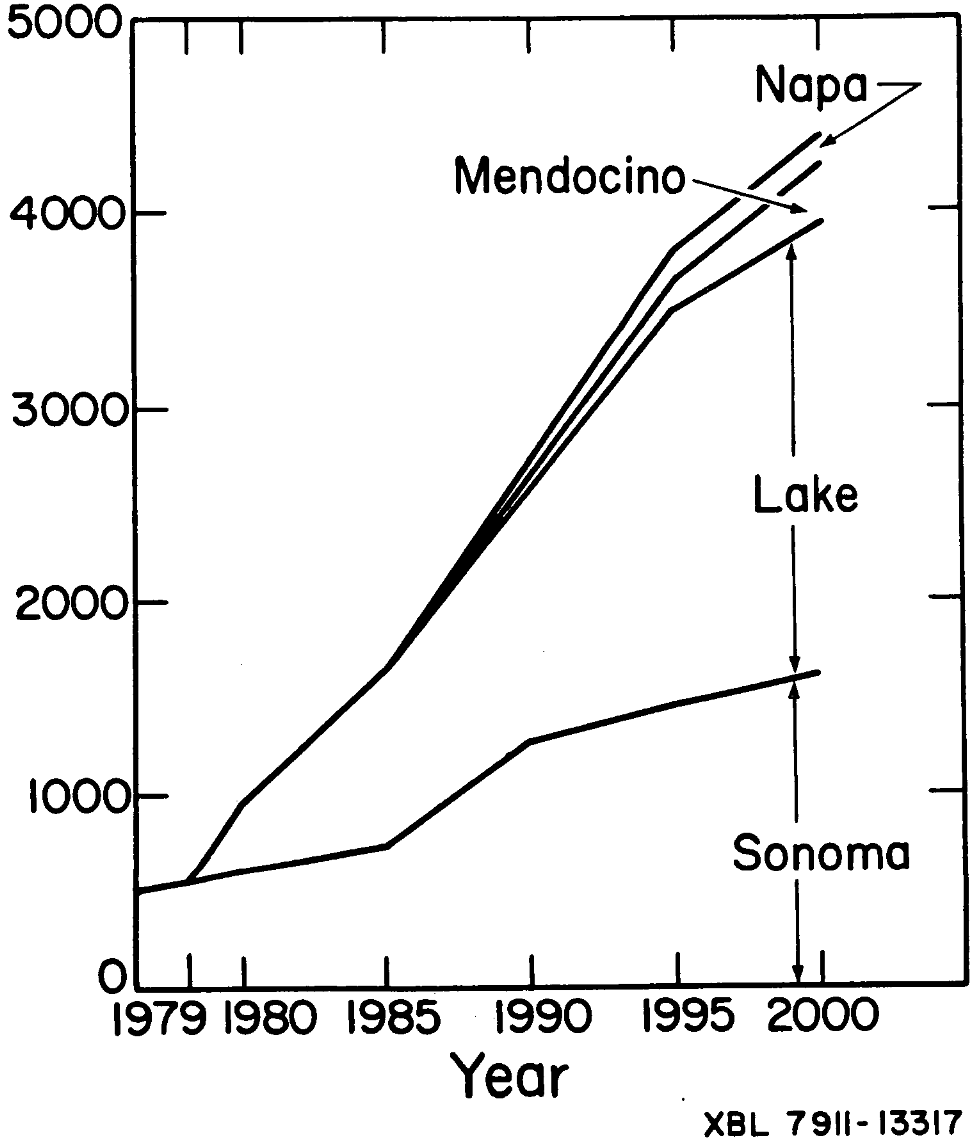


Fig. 3 County Level Capacity for the High Growth Scenario

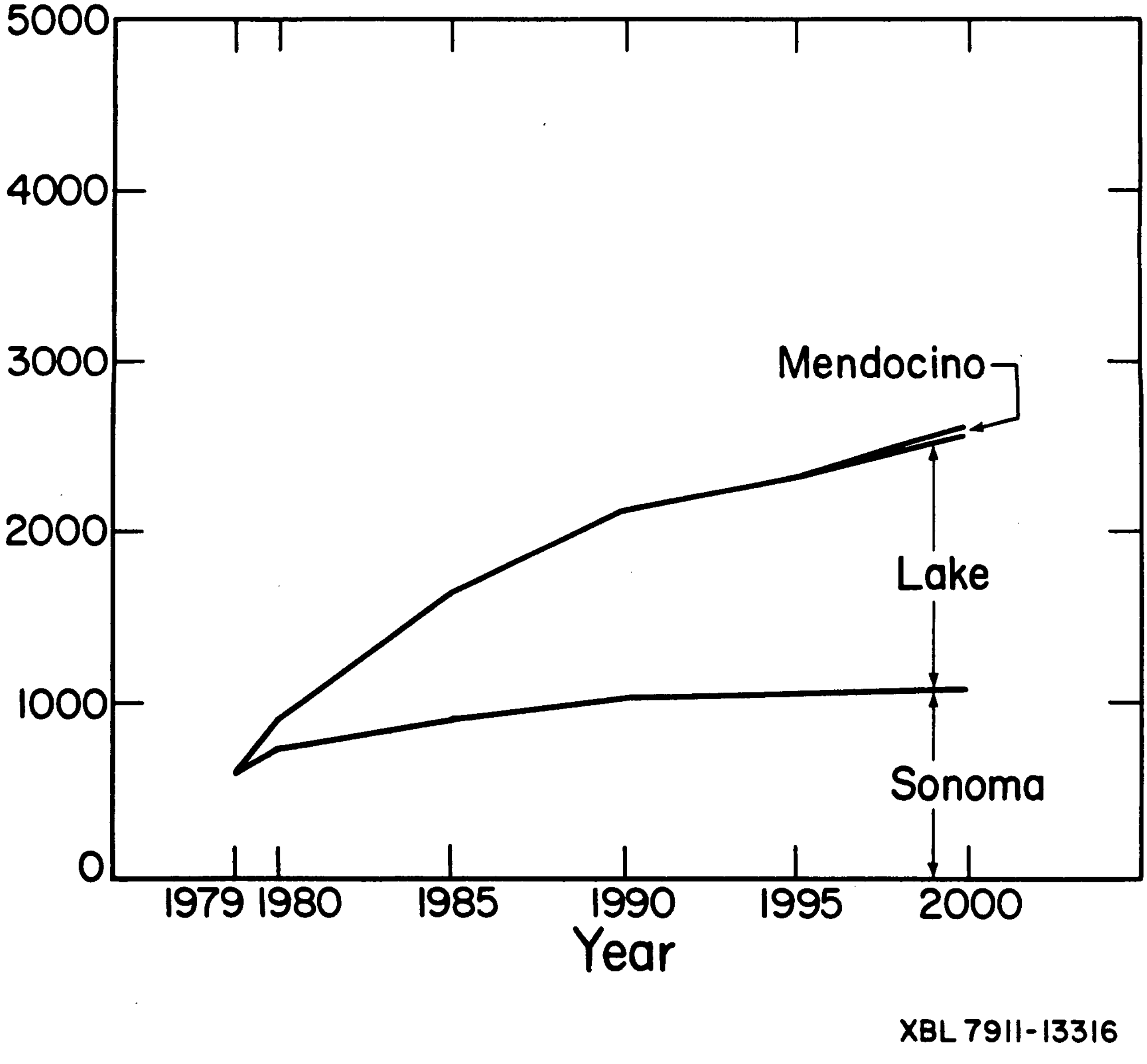


Fig. 4 County Level Capacity for the Low Growth Scenario

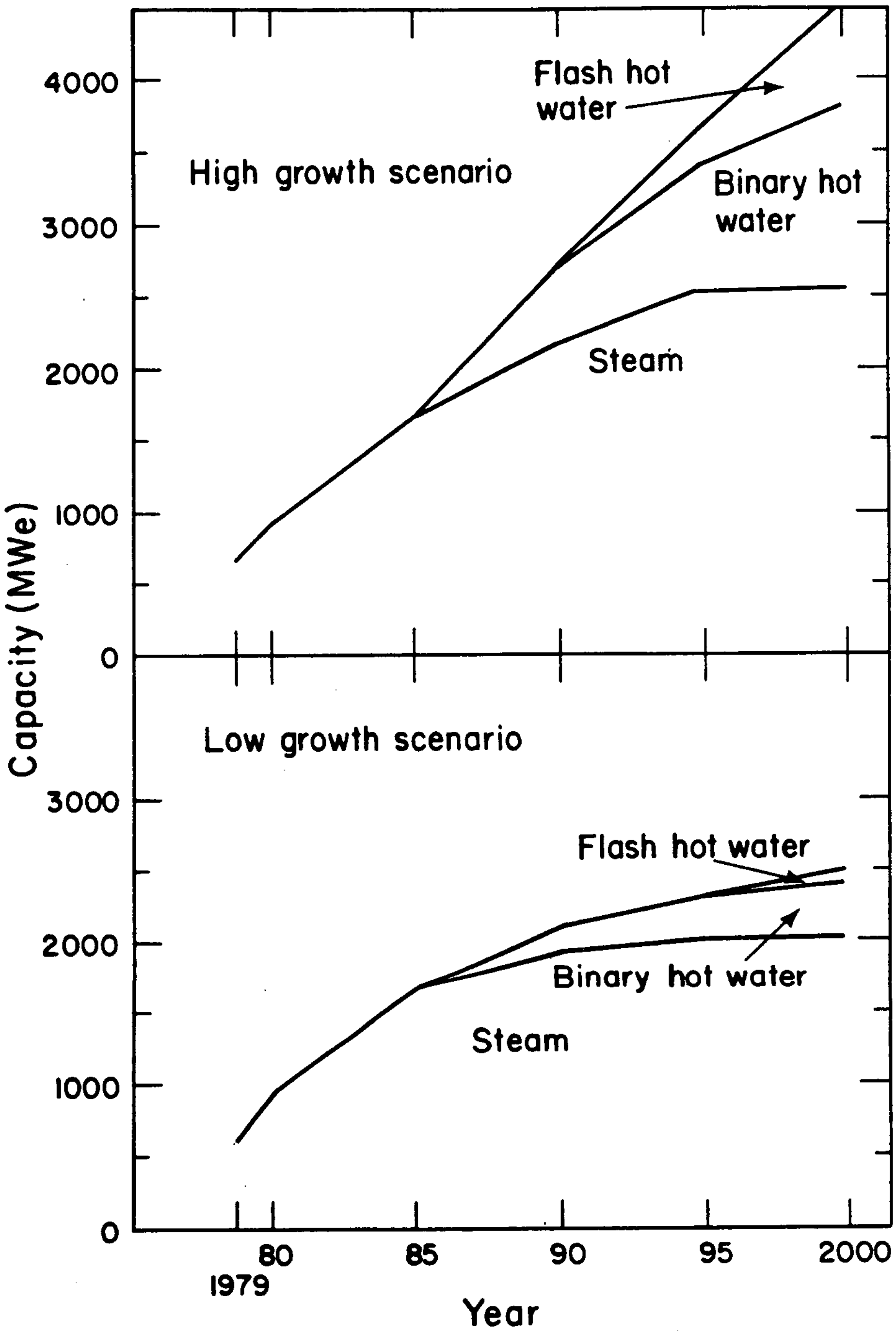


Fig. 5 Regional Capacity by System Type XBL 7912-5109

Table 5

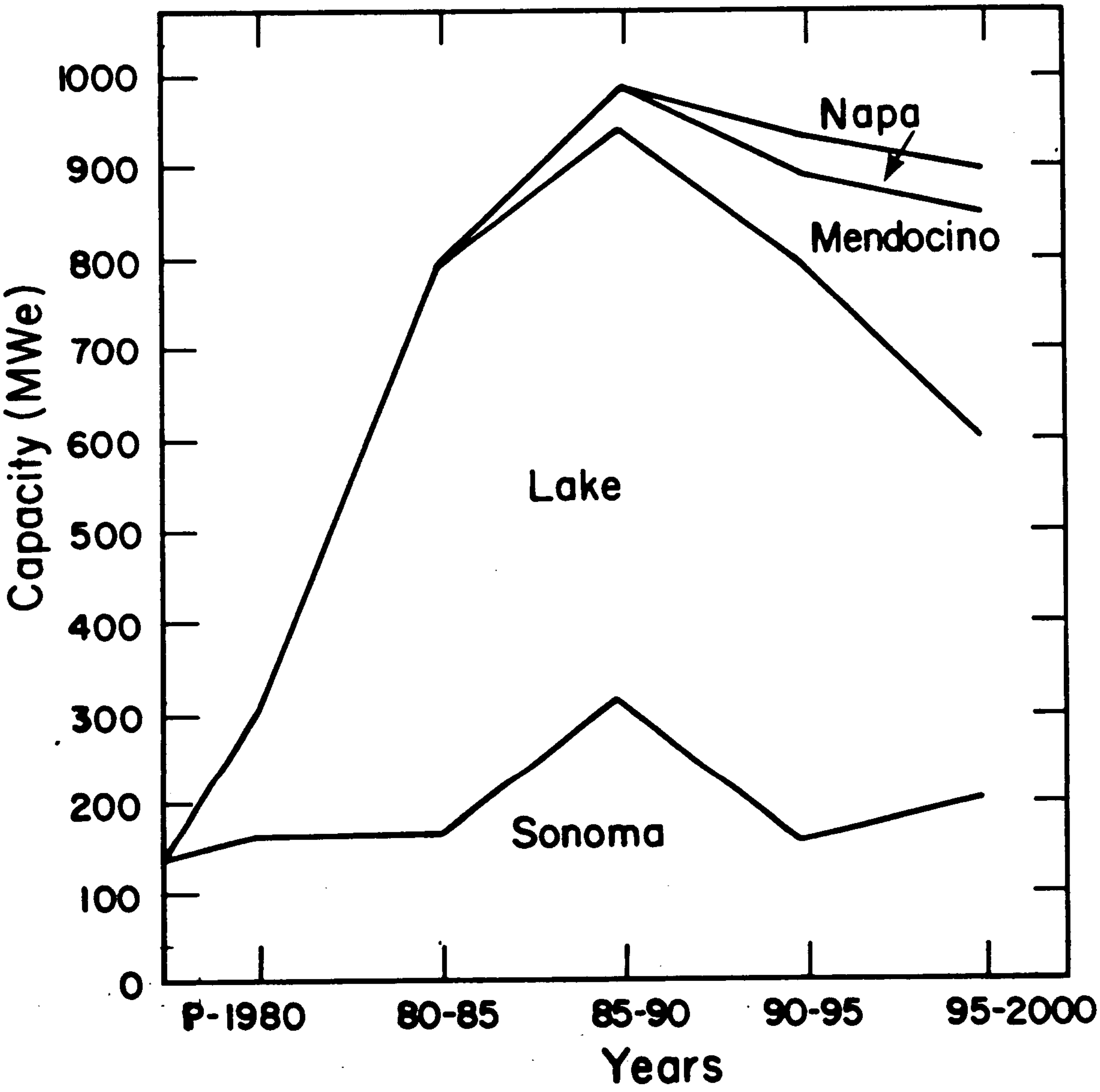
Required Capacity Additions By County

1. High Growth Scenario

TIME PERIOD: COUNTY (System Type)	Capacity Additions (MWe) Present - 1980	1980-1985	1985 - 1990	1990 - 1995	1995 - 2000
Sonoma (Steam)	165	165	165	0	0
(Hot Water)	0	0	150	150	200
Lake (Steam)	135	616	330	330	0
(Hot Water)	0	0	300	300	400
Mendocino (Steam)	0	0	0	0	0
(Hot Water)	0	0	50	100	250
Napa (Steam)	0	0	0	0	0
(Hot Water)	0	0	0	50	50
TOTAL	300	781	995	930	900

2. Low Growth Scenarios

TIME PERIOD: COUNTY (System Type)	Capacity Additions (MWe) Present - 1980	1980 - 1985	1985 - 1990	1990 - 1995	1995 - 2000
Sonoma (Steam)	165	165	55	0	0
(Hot Water)	0	0	50	50	0
Lake (Steam)	135	616	220	55	0
(Hot Water)	0	0	100	100	150
Mendocino (Steam)	0	0	0	0	0
(Hot Water)	0	0	0	0	50
Napa (Steam)	0	0	0	0	0
(Hot Water)	0	0	0	0	0
TOTAL	300	781	425	205	200



XBL 7912-5110

Fig. 6 Capacity Additions by County for the High Growth Scenario

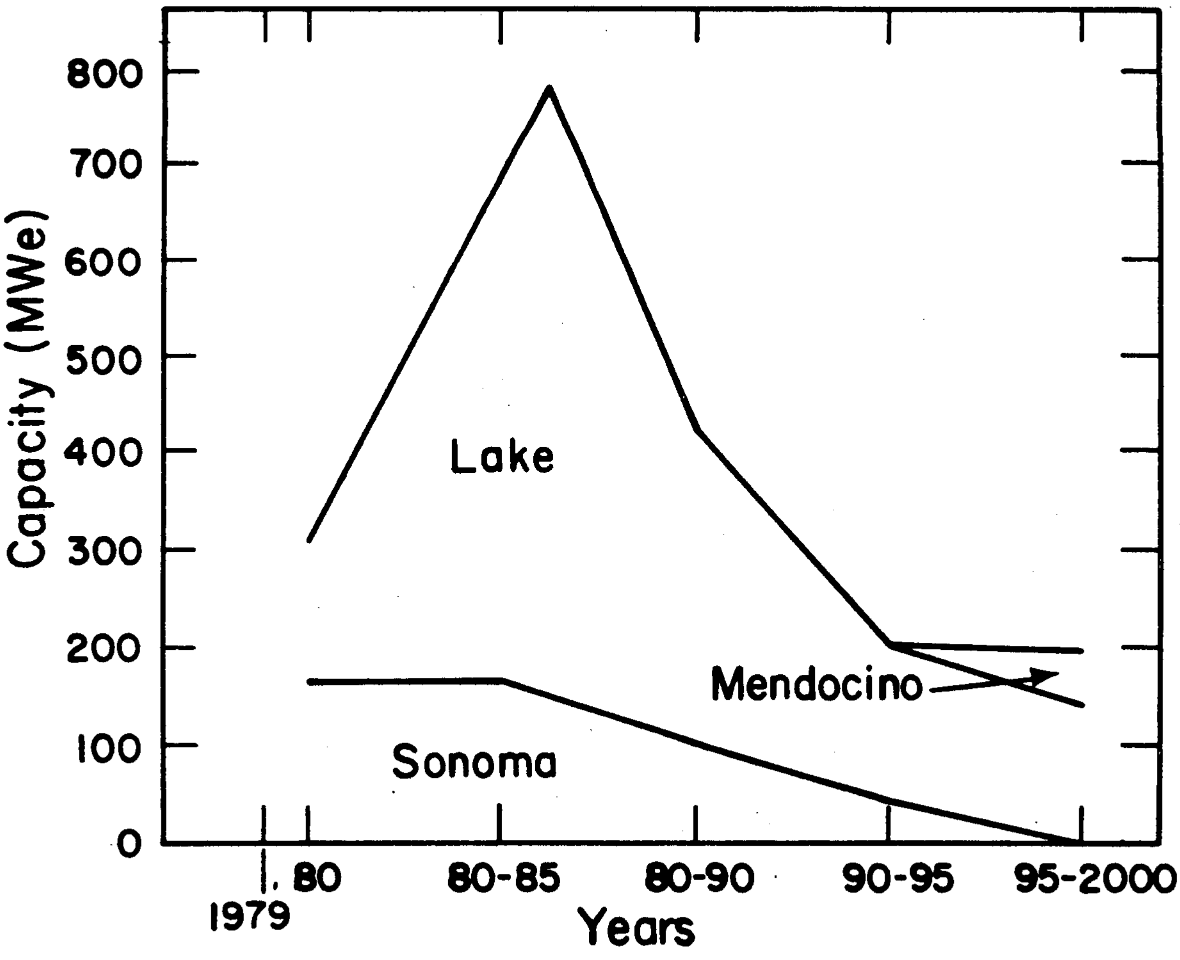


Fig. 7. Capacity Additions by County for the Low Growth Scenario

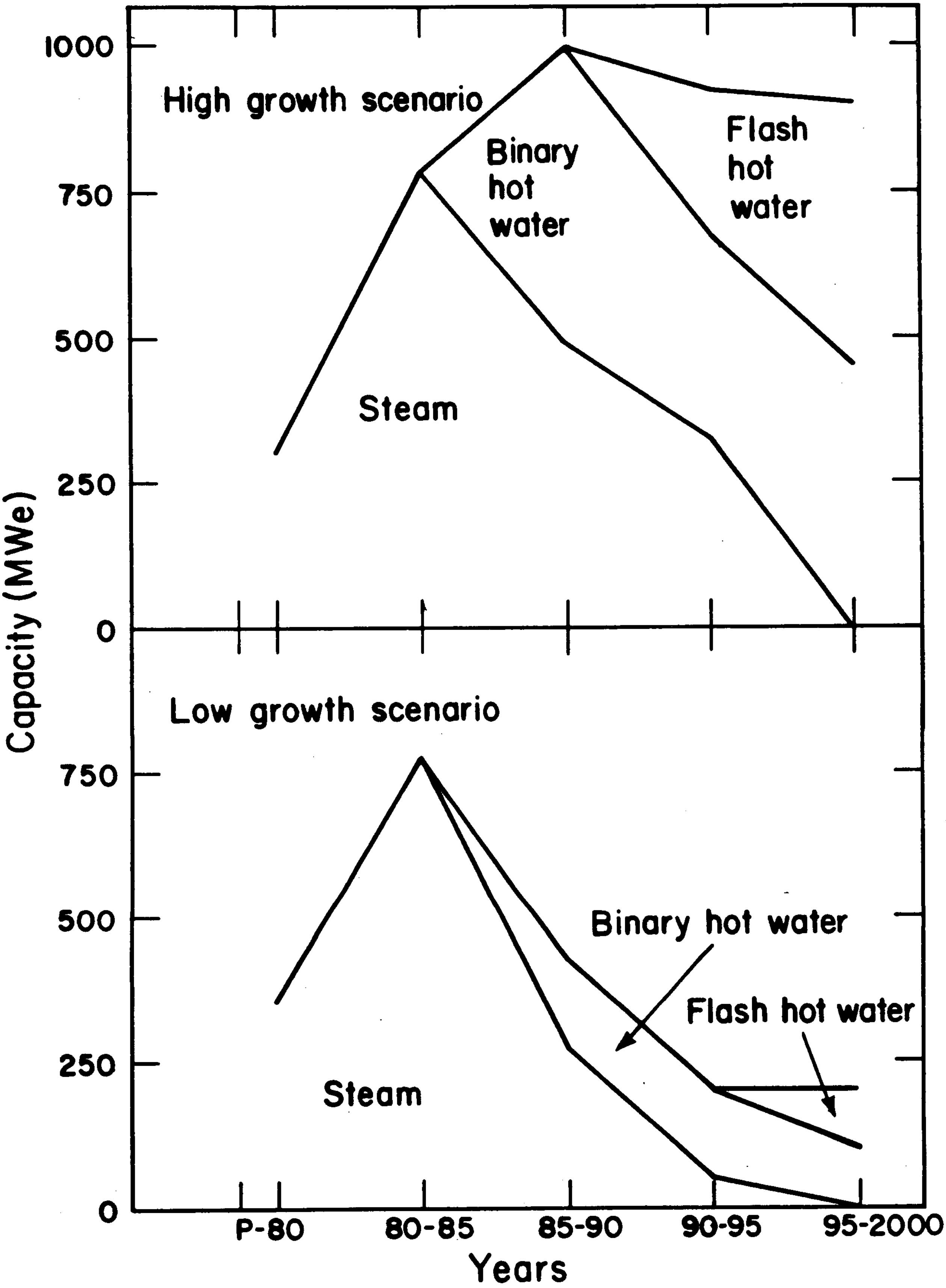


Fig. 8. Regional Capacity Additions by System Type

XBL 7912-5112

Table 6

Difference Between High Growth and Low Growth Scenarios
On-Line Capacity Difference (MWe)

1. Total Capacity

YEAR: COUNTY	1979	1980	1985	1990	1995	2000
Lake	0	0	0	338	785	1035
Sonoma	0	0	0	182	310	510
Mendocino	0	0	0	50	150	350
Napa	0	0	0	0	50	100
TOTAL	0	0	0	570	1295	1995

2. Steam

Lake	0	0	0	110	385	385
Sonoma	0	0	0	110	110	110
Mendocino	0	0	0	0	0	0
Napa	0	0	0	0	0	0
TOTAL	0	0	0	220	495	495

3. Binary

Lake	0	0	0	200	250	350
Sonoma	0	0	0	100	150	250
Mendocino	0	0	0	50	100	200
Napa	0	0	0	0	50	100
TOTAL	0	0	0	350	550	900

4. Flash

Lake	0	0	0	0	150	300
Sonoma	0	0	0	0	50	150
Mendocino	0	0	0	0	50	150
Napa	0	0	0	0	0	0
TOTAL	0	0	0	0	250	600

the late 1980's (Fig. 6) with a slight decline in the rate of additions thereafter. In the low growth scenario (Fig. 7) additions peak in the early 1980's with a sharp decline thereafter. This decline is caused by a delay in development of hot water resources and near saturation of the steam field. Binary systems first come on line in the 1985-90 time frame for both scenarios, but are quite limited in the low growth case throughout the scenario period. Flash systems appear in the early 1990's for the high growth scenario and in the late 1990's for the low growth scenario. For both scenarios, flash hot water development is limited before 2000.

Figures 9 through 16 represent the county-by-county detail scenarios for both high growth and low growth development paths. In these figures, capacity additions are a good surrogate for the year to year level of construction activity. Napa County (Figures 15 and 16) has a minimal involvement in the scenario before 2000 under both scenarios. Mendocino County (Figures 13 and 14) experiences rapid growth in the 1990's after the areas closer to the steam field have been developed (high growth scenario). The percent difference between high growth and low growth scenarios (before 2000) is greater in Mendocino County than in any other county. Under a low growth scenario, the bulk of Mendocino County development would be delayed until after 2000.

Sonoma County (Figures 11 and 12) experiences relatively slow growth until hot water systems are developed (1985) since most of that county's steam development occurred before 1979. Around 1985, a surge of hot water activity begins under the high growth scenario. Under the low growth scenario, a low level of binary system activity is maintained

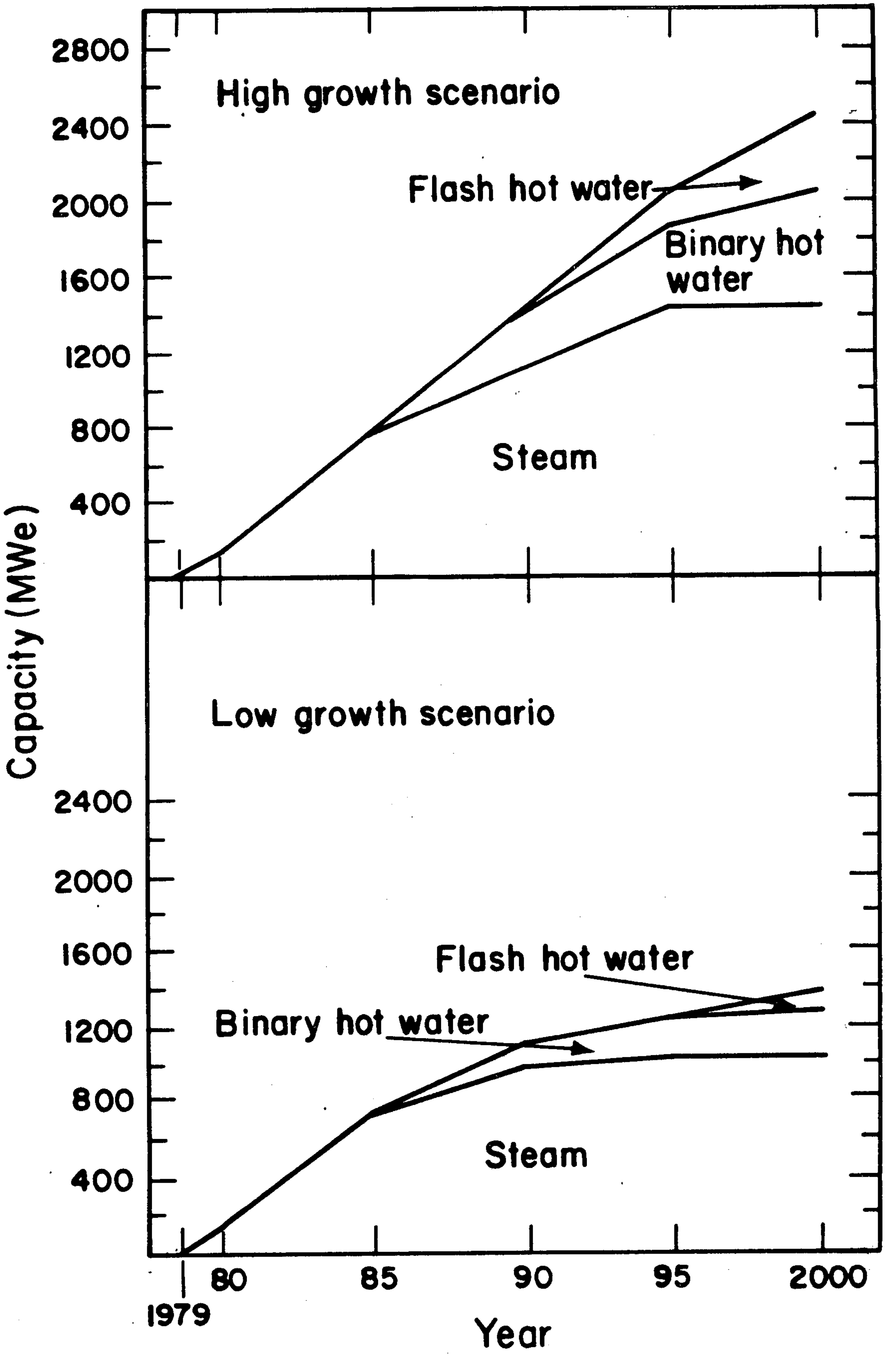


Fig. 9. Lake County Scenario Capacity by System Type

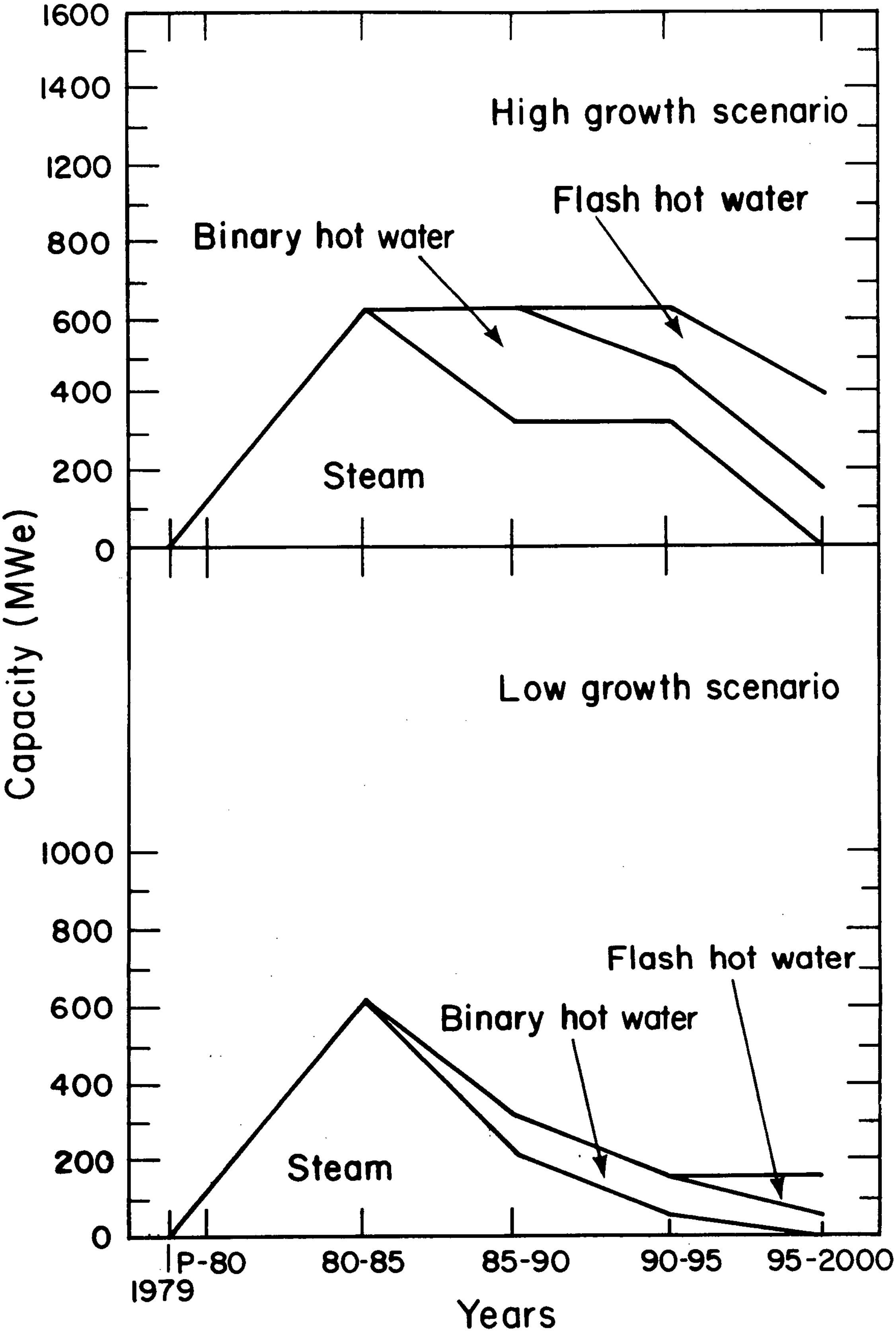


Fig. 10. Lake County Capacity Additions by System Type

XBL 7912-5114

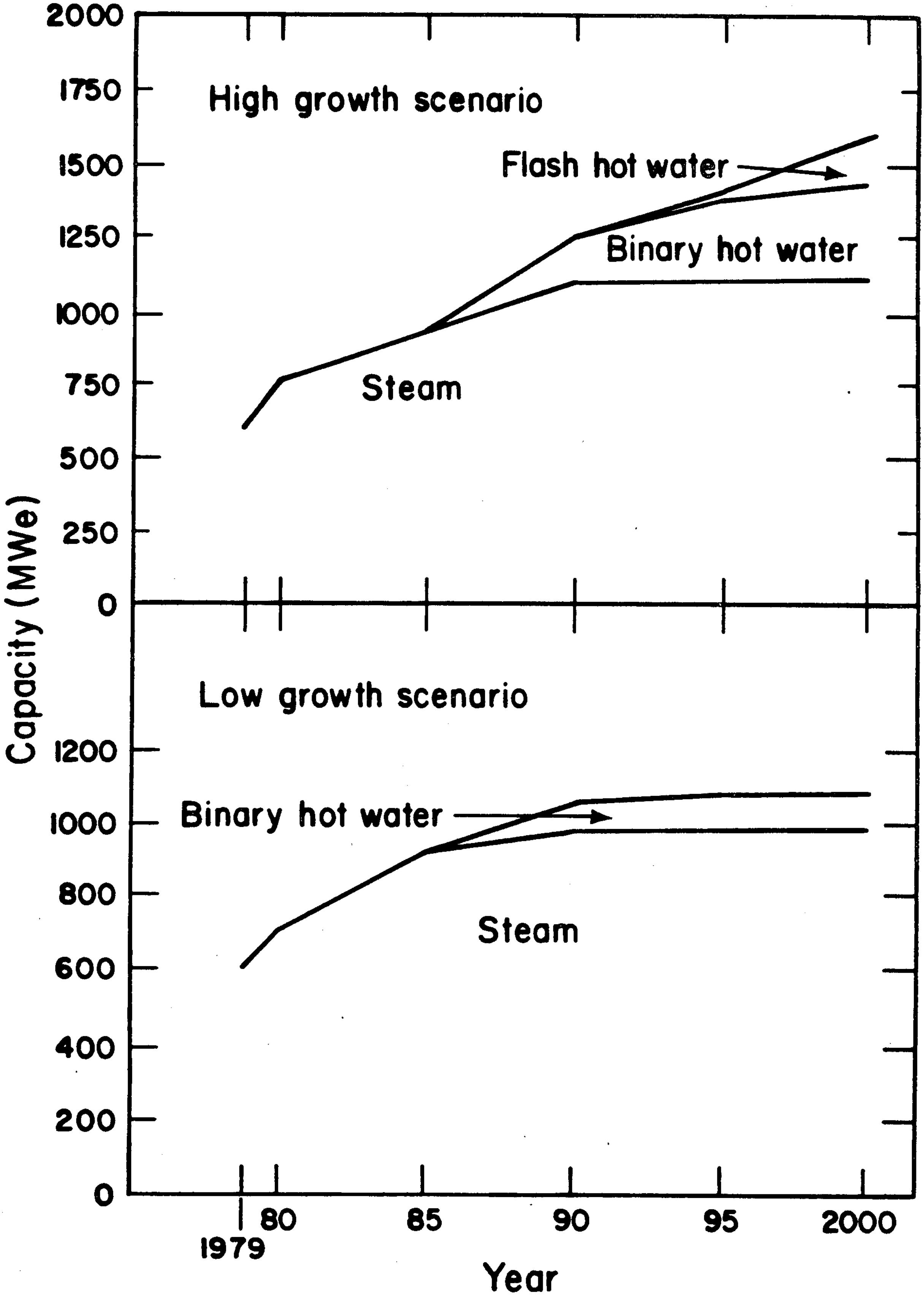


Fig. 11 Sonoma County Scenario Capacity by System Type

XBL 7912-5115

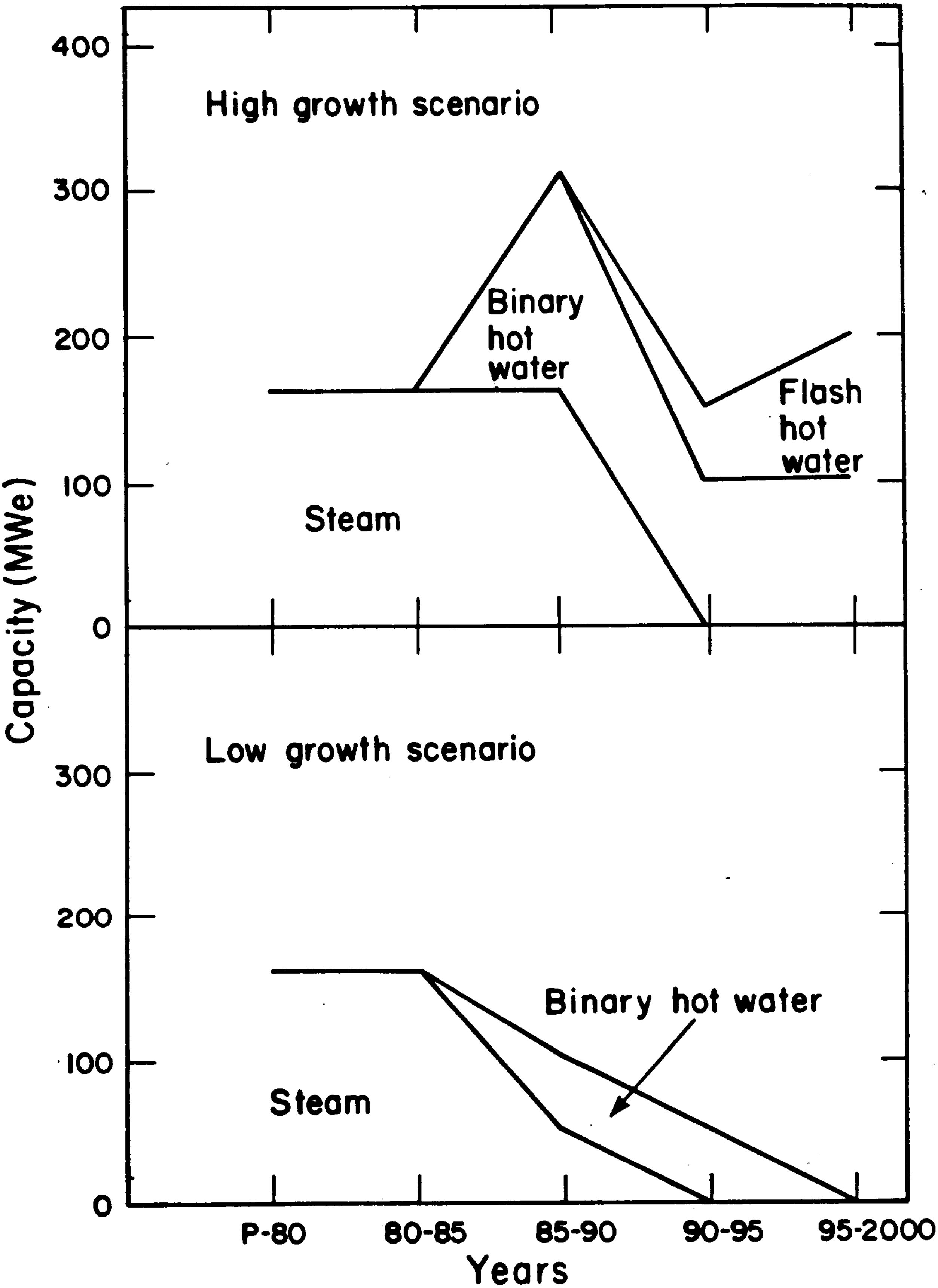


Fig. 12. Sonoma County Capacity Additions by System Type

XBL 7912-5116

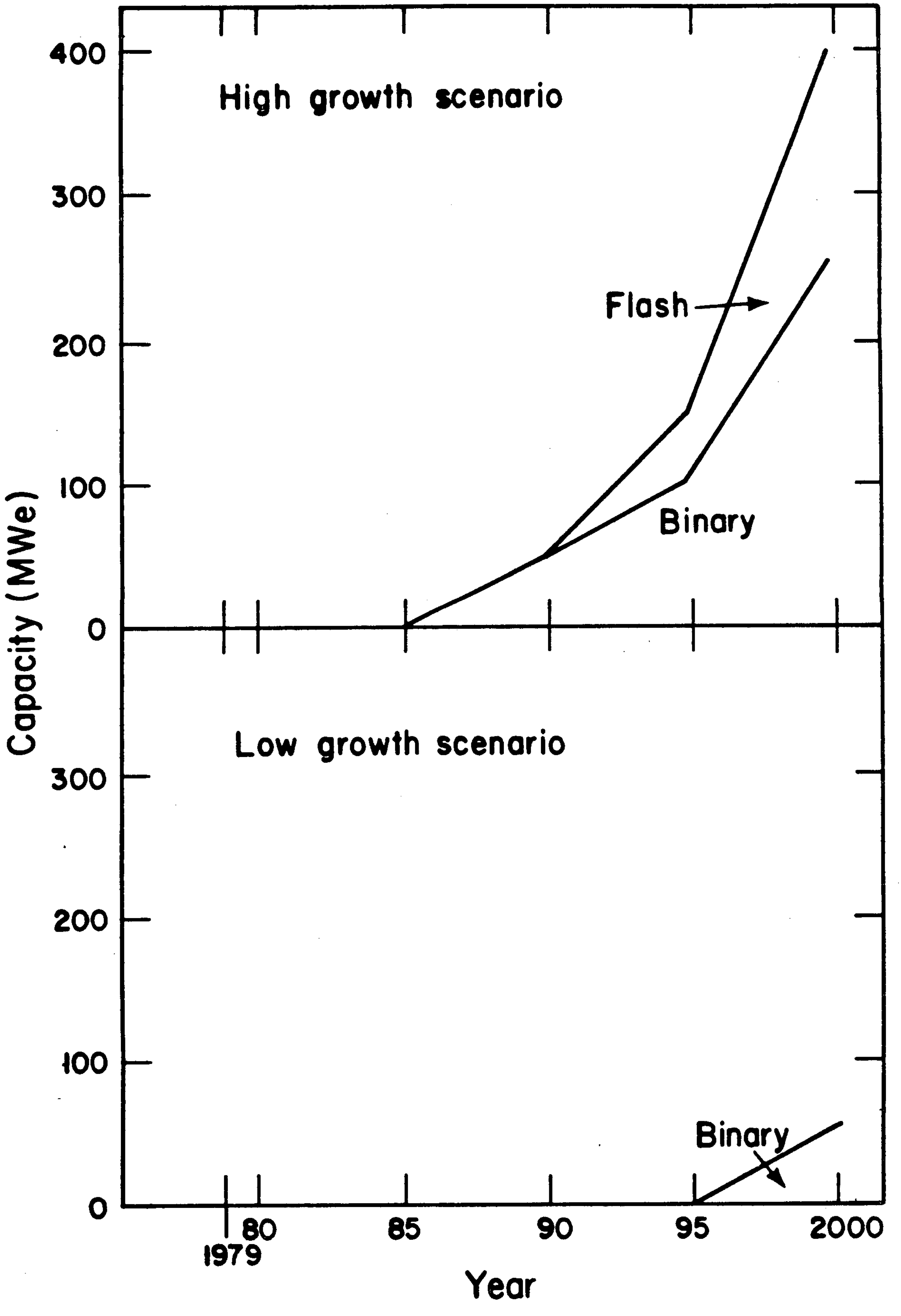


Fig. 13. Mendocino County Scenario Capacity By System Type

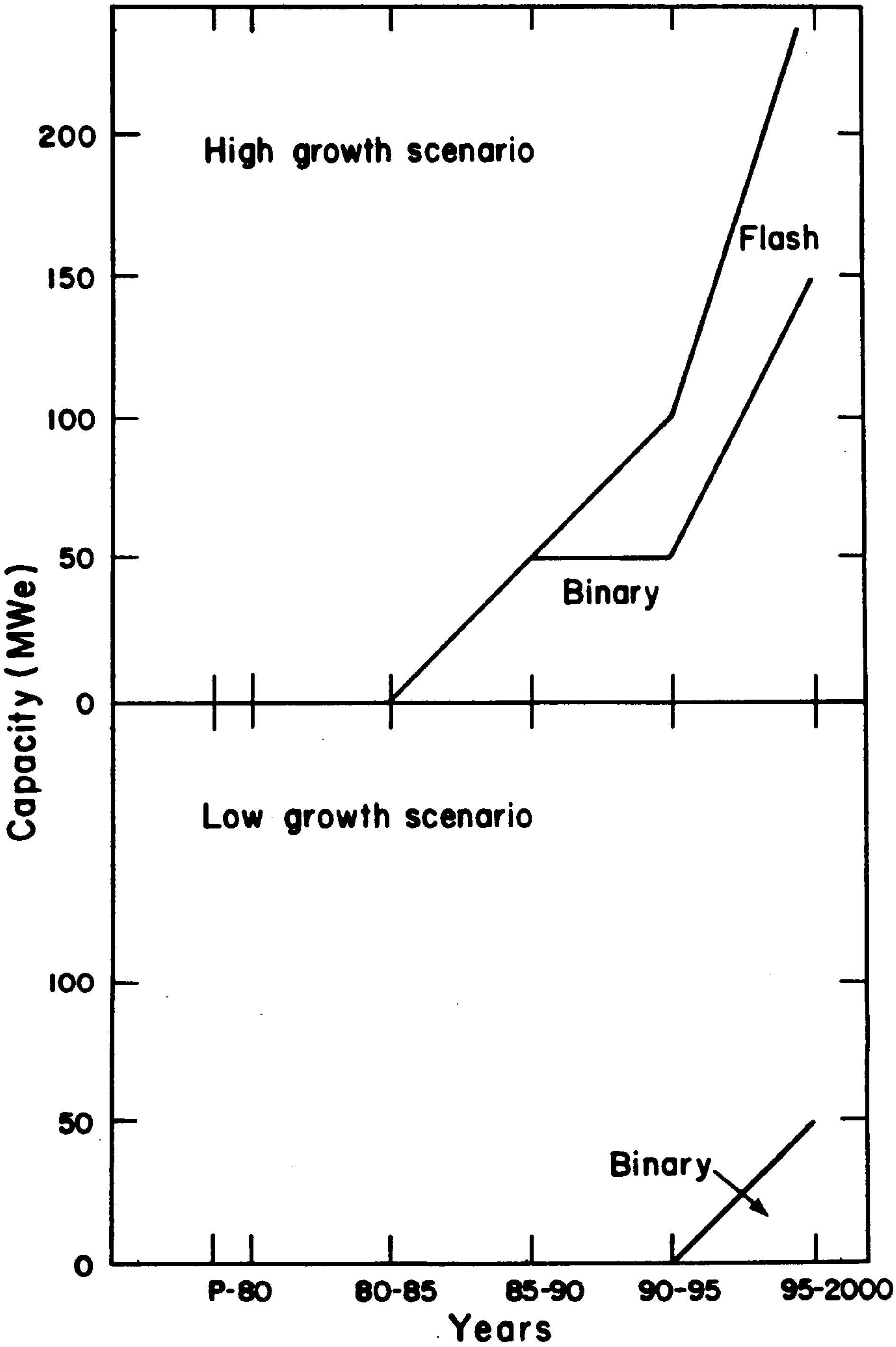


Fig. 14. Mendocino County Capacity Additions by System Type

XBL 7912-5118

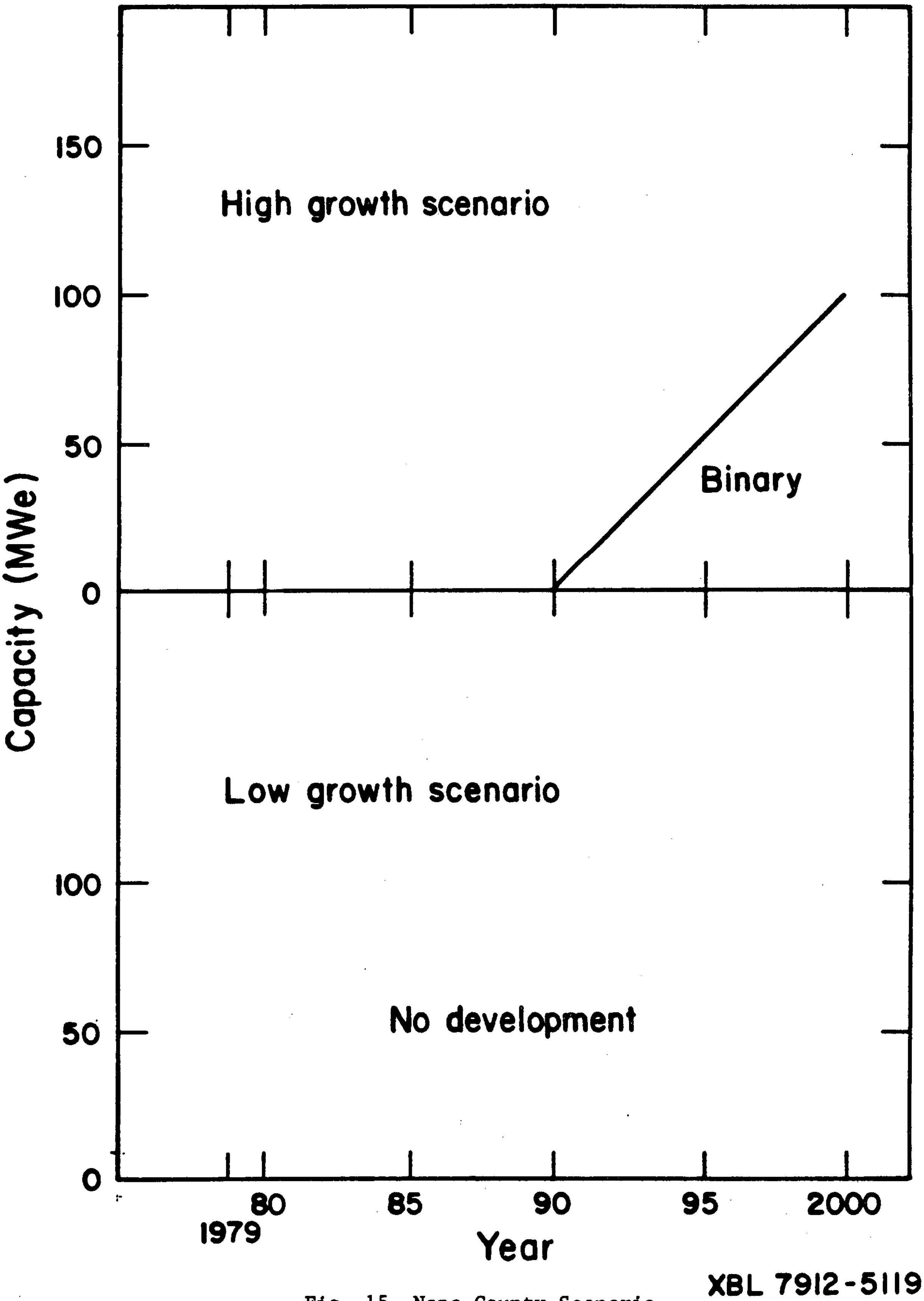


Fig. 15 Napa County Scenario
Capacity by System Type

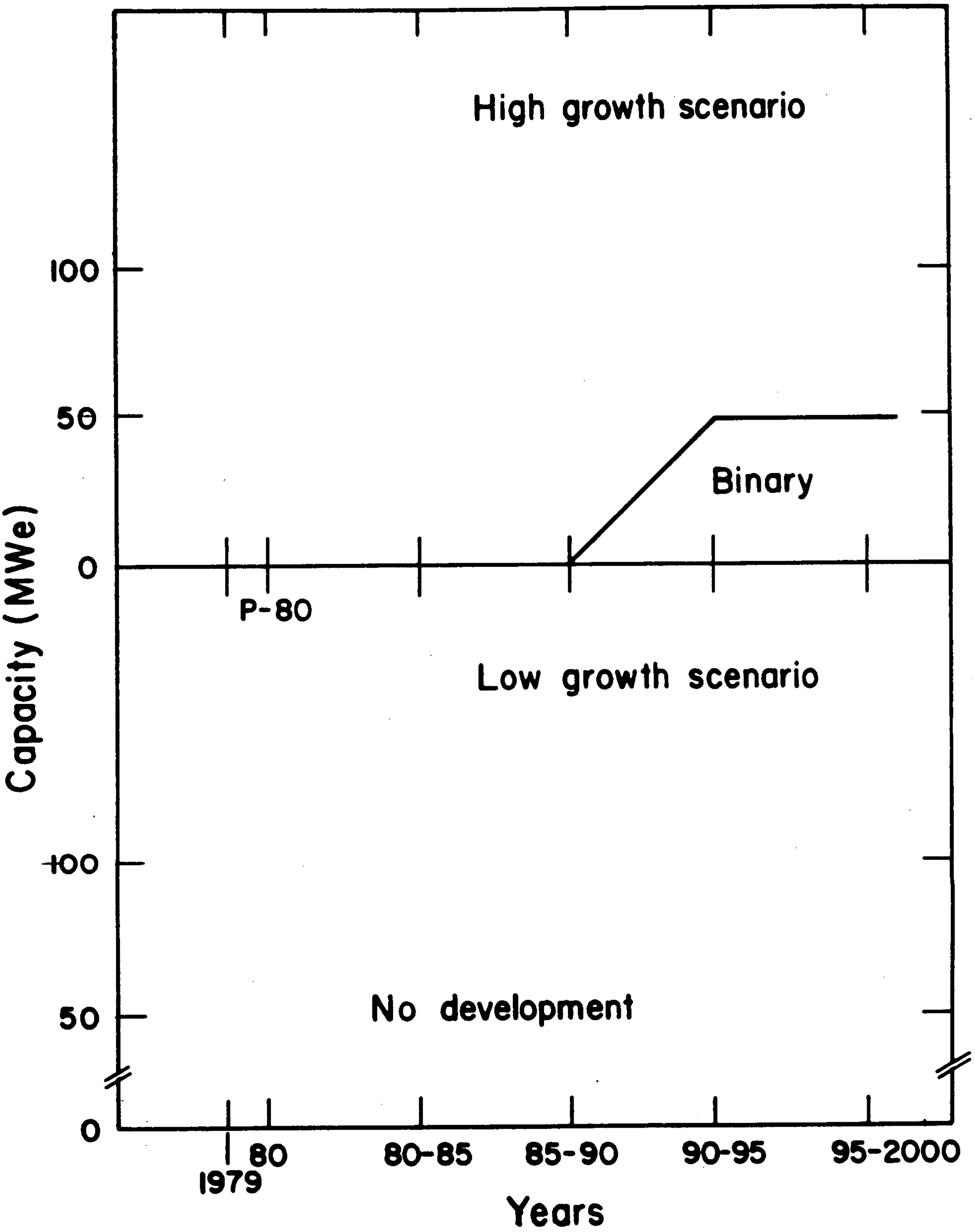


Fig. 16. Napa County Capacity Additions by System Type

XBL 7912-5120

until 2000. Lake County (Figures 9 and 10) experiences the greatest amount of activity, yet the level of activity remains fairly constant across time for both high growth and low growth scenarios. Further, capacity growth (Figure 9) is relatively steady for both scenarios in Lake County.

The county level scenarios were translated into annual capacity increases for steam (110 MWe) and hot water (50-55 MWe) plants by scheduling plant-on-line dates so as to minimize regional year-to-year perturbations in drilling activity and direct employment levels. The resulting plant construction schedules and plant type designations are shown on Figures 17 and 18 for the high and low growth scenarios.

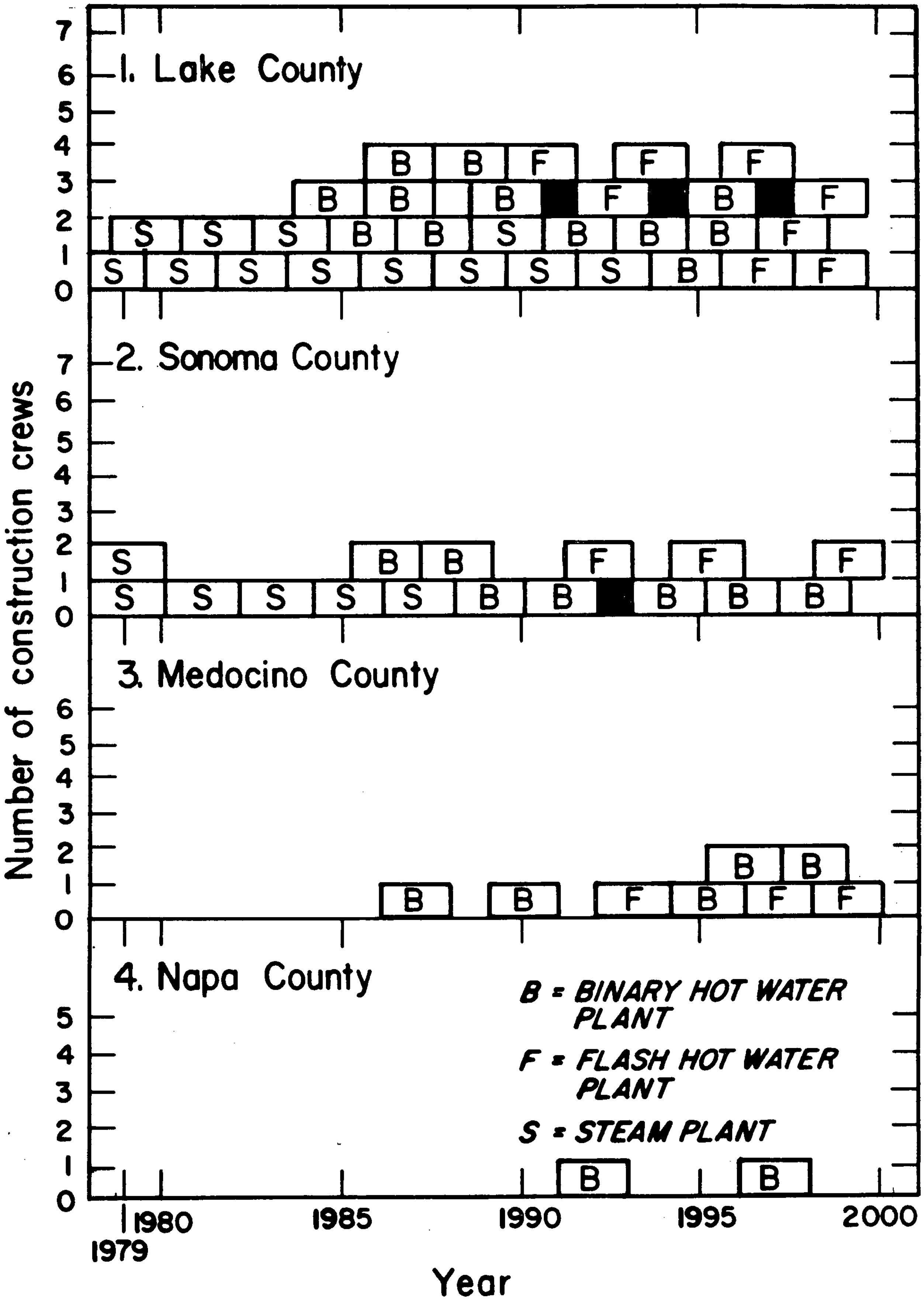


Fig. 17. Plant Construction Activity By County and Type of System For the High Growth Scenario

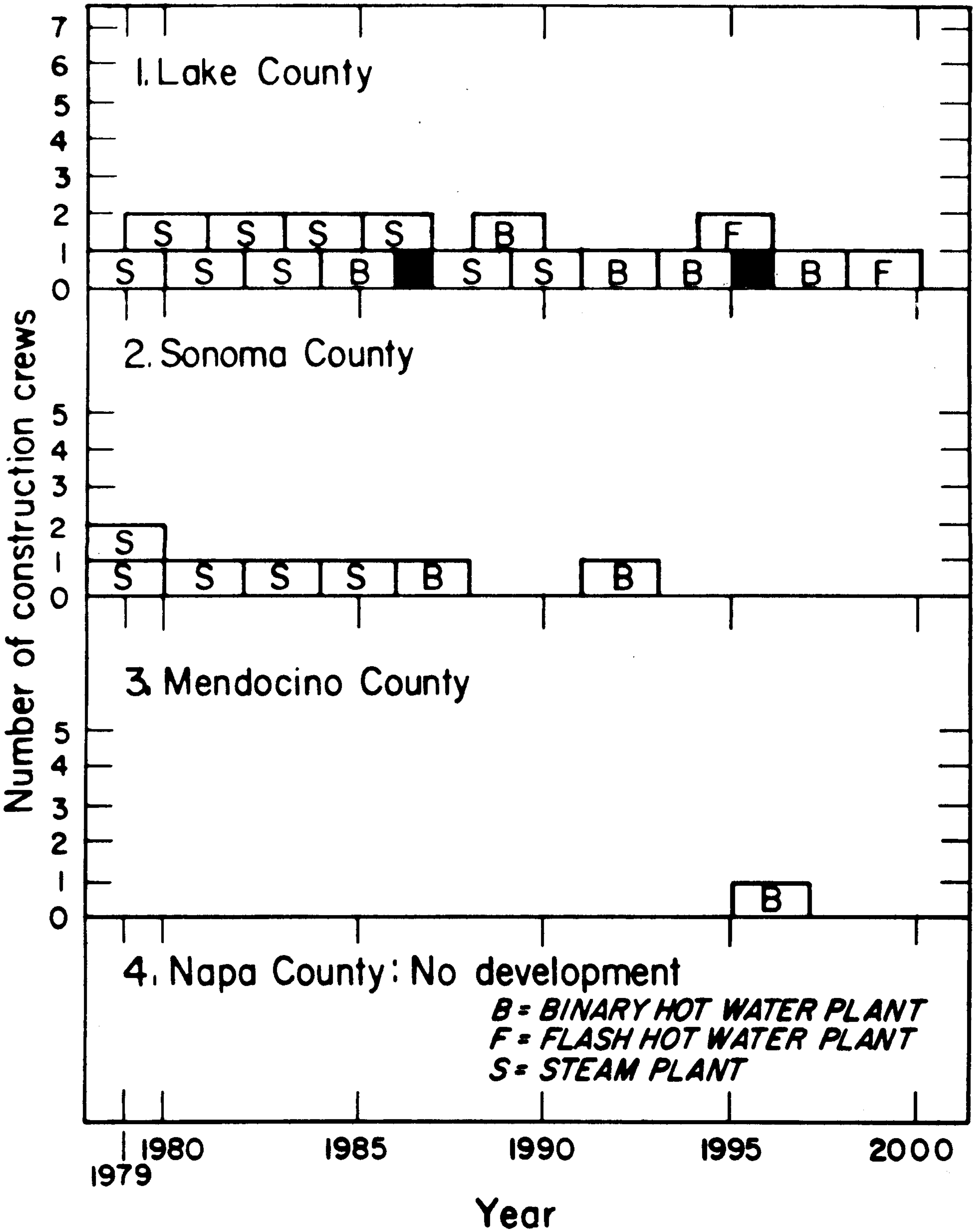


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Fig. 18. Plant Construction by County and Type of System For the Low Growth

III. EMPLOYMENT AND IN-MIGRATION EFFECTS OF ELECTRICAL GEOTHERMAL DEVELOPMENT

Description of the Geothermal Industry Employment Market

Geothermal power generation is generally considered to be a capital intensive industry. The amount of money spent for capital assets (equipment and machinery) is high and the number of employees (total labor cost) is relatively low. There are two major phases in geothermal development: 1) Exploratory well drilling, field development and plant construction and 2) the operation and maintenance of the plant. Exploration, drilling and construction activities require more workers than do the operation and maintenance of the power plant and steam field. Often both phases occur continuously in an area such as The Geysers where a long series of plants are being built.

Field Operations

A geothermal company usually possesses no drilling equipment itself, and contracts the drilling to an "operator". Operators are mobile drilling companies who use large oil drilling rigs with a small nucleus of regular employees who travel with the operator and rig wherever it goes. Large oil-drilling-type rigs are used for all deep drilling for both exploratory (step-out) and field development (fill-in) wells. The drill rig is typically operated 24 hours a day for 60-120 days and requires a field staff of 21-24 workers per rig. The field staff is usually divided into 4 crews of 5-6 people each, and a rig supervisor.

In addition to the four crews per rig, there are other related jobs in geothermal operations. The typical geothermal development company has one or more drilling foremen who oversee all drilling in the leasehold by all operators under contract. One or more foremen supervise construction of roads and well pads by a contracted crew of about ten people per site. These men operate bulldozers, scrapers, water trucks, and perform related labor. Another foreman supervises contracted workers who repair equipment, test wells, build mufflers, perform revegetation work, and do other related tasks. A geothermal company occasionally contracts for special service personnel such as welders, roustabouts, surveyors, backhoe operators, drilling mud engineers, mulchers, security guards, and heavy equipment haulers. The company may also employ, or contract services of, reservoir engineers, mechanical and civil engineers, geologists, and ecologists as required. In a large scale geothermal operation, activity is fairly constant, depending upon the granting of drilling permits.

With 9 rigs operating in the Lake-Sonoma Geysers area (Jan. 1979) with 24 men per rig, there are approximately 220 "slots" or drilling jobs at any one time. Yet there may be 250-300 drillers living in the surrounding area. The labor market is very fluid with personnel changes occurring all the time. However, the demand for labor is restricted to this pool of specially skilled individuals. It is very difficult for an outsider, especially an unskilled one, to break into the "pool". Even for a skilled new arrival, getting a job often requires personal contacts and inside information.

Steam workers maintain a very transient lifestyle in the pursuit of their work. Since the drilling rigs are quite mobile, the workers must be also. The majority of drillers seem to "flow" throughout the country as word of new jobs spreads. They may only stay in an area a few years even though drilling continues for some time. If they find it difficult to get a job after a few months in Lake County, they may move to Sacramento, Bakersfield, Long Beach, or out of state. Some move their families only after they have secured employment for some length of time.

Power Plant Construction

Power plant construction extends over an 22 to 26 month period and employs a peak of about 80 people for a 110-120 MWe plant (see Figure 19). 50-55 MWe units require somewhat less construction effort. Employment scaling factors of 0.66 for 55 MWe steam or flash hot water plant construction labor requirements and of 0.71 for binary plants were obtained from recent reports by MITRE Corp. (1978) and by SRI (1977). PG&E, which operates the existing Geysers Power Plant, maintains a general construction crew of 10-12 for supervision of power plant construction and other miscellaneous work.

Power Plant Operation

Operation and maintenance of the existing power plants required a PG&E staff of 45 in 1976 and a staff of about 50 with the addition of Unit 12 (see Table 7). For each new plant, PG&E anticipates a need of only 4 additional operational employees, since each plant is to be connected to the master control center at Units 5 and 6. With the completion of Units 13, 14, and 15, the PG&E operation and maintenance staff will increase to about 60 people. Base plant staffs will be required for other power companies (e.g. NCPA, CDWR, SMUD) for initial

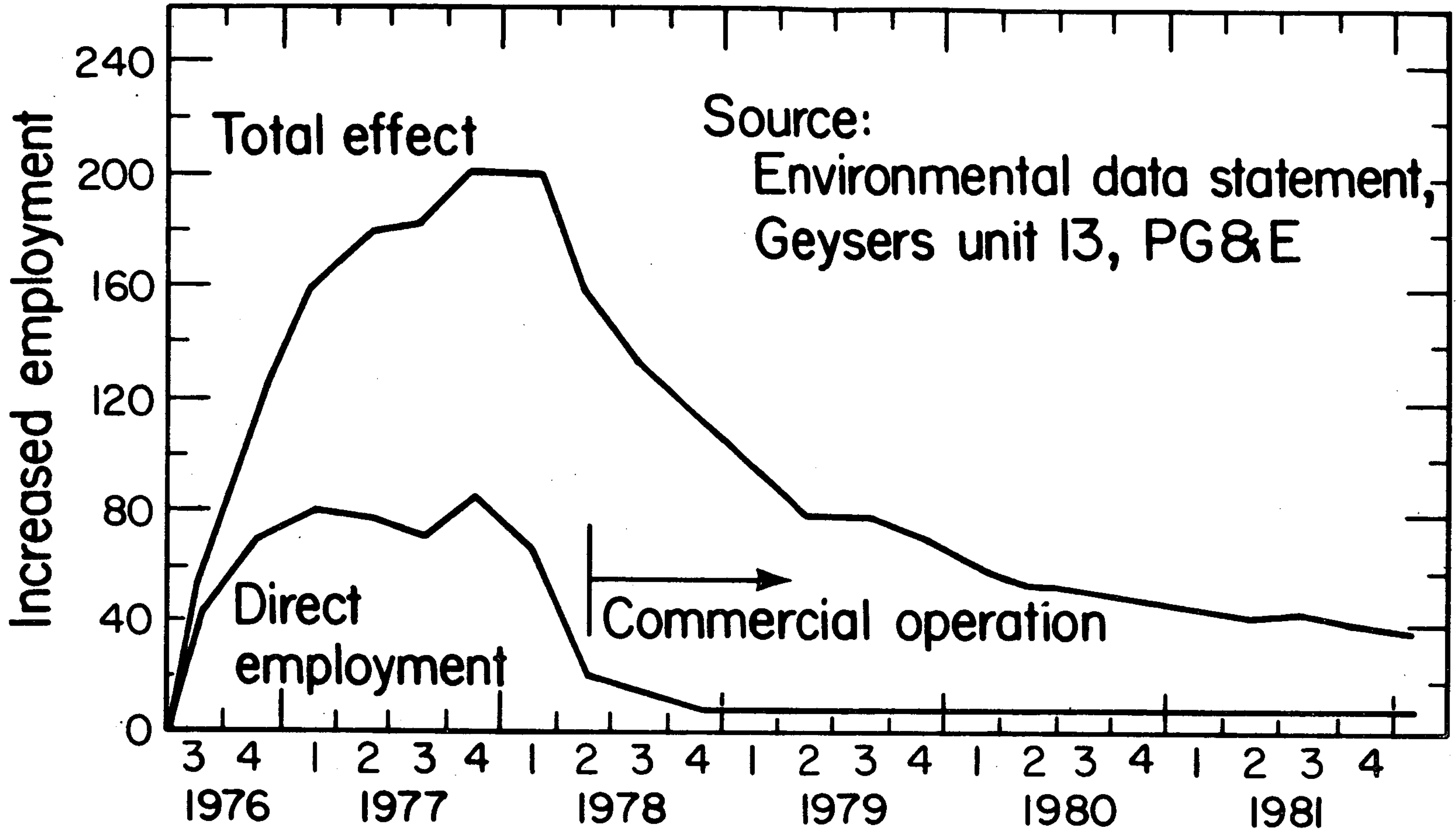


Fig. 19. Local employment resulting from operation of unit 13 (by quarters)

XBL 773-505A

Table 7

Work Force - Operation and Maintenance of PG&E's 12 Power Plants

A 50-person work force is necessary for The Geysers Power Plant:

1 Plant Superintendent	2 Instrument Repairmen
1 Operating Foreman	2 Certified Riggers
1 Shift Foreman	1 Rigger
2 Maintenance Foremen	5 Helpers
15 Shift Operators	2 Office Clerks
8 Machinists	1 Material Facility Man
6 Electricians	1 Power Plant Engineer
1 Control Technician	1 Tool Clerk

For unit overhauls, this force is supplemented by approximately six men brought in from other plants in the San Francisco area.

SOURCE: Environmental Data Statement, Geysers Unit 13, PG&E, and personal discussion with PG&E personnel, 1979.

units with subsequent staff additions comparable to PG&E estimates.

Scenario-Related Direct Employment

Components of Direct Labor

Direct employment associated with the geothermal development scenarios developed for this study will be the total of three components: plant construction, plant operation, and field development and operation. Data for the first two of these components were taken from Figures 17 and 18 for the phasing of plant construction and operation, and from Vollentine, Kunin and Sathaye (1977) for the distribution of direct labor over time for each individual plant. A base staff of 20 was assumed as the operational force for the first plant brought on line by each new utility company (the average response from a variety of government and industry personnel queried) with subsequent plants requiring incremental staff additions similar to those projected by PG&E (4 people/plant).

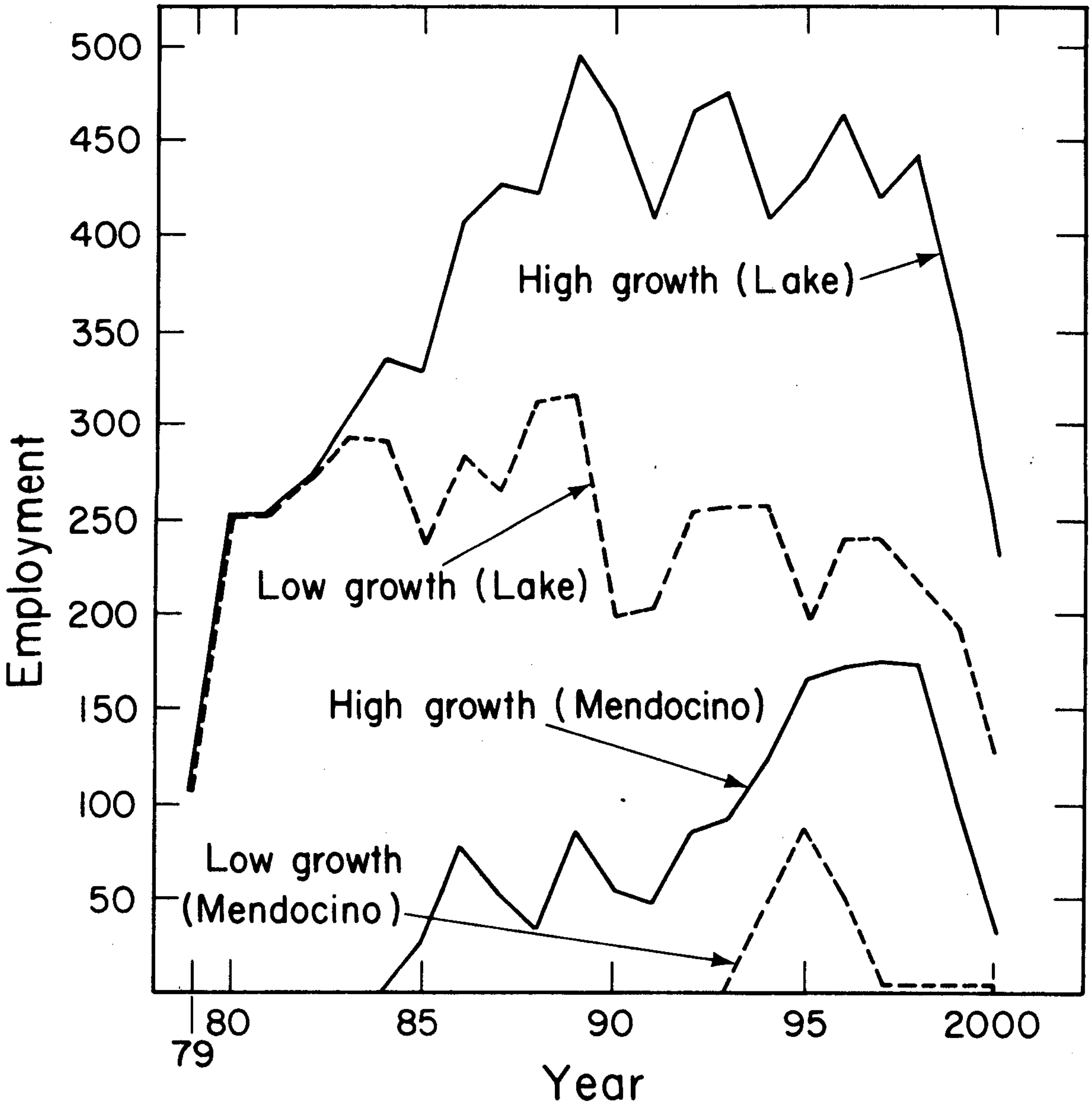
Drilling activity includes both exploratory drilling and field development drilling to support planned power plant expansion and can take place several years before a plant actually goes on line. Historical patterns of drilling activity were obtained from the California Division of Oil and Gas data and were compared to existing and planned power plant expansions. The resulting average pattern of exploratory and field development drilling in advance of a new plant was used as a base to characterize all drilling activity and associated employment throughout the period covered by the scenario.

Drilling employment was allocated to specific counties according to the location of the power plant which drilling activity supported. It is possible that any specific county may not "feel" some of this drilling activity since payrolls, company offices and employee residences may be physically located elsewhere. It is also possible that drilling activity for a plant to be located in one county may occur in a different county. Some error will therefore exist in the absolute numbers presented in the county level employment tables. However, this error is small with respect to the overall magnitude of the forecast direct employment.

Forecast Levels of Employment

From the data described above, employment patterns associated with each scenario were calculated and are presented on Figures 20, 21 and 22 for the individual counties and the region as a whole, and are summarized in Table 8. The fluctuation shown between adjacent years is based on the assumed distribution of plant construction within each five year period and is thus somewhat artificial. In effect, we assumed that construction of each plant began on January 1st and ended on December 31st of the following year. In reality, construction start times for individual plants would vary throughout the year. This will dampen the sharp increases and decreases in employment shown in Figures 20-22 between adjacent years, but will not alter the overall trend in employment or the peak employment levels.

It should be noted that direct employment levels are low. In the high growth scenario, Lake County peaks at about 475 employees (1993) with the regional total peaking at 855 in 1996. While these numbers are significant, it must be remembered that they represent less than 2



XBL 7912-5132

Fig. 20. Direct Geothermal Employment for Lake and Mendocino Counties

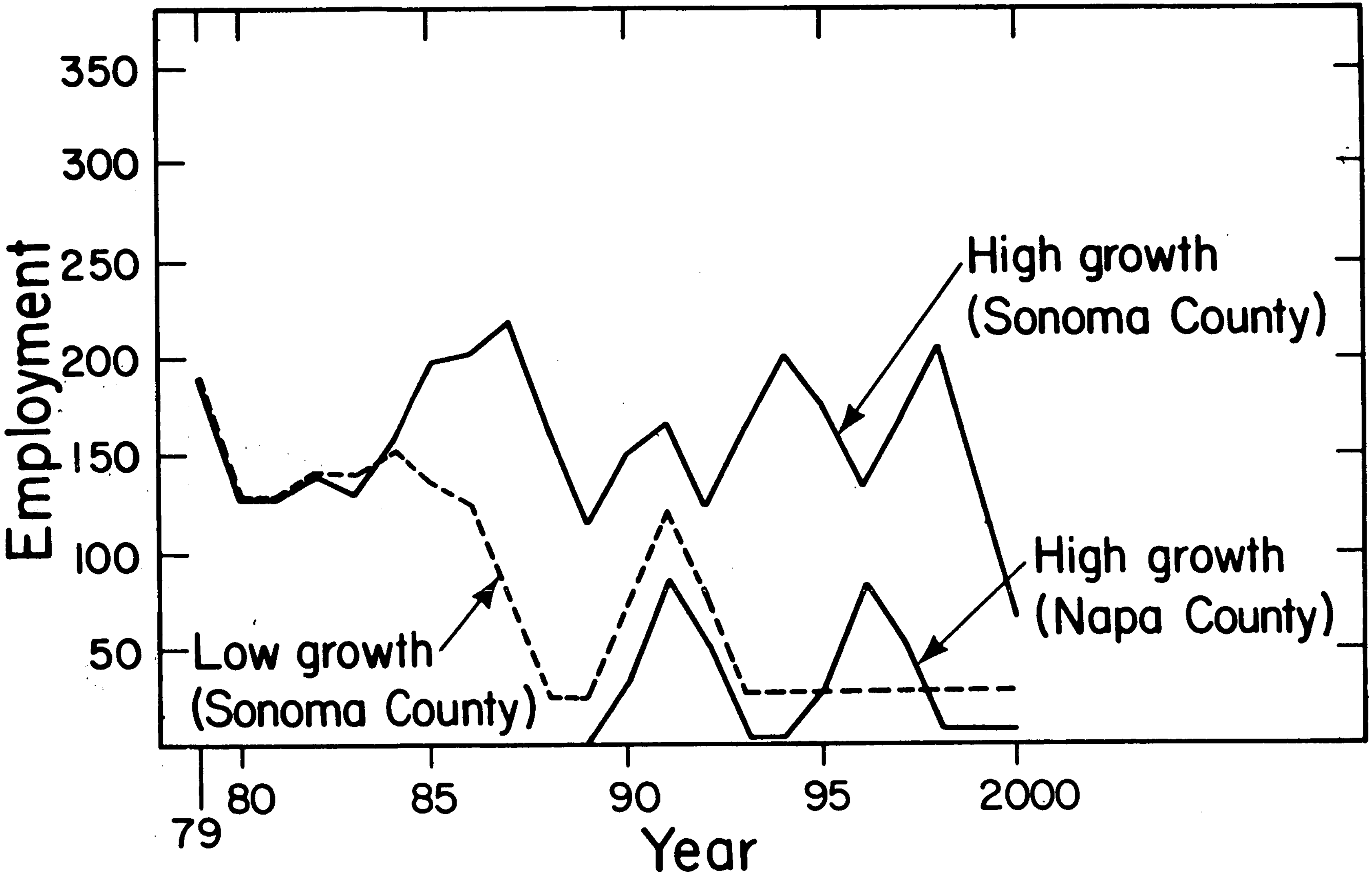


Fig. 21. Direct Geothermal Employment For Sonoma and Napa County

XBL 7912-5133

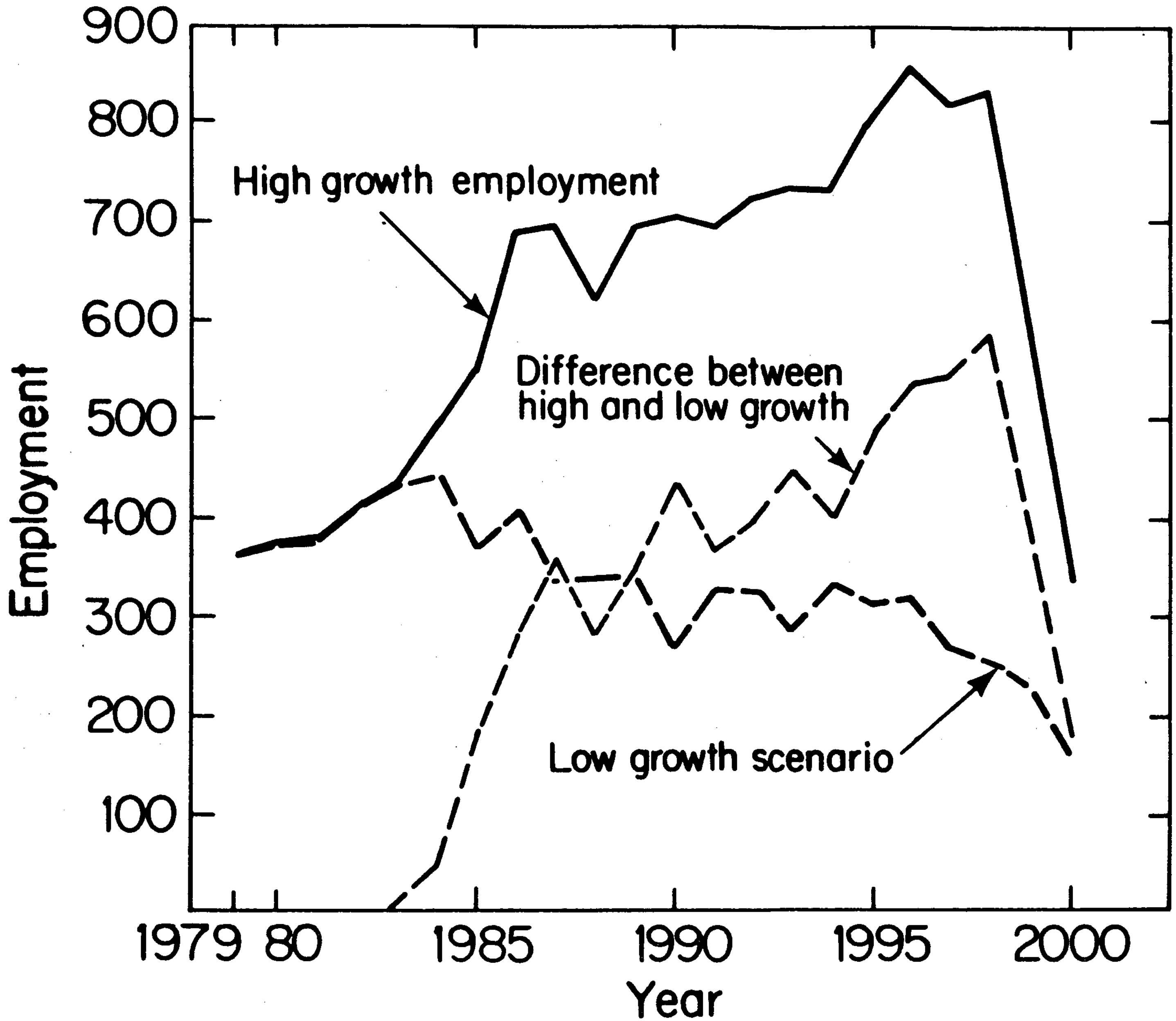


Fig. 22. Direct Employment for the Geysers Region XBL 7911 - 13314

Table 8

Regional Direct Geothermal Employment

Year	High Growth Scenario					Low Growth Scenario				Difference between High and Low Case
	Lake	Sonoma	Mendocino	Napa	Total	Lake	Sonoma	Mendocino	Total	
79	174	189			364	174	189		363	1
80	247	128			375	246	128		374	1
81	251	128			379	250	128		378	1
82	271	140			411	270	141		411	0
83	305	130			435	294	141		435	0
84	335	159			494	291	152		443	51
85	329	199	27		555	232	137		369	186
86	408	203	78		689	285	123		408	281
87	427	219	51		697	261	71		332	365
88	421	161	35		617	312	24		336	281
89	494	114	86		694	316	24		340	354
90	465	150	55	33	703	197	72		269	434
91	404	166	39	85	694	203	123		326	368
92	464	121	87	51	723	251	75		326	397
93	478	162	91	4	735	255	28	48	283	401
94	406	200	122	4	732	255	28	87	331	487
95	429	174	165	30	798	196	28	51	311	537
96	464	134	171	86	855	239	28	4	318	546
97	418	169	175	55	817	239	28	4	271	582
98	442	206	174	8	830	216	28	4	248	365
99	349	132	100	8	589	192	28	4	224	365
2000	232	64	32	8	336	124	28	4	156	180

No employment in Napa for low growth scenario.

SOURCE: Environmental Data Statement, Geysers Unit 13, PG&E, and personal discussion with PG&E personnel, 1979.

percent of the projected work force (for Lake County in 1993) and far less than 1 percent of the regional work force (in 1996).

Other significant information can be obtained from Table 8 and Figures 20-22. First, the most rapid growth period for employment occurs at the beginning of the geothermal activity included in the scenario for each county. This period is currently well under way (if not completed) in Lake and Sonoma Counties. Second, after an initial surge in employment, county direct employment remains relatively constant throughout the scenario period. Exceptions to this trend occur principally in the counties where very little activity occurs at all (e.g. Napa County, or Mendocino County on the low growth scenario). Third, the years 1998 through 2000 are strongly influenced by the defined end of the scenario. This cutoff date in no way coincides with the anticipated end of construction activity in the region (which will occur well after 2000). However, the employment decreases shown here for 1999 and 2000 may be indicative of (but somewhat more severe than) what might be expected when expansion of the geothermal electrical capacity in the region actually does end.

Finally, Table 9 compares the direct employment impacts of the high and low growth scenarios. No significant difference appears until 1984 and 1985, as was discussed in the scenario development section of this report. Differences that do appear are relatively small. It is not likely that geothermal development will occur faster than the high growth scenario used here nor that it will occur slower than the low growth scenario. Thus, that portion of direct employment which is susceptible to external influence (for example local or county policy) is

Table 9

Difference Between High Growth and Low Growth Scenarios
For County and Regional Direct Employment

Year	Lake	Sonoma	Mendocino	Napa	Region
79	1	0			1
80	1	0			1
81	1	0			1
82	1	-1			0
83	11	-11			0
84	44	7			51
85	97	62	27		186
86	123	80	78		281
87	166	148	51		365
88	109	137	31		181
89	178	90	86		354
90	268	78	55	33	434
91	201	43	39	85	368
92	213	46	87	51	397
93	223	134	91	4	452
94	151	172	74	4	401
95	233	146	78	30	487
96	225	106	120	86	537
97	179	141	171	55	546
98	226	178	170	8	582
99	157	104	96	8	365
2000	108	36	28	8	180

*Number of employees (High Growth Scenario minus Low Growth Scenario) that employment shown on Table 9. In Lake County, for example, Table 9 shows a county wide difference of only 200+ employees, which represents approximately 1% of the projected county work force in 1990. This does not say that significant impacts will not occur but rather that their real impact appears to accrue at a scale lower than county level. While the numbers for Mendocino county, for example, are small, it is probable that their impact will be significant since the employment will be concentrated in the southeast corner of the county. This area is not densely populated, and thus would be susceptible to impacts far greater than those indicated from county level numbers.

Scenario Related Induced Employment

New activity in one sector generates activity in other sectors of the local economy. Thus, through direct purchase of a variety of equipment, goods and services, and through the personal spending of employees, geothermal activity will create new activity in other sectors. The activity in other sectors is "induced activity". The new employment in other sectors resulting from new geothermal activity is called induced employment. The ratio of total new employment (direct plus induced) divided by the direct employment is called an employment multiplier. Employment multipliers for a single geothermal power plant have been estimated by PG&E, were reported by Vollentine, Kunin and Sathaye (1977), and are shown on Figure 9. Two assumptions were made in using these figures for the current study. First it was assumed that each plant affects the economy independent of the influence of other plants. This will slightly overestimate induced employment since the actual cumulative effect of the simultaneous construction of several plants within a single region will, in general, be slightly less than the effect of one plant multiplied by the number of plants under construction. As a result, the induced employment calculated here more correctly represents an upper bound on induced employment than a forecast of actual induced employment levels. Secondly, it was assumed that induced employment levels for hot water plants will follow the same pattern shown for steam plants and will be scaled proportionally to the direct employment ratios of hot water to steam plants. No significant error is anticipated from this assumption. Employment multipliers used here were calculated separately for each quarter of the two year plant construction period for each new power plant.

The resulting estimated induced and total employment levels for each county for both the high and low growth scenarios are shown in Table 10. Figure 23 compares regional direct employment (from Table 8) with regional induced employment (from Table 10) for the high growth scenario. While the aggregate multiplier varies from year to year as a function of the specific number and type of plants under construction and operation, and of the particular phase of construction, it generally hovers at or just above two. The regional economy shows strong positive responses to even gradual increases in direct employment (see 1982-87 and 1995-1996 on Figure 23). It should also be noted that the period 1986 to 1993 shows relatively constant direct and indirect employment (e.g. little growth in employment). The surge after 1993 is associated primarily with new activity in Napa and Mendocino counties, while employment in Lake and Sonoma counties remains relatively constant after 1983. This pattern of stable long-term employment has many advantages for a county. However, it also means that the demographic impacts of

Table 10

Induced Employment By County

	Number of Employees								
	High Growth Scenario					Low Growth Scenario			
Year	Lake	Sonoma	Mendocino	Napa	Total	Lake	Sonoma	Mendocino	Total
1979	96	192			288	96	192		288
1980	287	478			765	287	478		765
1981	399	407			806	399	407		806
1982	472	356			828	473	356		829
1983	502	315			817	502	315		817
1984	625	253			878	487	253		840
1985	633	354			987	473	354		827
1986	714	399	73		1186	405	238		643
1987	820	449	138		1407	335	244		579
1988	802	442	87		1331	402	148		550
1989	855	368	133		1356	431	98		529
1990	874	295	162		1331	408	64		472
1991	835	343	95	73	1346	336	121		457
1992	983	303	133	138	1357	308	186		494
1993	839	284	160	87	1370	269	135		404
1994	776	355	170	58	1359	351	106		457
1995	756	391	281	24	1452	327	62	73	462
1996	821	365	331	81	1598	308	62	138	508
1997	778	326	370	146	1620	312	62	87	461
1998	755	382	392	95	1624	281	62	58	401
1999	693	343	325	66	1427	298	62	24	384
2000	478	251	202	32	963	217	62	8	287

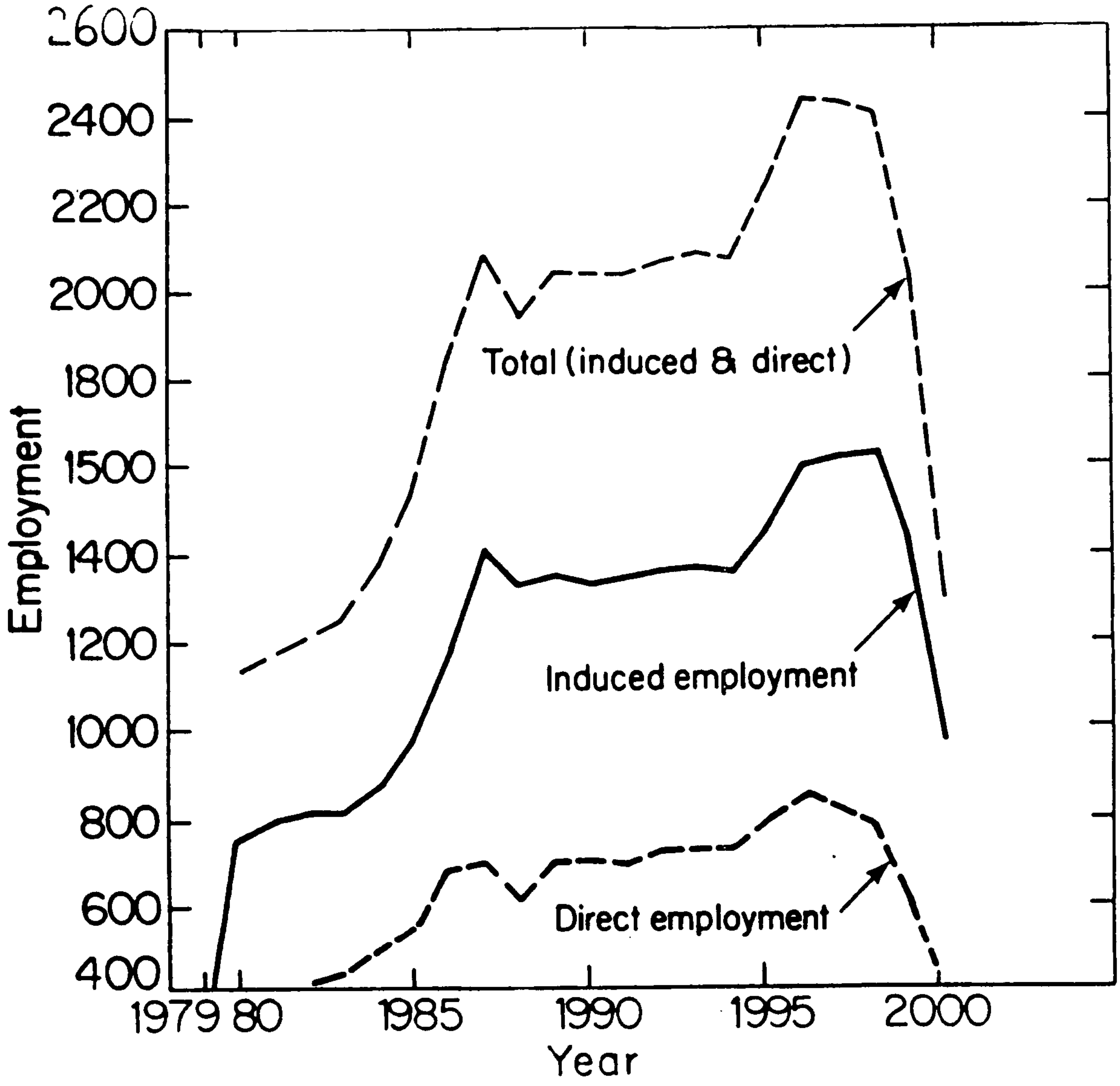


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Fig. 23. Regional Direct and Induced Employment for the High Growth Scenario

expanded geothermal activity in Lake and Sonoma Counties (e.g. increased in-migration) will happen primarily before 1983.

In-migration Resulting From Electrical Geothermal Development

Annual Available Jobs

The direct and indirect employment levels presented in the previous section represent total employment for each year. The number of people migrating into a county to work, however, will be based on the number of new jobs available in any year. The number of new jobs in any year equals the total number of jobs available in that year minus the total number of jobs available in the previous year (see Tables 11 & 12) plus the number of replacement openings occuring during the year. As can be seen, in some years there is a net loss of jobs, and after the initial surge of new jobs there are very few years where there is a large number of net new jobs either in one of the counties or in the region as a whole.

Not all of the direct employment jobs shown on Table 11 are available to in-migrants. As existing jobs end, an in-county pool of available labor is created which will absorb a large portion of the next year's new positions. When in any one year the number of in-county employees entering this geothermal labor pool exceeds the number of available jobs (negative numbers on Table 11), a carry over regional labor pool is created. It has been noted that such a labor pool in this industry is extremely fluid. Thus a portion of this pool may be expected to leave the region if no work is immediately available. However, those who stay will have a high priority in landing new jobs which become

Table 11

Annual Availability of New Jobs in the Electric Geothermal Industry

NUMBER OF NEW JOBS

	High Growth Scenario					Low Growth Scenario					Difference Between High and Low				
Year	Lake	Sonoma	Mendo-cino	Napa	Region-al Total	Lake	Sonoma	Mendo-cino	Napa	Region-al Total	Lake	Sonoma	Mendo-cino	Napa	Region-al Total
79	175	189			334	174	189			363	1	0			1
80	72	-61			11	72	-61			111	0	0			0
81	4	0			4	4	0			4	0	0			0
82	20	12			32	20	13			33	0	-1			-1
83	34	-10			24	24	0			24	10	-10			0
84	30	29			59	-3	9			6	33	20			53
85	-6	40	27		61	-59	-15			-74	53	55	27		135
86	79	4	51		134	53	-14			39	26	18	51		95
87	19	16	-27		8	-24	-52			-76	43	68	-27		84
88	-6	-58	-16		-36	51	-47			4	-57	-11	-16		-84
89	73	-47	51		77	4	0			4	69	-47	51		73
90	-29	36	-31	33	9	-119	48			-71	90	-12	-31	33	80
91	-61	16	-16	52	-9	6	51			57	-67	-35	-16	52	-66
92	60	-45	48	-34	29	48	-48			0	12	3	48	-34	29
93	14	41	4	-47	12	4	-47			-43	10	88	4	-47	55
94	-72	38	31	0	-3	0	0	48		48	-72	38	-17	0	-51
95	23	-26	43	26	66	-59	0	39		-20	82	-26	4	26	86
96	35	-40	6	56	57	43	0	-36		7	-8	-40	42	56	50
97	-46	35	4	-31	-38	0	0	-47		-47	-46	35	51	-31	9
98	24	37	-1	-47	13	-23	0	0		-23	47	37	-1	-47	36
99	-93	-74	-74	0	-241	-24	0	0		-24	-89	-74	-74	0	-217
2000	-117	-68	-68	0	-253	-68	0	0		-18	-49	-68	-68	0	-185

Table 12

Annual Availability of New Induced Jobs Created by Activity in the Electric Geothermal Industry

NUMBER OF NEW JOBS

	High Growth Scenario					Low Growth Scenario				Difference Between High and Low				
Year	Lake	Sonoma	Mendo-cino	Napa	Reg-ional Total	Lake	Sonoma	Mendo-cino	Reg-ional Total	Lake	Sonoma	Mendo-cino	Napa	Reg-ional Total
1979	96	197	-		288	96	192	-	288	0	0			0
1980	191	280	-		477	181	286	-	477	0	0			0
1981	112	-71	-		41	112	-71	-	41	0	0			0
1982	73	-51	-		22	74	-51	-	23	-1	0			- 1
1983	30	-41	-		-11	29	-41	-	-12	1	0			1
1984	123	-62	-		61	-15	-62	-	-77	138	0			138
1985	8	101	-		109	-14	101	-	87	22	0			22
1986	81	45	73		199	-68	-116	-	-184	149	161	73		383
1987	106	50	65		221	-70	6	-	-64	176	44	65		285
1988	-13	- 7	-51		-76	67	-96	-	-29	-85	89	-51		-47
1989	53	-74	46		25	29	-50	-	-21	24	-24	46		46
1990	19	-73	29		-25	-23	-34	-	-57	42	-39	29		32
1991	-39	48	-67	73	15	-72	57	-	-13	33	9	-67	73	30
1992	-52	-40	38	65	11	-28	65	-	37	-24	-105	38	65	-26
1993	56	-19	27	-51	13	-39	-51	-	-90	95	32	27	-51	103
1994	-63	71	10	-29	-11	82	-29	-	53	-145	100	10	-29	-64
1995	-20	36	111	-34	93	-24	-44	73	5	4	80	34	-34	84
1996	65	-26	50	57	146	-19	0	65	46	84	-26	-15	57	100
1997	-43	-39	39	65	22	4	0	-51	-47	-47	-39	90	65	68
1998	-23	56	22	-51	4	-31	0	-29	8	8	56	51	-51	63
1999	-62	-39	-67	-29	-197	17	0	-34	-79	-79	-39	-33	-29	-180
2000	-215	-92	-123	-34	-464	-81	0	-16	-134	-134	-107	-107	-34	-367

available within the region (Vollentine, Kunin and Sathaye, 1977). No data were available to estimate how many workers move between counties in the region, or how soon they might leave the Geysers region if no work is available. It was therefore assumed that half of the workers entering the excess pool in any given year would leave, with the remaining workers having a weighted preference for available jobs in the region the following year.

In-migration Patterns

Using this job allocation scheme, the number of jobs available to in-migrants in the geothermal industry for the high and low growth scenarios is shown on Table 13. We assumed that all newly created induced jobs would be available to in-migrants since data were not available to prepare an allocation scheme in all local economic sectors. The average number of in-migrant geothermal workers with families was obtained from estimates by various industry, county, and state personnel. Similar data for induced employees and for average family composition were obtained from the California State Department of Finance data base used for state population projections. The resulting net in-migration (county total in-migrants minus geothermal workers leaving the region from the excess pool) is shown on Table 14. The difference in net in-migration between the two scenarios is shown on Table 15.

Table 13

New Geothermal Industry Jobs Available to Inmigrants By Year

Number of New Jobs

	High Growth Scenario					Low Growth Scenario				
Year	Lake	Sonoma	Mendocino	Napa	Region Total	Lake	Sonoma	Mendocino	Napa	Region Total
1979	174	189			363	174	189			363
1980	72	0			72	72				72
1981	1	0			1	1				1
1982	5	3			8	5	4			9
1983	34	0			34	24				24
1984	25	25			50		9			9
1985	0	40	27		67					0
1986	76	4	49		129	11				11
1987	19	16	0		35					0
1988	0	0	0		0	10				10
1989	23	0	21		44	1				1
1990	0	16	0	13	29		21			21
1991	0	6	0	11	17	1	10			11
1992	23	0	20	0	43	20				20
1993	3	9	1	0	13	1				1
1994	0	11	8	0	19			10		10
1995	8	0	13	10	31			28		28
1996	28	0	5	43	76	9				9
1997	0	7	1	0	8					0
1998	5	7	0	0	12					0
1999	0	0	0	0	0					0
2000	0	0	0	0	0					0
TOTAL	496	333	145	77	1051	329	233	38	0	600

Table 14

Net Geothermally Induced Immigration By County

	HIGH GROWTH SCENARIO						LOW GROWTH SCENARIO					
Year	Lake	Sonoma	Mendo-cino	Napa	Region-al Total	Cumula-tive Region-al Total	Lake	Sonoma	Mendo-cino	Napa	Region-al Total	Cumula-tive Region-al Total
1979	524	743			1267	1267	527	744	0	0	1266	1266
1980	697	858			1555	2822	520	558	0	0	1078	2344
1981	337	-125			212	3034	225	-111	0	0	114	2458
1982	230	- 68			162	3196	159	- 44	0	0	115	2573
1983	182	- 16			166	3362	103	- 41	0	0	62	2635
1984	326	21			347	3709	- 17	- 9	0	0	- 26	2609
1985	182	229	51		462	4171	- 28	28	0	0	0	2609
1986	328	142	313		783	4951	- 38	- 82	0	0	- 120	2489
1987	255	101	109		465	5409	- 57	- 59	0	0	- 116	2373
1988	139	33	57		229	5648	43	- 96	0	0	- 53	2320
1989	103	- 53	57		107	5755	49	- 78	0	0	- 29	2291
1990	50	- 77	10	25	8	5763	- 52	39	0	0	- 13	2278
1991	- 76	- 16	- 32	271	147	5910	- 94	83	0	0	- 11	2267
1992	- 9	- 13	82	187	247	6157	+ 10	49	0	0	59	2326
1993	24	39	82	- 58	87	6244	- 28	- 58	0	0	- 86	2240
1994	- 62	155	44	- 91	46	6290	80	- 41	19	0	58	2298
1995	4	102	258	- 32	332	6622	- 18	- 44	198	0	136	2434
1996	117	- 18	161	153	413	7035	- 1	0	109	0	108	2542
1997	- 36	- 28	128	187	251	7286	- 2	- 8	- 76	0	- 86	2456
1998	- 23	31	64	- 57	15	7301	- 69	0	- 44	0	- 113	2343
1999	-133	- 76	-124	- 88	-421	6880	- 11	0	- 34	0	- 45	2298
2000	-322	-230	-245	- 51	-848	6032	-135	0	- 16	0	- 151	2147
TOTAL	2837	1734	1015	446	6032		1161	830	156	0	2147	

Table 15

Differences Between High and Low Growth Scenarios for Geothermally Induced County Level Net In-migration

Year	Lake	Sonoma	Mendocino	Napa	Total	Regional Cumulative Total
1979	2	- 1			1	1
1980	177	300			477	478
1981	112	- 14			98	576
1982	71	- 24			47	623
1983	79	25			104	727
1984	343	30			373	1100
1985	210	201	51		462	1562
1986	366	224	313		903	2465
1987	312	160	109		581	3046
1988	96	129	57		282	3328
1989	54	25	57		136	3464
1990	102	-116	10	25	21	3485
1991	18	- 99	- 32	271	158	3643
1992	- 19	- 62	82	187	188	3831
1993	52	97	82	- 58	173	4004
1994	-142	196	25	- 91	- 12	3992
1995	22	146	60	- 32	196	4188
1996	118	- 18	52	153	305	4493
1997	- 34	- 20	204	187	337	4830
1998	46	31	108	- 57	128	4958
1999	-122	- 76	- 90	- 88	-327	4582
2000	-187	-230	-229	- 51	-697	3885
TOTAL	1676	904	859	446	3885	

IV. DIRECT USE OF GEOTHERMAL ENERGY

Direct Use Applications

The dry steam field at The Geysers is of limited geographic extent (Figures 1 and 2). The steam field is bounded on the southwest by the Mercuryville fault zone and on the northeast by the Collayomi fault zone. Outside this steam bearing zone is a large area which is more likely to contain liquid-dominated geothermal resources.

Geothermal hot water has many potential, economically feasible non-electrical uses (Table 16). However, direct use of geothermal energy has had a slow start in the Geysers region partly because attention has been drawn to the dry steam resource which is so well suited for electrical generation. People in other areas of the U.S. and abroad have already directly employed geothermal energy for many non-electric uses. Most of the existing applications are commercially viable and have displaced significant amounts of conventional fuels. In the Geysers region, the various direct uses could either use lower temperature resources independent of electrical production, or be coupled with electrical plants. Non-electric use of the geothermal fluids could help to share the capital costs of wells and pipelines, supply an additional means of cooling the fluids, and thereby improve the thermodynamic efficiency of the entire system. Thus, feasible direct uses of geothermal energy might encourage earlier or more extensive electrical use of liquid-dominated resource areas near The Geysers. However, such cogeneration systems have not been considered in electric scenario development for this study and are not forecast to occur before 2000.

Table 16

Classification Scheme For The Geothermal Energy

A. Residential and Commercial
  1. Space heating
  2. Space cooling, air conditioning
  3. Domestic hot and cold water
  4. Swimming pools
  5. Cooking
  6. Clothes drying
  7. Refrigeration
  8. Horticulture
  9. Melting snow and ice on driveways and roads; unfreezing of sewer lines in arctic rural areas

B. Balneology/Tourism
  1. Health spas
  2. Hospitals, sanatoriums
  3. Tourist centers and resorts
  4. Bottled water

C. Agricultral
  1. Greenhouses for vegetables, flowers, tree seedlings
  2. Hot-beds, hot-houses
  3. Soil warming
  4. Animal husbandry-heating of fowl runs, pigsties, cattle breeding
  5. Irrigation
  6. Water desalination
  7. Cooling for food storage
  8. Thermal food culture-seaweed, algae
  9. Frost protection
  10. Plant cooling and humidity control
  11. Pest and disease control
  12. Fish culture (aquaculture and mariculture) pond culture, cage culture, flowing water culture; ayn, carp, catfish, eels, flatfish, lobster, mussels, oysters, rainbow trout, seabream, shrimp, whitefish, yellow tail; breeding of alligators and crocodiles

D. Agri-Business
  1. Drying-fish meal, grain, hay, paprika, rice, tobacco
  2. Canning
  3. Refrigeration
  4. Freeze drying-coffee, fish, fruit juices, meat, mushrooms, onions, shrimp, soups
  5. Brewing and distillation
  6. Sugar processing and refining
  7. Pasteurization of milk
  8. Production of dried milk, casein, and sucrose
  9. Seaweed harvesting and manufacture of alginates
  10. Cold for the production of protein and vitamin preparations
  11. Rice processing
  12. Cheese processing
  13. Dehydrated potato products

E. Electrical
  1. Dry steam
  2. Wet steam - low salinity
  3. Wet steam - high salinity
  4. Low enthalpy - less than 356°F

F. Industrial
  1. De-icing
  2. Space heating
  3. Refrigeration
  4. Pulp and paper manufacture
  5. Timber seasoning and drying, sawmills
  6. Hemp processing
  7. Textile processing, wool washing and drying
  8. Manufacture of plastic explosives
  9. Gasification of coal
  10. Hot feedwater for solar stills
  11. Cold for the production of synthetic rubber
  12. Sewage heat treatment

G. Minerals Recovery and Production
  1. Diatomite production
  2. Chemicals production-ammonia, ammonium-carbonate, chloride and sulfate, anhydrous gypsum, borax, boric acid, boron, bromine, calcium chloride, chlorine, dry ice, heavy water, hydrogen for fertilizers and for fuel, hydrogen chloride, iodine, lithium, magnesium, magnesium chloride, methane recovery for peak heating demands, methanol production for fuel, potassium chloride, soda ash, sodium bicarbonate, sodium chloride, sulfur
  3. Recovery of trace elements
  4. Fermentation-ethyl alcohol, butanol, acetone, citric acid
  5. Cement drying and curing
  6. All-weather mining
  7. Minerals recovery-gold, zinc, titanium, silver, lead, tin beryllium, copper, antimony

SOURCE: Peterson and El-Ramly, 1976.

In order to become a reality, any potential use of geothermal energy must be technically feasible, economically viable, and politically acceptable. This section presents an analysis of the factors affecting the feasibility and desirability of direct uses of geothermal energy in the Geysers region and presents a tentative scenario for the development path of direct uses within the region.

Several non-electrical uses of geothermal energy which show the most potential for use in the near future will be described, along with estimates of their physical and energy requirements. An attempt is made to point out which direct uses are most likely to be feasible in the Geysers region, and the external factors which may influence the emergence and success of those direct use applications. This section is intended to provide information necessary to clarify the choices available to the community for the use of local geothermal resources.

Suggested Criteria for Assessing Feasibility of Direct Use Applications

Many possible criteria could be used to judge the suitability of direct uses of geothermal energy. The choice of criteria is an important step in the planning process and can greatly influence which of the many potential direct use applications appear more desirable. This decision is generally based on the needs of the constituency to be served. The relative weighting given to each of the criteria listed below will therefore differ, depending on whether the decision is being made by a private company, or at the local, state, or national level of government.

Geothermal Resource Temperature.

The first several factors to be considered concern the engineering feasibility of the proposed direct uses. Foremost among these are the temperature and availability of the geothermal fluids. The greater the temperature and heat content, the greater the potential for direct use applications. Table 1 shows the temperature and thermal energy of the hydrothermal convection systems in the Geysers region, as estimated by the U.S. Geological Survey (Brook et al., 1978). These data are among the best publicly available on geothermal reservoirs in the Geysers area. Other data are proprietary information, belonging to the geothermal development companies which financed small heat probe wells and other geologic explorations. Unfortunately, except for the well-known vapor-dominated systems at The Geysers, only a small number of deep exploratory wells have been drilled for which temperature data are available.

Temperatures Necessary for Direct Use Applications.

Feasible direct use of geothermal heat requires that the geothermal resource be at least as hot as the temperature needed in the energy consuming process. The temperatures necessary for several potential direct uses are shown in Figure 24. Most of these process temperatures are below the available geothermal temperatures listed in Table 1. Thus a wide variety of applications are possible from a thermal viewpoint.

Lower-temperature sources are promising targets for geothermal applications because moderate temperature (90-150 degrees C or 194-302 degrees F) geothermal resources are about as numerous as hotter ones

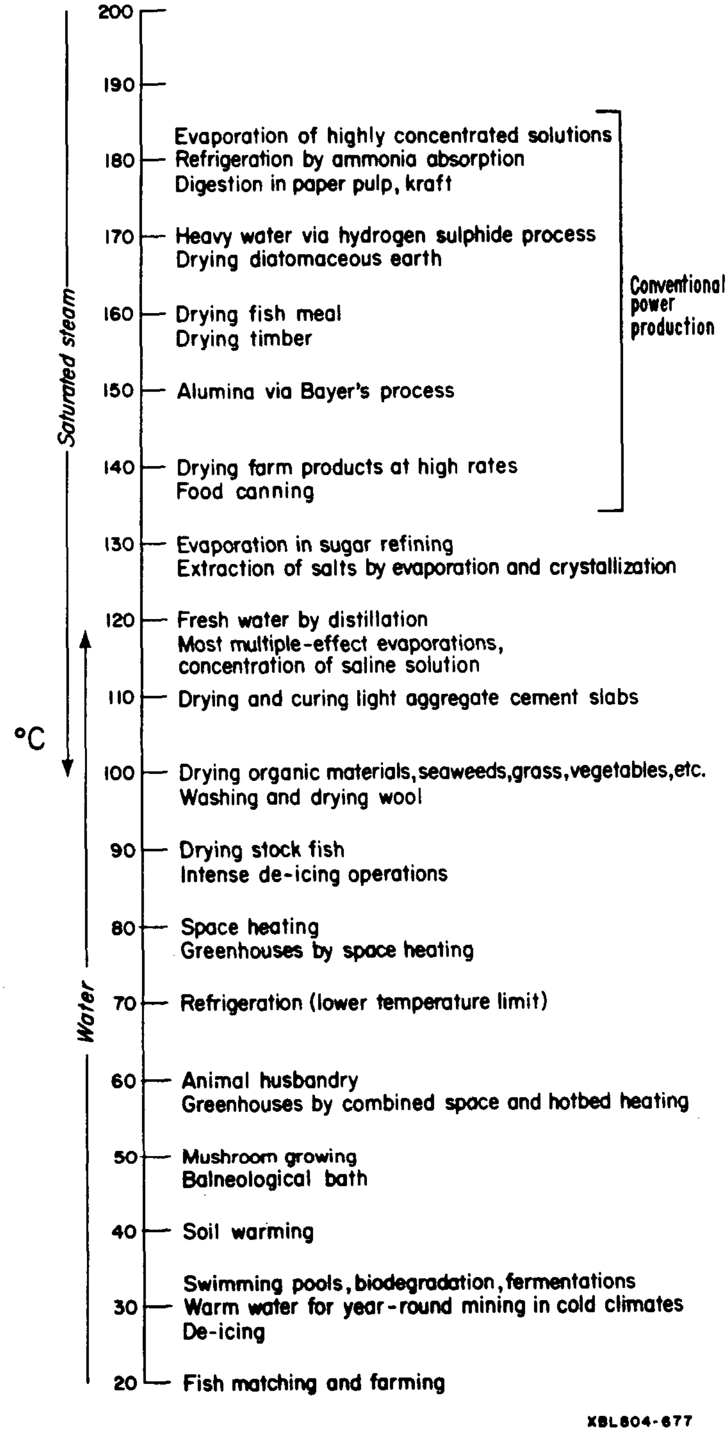

Fig. 24. Approximate Required Temperature of Geothermal Fluid for Various Applications

Source: Lindal, 1973.

(over 150 degrees C), with about 215 resource areas of each type in the United States. The estimated thermal energy which could be produced at the wellhead from these moderate-temperature resources is almost as high as from the higher temperature areas (176 vs. 210, x 10^{18} joules) (Brook et al., 1978).

Energy Consumption in the Proposed Application.

Production processes which consume a large amount of energy would seem *a priori* to have the best potential for an economically beneficial conversion from fossil fuels to geothermal energy. If a relatively large proportion of the cost of producing a product is for the energy used, then even a relatively small percentage savings in energy cost can produce a significant decrease in the total cost of production. The horizontal axis in Figure 25 shows heat cost as a proportion of total cost for several potential uses of geothermal energy. Using only this criterion, power generation, desalination and district heating are among the more promising possibilities.

Another way to look at energy consumption patterns is with total energy demand by end use, as in Figure 26. The heating energy uses shown in this figure represent about 41 percent of the total U.S. energy use (Ehrlich et al., 1977, p. 492). The lowest temperature heating uses in Figure 26 are space heating and residential and commercial water heating which account for about 23 percent of total energy use. Geothermal energy could be an important source of heat for these uses if the users can be located close enough to the geothermal resource.

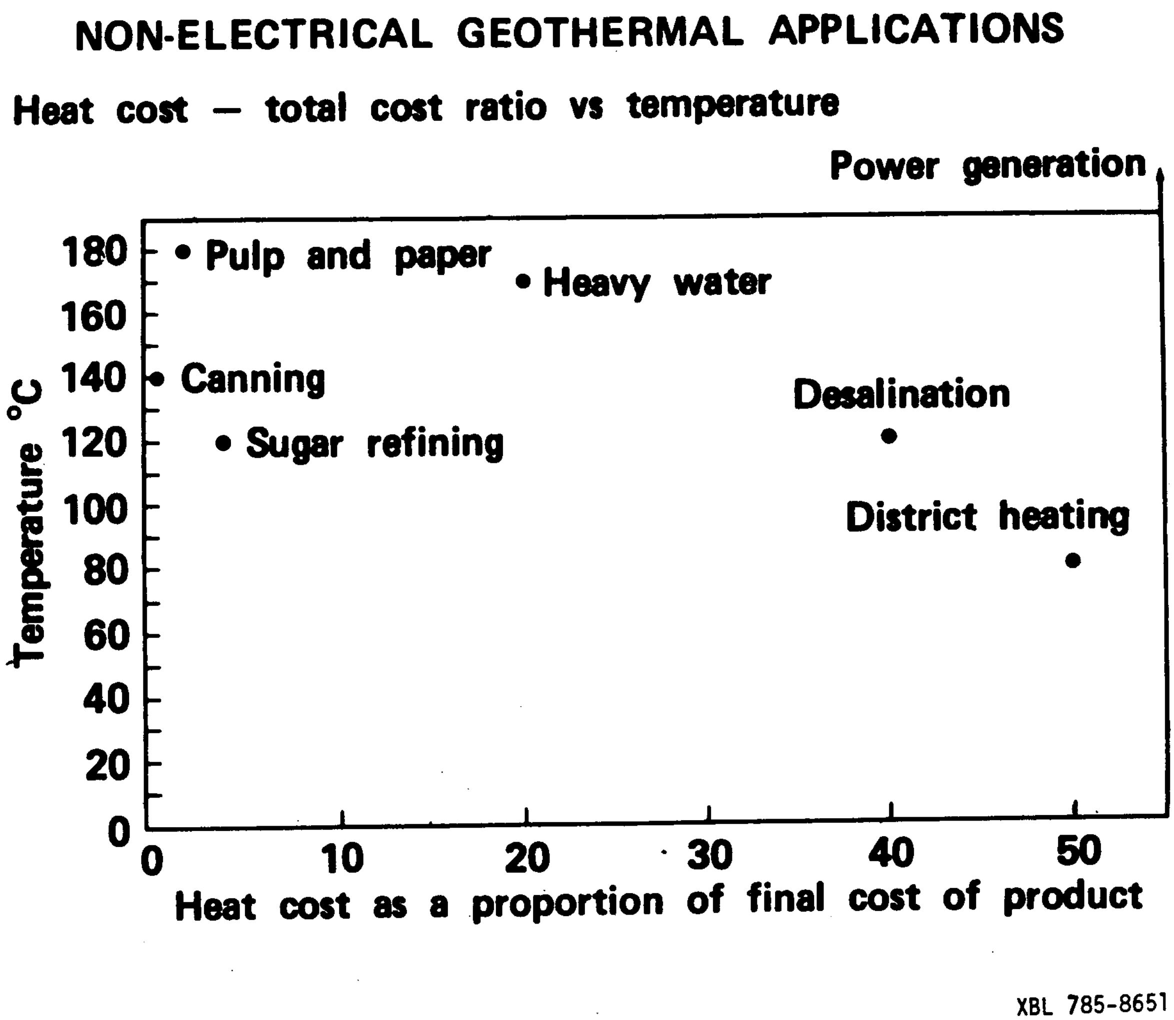

Fig. 25. Heat Cost and Temperature Relationships for Selected Non-electric Applications

Source: J.H. Howard, 1978. "Overview of Geothermal Technology" LBL 7048. May 1978.

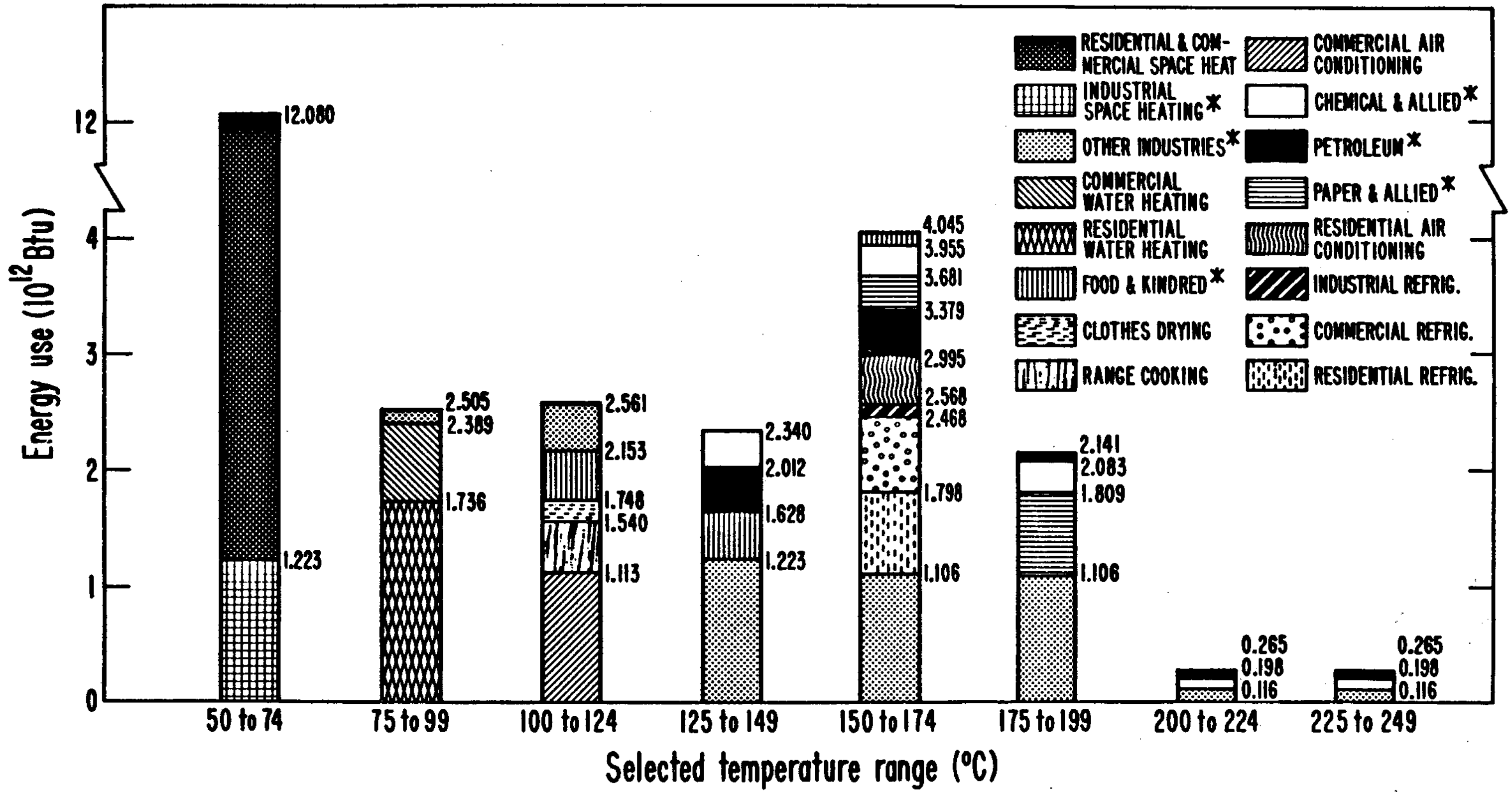

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Fig. 26 Estimated heating energy use in the U. S. in selected 25°C temperature ranges, (*) indicates process steam use in sector.

Source: Reistad, 1975.

Criteria for Choosing between Geothermal Energy and Other Alternatives.

The choice between using geothermal energy and any other source of energy for a particular application is primarily an investment decision and consideration must be given to the same factors as with any other investment. In addition, convenience, risk and reliability are important considerations. For direct uses, geothermal energy is often not as convenient as most fossil fuels because it must be used near its source. Further, geothermal systems are not as well-suited to fluctuations in heat requirement. Fossil-fueled auxiliary heaters may be needed for backup or extra heating during peak load periods.

Skalka (1978) considers uncertainty about the geothermal resource one of the most fundamental barriers to direct use development. Commercial financing is made more difficult because of this risk. Geothermal development companies often find themselves in the unenviable position of considering expensive drilling in an area in which they have only a small probability of commercial success. Understandably, only the most promising geothermal sites and uses are attractive for exploration and development. This tends to discourage development of lower temperature areas which are still well-suited for direct use applications.

A benefit which somewhat offsets the risk of geothermal development is its reliability as a heat source once the resource has been discovered and tapped. Unlike other energy sources, the supply of geothermal energy is not subject to the uncertainties of international trade, temporary shortages, labor problems, and the like.

Description of Possible Direct Use Applications

All direct uses of geothermal energy have one feature in common: the thermal energy is used directly without being first converted to electricity. The energy is extracted from geothermal steam and/or hot water, and is most often used as heat. Some applications use geothermal energy to power a heat-pump unit for space cooling or refrigeration.

Many different non-electrical uses have been suggested for geothermal energy, and many have been successfully implemented in various parts of the world (Peterson and El-Ramly, 1976). Since direct uses must be located near the geothermal resource, this discussion will concentrate on the most promising prospects for the Geysers region. Some uses which have been successful elsewhere, such as snow melting, diatomite drying and heavy industrial processes, will not be discussed. These are unlikely to occur within the Geysers region. Some other direct uses which might be feasible in the Geysers region will not be discussed here for two reasons. First, these are not considered to be promising near term alternatives. Second, this group of applications have been analyzed in detail by other authors. They include livestock production facilities (Longyear et al., 1979), pulp mills (Hornburg and Lindal, 1978), and multi-use applications of geothermal fluids (Barnea, 1975).

The remaining list of direct uses for the Geysers area includes applications in the general categories of agriculture, process heat, space heating, and balneology (health spas). These direct uses are technically feasible and most of them would be compatible with the agricultural, residential, and recreational land uses prevalent near the geothermal resource. The deciding factors in their possible future implementation will be economic viability and social and political decisions. Decisions made by local and county governments will be particularly important. The most promising of the possible direct uses will now be described, as a first step toward facilitating those decisions. The choice of which direct applications to describe here in detail was made both on the basis of economic potential in the Geysers region and also to illustrate important factors to consider in planning for successful direct use of geo-heat.

Geothermally Heated Greenhouses

Heating of greenhouses is currently one of the most common direct uses of geothermal energy. Installations exist in the Soviet Union, Hungary, Iceland, Japan, New Zealand, Italy, and the United States. In April, 1978, the first group of tree seedlings for reforestation was planted in a new geothermal greenhouse complex near Klamath Falls, Oregon (Laskin, 1978). At least two greenhouse operations, Hobo Wells, Inc. and Honey Lake Farms, are producing vegetables in the Wendel-Amedee geothermal area east of Susanville, California. These greenhouses grow cucumbers and tomatoes in gravel and water without soil, using a technique called "hydroponics" (Gutman 1975, Boren and Johnson, 1978).

In a greenhouse, geothermal heat is transferred from the geothermal fluid to the air inside the greenhouse by a heat exchanger. Geothermal hot water temperatures of at least 87 degrees C (187 degrees F) are usually required, but temperatures as low as 60 degrees C (140 degrees F) can be used if the geothermal water is used to heat both the air and soil in the greenhouse (Lindal, 1973).

The amount of hot water needed for a greenhouse complex depends on the delivered temperature of the geothermal water, ambient temperature, size of the greenhouse complex, and efficiency of heat extraction from the water. Heating system design information can be found in Pate (1978) and in Tinus and McDonald (1979).

The conifer seedling nursery in Klamath Falls mentioned earlier consists of four greenhouses and a central walkway, totaling 27,450 square feet of floor space. Peak geothermal flow has been 800 gallons per minute of 188 degrees to 190 degrees F. water (Laskin, 1978). This is equivalent to 400,000 pounds per peak hour (10,400,000 BTU's per hour). If supplied by natural gas at a price of 28 cents per therm (100,000 BTU), this peak load would have cost $29.12 per hour to supply.

The peak load is not as important for cost comparisons as the total annual heating costs. Data were not available on total annual geothermal heat use by the Klamath Falls greenhouses, but such information is available from a smaller installation heated by natural gas. In Davis, California, the California Division of Forestry operates two 3600 square foot greenhouses for raising conifer seedlings. This is about one-fourth the total size of the Klamath Falls operation. Annual natural gas usage for this facility amounted to about 9966 therms which cost $2588 (6/78 through 5/79) (Eden, pers. comm.). Thus the use of geo-heat at the Klamath Falls greenhouse saves about $7500 to $10,000 annually.

The primary benefit of greenhouse plant production is the major increase in crop yield achieved in a controlled environment. The Honey

Lake Farms hydroponic geothermal greenhouses produce an average of 1500 pounds of cucumbers per week in each 124 by 30 foot greenhouse (Boren and Johnson, 1978). This is equivalent to 228 tons per acre, 18 times California's average yield of field-grown fresh cucumbers (California Department of Food and Agriculture, 1979). Similar results are expected for tomatoes with weekly harvests of 850 pounds per greenhouse expected at Honey Lake Farms.

This boost in yield is attained with a significant savings in water use due to reduced evapotranspiration. Each greenhouse at Honey Lake Farms uses only 225 gallons per day of irrigation water, less than 10 percent of the amount needed for the same yield grown outdoors. The planned full development of 205 greenhouses at Honey Lake will use only 92 acre-feet of water per year, 56 percent for irrigation and 44 percent for evaporative cooling (Boren and Johnson, 1978). These 205 greenhouses use only about 4 percent of the projected water needs of a single 55 MW binary power plant. Non-hydroponic greenhouses would use slightly more water, but still much less than open-field agriculture.

A second system of greenhouse heating which is compatible with geothermal hot water has the potential for eliminating all fresh water use. A greenhouse in Puerto Penasco, Sonora, Mexico, is heated with warm seawater (only 80 degrees F) from the Gulf of California. The warm seawater is sprayed into columns packed with corrugated asbestos. Air from the greenhouse is continuously circulated through the packed columns, so that the heater is actually a direct-contact heat exchanger. This heating system maintains relative humidity at almost 100 percent, which reduces fresh water consumption in two ways (a maximum of 300 gallons per day is needed in July, the hottest month, for each 4600 square foot greenhouse). First, the high humidity reduces evapotranspiration. Second, the high humidity causes fresh water to condense on the inside of the walls and roof during the night. During the winter, as much as 1500 gallons per night will form in each house, greatly exceeding the amount of water used by the plants (Callejas, 1967). The excess can be stored for use in summer, when less condensate forms. Thus each greenhouse is also a desalination plant capable of supplying all its fresh water needs (Jensen, 1971). The insulating qualities of the walls and roof could be adjusted for optimum energy and water use. An insulating exterior would use less energy and produce less water. Most geothermal fluids in the Geysers area contain a smaller proportion of dissolved solids than seawater, and are much hotter. This system shows promise for use in the Geysers region.

The large increase in crop production and decreased water use achieved in greenhouses are not free benefits. Controlled environment greenhouses represent a much more intensive use of land than open-field agriculture, and therefore require larger quantities of some inputs per acre of land. One input needed in greater quantities is labor. Greenhouse crop production requires approximately one full time employee for every 6000 square feet (Hannah, 1975). The four greenhouses near Klamath Falls mentioned earlier are expected to produce 50,000 to 80,000 containerized tree seedlings per day with a crew of 4 to 5 people. This could expand to 200,000 per day with 18 employees (Laskin, 1978). The planned full development of 205 geothermal greenhouses at Honey Lake Farms is expected to employ a total of 150 persons, yet few will be directly associated with the geothermal energy system.

Greenhouse vegetable production can range from 20 to 50 tons per employee per year, depending on the crop, length of growing season, and efficiency of production methods. Labor requirements for greenhouse operations are not as seasonal as in many other agricultural businesses. If crop production is not continuous throughout the year, more people would likely be employed in winter than in summer because crop prices are higher in winter.

Crop Drying with Geothermal Energy

Crop drying is an attractive agribusiness application of geothermal energy. This energy-intensive process is necessary to preserve and enhance the quality of many crops. The California crops most commonly dried in natural gas-fueled driers are listed in Table 17. The most important among these from the standpoint of production and energy use are alfalfa, hay, cotton, prunes and onions. The agricultural products which could be dried with geothermal heat in each of the four counties in the Geysers region are listed in Table 18. The bulk of these crops are produced in Lake and Mendocino counties. In addition, a large quantity of peaches, apricots, and other fruits are brought from Yolo County into Lake County to be dried (Tompkins, pers. comm.).

The most important factor in the economic viability of crop drying is the total cost of drying per ton of product. This total cost is composed of the fixed cost (mostly for purchase of capital equipment) and the variable costs for drying fuel and transportation of crops to and from the drier site. Fossil-fueled crop driers have relatively low capital costs and high operating costs. Their low capital costs make them suited to installations in which crops need to be dried for only a few

Table 17

Requirements of Natural Gas for Dehydration in California, 1976
(Cervinka et al. 1978)

Product	Total Production(1000 tons)	Percent Dried	Amount Dried (1000 Tons)	Gas Use (therms/ton)	Percent of total gas use
Alfalfa Hay	7,554.0	1	90.7	90.0	18.6
Corn	893.2	70	625.2	2.0	2.9
Cotton	595.7	75	446.8	15.1	15.4
Rice	1,169.4	70	818.6	3.8	7.2
Almonds	230.0	10	23.0	21.0	1.1
Grapes	3,620.0	0.6[a]	21.0	30.0	1.4
Prunes	145.0	100	145.0	90.0	29.9
Walnuts	185.0	40	74.0	21.0	3.6
Onions	415.6	85	353.3	24.6	19.9
TOTAL					100.0

[a]Only the "golden bleached" variety of raisins are not sun-dried.

Table 18

Production and Harvest Period for Selected Crops in the Geysers region
(Production data are in tons per year, except as noted)

	Lake	Mendocino (1977 data)	Napa	Sonoma	Harvest Period
Grains and Alfalfa					
Alfalfa Hay	4,695	8,510			May - September
Barley	275	750	48	130	June 1 - Aug. 25
Wheat	315	135	60	60	June 15 - Aug. 15
Oats	546	550	----	1,200	
Sorghum	438	11,200	----	126	Sept 15 - Nov. 25
Corn	180	22,500	----	----	Sept 15 - Dec. 1
Safflower	295	----	----	----	July 1 - Sept. 15
Fruits and Nuts					
Prunes (dry weight)	127[e]	788	153[e]	6,940	June 15 - Aug. 1
Pears (total)	47,464[d]	41,930[d]	----	4,500	July 10 - Sept. 10
(dried)	3,960[a]	4,170	----	4,540[c]	
Apples (total)	----	7,180	650[e]	72,460[d]	July 15 - Oct. 30
(dried)	----	4,370[c]	----	14,930[a]	
Walnuts	4,686	65	382	298	Sept. 25 - Nov. 5
Almonds	9	----	----	----	Aug. 25 - Oct. 15
Vegetables					
Acres	10	----	----	240	
Total Value ($1000)	13	115	55	1,739	
Livestock Products					
Milk (1000 CWT)	----	163[e]	272	4,544	All year
Dollar Value($1000)	----	1,679	2,815	46,499	
Eggs(1000 dozens)	424	----	5,595	27,892	All year
Dollar Value($1000)	231	60	2,876	13,193	

[a] Fresh weight.
[b] Dry weight.
[c] Includes all not sold as fresh fruit.
[d] One of the five leading counties in the state.
[e] Approximate.

Source: County Agricultural Commissioner's Reports (1978 season), and California Department of Food and Agriculture (1978 season).

months a year. For example, most U.S. grain dryers operate LP gas dryers for a few months each year.

In contrast, the higher capital costs of a geothermal drying system can best be justified in applications where lower operating costs become the dominant economic factor. This is the case when the crop is dried all year, as with the new geothermal onion drier at Brady Hot Springs, Nevada, or the proposed geothermal alfalfa dehydrators in the Klamath Falls area of Oregon (Lienau, 1978).

A geothermal crop-drying facility can be economically successful where the potential exists to dry several crops in a multi-crop drying center (MDC), as described by Gordon et al. (1978). The objective in this approach is to dry several different crops at different times of the year, so that each crop can help to cover the cost of the equipment. The harvest and drying periods of some crops grown in the Geysers region are shown in Figures 27 and 28. An MDC operation in this area could be operational for about 6 months of each year.

While alfalfa at first appears well suited for geothermal drying in the Geysers region, this crop is always dried in rotary drum dryers which require large product flows (minimum 10,000 tons per year) to be economical. Alfalfa crops in Lake and Mendocino counties are too small to support such a dryer (Tompkins, pers. comm.). This particular application is better suited to the Imperial Valley where there is a continuous supply of both geothermal brine and alfalfa (Wright, 1978).

The drying of walnuts, almonds and grain crops is a more promising application of geo-heat since the equipment already exists in the

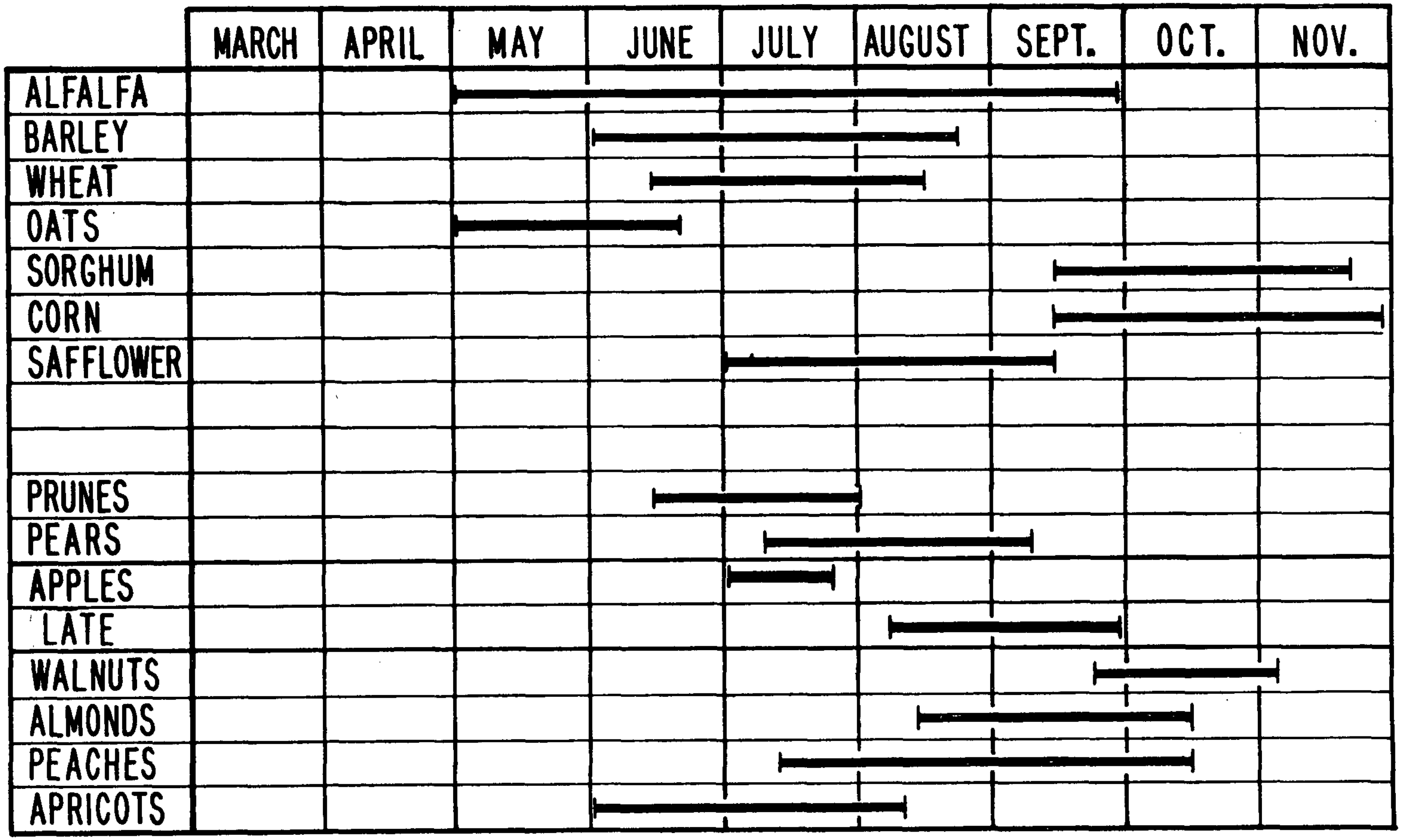

Fig. 27. Harvest periods of selected crops grown in the Geysers Region. XBL804-674

Source: California Department of Food and Agriculture (1979).

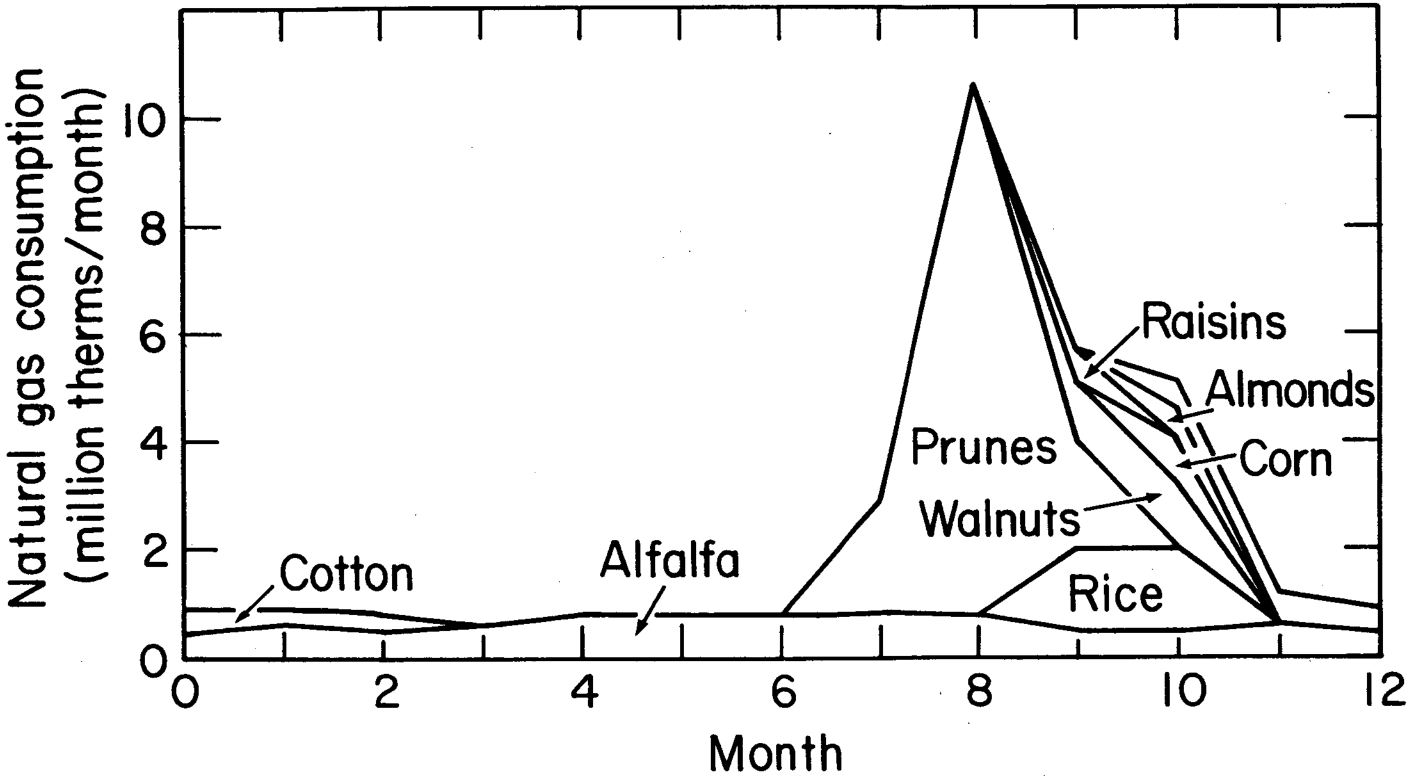

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Fig. 28. Yearly Distribution of Natural Gas Usage For Crop Dehydration in California

Source: Cervinka et al., 1978

Geysers region. These crops are usually dried in large bins through which heated air is blown, the heat usually coming from LP gas. Conversion to geothermal energy would involve replacing the LP gas burners with finned-tube heat exchangers through which the geothermal fluid flows. Procedures and equipment for harvesting and drying walnuts, a major Lake County crop, are described by Olson et al. (1978). Drying temperatures must not exceed 110 degrees F, a temperature easily achieved by even moderate quality geothermal resources. Such low temperatures should also be suitable for drying grain crops.

Fresh fruit drying is well-suited for available geothermal heat sources in Lake and Mendocino Counties. Most Lake County prunes (a major energy user) are currently sent to dryers in Colusa County or in Healdsburg, Sonoma County. Lake County has only two crop-drying companies, both located in Kelseyville. The Mariani Packing Company and the Kelseyville Packing Company dry pears from Lake County and peaches and apricots from Yolo County (Tompkins, pers. comm.). Currently, both of these packing companies dry fruit by coating it with sulfur and sun drying on trays. This method faces the risk of product damage from rain and produces significant air pollutants. The sulfur reacts with atmospheric oxygen to form sulfur dioxide, a toxic gas which has damaged nearby crops and vegetation.

A study by the Lake County Air Pollution Control District indicates that a single 150,000 lb/hr. supply well and one reinjection well could provide enough energy for crop drying, fruit canning, and refrigeration for fruit storage (Tompkins, pers. comm.). Such an integrated food processing plant could provide a significant number of new jobs in the county. Possibilities for crop drying in Mendocino County are more difficult to assess due to limited information on the extent and temperature of the geothermal resource. Mendocino County has the advantage of good surface transportation (U.S. 101) if usable geothermal resources can be found in that area.

Geothermal Energy in the Wood Products Industry

Most lumber is dried by a batch process at the sawmill site. The lumber is stacked with spacers to allow air flow, and hot air is blown through the stacked lumber while temperature and relative humidity are controlled. The air is heated by steam passing through a finned-tube heat exchanger at a pressure of about 15 pounds per square inch and about 250 degrees F (121 degrees C). The steam is generated by burning fossil fuels or waste wood (Dost, pers. comm.). Several sawmills presently exist in the Ukiah and Cloverdale areas, most with drying facilities. The nearest geothermal resource area to these mills is several miles to the east and is too far to economically transport the geothermal fluids. The three remaining possible means of using geo-heat would be to move the drying part of the operation, move the whole sawmill, or discover economical geothermal resources nearby. None of these options appears very promising.

Moving the lumber drying operation away from the sawmill would increase transportation costs, and generate additional loading and unloading costs. Most lumber is shipped from the sawmill/drier site to the customer in mixed batches of several sizes and grades of lumber. A drier located away from the mill would require the creation of large storage facilities at both the mill and drier sites (McKillop, pers.

comm.). Moving an entire existing sawmill to take advantage of inexpensive geothermal heat would be prohibitively expensive, considering the economic scale of benefits to be gained. Choosing to locate a new sawmill in a geothermal area is a more feasible solution. Unfortunately, the sawmill capacity in California's north coast area is far greater than that needed to process the current timber harvest (McKillop, pers. comm.) and new sawmill construction during the scenario period is very unlikely.

Discovery of economically usable geothermal resources near Cloverdale or Ukiah is possible, but unlikely in the near term. Current geothermal exploration in Mendocino County is centered in two areas. A deep exploratory well is currently (10/79) being drilled in the extreme southeastern corner of the county, near the Geysers field. A series of shallow heat probes have also been drilled by Phillips Petroleum Inc. on Masonite Corporation lands (between Boonville on the south and Orr Hot Springs). Exploration in the Ukiah-Cloverdale area is not expected in the near future.

Perhaps the most important reason that sawmills are unlikely to use geothermal heat is that they already have a readily available heat source in the form of wood wastes. An increasing number of sawmills are using sawdust, bark, and wood scraps in boilers to produce drying steam so that about 35 percent of heat energy used in sawmills comes from wood wastes. Wood powered boilers currently cost less than comparable geothermal systems, and reduce the sawmill's waste-disposal problem. It is therefore unlikely that this potential direct use of geothermal energy will be realized in the Geysers region during the scenario period.

Geothermal Refrigeration and Air-Conditioning

Geothermal-powered refrigeration units can compete with electric units in residential and commercial space conditioning and in freezing or cold storage of food products. The basic function of all cooling systems is to remove heat from a cooler place and release that thermal energy into a warmer place. Input energy is required to power these "heat pumps". The input energy can be supplied by electric power, by burning natural or LP gas, by solar collectors, or by geothermal fluids. Three different types of cooling systems can use geothermal heat as their primary energy source. These are the Absorption cycle, the Rankine cycle system and a newer system that uses a vapor-jet compressor.

In order to illustrate the potentials and problems with each of these systems, it is first necessary to understand how a heat pump works. The working fluid in a cooling system is a refrigerant with a low boiling point, such as Freon or isobutane. The electric heat-pump system can be used as an illustration of the basic functions of a cooling system (Figure 29, top). Beginning on the left side of Figure 29, the low-pressure refrigerant vapor is raised to a higher pressure by a compressor powered by an electric motor. The high-pressure vapor is then condensed to a liquid in a heat exchanger (condenser). The heat removed from the refrigerant is absorbed by water flowing through the condenser and then rejected to the outdoor environment. After leaving the condenser, the pressurized refrigerant liquid passes through an expansion valve to become low-pressure liquid and absorbs heat from the room to be cooled as it vaporizes. Heat energy is removed from the room

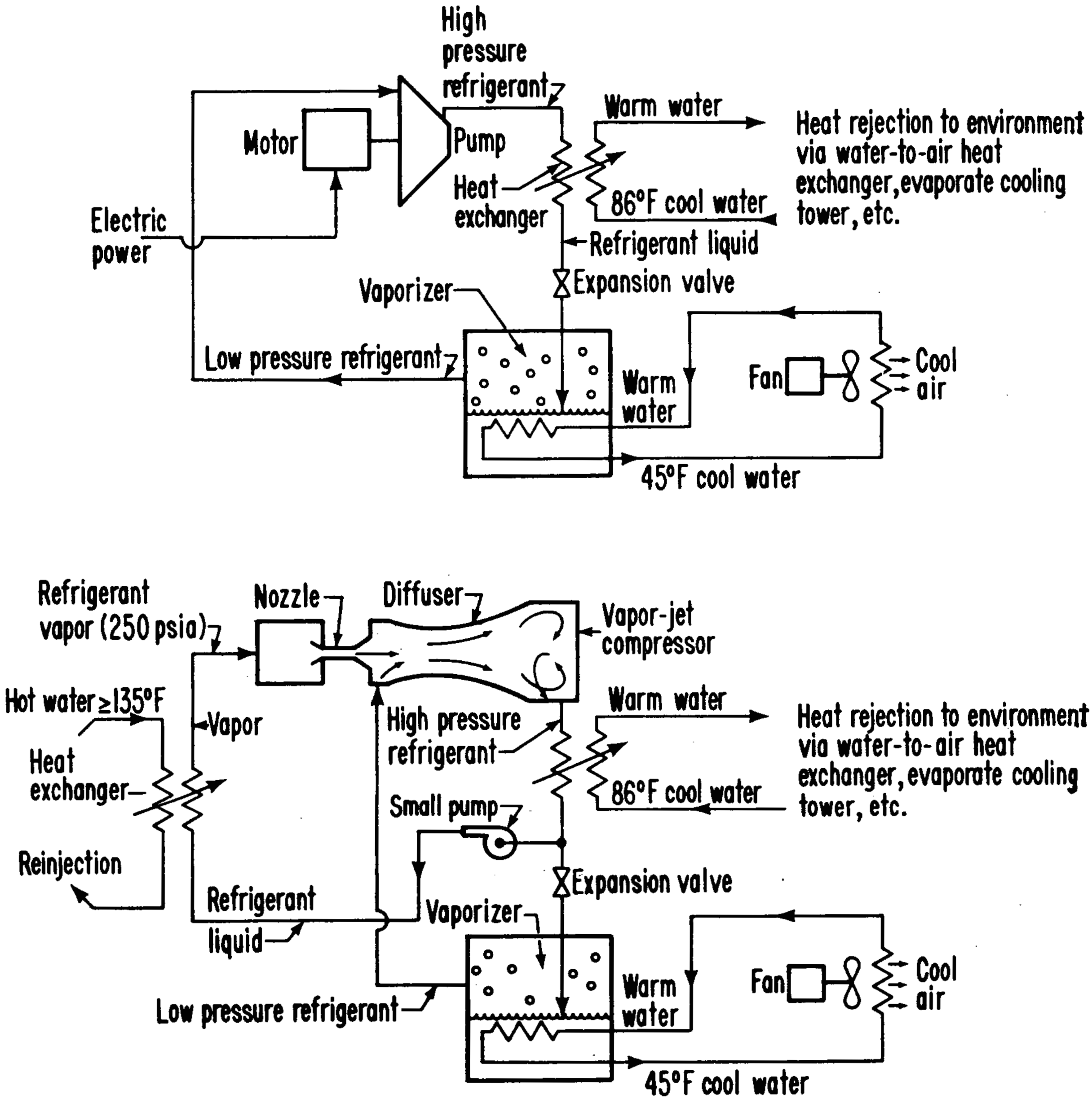

Fig. 29. Schematic of Electric and Geothermally Powered Heat Pumps

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to be cooled (lower right) and rejected into the environment (upper right), using energy supplied from outside (left side).

The advantages of an electric heat-pump cooling system include its relatively simple design, low capital cost, and low maintenance requirements (Table 19). The major disadvantage of an electric heat pump is the large amount of electric power used in operation, and resultant high operating costs.

A new heat-pump system developed by Sierra Solar Systems is conceptually similar to an electric heat pump (Lee, pers. comm.), but the motor and compressor are replaced by a solar or geothermal-powered vapor-jet compressor. This system uses the principle that a jet or spray of fluid will create a partial vacuum which can be used as a pump. The same principle is used in the air ejectors of power plant condensers and in many other applications.

This system replaces the electric motor and compressor of an electric heat pump, but with a lower efficiency. The conversion of potential energy to kinetic and back to potential energy in the vapor-jet compressor is the major loss of efficiency and is currently the main disadvantage of this system. The main advantage of the vapor-jet cooling system is that it can be operated using solar energy or geothermal hot water at or above 135 degrees F (Lee, pers. comm.). Its simple design should provide for low operating and maintenance costs for a small unit. Due to their design concept, these heat pumps cannot be made in large-capacity sizes.

Although the vapor-jet compressor system shows promise for the

Table 19

Characteristics of Three Types of Cooling Systems

	Advantages	Disadvantages
Electric heat pump	Low capital cost Simple design High efficiency Proven technology Low Maintenance	High operating costs Need for electric power
Vapor-jet compressor	Ability to use geo-thermal energy Low operating costs Low capital costs Simple design Low maintenance costs	Low efficiency at present Unproven technology
Absorption cycle	Ability to use geo-thermal energy Low operating costs High efficiency Proven technology	High capital cost Complex design Frequent maintenance

future, there is a third heat pump system suitable for use with geothermal steam or hot water. This is the absorption air-conditioning system. Its technology is well-developed and it can use geothermal heat very efficiently. The absorption heat pump system is technically more complex than the vapor-jet compressor, but the inputs and outputs are the same.

The higher efficiency of an absorption cooling unit is partially counterbalanced by somewhat higher capital costs. With absorption technology, smaller cooling systems have much higher capital costs per ton of cooling capacity than do larger systems. Thus absorption cooling systems are best suited to large applications (See Table 20).

Absorption cooling units have been successfully used with geothermal hot water in several locations. Among these are the vegetable packing sheds for the Honey Lake Farms geothermal greenhouses near Susanville, which were described earlier. A resort hotel in Wairakei, New Zealand, is also heated and cooled using geothermal energy in an absorption cycle system. Its high efficiency makes the absorption cycle an economically viable cooling system for applications which are in use a large percentage of the time. These could include food-processing plants (Breindel et al., 1978), air-conditioning of office buildings, cooling wine cellars, or other such uses.

Geothermal Space Heating

In many geothermal resource areas, the use of geothermal heat for space heating is both the simplest and most beneficial use for the hot-water resource. The process involves pumping geothermal fluid through a

Table 20

Temperature and Size Criteria for Geothermal Refrigeration Systems

Geothermal Resource Temperature Range	Refrigeration System Capacity	Preferred Technology
135^{o} - 180^{o}F. (Hot water)	small systems (under 10 tons)	Vapor-jet
	medium systems (10-25 tons)	Vapor-jet or absorption
	large systems (over 25 tons)	Absorption
180^{o} to 400^{o}F (hot water or steam)	all sizes	Absorption
Over 400^{o}F (steam)	large systems	Rankine cycle

Source: Dao, pers. comm.

heat exchanger which heats the air inside a home or business. In the late nineteenth and early twentieth century, geothermal heat was extensively used in Calistoga, before low natural gas prices caused a gradual decline in its use. Geothermal heating systems are currently being used in Boise, Idaho; Klamath Falls, Oregon; and in many other areas around the world.

Today, only two homes are heated by geothermal hot water in the Geysers region. The owners of the "Old Faithful Geyser" in Calistoga heat their home with geothermal energy (Cream, pers. comm.). Another home located about six miles southeast of Kelseyville uses geo-heat. At this home, a well being drilled for irrigation purposes struck hot water at a depth of 500 feet. The ten-inch diameter well produces about 60 gallons of water per minute at 130 degrees to 160 degrees F. The water is used for space heating and hot water for showers, but the boron content is too high for continuous irrigation (Tompkins, pers. comm.).

The key criteria for developing space heating applications of geothermal resources are the depth of the resource and its proximity to the point of use. Well cost depends upon the type of rock being drilled, but always increases rapidly with depth. Long surface transport both reduces the heat content of the fluid at the point of use and increases the capital cost of the system. To be economically feasible, a geothermal heating system must show a positive payback to the user. This means that the capital cost of the energy system and associated interest charges must be exceeded by the savings achieved in heating fuel costs. The mild climate of the Geysers region already results in heating costs below the national average. Therefore, a geothermal heating system will probably be economically attractive only when capital costs are held to an absolute minimum (i.e. shallow wells and minimum surface transport).

In the Geysers region, geothermal space heating in the near future is most promising in Calistoga because the shallow depth geothermal reservoir and the presence of several available wells make the system economically attractive. Any new geothermal drilling would require a public hearing process before the granting of a conditional use permit by the Planning Commission. For new uses of existing wells, permission would have to be obtained from the Napa County Environmental Health Officer (Noble, pers. comm.). Other areas with geothermal heat at shallow depth, such as near hot springs, are also potential locations for geothermal space heating. Existing hot-spring resorts use geothermal heat as their main tourist attraction. Very few, however, make direct use of geothermal energy for space heating (Lund, 1976). This use represents a cheap and simple application which could be more fully utilized.

In those areas in the Geysers region without shallow geothermal reservoirs, drilling wells specifically for space heating applications is marginally attractive at best. Fortunately, it is likely that a considerable number of wells will be drilled which prove to be uneconomical for electrical use (Thomas, pers. comm.). Space heating applications using these wells will depend upon the chance that a few wells are located close enough to user communities.

One means of efficiently using these deep geothermal wells is the establishment of a district heating system. A district heating system involves supplying thermal energy from a single source to many users in a limited geographic area. The components of the system include one or more production wells, a transportation pipeline, a distribution pipeline system, heat exchangers or other equipment at the point of use, a return pipeline, and one or more reinjection wells. Customers are usually billed depending on the volume of hot water they draw from the system.

A district heating system in the Geysers area could be supplied by the heat output of one or two typical wells. The maximum hot water transportation distance, for both technical and economic reasons, is in the range of two to four miles. The longer distances may only be possible with a large community, in which several heavy users of thermal energy exist (e.g. heavy industries).

The distribution of hot water to individual residences would be the major expense of a district heating system in the Geysers region, because of the low density residential pattern near the areas of geothermal development. Due to the cost of the distribution system, geothermal district heating is most economical where thermal energy use per unit of land area is high. This heat use pattern is often found in densely populated residential or commercial areas, or where industries use large amounts of thermal energy. In other areas where geothermal heating systems are in use, such as Boise, Idaho, and Klamath Falls, Oregon, the systems were initiated in the downtown area where the density of heat use is greatest. The systems were later expanded to other parts of the community when the economics of the expansion was demonstrated. Establishment and expansion of a district heating system is easiest when individual buildings have been previously designed for ease of conversion to geothermal heating.

Development Path for Direct Use Applications

The economic considerations which guide electrical development will also be evident in the development of direct uses of geothermal energy in the Geysers region. The first direct-use applications will be operations in which geothermal heat can result in significant fuel cost savings (maximum return) with a minimum of risk (see Table 21) and small capital investment. This first group of applications (Group 1 on Table 21) will most likely be energy-intensive operations with proven geothermal technology including: crop drying, greenhouse crop production, and heating one or more commercial buildings. In favorable locations, shallow wells can be used to supply heat to homes and hot springs resorts.

The risks inherent in starting a small business are considerable, even under the best of conditions. Being among the first to use an alternative energy source involves some additional risk which many entrepreneurs cannot bear. Accordingly, the best prospects for initial direct use applications, even in the Group 1 end-use operations listed above, will probably be to retrofit an existing business in the Geysers region or to relocate an established business within the region into a location where known geothermal resources can be used.

After the feasibility and benefits of these low risk retrofit direct-uses have been demonstrated in the Geysers region, other uses will appear. This second phase will emphasize new projects designed for use with geothermal energy but still primarily within the Group 1 list on Table 21. This phase should include greenhouse operations, some crop

Table 21

Assessment of the Relative Feasibility of Several Possible Direct Uses of Geothermal Energy in the Geysers Region

<u>Group 1:</u> Includes those direct applications which are already economically feasible, using existing shallow wells or non-commercial wells drilled for electrical production.

Greenhouse vegetables or tree seedling production and packaging.

Space heating in Calistoga - Individual homes or district system.

Crop drying in Lake County - Fruits and Walnuts.

Small-scale industrial processing - if transportation is not too great a problem.

Heating large commercial buildings.

Hot springs resorts - balneology and space heating

Absorption cycle cooling for high-use installations.

<u>Group 2:</u> Includes those direct applications which: a) are not as economically promising as those in Group 1; or b) need more research and development work; or c) depend on the availability of geothermal resources.

Space heating in new housing developments-need to develop confidence in geothermal heating in the Geysers area and plan ahead to reduce distribution costs.

Livestock production facilities.

Vapor-jet compressor cooling system-need to improve efficiency.

Multi-use applications.

Dependent on Resource Availability:
Mendocino County, all applications, especially greenhouse crop production, fish processing, crop drying, pulp and paper industry.

<u>Group 3:</u> Includes those direct applications for which substantial barriers to development exist in the Geysers region.

Heavy industrial processes - barriers include transportation, land use, quality and temperature of steam, etc.

Lumber drying - biomass is a simpler source of energy, transportation problems, excess sawmill capacity.

drying, and both individual and multiple structure space conditioning uses. The implementation of the more complex direct uses requires coordination among the resource users in order to be successful. Even for direct use operations which are economically viable as separate projects, careful planning at the local level will help to promote an orderly pattern of development which is responsive to community needs.

While the simple direct uses described as Group 1 on Table 21 may be expected to evolve in most of the Geysers region counties in the mid-to-late 1980's, the more complex direct use operations are not expected before the 1990's.

It is generally assumed that direct use applications will be supplied with local shallow wells since the fuel savings from direct uses can rarely cover the cost of even a single deep well. However, as exploration and electrical development expand into more populated areas, a number of deep exploration wells drilled for electrical production but which are not satisfactory for this end use will be available for other uses. Capital costs for these unsuccessful wells are generally accounted into the electrical production fuel costs and thus need not be borne by some other end user. In general, producers consider a little revenue from direct use to be preferable to no revenue at all. The geothermal development companies seem to be willing, even anxious, to pursue direct use applications either as a cooperative venture or for direct sales to an end user (Stolesen, Thomas, pers. comm.). Availability of these deep wells may accelerate the development of energy-intensive uses and of more complex uses (e.g. district heating or a large greenhouse complex).

Additionally, direct uses could be cascaded off the waste stream from an electrical power plant before reinjection. This type of cascade system has a significant advantage over similar operations with conventional plants since the geothermal power plant or the direct user could shut down without affecting the operation of the other. However, utilities are traditionally unenthusiastic about cogeneration operations, and PG&E has not expressed interest in such an arrangement at The Geysers. Individual shallow wells and arrangements with field producers appear much more feasible within the scenario period. Cascade systems are not included in the scenarios for this project.

The rate of direct use development in the Geysers region can be estimated by comparing other geothermal resource areas in which direct use development has already begun. However, two factors, unique to the Geysers region, will tend to slow development in this area relative to other locales (e.g. Klamath Falls, Susanville). First, the geothermal reservoir in most of the Geysers region is located beneath several thousand feet of hard volcanic rock, whereas in the other areas the resource is typically found beneath a few hundred feet of softer rock. This will increase capital costs in the Geysers area. Second, the transportation cost between a business located at the Geysers geothermal resource and larger outside markets is prohibitive for many products. Some businesses which might otherwise be attracted into the area to use geothermal heat may see their expected profits eroded by the increased cost of transporting raw materials in and products out. Thus, development of businesses able to use locally-available raw materials and to sell to local markets will be the most likely targets for the Geysers area and will retard the overall rate of growth of direct use geothermal energy below that experienced in many other areas.

Local Employment and Demographic Effects of Direct Use

Estimating employment levels as a result of direct use of geothermal energy development uses a different methodology than employment estimates for electrical development. This difference is necessitated by the dissimilarities in the characteristics of the two types of development. Geothermal electrical development requires high-technology equipment and engineering, large capital resources, and substantial labor. These factors limit development participation to a few large corporations. In contrast, the multitude of direct use applications (see Table 16) rely primarily on simple technology with considerably lower total capital cost. Therefore, a potential exists for a wide spectrum of local homeowners and entrepreneurs to become involved in direct use development. The much larger number of potential participants makes employment estimates for direct use development difficult and tentative at best.

With local support and state and federal assistance, geothermal direct use could eventually provide an important part of the energy needs of the Geysers region. In contrast, the employment levels resulting from direct-heat utilization are not likely to be high even in comparison to the employment levels of electrical production from geothermal energy. A large investment is usually necessary for purchase of equipment, but little labor is necessary for set up and very little during normal operation. The majority of the heat exchangers, pipes and other equipment will probably be imported into the Geysers region, so few (if any) new jobs will develop in the manufacturing sector.

Retrofitting of an existing home or business to use geothermal energy is the forecasted course of initial direct-use development (through the late 1980's) which will further minimize any effect on employment patterns. Further, most likely kinds of geothermal direct heat systems require little or no additional labor for operation and maintenance (Table 22). Installation of these systems is expected to provide jobs for 2 to 20 persons for a short installation period, about 1-2 months. In the early stages of direct use development, this small amount of labor will probably be provided by existing services such as local plumbers and electricians. Later, small direct use development companies may be formed to install and maintain geothermal systems. These would probably be similar to today's small solar-development companies, with an average of about 2-15 employees. By the end of our study period (in the year 2000), employment in the installation and maintenance of direct-use systems is unlikely to exceed the equivalent of twenty full-time jobs in either Mendocino or Lake Counties. The Calistoga area of Napa County may provide 5-10 full-time jobs, with more positions available during the installation phase of a district heating system. No direct use is expected to occur in the Sonoma County portion of the Geysers field.

Another employment effect of direct use which is more difficult to quantify is the number of non-energy related jobs which may be generated by new businesses based on geothermal energy, or by businesses moving into the Geysers region to utilize this resource. Because of the capital costs of geothermal direct-use systems and the remote location of

Table 22

Potential Employment Levels and Locations for Selected Direct Uses of Geothermal Energy in the Geysers Region

Direct Use Application	Primary Geothermal Employment per Operation		Secondary Employment per Operation due to Geothermal Use		Estimated Maximum no. of sites by year 2000	Most Likely Counties
	Startup	Continuous	Low	High		
Greenhouse Crop Production	2-25	1	6	150	4	LMN
Crop Drying	2	0-1	0	1	4	LM
Lumber Drying	2	0-1	0	1	1	LM
Canning Fruit	2-25	0-1	0	20	2	LM
Fish Processing	2-25	n.a.	10	20	1	M
Space Heating						
Individual Homes	2	0	0	0	200	LMN
Commercial Users	2-6	0	3	10	20	LMN
District Systems	2-25	5	0	0	3	LMN
Space Cooling						
Homes	2	0	0	0	200	LMN
Wineries, offices, etc.	2-25	0-1	0	0	10	LMN
Hot Springs Resorts	2	0-1	3	9	10	LMN

most of the geothermal resource, companies most likely to use geothermal energy are those with high thermal energy requirements and relatively low transportation needs. Some of the most likely users already exist in the Geysers region (Table 22), and the retrofit of a geothermal system for these activities would generate few new permanent jobs, as discussed above. New businesses likely to move into the Geysers region to use geothermal heat may include some types of light manufacturing and food processing. These are typically employers of only small numbers of people. Their effect on the number of jobs available is not likely to be large unless several such businesses are induced to relocate to the Geysers region.

In summary, the overall employment effects of direct use development will be small. Except for one major potential employer (greenhouse crop production), probable direct use applications are capital intensive but not labor intensive. Considering the small numbers of employees in most of the applications in Table 22 and the possibility that not all of these applications may be economically feasible, total employment in direct use applications in any one county in the Geysers region is unlikely to be significant.

Direct and indirect employment resulting from direct use of geothermal energy will probably not exceed 20-30 full-time jobs in each of Lake and Mendocino Counties, and fewer in Napa and Sonoma Counties. Even those low levels will probably not be reached until the mid to late 1990's.

V. DEMOGRAPHIC IMPLICATIONS

Assessing Current Population Trends

Two basic problems confronting this task were the lack of a statistically reliable population data base at and below the county level more recent than the 1970 census and the lack of reliable population forecasts. Since 1970, all four counties in the Geysers region have experienced accelerated population growth. Various techniques used to estimate short term population change have tended to produce widely divergent estimates of county level population in the four counties in the late 1970's. Throughout this period the most rigorous analysis, that by DOF, has consistently shown greater estimated errors in forecasting one and two year population changes in this region than in other parts of the state.

Most of the available forecasts are based on information developed by state agencies, primarily the California State Department of Finance (DOF) Population Research Unit and the California State Employment Development Department (EDD) Employment Data and Research Division. DOF population predictions are based upon projections of existing phenomena. That is, DOF's baseline population projection series assumes that the components of population change (e.g. fertility, mortality and net migration) will not drastically shift from the patterns established in the recent past. Thus DOF assumes that no major change (war, natural disaster or rapidly expanded geothermal activity) will occur that would alter the quantitative components of population (DOF, 1977). In a four county area where recent growth has exceeded both local projection and state growth rate, the validity of such an assumption may be challenged.

Thus, until the next census is taken in 1980, any explanation of socioeconomic trends, especially in Lake County, is somewhat speculative.

County Population Data

Tables 23 through 26 show the various sources of information reviewed and the discrepancy between DOF population estimates and the data source most in disagreement with DOF's figures.

The available data collected from county level sources were found to be generally inadequate for our purposes because such data either: 1) referenced DOF as the original data source, e.g., Lake County Chamber of Commerce, or 2) the premises, assumptions and variables used were not clearly and unbiasedly developed or are not widely recognized as reliable surrogates for population; e.g. Lake County Sheriff Department and Mendocino's Planning Department's population estimates. Therefore, data developed at the county level were not used as part of the data base for estimating population change in this study. Instead, the forecasts used here are derived from the Department of Finance, Population Research Unit's projections and future trends. Projected population for each county for a given year is reviewed by DOF when historical data for that year are available. From this review a revised population estimate, an error of projection estimate, and some concept for the source of the error may be obtained. Base year (1979) population estimates were obtained by applying the 1977-1978 correction factor to 1979 projected population. 1980-1985 projections were corrected by a linearly declining portion of this 1979 correction factor in order to prevent discontinuities. DOF projected annual population change estimates

Table 23

NAPA COUNTY

County Population Estimates and Projections By Data Source
1970 - 2000
(Population in Thousands)

Data Source	Census 1970	1975	1977	1978	1980	1990	2000
1. California State Dept. of Finance (DOF) Sept. 1977	79.14	90.6	93.1	94.0	100.3	125.7	151.0
2. Pacific Gas& Electric "Outlook'79"				96.4	99.1		
3. Bureau of Land Management, Social Profile, Ukiah District		88.2			101.6	126.6	
4. Association of Bay Area Governments (ABAG) "Projections '79"		90.0			98.6	109.6	118.1
5. California State Employment Development Dept., 1979				94.0	98.6		
% Discrepancy from DOF:		3%		3%	2%	13%	22%

Table 24

MENDOCINO COUNTY

County Population Estimates and Projections By Data Source
1970 - 2000
(Population in Thousands)

Data Source	1970	1975	1977	1978	1980	1990	2000
1. California State Dept. of Finance (DOF) Sept. 1977	51.10	57.4	61.4	63.9	65.0	80.8	96.3
2. Pacific Gas & Electric "Outlook'79"				62.7	64.3		
3. Bureau of Land Management, Social Profile, Ukiah District	55.8				65.1	79.5	
4. Mendocino Co. Chamber of Comm., 1975	56.6						
5. PG&E Mendocino Co. District Ofc., Customer-Growth Table				63.5			
6. California State Employment Development Dept., 1979				63.5	66.9		
7. Mendocino Co. Housing Permit Survey, 1979				73.9			
8. Mendocino Postal Survey, 1979				58.9			
% Discrepancy from DOF:	10%			15.6%	3%	2%	

Table 25

LAKE COUNTY
County Population Estimates and Projections By Data Source
1970 - 2000
(Population in Thousands)

Data Source	Census 1970	1975	1977	1978	1980	1990	2000
1. California State Dept. of Finance (DOF) Sept. 1977	19.55	25.4	29.4	31.7	32.5	42.2	49.7
2. Pacific Gas & Electric "Outlook'79"				30.5	31.8		
3. Bureau of Land Management, Social Profile of Ukiah District, 1975		24.1			28.2	34.1	
4. Lake County Chamber of Commerce		25.5	28.5	29.5	33.0	42.8	50.4
5. Lake County Sheriff Dept.			30.4	42.8	52.6		
6. California State Employment Development Dept., 1979				31.7	34.3		
% Discrepancy from DOF:		5%	7%	35%	62%	24%	1%

Table 26

SONOMA COUNTY
County Population Estimates and Projections By Data Source
1970 - 2000
(Population in Thousands)

Data Source	1970	1975	1977	1978	1980	1990	2000
1. California State Department of Finance (DOF, Sept. 1977)	204.89	247.1	262.5	271.6	279.2	354.8	427.7
2. Pacific Gas & Electric "Outlook '79"				278.0	283.3		
3. Bureau of Land Management, Social Profile, Ukiah District		244.5			300.5	395.4	
4. California State Employment Development Department, 1979				271.9	284.9		
5. Association of Bay Area Governments (ABAG) "Projections '79"		245.4		350.8			435.6
% Discrepancy from DOF:		1%		26%	11%	11%	2%

beyond 1985 were used without correction.

The Department of Finance's population estimates are widely used by planners in various business, government and non-profit agencies throughout the state and are consistent with accepted methodologies and quality control checks. DOF estimates population change based upon death records, birth certificates, Federal income tax returns, school enrollment statistics, Medicare statistics, military and other institutional population statistics, driver license address change file, voter registration records and data supplied by both local and national agencies. In comparing DOF estimates with 33 county censuses performed since 1970, the Department has maintained accuracy levels of plus/minus 2 percent in two-thirds of the counties and in only two counties were errors in excess of five percent (DOF, 1978). The use of corrected estimates for Geysers area counties for this study means that potential errors in the upper end of this error range should be avoided in our forecasts.

Recent In-migration Trends

California's recent net in-migration has varied from a high of 320,000 new residents in 1963 to a low of 10,000 in 1972. Since 1972, DOF has projected net in-migration at an average of around 150,000 per year. The latest in-migration estimate (233,000 for FY 78), if accurate, represents the highest level since 1964. The revised estimated components of change in the State's population is shown on Table 27 (DOF, 1978).

DOF analyses have found that the recent growth rate for non-

Table 27

Estimated Components of Change in California's
Civilian Population, 1971-1978
(in Thousands)

	1971	1972	1973	1974	1975	1976	1977	1978
Civilian Population	19,943	20,122	20,254	20,610	20,909	21,239	21,612	22,023
Net Change from Pre-ceeding Year	299	179	232	256	299	330	373	411
Natural Increase	184	144	130	131	145	153	174	178
(Births)	(352)	(313)	(303)	(301)	(316)	(323)	(342)	(351)
(Deaths)	(168)	(169)	(173)	(170)	(171)	(170)	(168)	(173)
Net Migration	81	10	100	122	151	174	199	233

metropolitan areas is double that for metropolitan areas. This is reflected, for example, in Lake County's population growth of 62.2 percent between 1970 and 1978. Only two other counties in California exceed this rate (EDD, 1979). In fact, Lake County is considered the fastest growing of any of the north coast counties (see Table 28); a large fraction of this growth consists of new residents over age 55.

Change in population and components of change are calculated annually by DOF for each county. Table 28 lists the components of change for the year 1970-71 and 1977-78 for each county in the Geysers region while Table 29 summarizes the net change from 1970 to 1978, and Table 30 shows long term historical (1950-70) trends.

The State of California is expected to continue to exceed the national average for population growth (PG&E, 1979). All four Geysers region counties are also expected to experience high annual growth ranging from a low of 1.5 percent (Sonoma) to a high of 4.3 percent (Lake) between years 1979 and 1980. The State Department of Finance's net in-migration pattern projects total increase of 41,000 in this region.

County Population Characterization

A population characterization summary for each county follows. The characterizations of the four counties consist of population, geographic area, economic, and labor force trends and outlook. Generally, the region has experienced large population gains in all counties except Mendocino since 1950 (See Table 31), and Mendocino has experienced rapid growth since 1970. Per capita income is below state average in all four counties (see Figure 30) and unemployment rates in Lake and Sonoma Coun-

Table 28

Annual Change in Population and Components of Change
Comparing Years 1970-71 VS. 1977-78

Year/ County	Total Pop.	Milit. Station	Civil-an Pop.	Milit. Grp.Qtrs.	State Inst.	College	Basic Civil-an Pop	Births	Deaths	Natl. Incr.	Trans-fer	Migration
1970-71												
Lake	1231	0	1231	0	- 17	0	1248	257	350	- 93	24	1317
Napa	1784	- 6	1790	0	- 48	29	1803	1122	929	193	108	1502
Mendo.	1084	- 33	1117	0	-322	0	1406	958	542	416	76	914
Sonoma	7740	38	7702	- 32	-391	0	8170	3587	2122	1465	280	6425
TOTAL REGION	11839	1	11840	- 39	-778	29	12627	5924	3943	1981	488	10158
1977-78												
Lake	2379	0	2379	0	- 7	0	2386	414	433	- 19	0	2405
Napa	889	0	889	0	- 71	- 20	980	1025	1012	13	0	967
Mendo.	2479	0	2479	0	- 15	0	2494	1044	503	541	0	1953
Sonoma	9176	0	9176	- 196	- 29	0	9401	3885	2400	1485	0	7916
TOTAL REGION	14923	0	14923	- 196	-122	- 20	15261	6368	4348	2020	0	13241

Source: Population Research Unit
Department of Finance, 1977 and 1979

Table 29

Components of Population Change
April 1, 1970 to July 1, 1978

County	4/70	7/78	Increase	%	Births	Deaths	Net Migration
LAKE	19,548	31,700	12,200	62.2	2,300	3,400	13,300
MENDOCINO	51,101	63,900	12,800	25.0	7,700	4,500	9,600
NAPA	79,140	94,000	14,900	18.8	8,500	8,000	14,400
SONOMA	204,885	771,600	66,700	32.6	28,200	19,500	58,000
REGION	354,674	461,200	106,660	30.0	46,700	35,400	95,300
STATE	19,971,069	22,297,000	2,326,300	11.6	2,690,200	1,404,000	1,040,100

Source: DOF, 1977, 1979

Table 30

Population and Per Capita Income Trends
for years 1950, 1960, 1970

County	1950 Total Population	1950 Per Capita Income (K$)	1960 Total Population	1960 Per Capita Income (K$)	1970 Total Population	1970 Per Capita Income (K$)	% Change Per Decade 1950 - 1960 POP.	% Change Per Decade 1950 - 1960 $	% Change Per Decade 1960 - 1970 POP.	% Change Per Decade 1960 - 1970 $
Lake	11,481	1.4	13,786	2.6	19,548	3.4	20	86	42	31
Mendocino	40,854	1.5	51,059	2.0	51,101	3.6	25′		01	80
Napa	46,603	1.3	65,890	2.3	79,140	4.3	41	77	20	87
Sonoma	103,405	1.5	147,375	2.6	204,885	3.9	73	58	39	50
Region Total	202,343	1.4	278,110	2.3	354,674	3.8	37	64	28	65
STATE	10,586,223	1.9	15,717,204	2.7	19,953,134	4.4	48	42	27	63

Source: Income from U. S. Department of Commerce (1979). Population from Bureau of Land Management (1975).

Table 31

Population Trends & Projections
By County

1950 - 2000

YEAR	LAKE COUNTY	% CHG	MENDOCINO COUNTY	% CHG	NAPA COUNTY	% CHG	SONOMA COUNTY	% CHG
1950[1]	11,481	20	40,845	25	46,603	41	103,405	43
1960[1]	13,786	41	51,059	0	65,890	20	147,375	39
1970[1]	19,548	30	51,101	12	79,140	15	204,885	21
1975[2]	25,400	30	57,400	13	90,160	11	247,100	13
1980[2]	32,500	28	65,000	12	100,300	12	279,200	13
1985[2]	38,000	17	72,800	11	112,800	11	316,300	12
1990[2]	42,200	9	80,800	10	125,700	10	354,800	11
1995[2]	46,100	8	88,600	8	138,700	9	392,300	7
2000[2]	49,700		95,300		151,000		427,700	

1. U.S. Census, 1970

2. DOF, 1979

3. Numbers represent the precent increase from the year associated with any row to the next listed year.

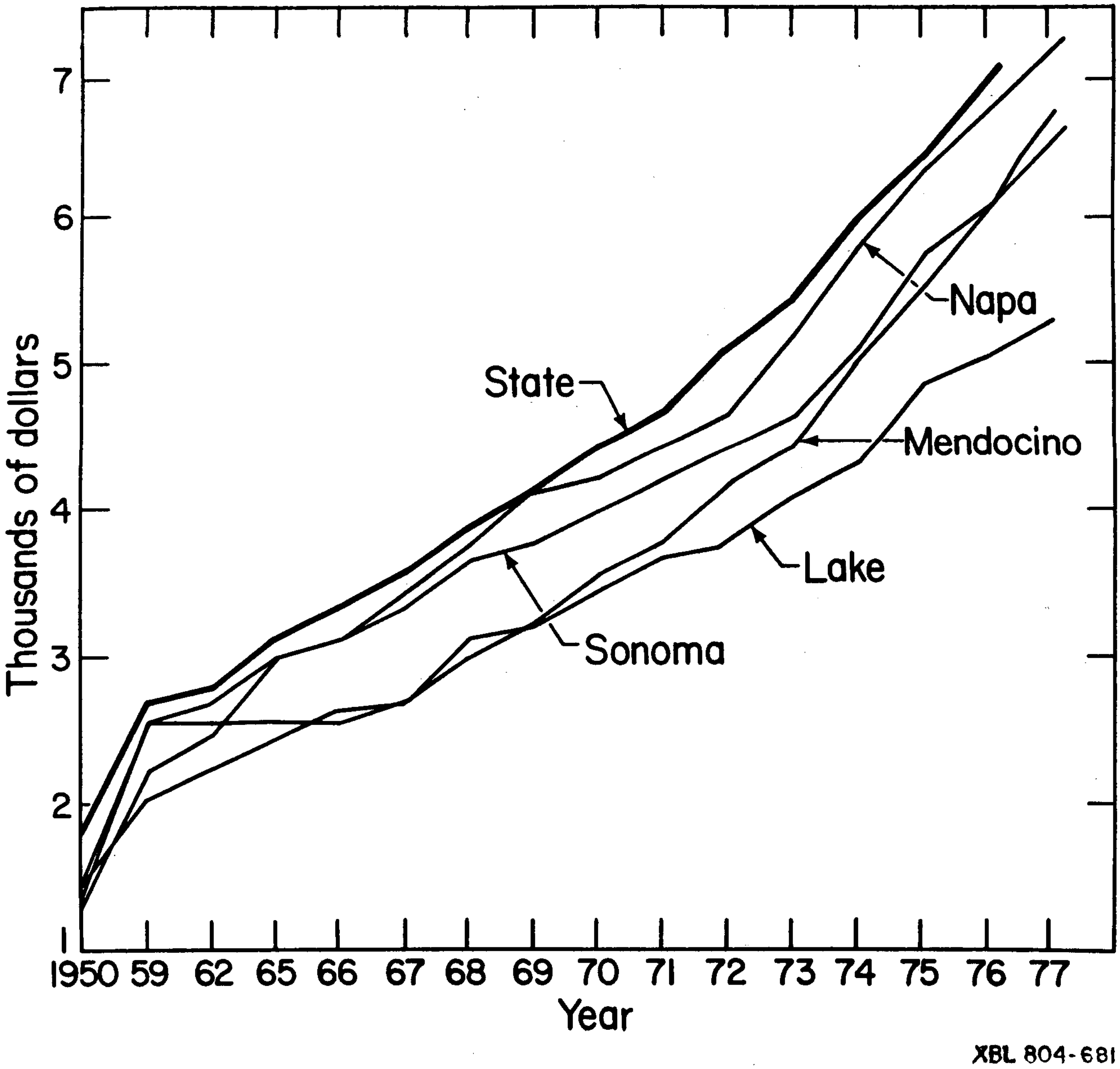


Fig. 30. Per Capita Personal Income; State and Four County Comparison, 1950-1977

Source: Income from U.S. Department of Commerce (1979)
Population from California Department of Finance Population Research (1979)

ties exceed State averages (BLM, 1975).

Following the narrative profile of each county, figures and tables are used to illustrate the population's social characteristics, with emphasis on: labor force by race, sex and age; poverty level projections; and population and labor force statistics on the youth (age 14-21 yrs.).

Lake County

1. Population and Geographic Description:

Lake County is bounded by Mendocino County on the west, Sonoma and Napa Counties to the south and Yolo, Colusa and Glenn Counties on the east. The county has no major highway, but State Highway 20 connects the area to US 101 and Interstate 5. The county is most noted for Clear Lake, with over 43,000 acres of surface water (5 percent of the county's land) and is California's largest natural lake (EDD, 1979). Extensive recreational facilities exist around the lake. Lake County's Chamber of Commerce estimates that 100,000 vacationers use the lake during the summer months.

Lake County's population grew 62.2 percent during the period 1970-1978 and is the fastest growing county in the region. The majority of these new residents were over age 55, adding to the county's already large retirement community (see Figure 31). Lakeport, the county seat and the only incorporated city, experienced a growth of approximately 575 new residents between 1970 and 1973 (EDD, 1979). The county population is predominantly rural (70 percent), and racially composed of 96.8 percent white and 3.2 percent non-white (Lake Co. Chamber of Commerce,

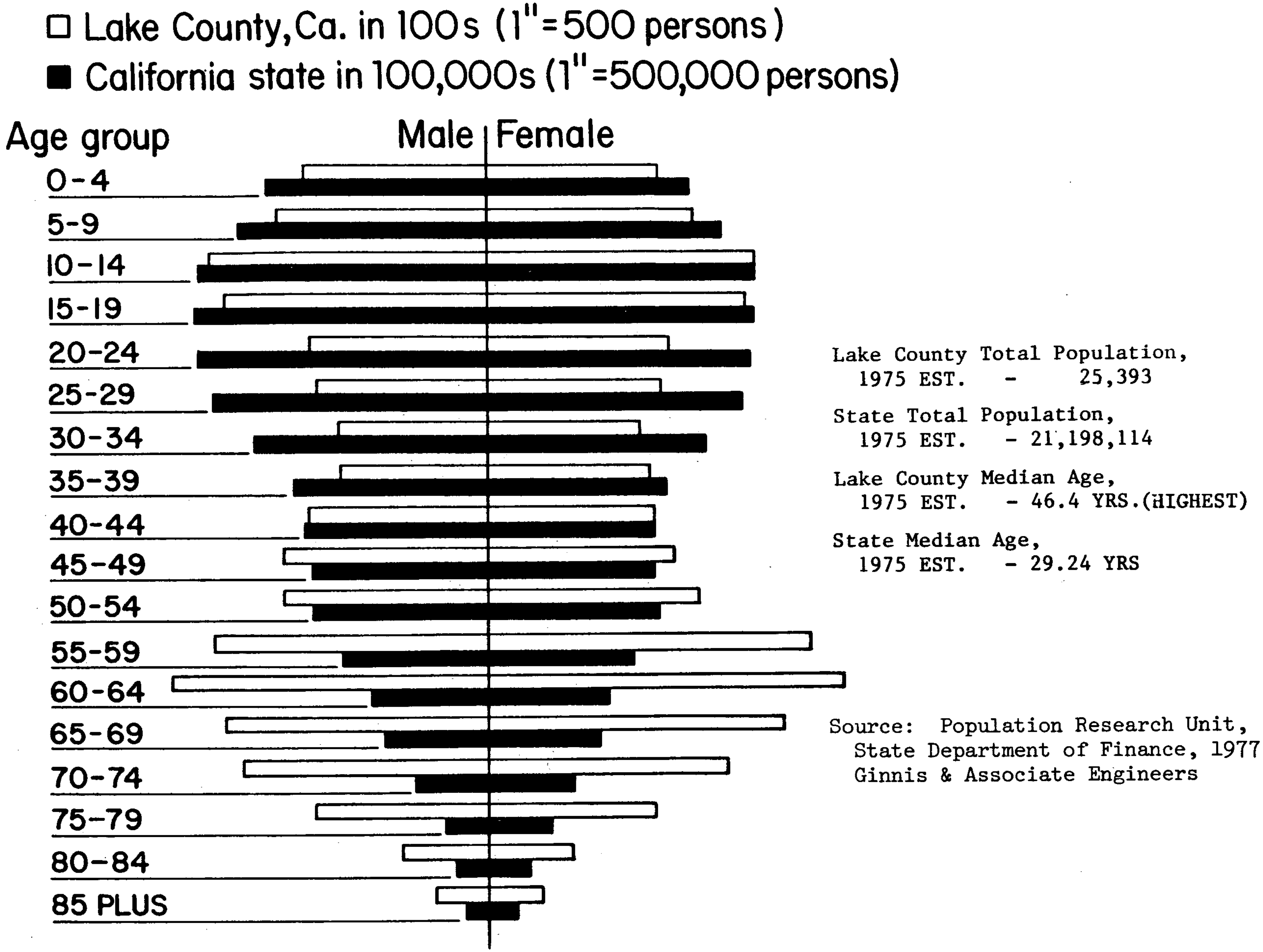


Fig. 31. 1975 Population Age Tree

XBL 804-673

1979).

Past trends indicate that an aging population in a county results in a decrease in total population, in school age population, and in the county's young adult population group. San Francisco County's population is an example of this trend. Lake County, however, has a population distribution that is unique: a rapidly increasing school-age population (most of whom were not born in Lake County), a decline in the parent-age population group (20-39 years old), a steady middle-age population (40-54 years old) and a high older adult population (55-85 years old). (Ginnis & Assoc., 1979, DOF, 1979).

Lake County is the only county in the state where deaths exceed live births. Since 1970, there have been an average of 409.1 deaths per year, compared to an annual average of 280.8 live births per year (see Table 28). Thus the increase in population since 1970 reflects heavy in-migration at an average 1640 persons per year.

2. Economic and Labor Force Trends

The California Employment Development Department (EDD) projects employment to continue its current upward trend in Lake County, while unemployment is forecasted to rise slightly in 1979 and then decline below 1978 levels in 1980 as employment levels rise. However, the annual unemployment rate will continue to outpace state and national rates due to the large number of seasonally unemployed job-seekers from the county's two major industries, tourism and agriculture (EDD, 1979). Table 32 illustrates the county's employment/unemployment trends. 1979 and 1980 figures are projections from EDD.

Table 32

Lake County Labor Force Trends and Projections

	1978	1979	1980
Civilian Force Labor*	12,375	13,000	13,525
Employment	11,250	11,800	12,325
Unemployment	1,125	1,200	1,200
Unemployment Rate	9.1	9.2	8.9

Source: Employment Development Division, 1979

*Employment includes persons involved in labor-management trade disputes.

Wage and salary worker statistics for 1978, 1979 and 1980, by industry in Lake County are shown in Table 33. Figure 30 shows Lake County per capita personal income being lower than that of any other county in the region. Further, Lake is the only county where this income statistic is falling further below, rather than catching up with the state average.

In broad terms, Lake County's labor market has a shortage of highly skilled labor and an abundant supply of semi-skilled and unskilled workers. The current trend toward skilled employment growth will create an increasing demand for workers with specific training, skills or experience and a growing surplus of semiskilled and unskilled job-seekers (EDD, 1979).

Lake County's demography is characterized by a civilian labor force population with a small non-white population group (Table 34), a median income below the state average, a large portion made up of retirees living on fixed incomes (in 1974 government transfer payments comprised 33 percent of total county personal income, as shown on Table 35), high unemployment among youth (Table 36) and, a high percentage of the county population living below poverty level (see Table 37).

Napa County

1. Population and Geographic Description

Napa County is part of the nine-county "Bay Area" and the seven county "Redwood Empire". Located 45 miles west of the Pacific Ocean, the county is surrounded by Lake County on the north, Sonoma County on the west and Solano County on its southeastern borders. Napa county is

Table 33

Annual Averages
Wage and Salary Workers

	Annual Averages[1]		
	1978	1979	1980
Wage and salary workers[2]	7,000	7,350	7,725
Agriculture, agric. svcs, forestry & fisheries	700	725	750
Nonagriculture industries	6,300	6,625	6,975
Construction & mining	500	500	475
Manufacturing	275	300	300
Transportation & public utilities	375	350	375
Wholesale Trade	175	200	200
Retail Trade	1,400	1,550	1,775
Finance, insurance & real estate	325	350	375
Services	1,550	1,625	1,770
Government	1,700	1,750	1,775

1/ Data for 1978 are preliminary; 1979 and 1980 figures are forecast.
2/ Wage and salary employment is reported by place of work and does not include persons involved in labor-management trade disputes.

Table 34

Lake County

Civilian Labor Force By Race, Sex, and Age
1980 (projected)

	Total	White	Black	Other	Spanish American (a)
Both sexes Total (b)	13530	113000	60	460	570
Male Total	8000	7680	50	270	340
16	110	100	(c)	(c)	10
17	150	150	(c)	10	10
18	150	140	(c)	10	10
19	130	130	(c)	10	10
20	120	120	(c)	(c)	10
21	110	110	(c)	(c)	10
22	110	100	(c)	(c)	10
23-24	250	240	(c)	10	20
25-34	1540	1470	10	60	80
35-44	1380	1290	30	50	50
45-49	780	740	10	30	20
50-54	880	860	10	20	50
55-59	940	910	(c)	30	30
60-64	780	760	(c)	20	10
65+	570	560	(c)	10	10
Female Total	5520	5320	(c)	200	230
16	70	70	(c)	(c)	(c)
17	130	120	(c)	10	10
18	130	130	(c)	10	10
19	150	140	(c)	10	10
20	130	130	(c)	10	10
21	120	110	(c)	10	10
22	110	110	(c)	10	10
23-24	220	210	(c)	10	(c)
25-34	1130	1090	(c)	40	10
35-44	990	950	(c)	40	80
45-49	480	460	(c)	20	30
50-54	530	500	(c)	30	30

(a) The Spanish American population is defined as persons of Spanish language or Spanish surname. Spanish Americans are also counted in the racial categories as white, black or other races.
(b) Parts may not add to totals because of independent rounding.
(c) Less than 5.

Due to improvements in the methodology for preparing these labor force estimates, the data are not comparable to estimates published in previous years.

Table 35

Lake County Social Payments Statistics

A. Social Security Recipients End of December 1977[a]

	Number of People
Total	10,239
Sex	
Adult Male	4,528
Adult Female	4,884
Age	
Under 65	3,558
65-71	3,531
72 and over	3,150

B. Public Assistance Recipients September 1978[b]

	Number of People
Aid to Families with Dependent Children	2,071(families)
Food Stamp Recipients	1,755
General Home Relief Recipients	0
Children in Foster Family Homes	29
Children in Institutions	1

a. Source: Social Security Administration
b. Source: EDD, 1979

Table 36

Lake County Youth Statistics

A. Youth, 16-21 Years Old Population and Labor Force Status for 1980 (projected)

	Number of Individuals
Population	2,670
Labor Force	1,500
Unemployment	320
Unemployment Rate	21.4

B. Youth, 14-21 Years Old, Not in School and Not High School Graduates, by Race, Sex, and Age a/ 1980 (projected)

	Total	White	Black and Other	Spanish American c/
TOTAL	290	250	40	10
Male				
Total	180	170	10	10
14-15	b/	b/	b/	b/
16-17	70	70	b/	10
18-19	60	50	10	b/
20-21	50	50	b/	b/
Female				
Total	110	80	30	b/
14-15	b/	b/	b/	b/
16-17	30	20	10	b/
18-19	60	60	b/	b/
20-21	30	10	20	b/

a/ Excludes wives, heads of families, and members of armed forces. Parts may not add to total because of independent rounding.
b/ Less than 5.
c/ Spanish Americans are defined as individuals of Spanish language or Spanish surname. Spanish Americans are also included in the racial categories as white, black, or other races.

Source: EDD, 1979

Table 37

Lake County Persons Below Poverty Level a/
1980 (projected)

	Total	White	Black and Other	Spanish American c/
TOTAL	6,010	5,760	250	590
Male				
Total	2,410	2,300	110	250
14-21	270	260	10	70
22-44	370	330	40	60
45-54	330	320	10	110
55-59	210	210	b/	b/
60-64	340	340	b/	b/
65+	870	830	40	b/
Female				
Total	3,610	3,460	150	340
14-21	390	360	30	70
22-44	640	620	20	260
45-54	360	350	10	b/
55-59	230	230	b/	b/
60-64	590	590	b/	b/
65+	1,400	1,310	90	b/

a/ Excludes individuals living in group quarters. Parts may not add to total because of independent rounding.

b/ Less than 5.

c/ Spanish Americans are defined as individuals of Spanish language or Spanish surname. Spanish Americans are also included in the racial categories as white, black, or other races.

Source: E.D.D. 1979

45 miles north of San Francisco-Oakland, which serve as the county's basic trading area (BLM, 1975). The City of Napa is the county seat and is one of the four incorporated cities within the county's 758 square miles. All four cities are located in the Napa Valley, nationally known for its wine industry. The mountain ranges which surround Napa Valley have an elevation of up to 4,400 feet and are a major recreational resource for the San Francisco Bay Area. Lake Berryesa, located in the county's eastern mountain range, is the most significant recreational attraction in the county (EDD, 1979).

Napa County's population increased an estimated 18.8 percent (14,860 new residents) between 1970 and 1978. This increase brought the county's total population to 94,000 as of July, 1978 (DOF, 1979). Of the four incorporated cities, Calistoga had the largest percent increase (81.7 percent - see Table 38), but the City of Napa had the largest absolute population increase (12,670 or 35.2 percent). The City of Napa, the commercial and residential hub of the county, has sought to control its fast-paced growth. In 1979, the City of Napa adopted a growth management plan. The goal of this plan is to limit the city's growth to 75,000 by the year 2000 by restricting residential construction (EDD, 1979).

Unincorporated areas of the county outside the Napa Valley have not displayed any substantial growth. In fact, these areas have shown a moderate decrease. The trend of migration toward the urban centers has acted to conserve the county's agricultural and scenic land resources outside of the Napa valley (EDD, 1979).

Table 38

Napa County and Incorporated City Populations

	1970[1]	1978[2]	1970-1978 % Change
Napa County	79,140	94,000	18.8
Calistoga	1,882	3,420	81.7
Napa	35,978	48,650	35.2
St. Helena	3,173	4,230	33.3
Yountville	2,332	2,950	26.5

1. U.S. Census, 1970
2. DOF, July 1978

2. Economic and Labor Force Trends

Labor force trends in Napa County are expected to follow the same pattern as in the Vallejo-Fairfield-Napa Standard Metropolitan Statistical Area (SMSA) as a whole. This pattern projects total employment for Napa County to have expanded by 900 between 1977 and 1978 and to increase an additional 2,500 to a total of 32,400 employed persons by 1980 (see Table 39). Between 1977 and 1978, unemployment in the Vallejo-Fairfield-Napa SMSA fell by 1400, resulting in an average unemployment rate of 6.6 percent. The unemployment rate in Napa has historically been lower than that of the total SMSA area and there is no anticipated change in this trend.

Projected employment gains are in service, retail trade and manufacturing industries (see Table 39). Increases in total employment are attributed to increased population, and increased participation of women and youth in the labor force (EDD, 1979).

Per capita income in Napa County continues to rise, although it is slightly (4%) below the state average. Figure 30 shows a comparison of Napa County's per capita personal income from 1950 to 1977 with that of the State's. Napa County's major economic and labor force trends include:

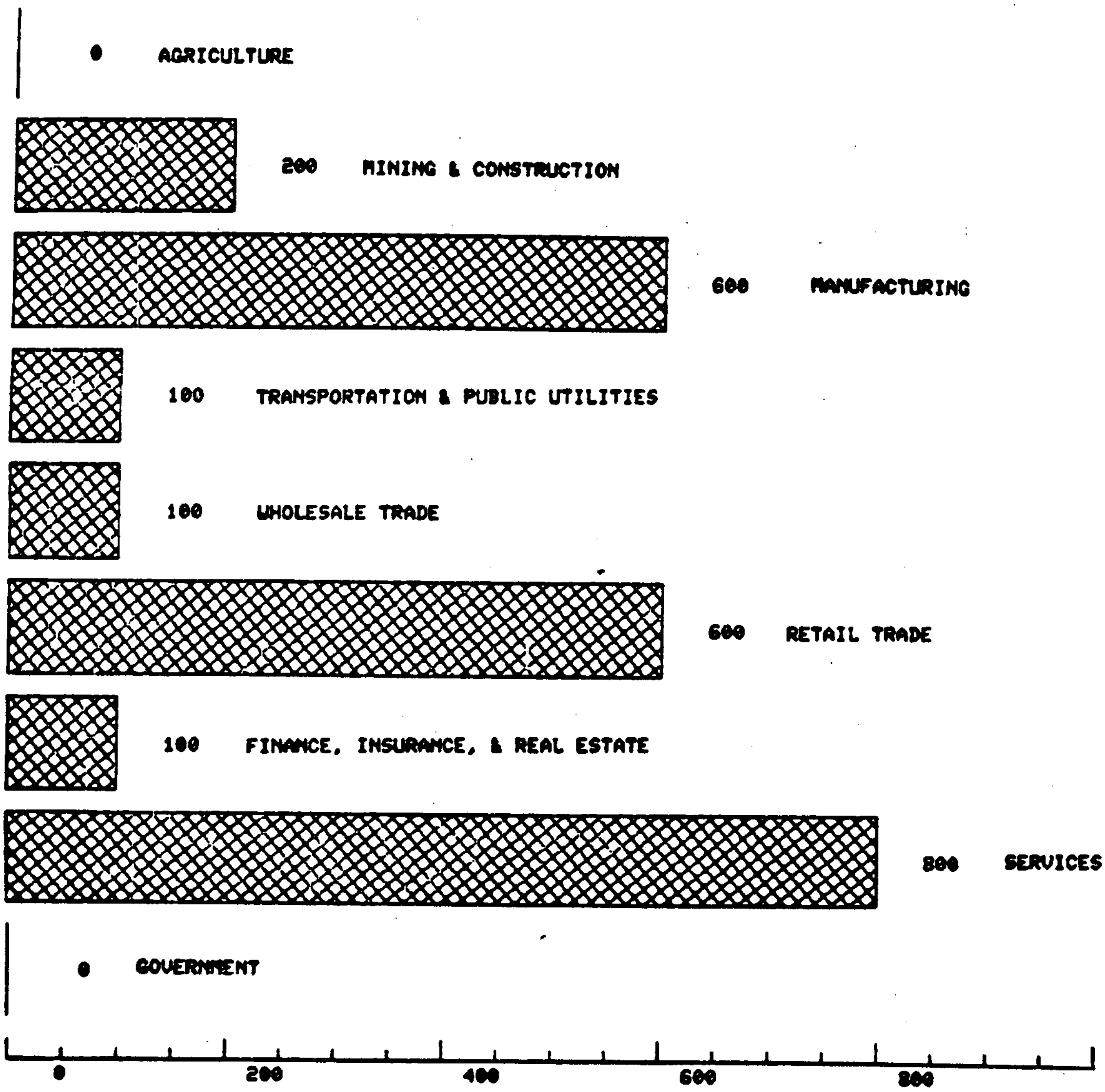
- Non-agriculture wage and salary growth will slow slightly during 1979-1980.
- Payroll expansion is projected in every major industry division.
- Services, retail trade and manufacturing account for 75 percent of all new jobs.
- Per capita income is continuing to rise. This trend is projected to continue.

Table 39

Projected Employment Growth

By Major Industry

Napa County
1978-1980



Source: EDD, 1979

- Youth unemployment is projected at a rate of 12.7 percent by 1980.

Tables 40 through 42 are social data included to provide additional characterization of Napa county.

Mendocino County

1. Population and Geographic Description:

Located about 100 miles north of San Francisco, Mendocino County is bounded by the Pacific Ocean, and on the inland sides by the "Redwood Empire" counties of: Humboldt, Trinity, Tehama, Glenn, Lake and Sonoma. Most of the county's 3,500 square miles are rural and the traditional mainstays of local economy are abundant timber resources and agriculture. The scenic coastline and outdoor recreational facilities have become an increasingly popular tourist resource and are now comparable to timber and agriculture in importance to the local economy. (Mendocino County Chamber of Commerce, 1979).

Ukiah, the the county's largest city and county seat, is located along the U.S. 101 corridor, where most of the county's population is centered. Between 1970 and 1978, the county's total population increased by 12,800, or 25% (see Table 43). For the 15-year period prior to 1970, Mendocino County's population remained fairly constant at an average of 49,900. The 1970 urban/rural distribution was 34.5 percent urban and 65.5 percent rural. Most of the recent growth has occurred in unincorporated communities (DOF, 1979).

The county projects continued population growth because of the: 1) attractiveness of the rural nature of the county, 2) increased retail

Table 40

Napa County

Civilian Labor Force by Race, Sex, and Age
1980 (projected)

	Total	White	Black	Other	Spanish American(a)
Both sexes Total (b)	41200	39960	300	940	3140
Male Total	24960	24200	210	550	1890
16	310	310	(c)	(c)	40
17	480	470	(c)	10	60
18	580	570	(c)	10	80
19	640	630	(c)	10	100
20	570	550	(c)	10	50
21	570	550	(c)	10	50
22	530	520	(c)	10	50
23-24	1150	1120	(c)	20	100
25-34	6410	6170	80	160	520
35-44	5210	5040	60	110	400
45-49	2120	2040	20	60	120
50-54	2030	1970	10	40	120
55-59	2180	2120	20	40	120
60-64	1450	1420	10	30	60
65+	750	730	10	10	30
Female Total	16240	15760	90	390	1250
16	200	200	(c)	(c)	20
17	370	360	(c)	10	40
18	520	510	(c)	10	60
19	650	630	(c)	10	80
20	530	520	(c)	10	40
21	490	480	(c)	10	40
22	470	450	(c)	10	40
23-24	870	830	(c)	20	60
25-34	4220	4090	30	110	310
35-44	3270	3160	20	90	340
45-59	1230	1180	10	50	80
50-54	1200	1150	10	40	60
55-59	1110	1090	10	10	50
60-64	720	710	(c)	10	20
65+					

(a) The Spanish American population is defined as persons of Spanish language or Spanish surname. Spanish Americans are also counted in the racial categories as white, black or other races.
(b) Parts may not add to totals because of independent rounding.
(c) Less than 5.

Due to improvements in the methodology for preparing these labor force estimates, the data are not comparable to estimates published in previous years.

Source: EDD, 1979

Table 41

Napa County Youth Statistics

A. Youth, 16-21 Years Old Population and Labor Force Status 1980 (projected)

	Number of People
Population	11,140
Labor Force	5,910
Unemployment	750
Unemployment Rate	12.7

B. Youth, 14-21 Years Old, Not in School and Not High School Graduates by Race, Sex, and Age a/ 1980 (projected)

	Total	White	Black and Other	Spanish American c/
TOTAL	700	700	b/	120
Male				
Total	400	400	b/	100
14-15	60	60	b/	b/
16-17	130	130	b/	60
18-19	110	110	b/	20
20-21	100	100	b/	20
Female				
Total	290	290	b/	10
14-15	80	80	b/	b/
16-17	90	90	b/	b/
18-19	90	90	b/	10
20-21	40	40	b/	b/

a/ Excludes wives, heads of families, and members of armed forces. Parts may not add to total because of independent rounding.
b/ Less than 5
c/ Spanish Americans are defined as individuals of Spanish language or Spanish surname. Spanish Americans are also included in the racial categories as white, black, or other races.

Table 42

Napa County Persons Below Poverty Level a/
1980 (projected)

	Total	White	Black and Other	Spanish American c/
TOTAL	8,950	8,790	160	1,300
Male				
Total	3,370	3,290	80	520
14-21	800	750	50	200
22-44	720	710	10	180
45-54	220	210	10	10
55-59	110	110	b/	80
60-64	220	220	b/	b/
65+	1,290	1,290	b/	50
Female				
Total	5,580	5,500	80	780
14-21	780	760	20	100
22-44	1,130	1,110	20	380
45-54	500	490	10	130
55-59	370	360	10	20
60-64	460	460	b/	40
65+	2,340	2,320	20	120

a/ Excludes individuals living in group quarters. Parts may not add to total because of independent rounding.
b/ Less than 5.
c/ Spanish Americans are defined as individuals of Spanish language or Spanish surname. Spanish Americans are also included in the racial categories as white, black, or other races.

Source: E.D.D., 1979

Table 43

Mendocino County and Incorporated City Population
1970 - 1978

	1970[a]	1978[b]	% Change
Mendocino County	51,101	63,900	25.0
Fort Bragg	4,455	4,900	10.0
Point Arena	424	510	22.6
Ukiah	10,095	12,000	18.6
Willits	3,091	3,860	24.9

a. U.S. Census, 1970

b. DOF, July 1, 1978, City estimates as of January 1, 1978.

commercial development in the Ukiah area, 3) reduction in commute time to Santa Rosa via Highway 101 improvements, and 4) the comparatively lower land and housing costs in contrast to Sonoma or the Bay Area counties (Mendocino Chamber of Commerce, 1978). The Mendocino County Planning Department has made an unofficial estimate of the county's current population as 73,000. This projection is 9,000 greater than the DOF estimate of 63,900 residents. Current DOF population projections do not reach 70,000 until 1985.

2. Economic and Labor Force Trends

Mendocino county's employment growth rate slowed below the state's 1978 rate after two years of rapid growth. This slower trend is projected to continue through 1980, primarily because of the depressed lumber industry and the lack of any new major industrial development within the county. Unemployment is forecasted to rise during 1979, but to fall below 1978 levels by the end of 1980 (see Table 44). Due to the seasonal pattern of Mendocino's major industries (lumber, agriculture, and tourism), unemployment rates should continue to outpace state and national rates (EDD, 1979). While agricultural jobs are expected to increase slightly in 1979 and 1980 due to larger pear and wine grape harvests, lumber industry jobs are expected to decline during the next 20-30 years (BLM, 1978).

Like Lake County, Mendocino County has a shortage of highly skilled workers and an abundance of semi-skilled and unskilled workers. This trend is projected to continue in the near future. As a result, geothermal employment will involve a higher than average in-migration rate to satisfy the need for skilled positions (EDD, 1979). Per capita income

Table 44

Mendocino County Labor Force Trends
And Annual Averages By Industry[1]

1978, 1979, 1980*

	1978	1979	1980
Civilian Labor Force	28,700	29,175	29,650
Employment	26,075	26,400	26,950
Unemployment	2,625	2,775	2,770
Unemployment Rate	9.2	9.5	9.1
Wage & Salary Workers	22,250	22,425	22,675
Agriculture, Agric. serv., forestry and fisheries	1,275	1,300	1,325
Nonagriculture industries	20,975	21,125	21,350
Construction & mining	850	800	750
Manufacturing	5,400	5,275	5,225
Lumber & Wood Products	3,675	3,600	3,500
Other manufacturing	1,725	1,675	1,725
Transport & public utilities	1,000	1,025	1,050
Wholesale trade	675	700	700
Retail trade	4,125	4,325	4,500
Finance, insurance and real estate	650	675	700
Services	3,925	3,875	3,975
Government	4,350	4,450	4,450

From EDD, 1979

*1978 data preliminary, 1979 and 1980 are forecast is about $800 below state average and is expected to remain below the state average.

The tables of social data that follow (Tables 45-48) indicate:

- 14 percent of the population will be below the poverty level by 1980.
- Social Security and Public Assistance recipients total approximately 20,000 or 31 percent of the population.
- High unemployment among youth (age 16-21) is projected to be 21.8 percent by 1980.

- Highlights of Mendocino's economic and labor force trends are:
- Employment growth rate will remain below that of the State's during 1979-80.
- Employment growth will improve only slightly in 1980; the largest number of new jobs will be created in the retail trade sector and will emphasize tourism related activities.
- Both lumber and construction employment are expected to decline during 1979 and 1980.

Sonoma County

1. Population and Geographic Description

Sonoma County is coterminous with the Santa Rosa SMSA and is one of California's original 27 counties. It is the northernmost of the nine San Francisco Bay Area counties. Bordered by the Pacific Ocean, Marin County and the San Pablo Bay on the west and south and by Mendocino, Lake and Napa counties on the east and north, the county has an area of 1,579 square miles.

DOF estimates that Sonoma County's population has risen by 32.6 percent since the 1970 census to 271,600 in 1978 representing a steady rate of increase three times that for the state as a whole (DOF, 1978).

Table 45

Mendocino County Civilian Labor Force
by Race, Sex, and Age 1980 (projected)

	Total	White	Black	Other	Spanish American a/
Both sexes Total b/	29650	28400	200	1050	1920
Male					
Total	17530	16790	140	590	1160
16	260	250	c/	10	20
17	360	350	c/	10	30
18	380	360	c/	20	40
19	350	340	c/	20	40
20	340	330	c/	10	40
21	340	330	c/	10	40
22	350	340	c/	10	40
23-24	830	800	c/	30	100
25-34	5030	4790	30	210	250
35-44	3660	3530	40	90	270
45-49	1390	1320	20	50	90
50-54	1470	1400	20	50	60
55-59	1370	1310	10	40	70
60-64	840	810	c/	20	40
65+	560	540	c/	20	20
Female					
Total	12120	11610	50	460	760
16	160	150	c/		20
17	300	290	c/	10	30
18	340	330	c/	10	40
19	410	390	c/	10	40
20	370	360	c/	10	30
21	340	330	c/	10	30
22	330	320	c/	10	30
23-24	620	590	c/	20	50
25-34	3540	3360	20	160	160
35-44	2410	2300	10	100	210
45-49	870	830	c/	40	50
50-54	920	880	c/	40	50
55-59	760	740	c/	20	30
60-64	480	470	c/	10	10
65+	280	270	c/		10

a/ The Spanish American population is defined as persons of Spanish language or Spanish surname. Spanish Americans are also counted in the racial categories as white, black or other races.

b/ Parts may not add to totals because of independent rounding.

c/ Less than 5.

Source: EDD, 1979.

Table 46

Persons Below Poverty Level a/ 1980 (projected)

Mendocino County

	Total	White	Black and Other	Spanish American c/
TOTAL	8,960	8,280	680	350
Male				
Total	3,690	3,370	320	230
14-21	630	550	80	50
22-44	950	860	90	130
45-54	350	340	10	b/
55-59	130	120	10	b/
60-64	420	370	50	b/
65+				
Female				
Total	5,270	4,910	360	120
14-21	830	720	110	50
22-44	1,490	1,370	120	70
45-54	520	500	20	b/
55-59	360	360	b/	b/
60-64	410	370	40	b/
65+	1,670	1,600	70	b/

a/ Excludes individuals living in group quarters. Parts may not add to total because of independent rounding.

b/ Less than 5.

c/ Spanish Americans are defined as individuals of Spanish language or Spanish surname. Spanish Americans are also included in the racial categories as white, black, or other races.

Source: E.D.D., 1978

Table 47

Mendocino County Transfer Payments

A. Social Security recipients, End of December 1977[a/]

Total (number of persons)	10,717
Sex	
Adult Male	4,241
Adult Female	5,043
Age	
Under 65	4,032
65-71	3,285
72 and over	3,400

B. Public Assistance receipients, September 1978[b/]

Aid to Families with Dependent Children	4,695 families
Food Stamp Recipients	4,166
General Home Relief Recipients	41
Children in Foster Family Homes	109
Children in Institutions	30

Source: a/ Social Security Administration
b/ Public Welfare in California

Table 48

Mendocino County Youth Statistics

A. Youth, 16-21 Years Old Population and Labor Force Status 1980 (projected)

	Numbers of People
Population	6,740
Labor Force	3,950
Unemployment	860
Unemployment Rate	21.8

B. Youth, 14-21 Years Old, Not in School and Not High School Graduates, by Race, Sex, and Age a/ 1980 (projected)

	Total	White	Black and Other	Spanish American c/
TOTAL	600	530	70	10
Male				
Total	310	280	30	b/
14-15	60	60	b/	b/
16-17	80	80	b/	b/
18-19	110	90	20	b/
20-21	60	50	10	b/
Female				
Total	290	250	40	10
14-15	80	70	10	10
16-17	70	60	10	b/
18-19	80	80	b/	b/
20-21	60	40	20	b/

a/ Excludes wives, heads of families, and members of armed forces.

b/ Less than 5.

c/ Spanish Americans are defined as individuals of Spanish language or Spanish surname. Spanish Americans are also included in the racial categories as white, black, or other races.

Source: E.D.D., 1979

This steady rise in population is partly the result of high levels of in-migration. Between 1970 and 1978, EDD estimates that net in-migration accounted for 87 percent of the 66,700 increase in population. This heavy in-migration is attributed to Sonoma County's rural atmosphere and relatively low housing and real estate property costs, coupled with the development of a commuter population to San Francisco Bay Area (an estimated 3,000 residents commute to San Francisco daily). In addition, numerous manufacturing firms have recently located in Sonoma County because of lower priced industrial property, good transportation access, and an adequate skilled labor supply. As shown in Table 49, population growth has been confined primarily to the incorporated cities of the county (EDD, 1979). DOF estimates that total county population will be 427,669 by the year 2000, about double the 1975 population level.

2. Economic and Labor Force Trends

The EDD forecasts a slower employment growth during 1979-80 than their previous forecasts (1976-78) had indicated. Nevertheless, Sonoma County is expected to experience continued strong economic growth. Total employment between 1978 and 1979 increased by 3.7 percent; the 1980 employment growth rate is expected to reach 4.1 percent. The civilian labor force is expected to expand slightly in 1979, but employment opportunities are not expected to reach the expanded labor force. Therefore, an unemployment rate of 7.7 percent is projected for 1979. EDD does expect a 1980 rise in employment which will absorb some of the increased labor force resulting in an unemployment rate of 7.3 percent in 1980 (see Table 50).

Table 49

Sonoma County and Selected Cities Population
For 1970 - 1978

	1970	1978	% Change
Sonoma County	204,885	271,600	32.6
Santa Rosa	50,006	73,500	47.0
Rohnert Park	6,133	18,000	193.0
Healdsburg	5,438	6,575	20.9
Sonoma	4,112	5,725	39.2
Sebastopol	3,993	4,810	20.5
Cloverdale	3,251	3,750	15.3
Cotati	1,368	2,840	107.7

Source: Employment Development Department, 1979

Table 50

SONOMA COUNTY

Civilian Labor Force, Employment and Unemployment
1978 - 1980

	Annual Averages		Forecast	
	1977	1978	1979	1980
Civilian Labor Force	113,300	119,300	124,000	128,600
Employment	102,300	110,400	114,500	119,200
Unemployment	11,000	8,900	9,500	9,400
Unemployment Rate	9.7	7.5	7.7	7.3

Source: EDD, 1979

Agriculture remains the major economic base in Sonoma County dominated by wine production, the fastest growing segment of the agricultural sector. EDD projects an increase in farm production, thereby favorably affecting farm employment during 1979-80. (See Table 51).

Approximately 3 million tourists are attracted annually to the county's vineyards and recreation facilities. Recreation facilities vary from the coastline to wineries to Redwood forests. Most of the associated tourist traffic is concentrated on summer weekends. It has been estimated that on a typical weekend, 45,000 to 50,000 recreators travel to various parts of the county (BLM, 1975). Retail trade employment is greatly influenced by tourist-related industries, especially resorts, eating and drinking establishments, and service stations. EDD projects a larger absolute gain in county retail trade (1500 new jobs) than any other sector during the 1979-80 forecast period (EDD, 1979).

Highlights of Sonoma County's economy (see Table 51 to 53) include:

- Moderate employment growth is projected for 1979.
- Unemployment averaged 7.5 percent of the labor force for 1978; and projected at 7.7 percent for 1979, and slightly lower at 7.3 percent for 1980.
- Trade and services will lead county job expansion.
- Agriculture is projected to generate considerable farm and related employment through 1980.
- Total poverty level for 1980 is projected at 37,200 persons.
- Social security and public assistance recipients reached a combined total of 61,044 in 1978, approximately 22 percent of the population.

Summary of County Population Trends

Table 51

Employment and Growth Rates By Industry
1976, 1980, 1985--Santa Rosa SMSA (Sonoma County)

Industry 1/	Number of Employed Individuals 2/			% Compound Annual Average Growth Rate	
	1976	1980	1985	76-80	80-85
1	2	3	4	5	6
Total, All Industries 3/	85,600	98,100	111,900	3.5	2.7
Agriculture, Forestry, and Fisheries	5,000	5,600	5,900	2.9	1.0
Mining	400	400	400	0.0	0.0
Construction	5,500	6,400	7,000	3.9	1.8
Manufacturing	10,600	12,300	14,500	3.8	3.3
Durable Goods	7,100	8,400	10,300	4.3	4.2
Lumber and Wood	2,200	2,300	2,300	1.1	0
Machinery, Electrical Equipment & Instruments	3,500	4,600	6,200	7.1	6.2
All Other Durable Goods	3,600	3,800	4,100	1.4	1.5
Nondurable Goods	3,600	3,900	4,200	2.0	1.5
Food and Kindred Products	2,200	2,300	2,400	1.1	0.9
All Other Nondurable Goods	1,400	1,600	1,800	3.4	2.4
Transportation, Communication, and Utilities	4,400	5,000	5,600	3.2	2.3
Transportation	2,000	2,200	2,500	2.4	2.6
Communication and Utilities	2,400	2,800	3,100	4.8	2.1
Trade	20,200	23,400	27,100	3.8	3.0
Wholesale Trade	2,900	3,400	3,900	4.1	2.8
Retail Trade	17,300	20,100	23,200	3.8	2.9
Food and Dairy Stores	2,600	2,900	3,300	2.8	2.6
Eating and Drinking Places	4,600	5,700	6,900	5.5	3.9
All Other Retail Trade	10,100	11,500	13,000	3.3	2.5
Finance, Insurance, and Real Estate	4,500	5,100	5,800	3.2	2.6
Services	30,400	34,900	40,000	3.5	2.8
Medical and Other Health	9,300	10,900	12,800	4.0	3.3
Education	8,400	9,600	10,900	3.4	2.6
All Other Services	12,700	14,300	16,200	3.0	2.5
Public Administration	4,400	4,900	5,600	2.7	2.7

1/ Major industries are aggregated here according to the census classification method. All classes of civilian workers are included (private wage and salary, self-employed, unpaid family, and government). A major production of government workers are assigned to the various industries in which they would appear if they were in private employment, i.e., construction crafts workers employed by government agencies are counted with construction; municipal utility workers are counted with transportation, communications, & utilities; and public school employees are included with education as part of the services industries. Remaining in public administration are such groups as public officials, police officers and fire fighters, and employees of regulatory agencies.
2/ Industry totals have been rounded to the nearest hundred.
3/ Individual line items may not add to totals because of rounding.
Source: EDD, 1979

Table 52

Sonoma County Persons Below Poverty Level a/
1980 (projected)

	Total	White	Black	Other	Spanish American c/
TOTAL	37,200	34,740	1,250	1,210	4,290
Male					
Total	14,400	13,210	650	540	2,060
14-21	3,440	3,110	140	190	600
22-44	4,040	3,470	370	200	900
45-54	980	920	40	20	110
55-59	850	780	30	40	50
60-64	1,020	970	10	40	90
65+	4,090	3,970	60	60	310
Female					
Total	22,790	21,520	600	670	2,230
14-21	4,860	4,480	180	200	820
22-44	5,300	4,740	270	290	870
45-54	1,740	1,620	40	80	150
55-59	1,270	1,220	30	20	90
60-64	1,670	1,650	10	10	50
65+	7,970	7,820	70	80	260

a/ Excludes individuals living in group quarters. Parts may not add to total because of independent rounding.
b/ Less than 5.
c/ Spanish Americans are defined as individuals of Spanish language or Spanish surname. Spanish Americans are also included in the racial categories as white, black, or other races.

Source: E.D.D., 1979

Table 53

Sonoma County Youth Statistics

A. Youth, 16-21 Years Old Population and Labor Force Status 1980 (projected)

	Number of Persons
Population	28,160
Labor Force	16,270
Unemployment	2,850
Unemployment Rate	17.5

B. Youth, 14-21 Years Old, Not In School and Not High School Graduates, by Race, Sex, and Age a/ 1980 (projected)

	Total	White	Black	Other	Spanish American c/
TOTAL	2,030	1,840	60	130	160
Male					
Total	1,030	950	40	40	70
14-15	210	200	b/	10	10
16-17	240	190	40	10	10
18-19	290	270	b/	20	10
20-21	290	290	b/	b/	40
Female					
Total	1,000	900	10	90	90
14-15	150	130	b/	20	b/
16-17	270	260	b/	10	10
18-19	320	280	10	30	30
20-21	260	230	b/	30	40

a/ Excludes wives, heads of families, and members of armed forces. Parts may not add to total because of independent rounding.

b/ Less than 5.

c/ Spanish Americans are defined as individuals of Spanish language or Spanish surname. Spanish Americans are also included in the racial categories as white, black, or other races.

Source: E.D.D., 1979

The Geysers region is predominately rural. While growth is occurring in all four counties, substantial population growth is occurring only in Lake County (5.4%) as of 1978. Compared to a current state growth rate of 1.9 per year, the rate for Napa, Sonoma, and Mendocino counties are respectively 2.1 percent, 2.0 percent and 1.6 percent. The in-migration component of this growth is dominated by county specific trends. Sonoma and Napa counties are developing urban and suburban commuter populations to balance their historic rural and agricultural character. Mendocino is the only county where the bulk of recent growth has occurred in unincorporated areas, while Lake County's growth has been balanced between incorporated and rural areas.

Future in-migration rates for each county are forecasted by DOF as an extension of these current and recent past trends. Table 54 shows the in-migration rates for the four Geysers Region counties through 2000 used for this study. These forecasts represent a base case in-migration forecast and do not include the influence of expanded geothermal activity. The geothermally related in-migration rates derived in Chapter II are added to the base case rates in order to assess the impacts of a geothermal development scenario. As shown on Table 54, over 10,000 in-migrants (not including geothermally induced in-migrants) will arrive in the Geysers region annually during the rest of this century.

Although agriculture is the leading industry in all four counties, the economies of Sonoma and Napa are more diverse than those of Lake and Mendocino counties. Correspondingly, Lake and Mendocino counties have a shortage of available skilled labor and a surplus of unskilled and semi-skilled labor. Per capita disposable income for all four counties

Table 54

Net In-Migration

County	1978-1980	1980-1985	1985-1990	1990-2000
Lake	2000	1500	1250	1000
Mendocino	1000	1000	1000	1000
Napa	2000	2000	2000	2000
Sonoma	5500	6000	6000	6000

Source: DOF, 1978

is below state average but three of the counties (Napa, Sonoma and Mendocino) are approaching the state average. Sonoma, Mendocino and Lake Counties exceed state unemployment averages while Napa County's unemployment rate is lower than the State's rate.

VI. POPULATION IMPACTS OF GEOTHERMAL ENERGY DEVELOPMENT

In-Migration Data

Baseline (1975) county level population, population components and in-migration forecasts were described in the previous section. Net in-migration caused by geothermal activity was described earlier for two scenarios, a high growth and low growth scenario. Two sets of in-migration rates were defined for each scenario. The first included only in-migrants resulting from direct geothermal employment (direct impact). The second included in-migrants caused by direct and induced employment (total impact). Each of the four scenarios for geothermally related in-migration for the years 1979 through 2000 was treated as an incremental in-migration added to the DOF base line in-migration forecast. Thus total in-migration for each year in each county equaled the DOF base line in-migration plus the geothermal in-migration. Where there is forecasted a net out-migration due to geothermal activity, the total in-migration will be lower than the DOF base line. In-migration rates for the four cases are shown on Table 55.

DOF Cohort Survival Model

In-migration numbers shown on Table 55 were used to drive the California State Department of Finance's Compartmented Cohort Survival Population Projection Model for the Geysers region counties. This model requires specific input assumptions on fertility by age compartment, mortality by age compartment, and total state in-migration rates. Mid-range state base values for fertility and mortality were used for all runs. Base case county in-migration rates are based upon state in-

Table 55

Net In-Migration Rates for 1979 - 2000 By Counties

	High Growth Scenario: Direct In-Migration only				High Growth Scenario: Total In-Migration			
Year	Lake	Sonoma	Mendocino	Napa	Lake	Sonoma	Mendocino	Napa
1979	2332	5859	1000	2000	2524	6243	1000	2000
1980	2124	5500	1000	2000	2697	6358	1000	2000
1981	1501	5994	1000	2000	1837	5875	1000	2000
1982	1511	5974	1000	2000	1730	5932	1000	2000
1983	1592	6000	1000	2000	1682	5984	1000	2000
1984	1548	6057	1000	2000	1826	6021	1000	2000
1985	1527	6076	1051	2000	1682	6229	1051	2000
1986	1375	6007	1094	2000	1578	6142	1313	2000
1987	1287	6021	1004	2000	1505	6101	1109	2000
1988	1243	5984	1008	2000	1389	6033	1057	2000
1989	1294	5989	1017	2000	1353	5947	1057	2000
1990	1243	6031	993	2025	1300	5923	1010	2025
1991	987	6016	1002	2052	924	5984	968	2271
1992	1044	5990	1025	1992	991	5987	1082	2187
1993	1006	6018	1006	1971	1024	6039	1082	1942
1994	982	6020	1014	2000	938	6155	1044	1909
1995	1014	5994	1025	2019	1004	6102	1258	1968
1996	1052	5990	1011	2082	1117	5982	1161	2153
1997	989	6013	1001	1992	964	5978	1128	2187
1998	1011	6013	998	1975	977	6031	1064	1943
1999	960	5976	976	2000	867	5924	876	1912
2000	877	5939	939	2000	678	5770	755	1949

Table 55 (cont'd.)

	Low Growth Scenario Direct In-Migration Only				Low Growth Scenario Total In-Migrants			
Year	Lake	Sonoma	Mendocino	Napa	Lake	Sonoma	Mendocino	Napa
1979	2330	5860	1000	2000	2522	6244	1000	2000
1980	2138	5486	1000	2000	2520	6058	1000	2000
1981	1501	5960	1000	2000	1725	5889	1000	2000
1982	1511	6007	1000	2000	1659	5956	1000	2000
1983	1545	6000	1000	2000	1603	5959	1000	2000
1987	1498	6018	1000	2000	1483	5991	1000	2000
1985	1486	5996	1000	2000	1472	6028	1000	2000
1986	1265	5984	1000	2000	1212	5918	1000	2000
1987	1238	5975	1000	2000	1193	5941	1000	2000
1988	1269	5960	1000	2000	1293	5904	1000	2000
1989	1251	5987	1000	2000	1299	5922	1000	2000
1990	1221	6009	1000	2000	1198	6039	1000	2000
1991	958	6019	1000	2000	906	6083	1000	2000
1992	1038	5989	1000	2000	1010	6049	1000	2000
1993	1001	5958	1000	2000	972	5942	1000	2000
1994	996	5988	1019	2000	1080	5959	1019	2000
1995	986	6000	1052	2000	972	5956	1198	2000
1996	1018	6000	979	2000	999	6000	1109	2000
1997	990	5992	975	2000	998	5992	924	2000
1998	962	6000	985	2000	931	6000	956	2000
1999	955	6000	1000	2000	989	6000	966	2000
2000	946	6000	1000	2000	865	6000	984	2000

migration rates, 1960-1978 in-migration trends, and known or forecasted local growth trends.

The model uses one year time intervals and separates military, college students and others present because of administrative decision from the "basic civilian population." These two population components are treated separately using separate sets of basic input data.

Numerically, the model projects county population by applying four methods followed by minor adjustments for statewide total figures. A brief description of each of the four methods follows:

1. The Ratio Correlation Method uses a regression equation to estimate the civilian population for a given date without stating the migration separately. It is based upon the observed relationship to of changes in four different symptomatic data series to changes in distribution within the State for the 1960-70 decade. The series used are (a) births and deaths combined, (b) elementary school enrollment, (c) auto registration and (d) voter registration. The predictive equation for California for the 1970s is given by:

   $$Y = 0136+(2.534)(A)+(.1158)(B)+(.4573)(C)+(.1553)(D)$$

   where A, B, C, and D refer to the variables described above.

2. Component Method II, first developed by the Bureau of the Census, employs vital statistics to measure natural increase and school enrollment to measure net migration. The estimates made by this method are specific to the civilian population under 65. To this population is added an estimate of the population 65 and over based on Medicare statistics and an estimate of the military population.

3. The Administrative Records Method, a recently developed component method, uses administrative records (in this instance individual Federal income tax returns) to measure civilian intercounty migration and reported vital statistics to estimate natural increase. The tax returns are matched for the successive periods to determine the number of persons whose county of residence changed during the estimating period. A net migration rate based on the number of taxpayers changing residence is derived; this rate is then of taxpayers assumed to apply to the total population.

4. Driver's License Address Change Composite Migration Estimating Method is a component method in which migration of the population under 18 years old is estimated using a variation of Component

Method II, and migration of the population 18 to 64 years old is estimated using address changes on the California driver's license file. The number of migrants is estimated from the address changes by using the 1970 relationship of population to driver licenses for the ages 18 to 64 years. The resulting estimates of migration are added to the survived cohort of the civilian population under 65 years old. Also added to this number are estimates of in-migration from abroad, military barracks population and an estimate of the population 65 and over based on Medicare statistics.

The figures presented were calculated from a simple average of the four methods adjusted for changes in the institutional population and controlled to a State total. The state totals are consistent with those published by the U. S. Bureau of the Census in Series P-25 (DOF, 1979).

Model Results

Model results are presented in Figures 32 through 40. Figures 32, 34, 36 and 38 depict total county population increases from the 1978 population level. The increase is shown for the base case (no geothermal expansion) and for two other developmental scenarios. For Lake County (Fig. 32) and Sonoma County (Fig. 38) the "other" scenarios are the high geothermal growth total impact scenario and the low geothermal growth total impact scenario. For Napa County (Fig. 36) and Mendocino County (Fig. 34) the two "other" scenarios are the high geothermal growth total impact scenario and the high geothermal growth direct impact scenario. The low growth total impact scenario was omitted from Figures 34 and 36 because this scenario either included no activity within the county or because the included activity was too small to produce a measurable impact. Figures 33, 35, 37 and 39 present the incremental population increase due to geothermal activity for all four geothermal in-migration scenarios (total increase minus base case increase). Low growth scenarios are again omitted for Mendocino County

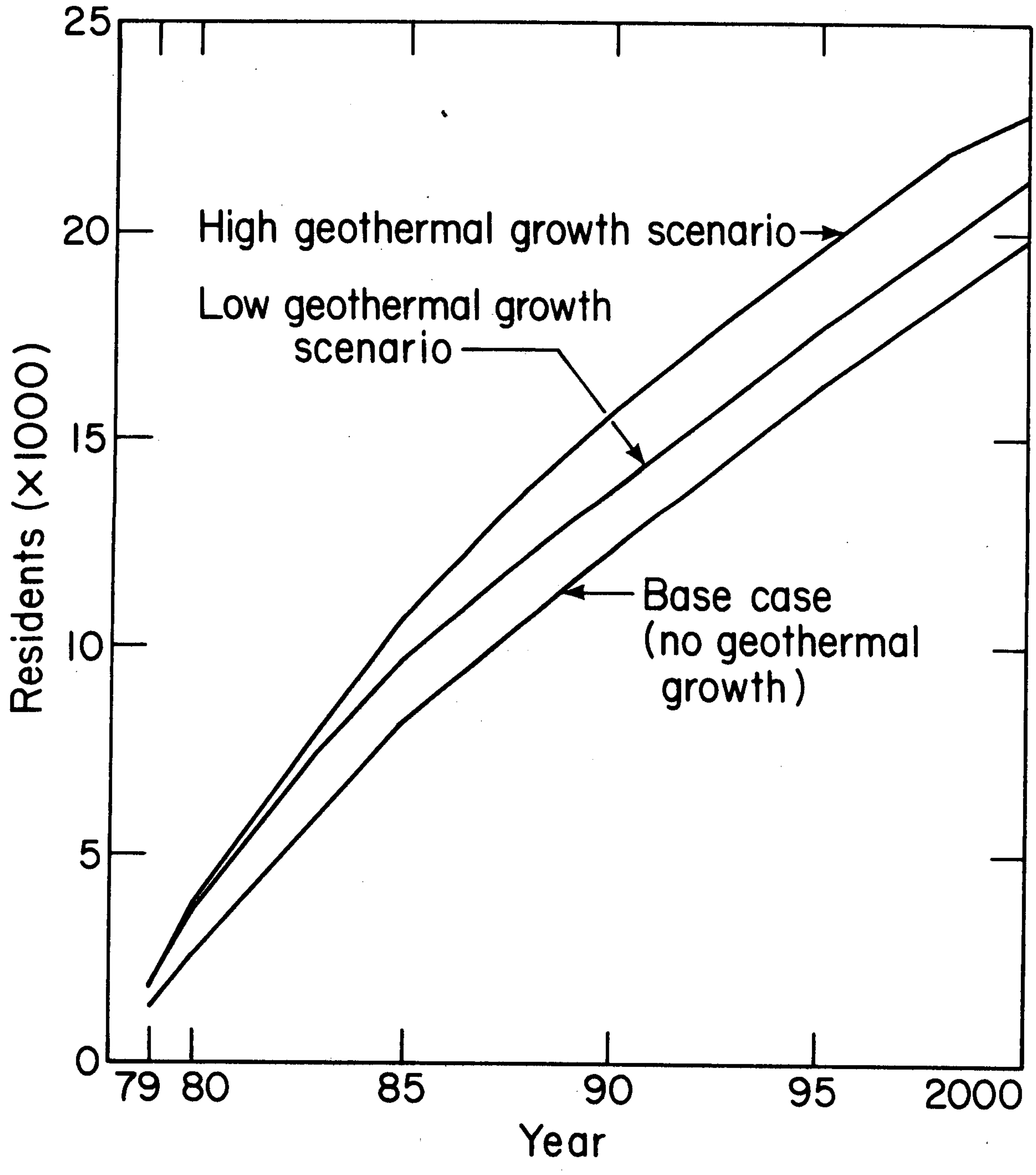


Fig. 32. Lake County Population Increase (over 1978 level)

XBL804-680

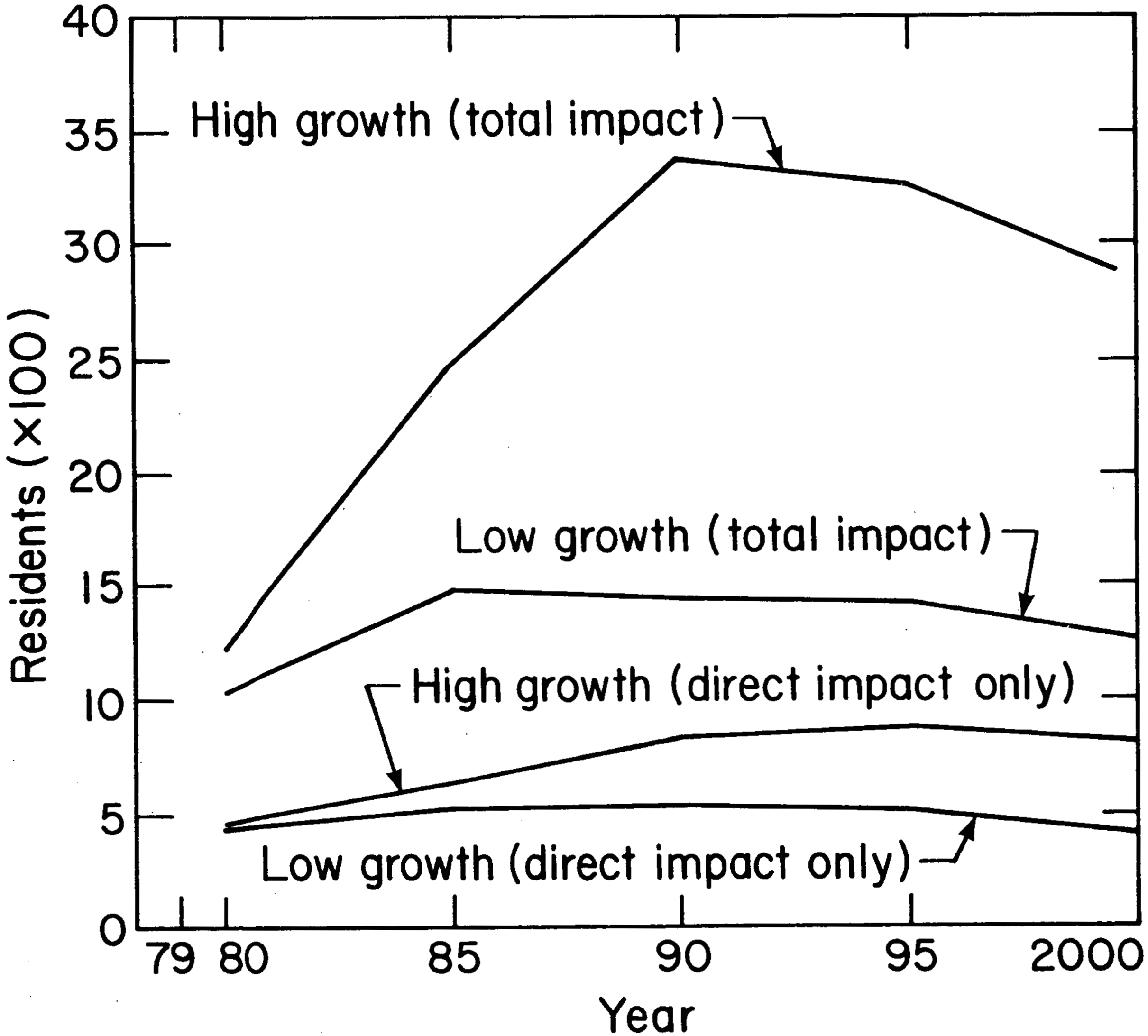


Fig. 33. Population Difference Between Base Case and Geothermal Scenarios for Lake County

XBL804-678

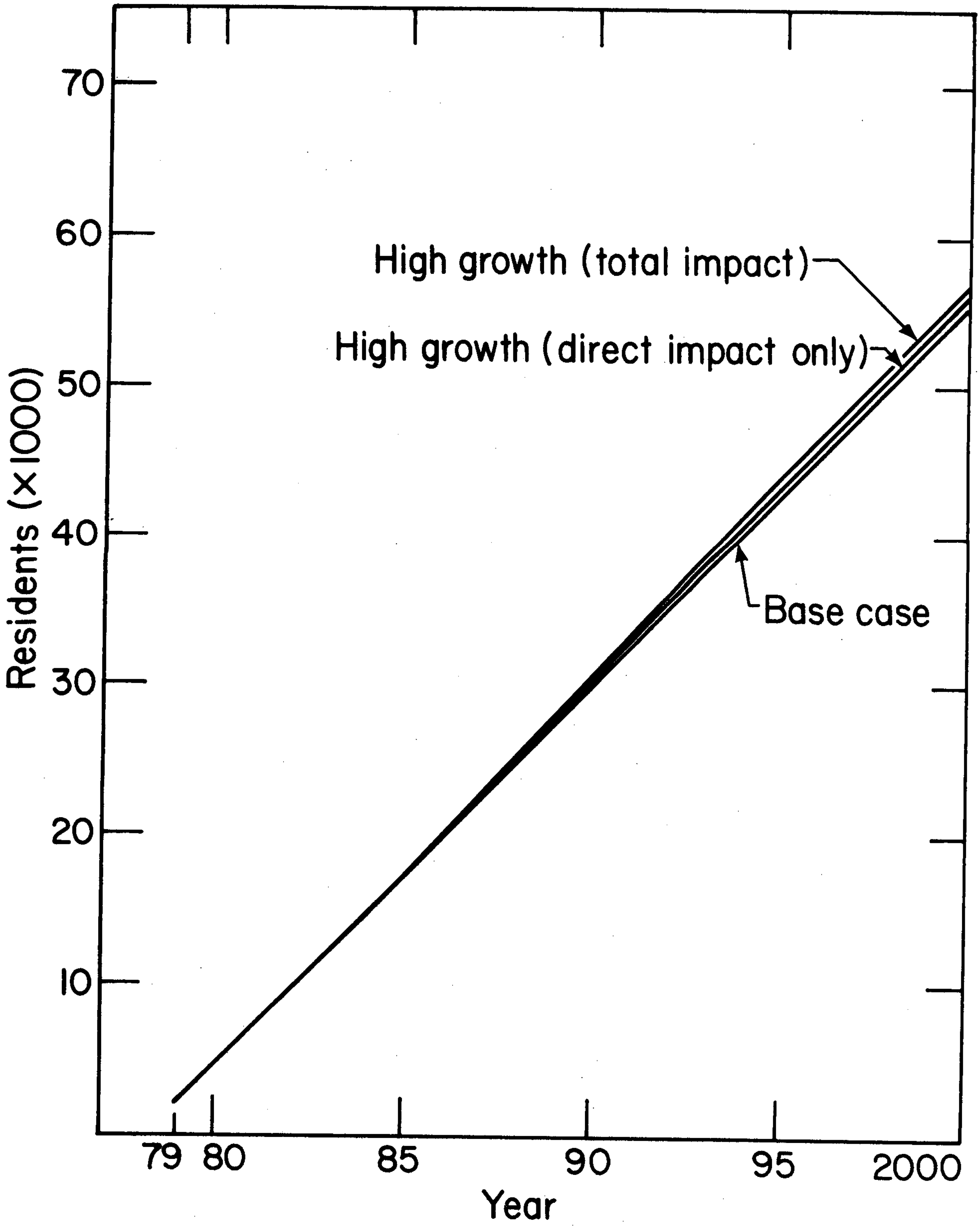


Fig. 34. Mendocino County Population Increase (over 1978)

XBL804-683

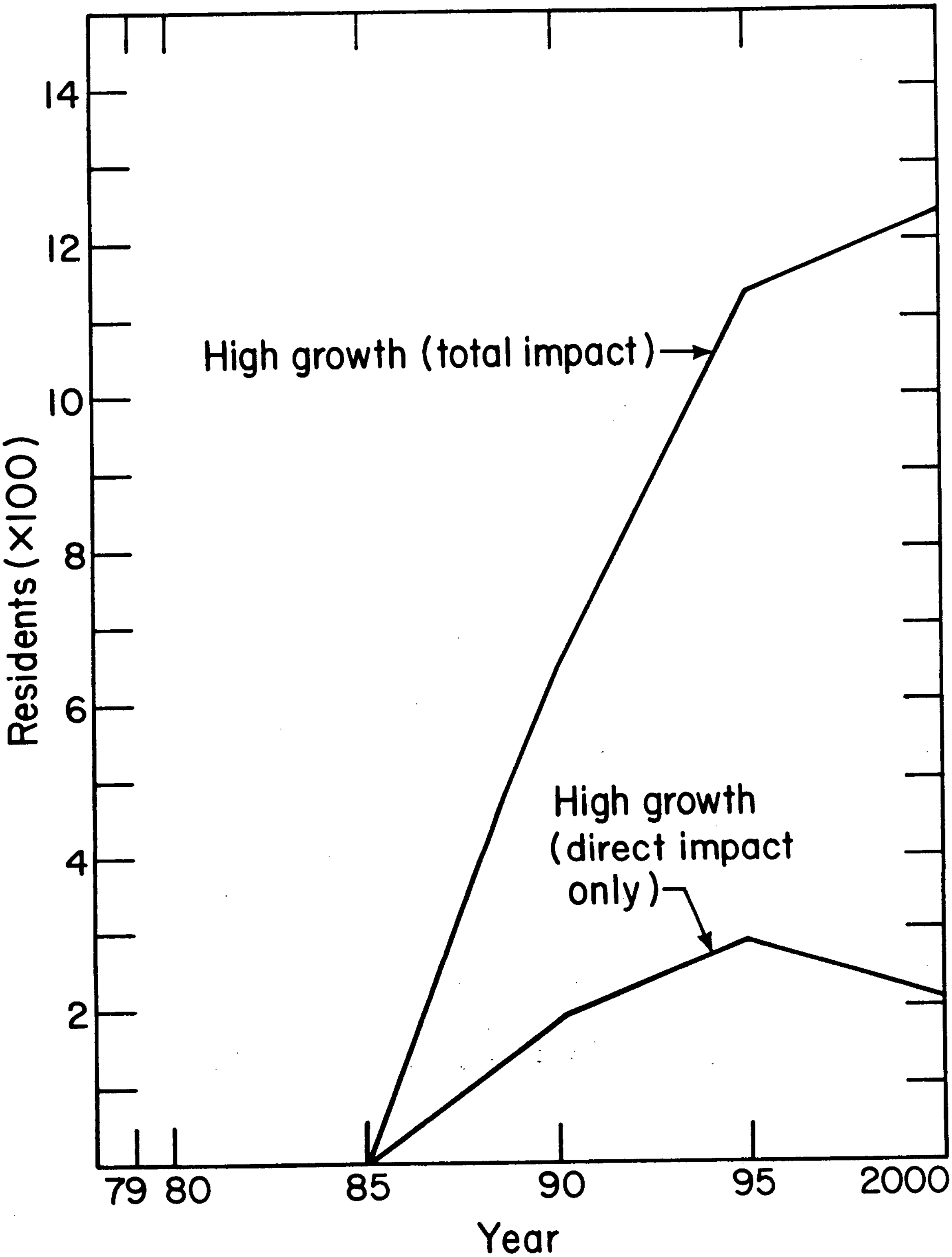
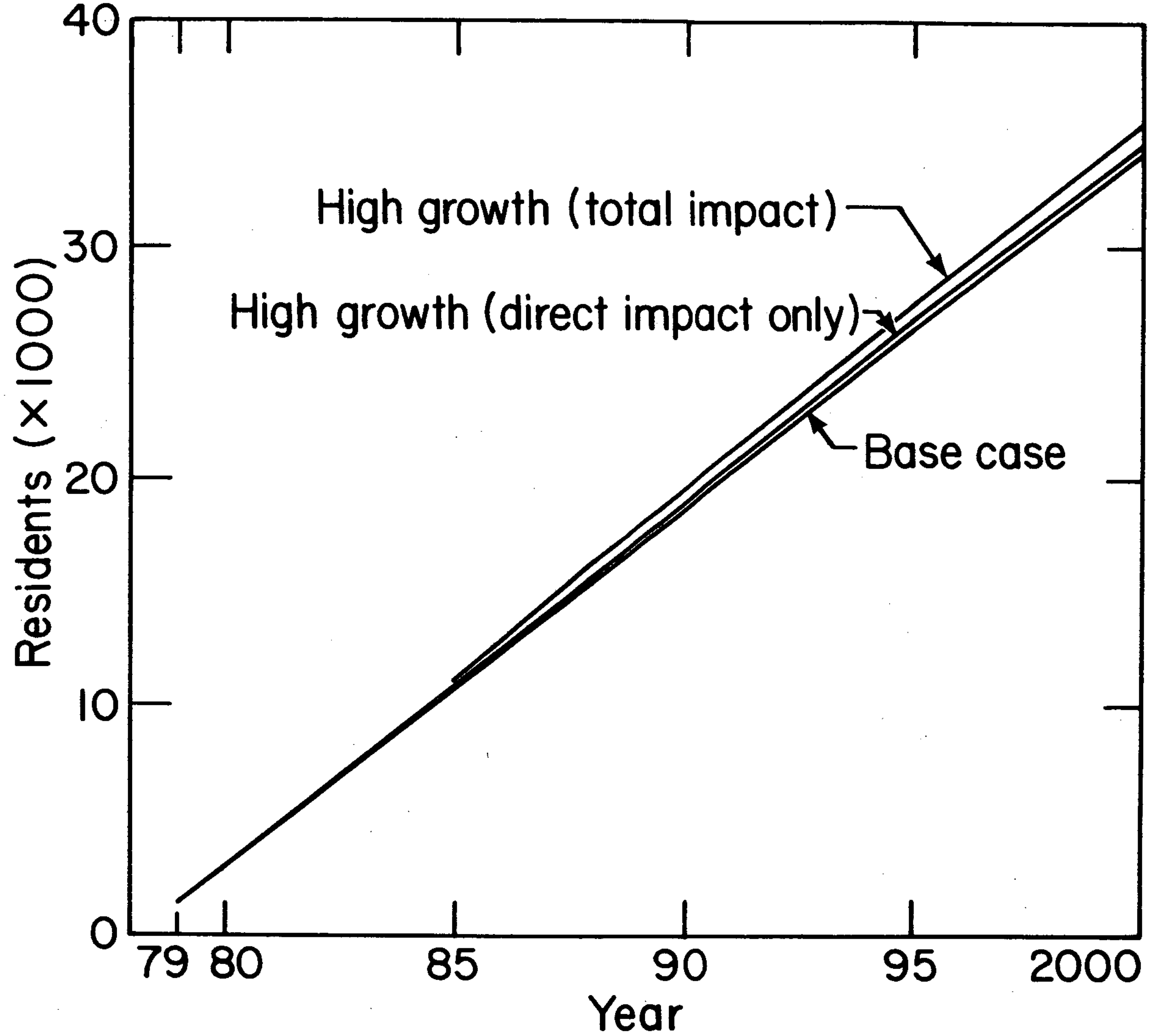


Fig. 35. Population Difference Between Base Case and Geothermal Scenarios for Mendocino County

XBL804-682



XBL 804-679

Fig. 36 Napa County Population Increase (from 1978)

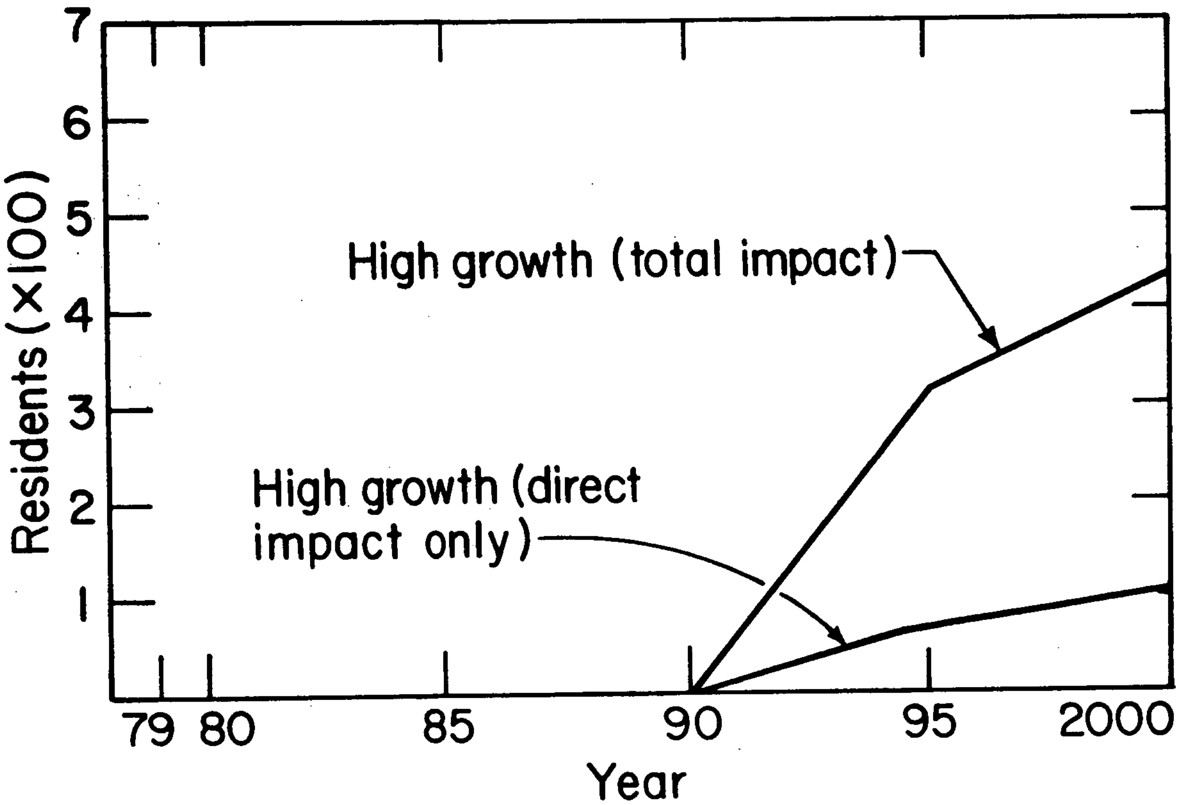


Fig. 37. Population Differences Between Base Case and Geothermal Scenarios for Napa County

XBL 804-686

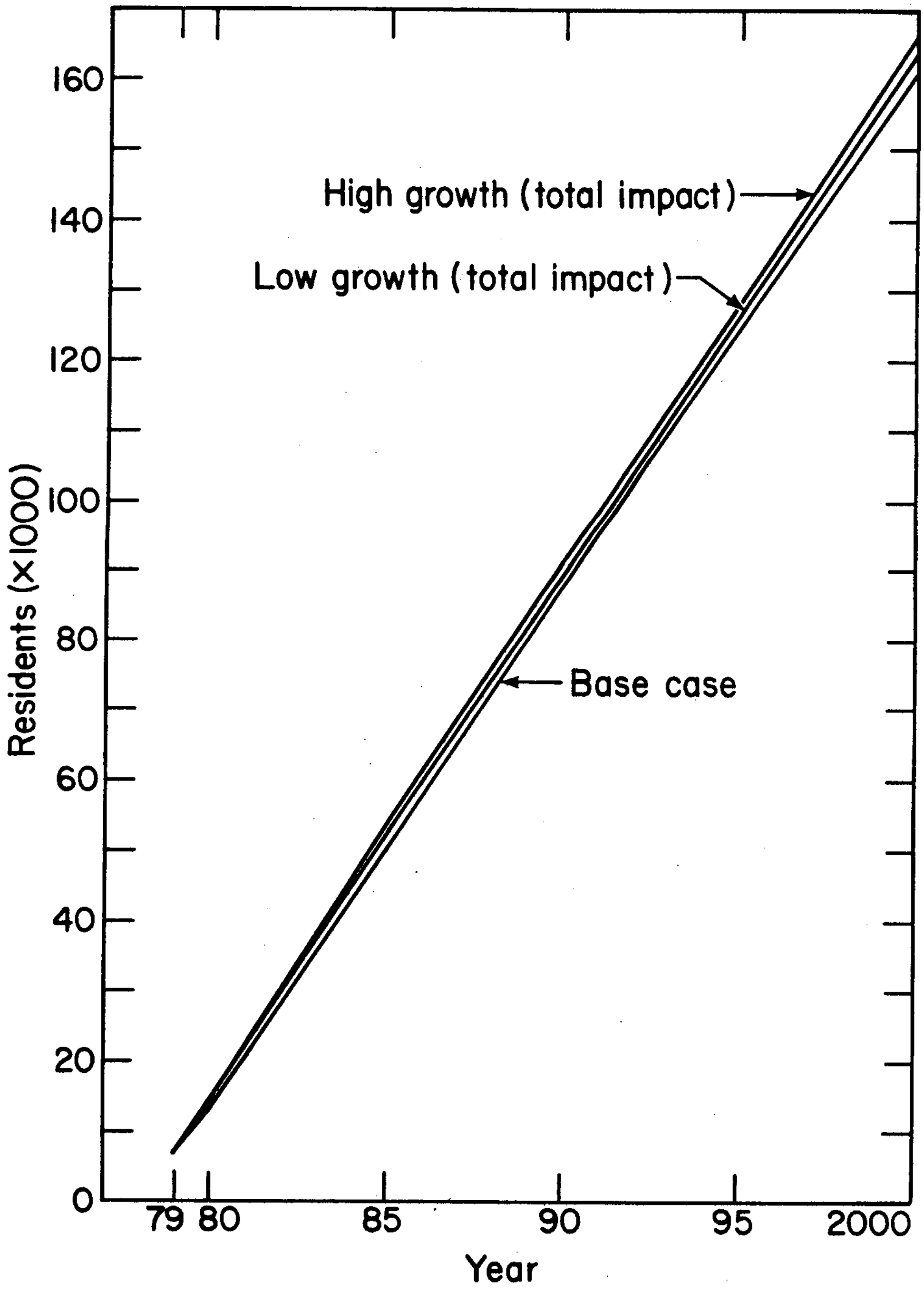


Fig. 38. Sonoma County Population Increase (from 1978)

XBL804-685

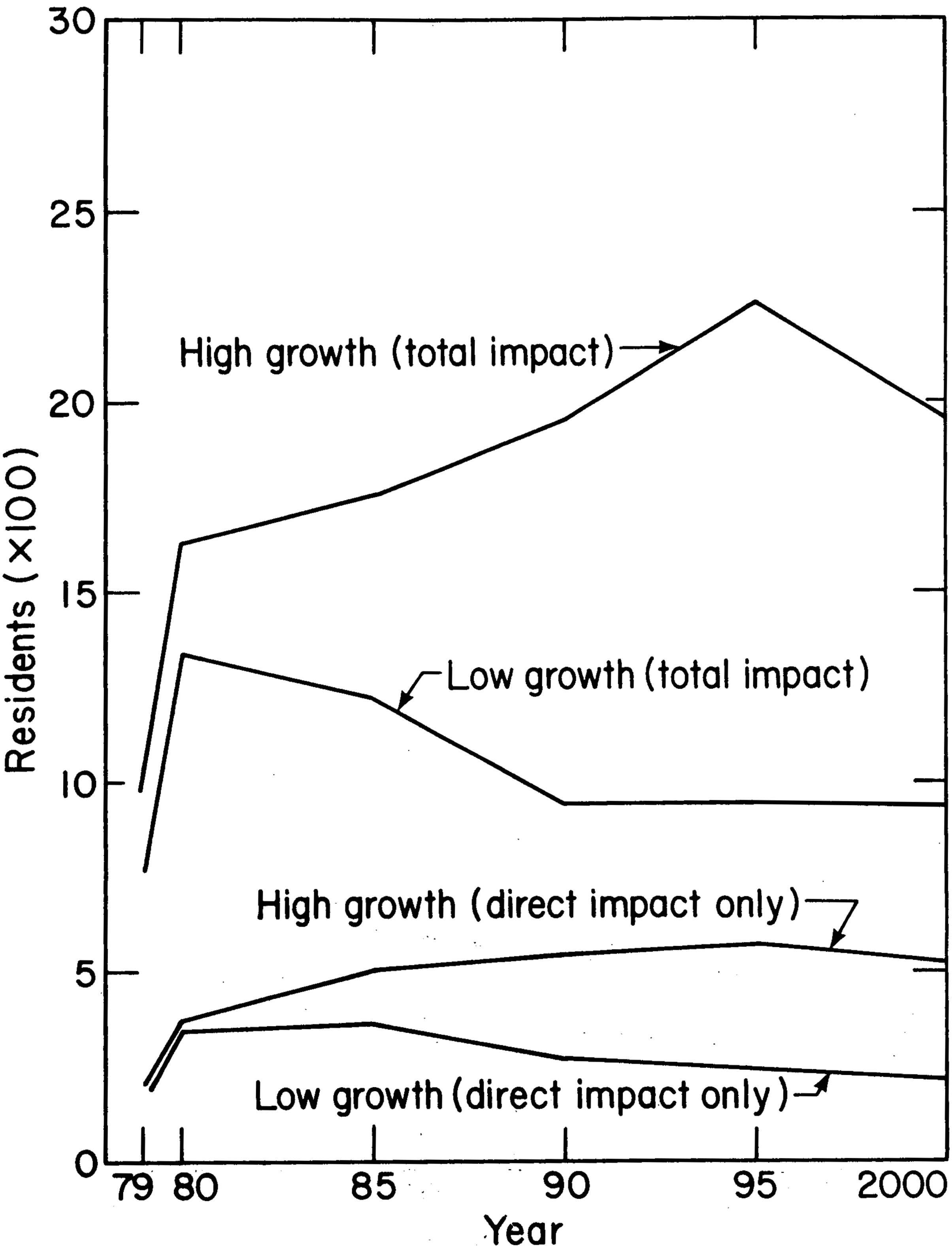


Fig. 39. Population Difference Between Base Case and Geothermal Scenario for Sonoma County

XBL804-684

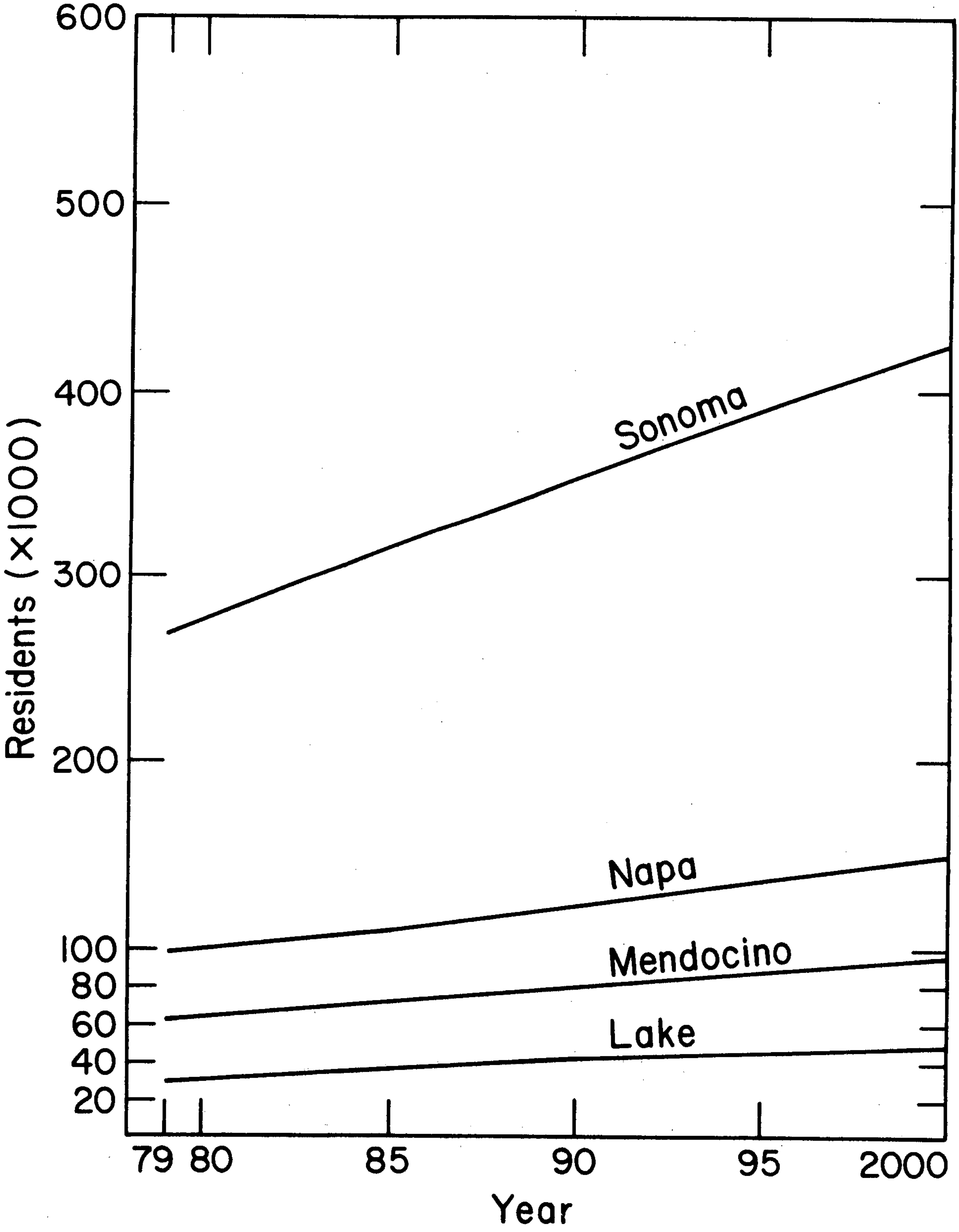


Fig. 40. Forecasted County Population For The Base Case Scenario XBL 804-687

(Fig. 35) and Napa County (Fig. 37) since these scenarios did not produce measurable impacts. Figure 40 shows forecasted county total population over time for the base case scenario.

The data on Figures 33, 35, 37 and 39 represent the absolute magnitude of the county level population impact of geothermal energy development in the Geysers region. The curves for "direct impact only" represent that incremental population associated with geothermal development and the resultant in-migration rates. The "total impact" curves represent the incremental population associated with both direct and induced employment and their resultant in-migration rates. The total impact curves represent an upper bound on the possible population impact since it was assumed that all induced employees will be additional in-migrants. In reality, some of these induced jobs would be filled by existing residents or by in-migrants included in the DOF base case in-migration forecast. The "direct impact only" curve assumes, in effect, that all of the induced employment comes from either existing residents or from in-migrants forecasted by the DOF base case. Actual population impact for either development scenario would then lie between "total impact" as an upper bound and "direct impact only" as a lower bound.

The regional population impact peaks in the early to mid 1990's for the high growth scenario but in the early to mid 1980's for the two counties with early scenario activity (Lake and Sonoma). Population impacts in the other two counties are still increasing at year 2000 when the scenario ends. The largest number of additional residents occurs in Lake County in 1990 under the high geothermal growth rate scenario where about 3000 residents would be present because of geothermal activity.

The significance of the absolute population increases shown on Figures 33, 35, 37 and 39 must be viewed in light of total county population (Figure 40) and of total county population increase (Figures 32, 34, 36 and 38). The presence of up to 2240 geothermally related inhabitants in Sonoma County in 1995 (Fig. 39) takes on a reduced significance since the number will represent only 0.6% of the total county population (Fig. 40) and, more importantly, only 1.8 percent of the total population increase between 1979 and 1995 (Fig. 40). 430 geothermally related inhabitants in Napa County in year 2000 (Fig. 37) also become insignificant since they represent only 0.3 percent of the county population in 2000 (Fig. 40) and only 0.8 percent of the population increase between 1979 and 2000. The remaining 99.2 percent of the county population increase over that period, and the forces driving the increase, will be of far greater concern to the county.

Significant impacts were found in Lake and Mendocino Counties. The total of 3390 geothermally related residents in Lake County in 1990 (Fig. 33) represent 8 percent of county population and about 20 percent of the population increase over that period. Thus, geothermal energy development will be a major, but not the primary, driving force behind Lake County population increase over the next decade. While geothermal resources are found (and under the high growth scenario will be developed throughout Lake County, the majority of the development will occur in the southwestern part of the county. In this part of the county, geothermally related population impacts will be far greater than forecasted by county-wide numbers.

A maximum of 1240 geothermally related residents of Mendocino County in 2000 (Fig. 35) will have little significance for the county as a whole (1.3 percent of county population, only 3.5 percent of population increase between 1979 and 2000). However, most of this growth is projected to be concentrated during the 1985 to 2000 time period and will represent 5.3 percent of the county population growth over that period. Further, the vast majority of the geothermally related population will be concentrated in the southeast corner of the county (in the general vicinity of Hopland). In this sub-county region, a population increase of 1200 people would be significant.

Finally, population impacts on a regional scale are significant only over the first several years of the scenario when activity levels are high in Lake and Sonoma Counties (see Table 56) where, during the 1979 to 1981 period, geothermally related population increases represent 10 percent of the total population increase.

In addition to specific population impacts, several trends emerged from the model results. First, direct geothermal population impacts represent a small fraction of the total population change, and are marginally significant or insignificant in all cases. Second, following the trend established for geothermal levels of employment, geothermally related increased population tends to rise rapidly to a maximum level and to then remain fairly constant over the life of the development activity. Third, the historical error of one and two year DOF county level population projections is between 1 percent and 2 percent. Thus, in all cases, except for the Lake County high growth scenario, geothermally induced population is smaller than the expected DOF forecast

Table 56. Maximum Regional Population Impacts of Geothermal Energy Development

	1980	1985	1990	1995	2000
Geothermally related population	2840	4268	5918	6994	6505
Total Regional Population	476,995	539,957	603,558	665,729	724,756
Geothermal Population as a % of Regional Population	0.6%	0.8%	1.0%	1.05%	0.9%
Total Regional Population Increase (over 1978)	25,700	92,098	157,000	219,500	278,700
Geothermal Population as a % of Total Population Increase	11.1%	4.6%	3.8%	3.2%	2.3%

error. This is not to say that the projections of geothermally related population increase presented here are in error, but rather that they are smaller than the expected error in the basic forecast onto which they have been added. Thus, the real value lies not in the absolute numbers of the projected population increase, but rather in their relative magnitude to both total county population and to non-geothermally related in-migration.

VII. CONCLUSIONS

A number of significant conclusions concerning the population impact of geothermal energy development; direct and indirect employment opportunities associated with geothermal development; and the potential for, attractiveness of, and employment impacts of various direct uses of geothermal energy were drawn from this study. The specific conclusions are:

1. The four Geysers region counties all have rapidly growing populations. However, geothermal energy development is not, and will not be, a principal driving force for population growth, and is a significant driving force in only one county (Lake County) for county level population changes.

2. The course of geothermal development in the Geysers area appears to be relatively fixed over the next 4 - 5 years. Following this period, the development path can vary widely as a function of various forces including the success of hot water system development in Imperial Valley, of the rate of electricity demand growth, the ultimate size and composition of the KGRA resource, and the success of other utility capital stock investments (e.g. Montezuma I).

3. New employment opportunities in the geothermal industry occur primarily during the initial development period within a county. After the first several plants are built, additional new capacity tends not to create new jobs, but rather to rehire workers from previous construction efforts. Further, multi-year gradual loss of jobs tends to occur following the initial buildup period.

4. Induced employment opportunities are substantially larger than direct geothermal employment opportunities, will be spread over a far greater range of job skills and will provide far more job opportunities for current residents than will geothermal development.

5. Direct employment levels resulting from even a high scenario will be small compared to the total county and regional labor force. Total employment impacts (direct plus indirect) are larger, but will still represent less than 2 percent of the regional work force.

6. The county level population impacts of geothermal energy development are not significant in Napa, Sonoma and Mendocino counties. Significant county level impacts will occur in Lake County if an aggressive geothermal development path is followed. Under such a program, as much as 8 percent of the Lake County population by 1990

could be present directly or indirectly as a result of geothermal activity. This additional population will represent over 20 percent of the county total population growth for that period.

7. While population impacts of geothermal energy development are generally small at the county level, it is possible that significant sub-county impacts may accrue in rural heavy development areas such as Cobb Valley (Lake County) or Hopland (Mendocino County).

8. Measurable county level population impacts of geothermal development in Lake and Sonoma Counties have already occurred. DOF revised estimates indicate that actual 1976-1978 Lake County in-migration was higher than DOF baseline projections by approximately the number of people shown here for the first three years of the scenario. Thus it may be expected that geothermally induced in-migration in Lake County will taper off in the early 1980's and that total population impacts will taper off by the mid-1980's. Population impacts in Mendocino County should not be felt until the mid to late 1980's and not in Napa until the mid to late 1990's.

9. Many direct uses of geothermal energy are probably feasible in the Geysers region (Tables 16 and 21), but none are presently being developed in accordance with their energy potential. Direct uses of geothermal heat could provide an important part of the energy needs of the Geysers region. In contrast, employment levels should not be high because most direct uses are not labor intensive (Table 22).

10. Greenhouse crop production is one feasible direct use which is an exception to the general rule that geothermal development is not labor intensive in that a large complex of geothermally-heated greenhouses could employ over 100 persons.

11. With the exception of geothermal greenhouses, direct and indirect employment from other geothermal direct uses will not be high. About 20 to 30 full-time jobs may be available in each of Lake and Mendocino counties, and fewer in Napa and Sonoma counties.

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