R E V I E W
D R A F T

MARKET ANALYSIS OF
GEOTHERMAL ENERGY FOR
CALIFORNIA AND HAWAII

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SUMMARY

- The market for electric power production in California is adequate to absorb geothermal resources as they are currently projected to come on-line to the year 2000.

- An acceleration of geothermal development could motivate utilities to displace planned fossil fueled and nuclear plants with geothermal power plants.

- The recent provision for federal tax incentives can have a dramatic impact upon increasing the return on investment, reducing the price of fuel, or overcoming the capital cost limitations of developing a geothermal resource. This should provide an acceleration of development activities.

- The market for geothermal electric power production in Hawaii is dependent upon an influx of new industry into the Islands, or shortages of petroleum products.

- The heavy reliance upon imported petroleum products in both states, makes native energy resources preferable wherever they can be supplied, because of balance of payment issues.

- The heaviest markets for direct heat industrial application are in the San Francisco Bay area, Los Angeles and other coastal counties in California. The Island of Oahu provides the major market in Hawaii.

- In the case of Hawaii and California the proven resources for direct heat industrial use do not coincide with the urban market locations.

- Economical processing of agricultural products may require scheduling of crop harvest times to assure adequate process plant utilization.

- Projected scenarios for power-on-line at the Heber site in Imperial County have accelerated by 1-2 years in the past year, indicating increased demand for geothermal energy.

- Energy conservation plans are in effect for many industries, indicating the concern over rising energy costs and energy availability, making geothermal more attractive.

- Geothermal energy is a heterogeneous product, which can be cost competitive, marginally competitive, or cost prohibitive, depending upon site, application, and market. Individual market analysis for particular applications will be necessary for product-specific ventures.

Recommendations include:

- Demonstration of liquid-dominated geothermal electric power generation.
- Enactment of tax incentives.
- Demonstration of industrial uses including
 - Food Processing
 - Lumber & Paper
 - Chemical
- Market analysis of Lumber & Paper industries in Northern California.
- Overview of the Chemical industries in California and Hawaii.

- Overview of the Food Processing industry in California.
- Assessment of industrial attitudes toward geothermal energy.
- Exploration of resources in proximity to major markets.

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MARKET ANALYSIS OF GEOTHERMAL ENERGY FOR CALIFORNIA AND HAWAII

1. INTRODUCTION

The purpose of this paper is to investigate the market for geothermal energy in California and Hawaii for both electric power production and direct use applications. [Geothermal energy is a heterogeneous product with a wide variety of applications.] The approach of this study is generic, although some particular industries are singled out because they are major energy users. *misplaced sentence interrupts flow of opening pp.*

Electric power generation is an important geothermal use and is being given considerable attention by the Department of Energy, the State Energy Commission, the Public Utility Commission and the public and private utilities. Electric power production is addressed within this paper; however, greater focus is placed upon direct heat applications, particularly industrial uses, which could stand to gain substantial benefits from development of geothermal resources. A market analysis of direct heat applications is a complex undertaking because there are so many possible applications and products. Such an analysis is usually performed for a specific product within a specified market. This document is an overview, prepared to help local, state, and federal decision makers, as well as to aid entrepreneurs to help in the preparation of site-specific market analyses. It is hoped that the document will be used as a working tool by those interested in developing the geothermal alternative energy use. The presentation provides more information than analysis.

California and Hawaii are both heavily dependent upon petroleum products for energy supply. The increasing costs of domestic and imported crude oil can have a substantial impact upon the cost of many products, including electric power, processed foods, lumber, paper, and chemicals. There now exists

an opportunity for entrepreneurial talent to take advantage of untapped resources which may provide a considerable competitive advantage for the present and the future.

Information reported in this paper includes an energy profile of each state, a discussion of the markets for electric power generation and direct heat applications, market indicators for major industrial uses, the results of a direct use overview prepared by SAI, a projection of local and national markets, a presentation of competitive energy costs, a discussion of capital cost limitations involved with producing competitive power, and the impact of tax incentives in making geothermal energy cost competitive.

CURRENT
2. ENERGY PROFILES

2.1 CALIFORNIA

6%?

California's energy supply is heavily dependent upon petroleum (69%) and natural gas (25%). The components of energy supply and demand are given in Figure 1. California consumes the largest amount of energy of the states in the Pacific Region. From 1970 to 1976, California's installed capacity for electric power generation increased at an average of 3.6% per year. In 1976, installed capacity was 35,300 MWe. Of California's electric power production, 33.0% goes to residential use, 32.4% to commercial activity, and 31.0% to industrial uses. Natural gas consumption in California in 1976 was 1.618 quads: 37% went to residential use, 13.2% to commercial, and 49.56% to industrial use. Manufacturing industries in California purchased .624 quads of fuel and electric energy for heat and power purposes in 1976. Table 1 below displays the energy purchased by major process heat users in the state and the cost of that energy.

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Table 1. Quantity and Cost of Purchased Fuel and Electricity for Heat and Power for Selected Industries in California - 1976

	Trillion BTU	Millions Of Dollars
Food & Kindred Products	98.5	223.2
Lumber & Wood Products	19.6	61.1
Paper & Allied Products	36.7	88.4
Chemicals & Allied Products	60.9	147.8
Petroleum & Coal Products	134.9	277.5

The OBERS Projections for earnings growth in California range from 3.7 to 4.2% per year. Population growth in California averages 1.2% per year.

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CALIFORNIA'S ENERGY SUPPLY
1978

CALIFORNIA'S ENERGY USAGE
1978

Figure 1. California's Energy Supply/Demand

Although California produces a large amount of crude oil, it has been importing large amounts of foreign crude. In the past year, Alaskan North Slope crude oil has lowered foreign crude oil's share of the California refiners' market from 49% in August 1977 to only 22% in August 1978. The foreign share of the market dropped from 29.4 million barrels to only 12.4 million barrels for the month of August. It is also planned that geothermal energy can reduce the dependence upon foreign oil still further. The State of California has optimistic estimates of potential power on-line, projecting geothermal to be 12% of California's installed capacity by 1985, 19.9% by 1995, and 15.1% by the year 2000. Bringing about such an aggressive development schedule would require sufficient federal assistance to achieve parity with alternative fuels. Issues such as tax incentives are particularly important in California where geothermal energy is vigorously competing with oil, gas, nuclear, and coal for a position in the utilities' energy mix. Of the two states, California stands to gain the most from development of its geothermal resources. Table 2 displays energy use projections for California to the year 2000 from the State Energy Commission.

not appropriate for
"Energy Profile" section.
However, should be
included in report
elsewhere.

Table 2. California Energy Use Projections
(In Trillion BTU)

Case	Year						Rate/Growth
	1975	1980	1985	1990	1995	2000	
Medium							
Residential	720	789	858	959	1054	1152	1.9
Commercial	420	490	605	748	935	1169	4.2
Industrial	1505	1506	1546	1650	1776	1955	1.1
Transportation	2095	2276	2363	2479	2730	2817	1.2
Total	4740	5061	5372	5836	6495	7093	1.6
Low							
Residential	720	721	740	769	764	755	0.2
Commercial	420	442	511	601	701	827	2.8
Industrial	1505	1506	1546	1650	1776	1955	1.1
Transportation	2095	1804	1717	1653	1775	1886	-0.3
Total	4740	4473	4514	4673	5016	5423	0.6
High							
Residential	720	859	950	1065	1158	1261	2.1
Commercial	420	552	710	923	1196	1557	5.3
Industrial	1505	1621	1885	2256	2675	3178	3.0
Transportation	2095	2415	2788	3172	3672	4126	2.7
Total	4740	5447	6333	7414	8701	10122	3.0

2.2 HAWAII

The energy supply in Hawaii is highly dependent upon petroleum products, all of which are imported. Bagasse, the waste product from sugar refining, is burned to generate electric power in the refineries. This fuel supplies 7.8% of the energy in Hawaii. A very small amount of hydroelectric power supplies .2% of the energy in the Islands.

Over half of the energy consumed in Hawaii is used for transportation (54.9%). Of this amount, 27.5% is consumed for air transportation, 15.6% for ground transportation, 3.5% for water transportation and 8.4% for military uses. The breakdown of energy supply and energy usage are given in Figure 2.

At the present time (1978) Hawaiian petroleum is consumed at a rate of 112,000 bbl/day or about 225×10^{12} BTU/-year. By 1985, it is projected that Hawaii's needs will be 140,000 bbl/day, a 25% increase in seven years. At this rate Hawaii will need an increment of 8.0×10^{12} BTU per year for each of the next seven years, in order to meet energy requirements.

From 1970 to 1976, Hawaii's installed capacity for electric power generation has increased at a rate of 4.3% per year. Installed capacity in 1976 was 1,400 MWe. Of Hawaii's electric power generation, 31.5% went to residential use, 20.4% to commercial use and 46.2% to industrial usage. There is very little natural gas consumption in Hawaii (only .004 quad was consumed in 1976) as it must be manufactured from fuel oil. Hawaii's manufacturing industries purchased .0096 quad in 1976, the main industries being sugar refining and pineapple processing. Sugar refining accounted for 44% of the fuel and electric energy used by the manufacturing sector, purchasing 4.2 trillion BTU's at a cost of \$10 million. Geothermal energy can contribute to both electrical and direct heat capabilities in Hawaii.

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be
chart

HAWAII'S ENERGY SUPPLY
1978

HAWAII'S ENERGY USAGE
1978

Figure 2. State of Hawaii Energy Supply/Demand

3. MARKET FOR ELECTRIC POWER PRODUCTION

3.1 CALIFORNIA

The California State Energy Commission has adopted electric utility sales forecasts and peak demand forecasts to the year 1995. Table 3 below displays the Commission's peak demand forecasts. The average growth rate from 1975 to 1985 is 4.1%. In order to accommodate this growth, the average yearly increase in capacity for the 10 year period is 1,440 MWe. For the years 1985 to 1995, the average increase in peak capacity will be 1,740 MWe per year.

Table 3. Commission Adopted Peak Demand Forecasts
(Megawatts)

Utility Service Area	1975	1980	1985	Growth Rate (75-85)	1995	Growth Rate (75-95)
LADWP	4,099	4,930	5,677	3.3%	7,573	3.1%
PG&E*	12,983	15,940	18,760	3.8	24,900	3.3
SMUD	1,272	1,560	1,846	3.8	2,400	3.2
SCE	10,193	12,901	15,864	4.5	23,288	4.2
SDG&E	1,619	2,234	3,006	6.4	4,985	5.8
TOTAL	28,894	36,005	43,307	4.1	60,746	3.8

* PG&E total includes SMUD. Table 3 total adjusted to remove double counting.

Source: CERCDC, California Energy Trends & Choices, Vol. 2, Electricity Forecasting and Planning.

The Commission has also adopted sales forecasts which are virtually identical to the peak demand forecasts; with an adopted 4.2% growth rate from 1975 to 1985, the considered range is from 2.3% to 6.7% per year. The adopted growth rate for 1985 to 1995 is 3.8% (the range considered was 1.9 to 5.9% growth per year). SDG&E has the highest projected growth rate, ranging from 3.3 to 7.5% per year. Table 4 displays the adopted sales forecasts.

Table 4. Commission Adopted Sales Forecasts* (Million kWh)

Utility	1975	1980	1985	Growth Rate (75-85)	1995	Growth Rate (75-95)
LADWP						
Adopted	18,625	22,898	26,487	3.6%	36,738	3.5%
High	18,625	24,277	30,621	5.1	49,961	5.1
Low	18,625	19,630	19,216	0.3	20,700	0.5
PG&E**						
Adopted	60,262	73,647	86,700	3.7%	118,654	3.4%
High	60,262	81,910	113,709	6.6	176,288	5.5
Low	60,262	69,435	74,804	2.2	86,852	1.8
SMUD						
Adopted	4,411	5,608	6,902	4.6%	10,005	4.2%
High	4,411	6,151	8,282	6.5	13,193	5.6
Low	4,411	5,076	5,538	2.3	6,244	1.8
SDG&E						
Adopted	8,141	10,785	14,500	5.9%	25,041	5.8%
High	8,141	14,034	20,032	9.4	34,456	7.5
Low	8,141	10,347	11,728	3.7	15,512	3.3
SCE						
Adopted	50,108	64,252	79,157	4.7%	106,174	3.8%
High	50,108	72,249	96,969	6.8	172,308	6.4
Low	50,108	58,972	66,842	2.9	76,449	2.1
TOTAL						
Adopted	137,136	171,582	206,844	4.2%	286,607	3.8%
High	137,136	192,470	261,331	6.7	433,013	5.9
Low	137,136	158,384	172,590	2.3	199,513	1.9

* The utilities listed account for 97.7 percent of statewide total sales. The remaining 2.3 percent are accounted for by the California Department of Water Resources, Imperial Irrigation District, Pacific Power and Light, California Pacific Utility Company, Sierra Pacific Power Company, and Surprise Valley Electrification Corporation.

** PG&E totals include SMUD. Table II-1 Total adjusted to remove double counting.

The utilities also project future growth, which in most cases will vary with the adopted forecasts of the Energy Commission. The Commission has criticized the individual utilities' projections for not including non-price conservation measures, not being consistent with Department of Finance projections of households, and projecting electricity prices too low. Generally, the utilities make higher projections. The utilities are conservative in nature, are responsible for providing adequate reliable power to their customers and would prefer to play it safe by having more reserves. Table 5 displays the forecast of major utilities' electric power additions in MWe. The state forecast provides for 7,302 MWe between 1980 and 1985; the utilities allow for 9,880 MWe. The utilities had to cut their forecast by 26% to conform with the State Energy Commission. These forecasts are based upon planned plant capacity. Some of the plants may not be constructed and the plans will have to be revised. SDG&E plans included the nuclear plant at Sundesert, which did not receive site approval. It is possible that this planned capacity will be provided through acceleration of geothermal energy development plans.

Most of the utilities have already planned for geothermal energy on-line without the benefit of increased federal participation. Table 6 displays the utilities' projections of geothermal electric power generation on-line, without federal assistance. A scenario of accelerated development is also displayed in Figure 3, indicating the possible impact of federal assistance, projected by the Mitre Corporation. It is apparent that the impact of federal involvement is highly significant. Tax incentives, procedural streamlining, technology development, environmental studies, and increased planning can all have an accelerating impact on development.

One possible measure of the impact can be estimated by noting the acceleration of the projected development at Heber, California. In the time frame of one year, the plans for

Table 5. Utility Electric Power Forecasts MWe

Utility	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
PG&E (1)	1,392	1,341	244	1,460	1,122	620	870	1,160	1,047	208	(Not Reported) →							
SCE (2)	1,404	184	1,095	--	1,785	26	187	680	1,634	2,563	1,139	176	881	530	780	980	668	1,418
LADWP (3)	135	205	20	43	--	--	--	117	--	220	797	128	248	148				
SDG&E (4)	228		496	176	44	176	487	--	487	--	200	200	200	300	--	300	200	500
SMUD (5)						150		100	100					1,100				
NCPA (6)				264	88		25	100										
PWR (7)					90	100			5		141						37.5	
Total	3,159	1,730	1,855	1,943	3,129	1,082	1,569	2,157	3,273	2,991								
	3,159	4,889	6,744	8,687	11,816	12,898	14,467	16,624	19,897	22,888								

- (1) PG&E as of 3/78
 (2) SCE as of 3/78
 (3) CADWP as of 2/78
 (4) SDG&E as of 3/78
 (5) SMUD as of 9/77
 (6) NCPA as of 7/77
 (7) PWR as of 3/78

$$\begin{array}{r}
 16,624 \\
 6,744 \\
 \hline
 9,880
 \end{array}$$

Table 6. Current California Utility Geothermal Additions Forecast

Utility	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
PG&E (1)	161	245	--	220	--	220	220	110										
SCE (2)									100				100			150		150
LADWP (3)							None Shown											
SDG&E (4)											200	200	200				200	
SMUD (5)								100	100									
NCPA (6)				88	88													
DWR (7)						110												
Additions MW	161	245	--	308	88	330	220	210	200	--	200	200	300	--	--	150	200	150
Cumulative MW	663	908	908	1216	1304	1634	1854	2064	2264	2264	2464	2664	2964	2964	2964	3114	3314	3464
JPL-Doe Scenario Cum MW	673	928	928	1198	1518	1888	2208	2668	3178	3828	4678	5628	6878	→				13900

- (1) PG&E as of 3/78 (Geysers steam)
- (2) SCE as of 3/78 (liquid domiziated)
- (3) LADWP as of 2/78
- (4) SDG&E as of 3/78 (liquid domiziated)
- (5) SMUD as of 9/77 (Geysers steam)
- (6) HCPA as of 7/77 (Geysers steam)
- (7) DWR as of 3/78 (Geysers steam)

C. Frederickson, JPL

Figure 3. Projection of Geothermal Electric Power Generation in California

geothermal development have been accelerated by one to two years. Activity in Imperial County has increased significantly and federal assistance has had a major role therein. Republic Geothermal received the first geothermal loan guaranty for a site at East Mesa. The state-of-the-art has been improved at such facilities as the Geothermal Test Loop Facility at Niland and the DOE Geothermal Component Test Facility at East Mesa. The federal government has sponsored several research contracts including participation with the County of Imperial to develop a geothermal element to the county plan. Such activity has allowed the county to plan for development and proceed to process permitting in a socially and environmentally secure framework. Continued federal participation can provide a catalyst to development. Figure 4 displays projections of geothermal electric energy on-line in California by the Mitre Corporation (1977), along with the updated scenario schedule prepared by SAI (1978). The acceleration in geothermal development expectations is evident upon examination of these projections, made one year apart.

The estimated busbar cost of geothermal power is an important factor in accelerating development. The more competitive the cost, the greater the development. An estimate was made of the range of costs in Imperial County for liquid-dominated resources to compare with estimates of oil, coal, and nuclear power. The "GEYSER" feasibility model was used to standardize the comparison. The parameters listed in Table 7 were used as variable inputs. Liquid-dominated geothermal appears to compare favorably with the ranges indicated, ranging from 37 to 58 mill/kWh.

Table 7. Comparison of Busbar Costs of Electric Power Using the "GEYSER" Model, Constant 1978 Dollars

	OIL	COAL	NUCLEAR	GEOTHERMAL
CAPITAL COSTS GENERATING PLANT	400-600/KW	700-1000/KW	1000-1200/KW	600-1000/KW
PLANT LIFE	30 YEARS	30 YEARS	30 YEARS	30 YEARS
LOAD FACTOR	75%	75%	75%	75%
BTU/KWh	8,500-10,500	8,500-10,500	10,160	21,500-31,600
FUEL COST PER MILLION BTU	\$2.40	\$1.50	\$.75	\$.75
CONSTRUCTION TIME	5 Years	5 Years	5 Years	2 Years
CASH FLOW OF CAPITAL EXPENDITURES	(5 yr. @ 20%) or (4 yr. @ 12.5%) (1 yr. @ 50%)	(5 yr. @ 20%) or (4 yr. @ 12.5%) (1 yr. @ 50%)	(5 yr. @ 20%) or (4 yr. @ 12.5%) (1 yr. @ 50%)	(2 yr. @ 50%)
RANGE OF BUSBAR COSTS	38-53 MILL/KWh	38-57 MILL/KWh	40-53 MILL/KWh	37-58 MILL/KWh

Figure 4. Comparison of Updated Scenario for Imperial County, SAI (1978) with MITRE (1977), Installed Capacity, Geothermal MW_e On Line

3.2 HAWAII

At the present time, Hawaii has sufficient power on-line to satisfy the demands of the Islands. The Hawaiian Electric Company has a total estimated capability of 1,209 MWe with peak demand at approximately 900 MWe. The Maui Electric Company (a subsidiary) has an estimated capability of 72 MWe with an additional 13 MWe available as standby power from a pineapple plantation. Peak demand on Maui in 1976 was 67 MWe. The Hawaii Electric Light Company (HELCO) has an estimated capability of 124 MWe. HELCO has contracts with two sugar companies to furnish 22 MWe of firm power. The peak demand on the Big Island of Hawaii reached 78 MWe in 1976.

The development of additional electric power capacity in Hawaii would appear to be dependent upon additional industry locating in the state. Presently HELCO is purchasing power from sugar companies at 30 mill per kWh and selling it for about two and a half times this amount. Development of geothermal power would be dependent upon the cost at which it can be supplied. Hawaii is concerned with its balance of payments problem, which is impacted heavily by virtual dependence on imported oil. Geothermal energy can substitute for residual fuel oil and thus help Hawaii become energy self-sufficient and ease the BOP pressures. The Hawaiian Electric Company plans to spend over \$180 million within the next five years for the Island of Oahu to develop 141 MWe of power. HELCO is planning on spending over \$50 million during the next five years for its construction program. HGP Well #1, the hottest geothermal well in the world, is located in the Puna district on the Island of Hawaii. A wellhead generator is being constructed which will provide approximately 5 MW_e of electric power. If used for direct heat application, such as sugar refining or other process heat uses, over 20 MW_t could be supplied. The Island of Hawaii is encouraging additional industry to locate in the area. At present, there is an unemployment problem on the Island, and an influx of industry could

stimulate the economy. One criterion for future development, however, is that it does not interfere with the tourist business or detract from the natural beauty of the state.

As of January 1977, electric energy consumers in Hawaii were paying between 45 and 120 mills per kWh, depending upon the usage level. Schedule "H" rates for commercial cooling, heating, air conditioning, and refrigeration service are as follows:

Capacity Charge: \$2.30 per month per KW of required capacity.

Energy Charge:

First	100 kWh per month	12 mills/kWh
Next	200 kWh per month	89 mills/kWh
Next	500 kWh per month	64 mills/kWh
All Over	800 kWh per month	46 mills/kWh

Typical electric bills for Hawaii indicate average costs ranging between 45 mill/kWh to about 87 mill/kWh for different cities, as shown in Table 8.

Table 8. Typical Electric Bills (Residential) for Hawaii, January 1, 1977

COMMUNITY	POPULATION	MINIMUM BILL		LIGHTING LIGHTING APPLIANCES REFRIGERATION	LIGHTING APPLIANCES REFRIGERATION AND COOLING	LIGHTING, APPLIANCES, REFRIGERATION, COOKING AND WATER HEATING			UTILITY SERVING COMMUNITY
		AMOUNT	5TH BIC			100 KWH	200 KWH	300 EWH	
HAWAII		\$		\$	\$	\$	\$	\$	
• AIEA	12 860	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• EWA	2 904	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• EWA BEACH	7 765	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• FOSTER VILLAGE	3 735	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• HALAWA HEIGHTS	5 809	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• HALEIWA	2 624	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• HILO	26 353	3 50		13 08	23 24	34 38	46 78	63 47	HAWAII ELECTRIC LT CO INC
• HONOLULU	324 871	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• KAHULUI	8 280	3 50		10 60	19 90	32 60	45 35	58 60	MAUI ELECTRIC CO LTD
• KAILUA	34 148	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• KANEHOE	29 903	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• KAPAA	3 794	3 49	25	10 77	21 74	37 83	53 38	68 92	CITIZENS UTL CO-KAUAI EL DIV /16
• LAMAHINA	3 718	3 50		10 60	19 90	32 60	45 35	58 60	MAUI ELECTRIC CO LTD
• LAIE	3 009	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• LIMU	3 124	3 49	25	10 77	21 74	37 83	53 38	68 92	CITIZENS UTL CO-KAUAI EL DIV /16
• MAILI	4 397	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• MAKAKA	4 644	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• MAKAKILO CITY	3 499	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• MAUNAWILI	5 303	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• MAWAKULI	6 506	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• PACIFIC PALISADES	7 044	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• PEARL CITY	19 332	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• WAHIANA	17 598	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• WAILAUA	4 047	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• WAIANAE	3 902	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• WAILUKU	7 979	3 50		10 60	19 90	32 60	45 35	58 60	MAUI ELECTRIC CO LTD
• WAINALU	2 982	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• WAINANALO BEACH	3 045	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC
• WAIPIAHU	24 150	2 70	24	8 02	15 25	25 09	34 99	45 29	HAWAIIAN ELECTRIC CO INC

Fuel costs have been escalating in Hawaii over the last five years, from 50 cents per million BTU (\$3.25/bbl) in 1971 to over \$2.00 per million BTU in 1977 (\$2.18 per million BTU at \$12/bbl). Hawaii presently derives 92% of its energy from imported fuel oil. As the price of oil escalates (over \$500 million annually), an increasing burden is placed upon Hawaii's balance of payments. Uncertainty with regard to future energy costs increases geothermal energy's desirability as a substitute.

4. DIRECT USE OVERVIEW OF CALIFORNIA (SUMMARY)

In the process of developing the Direct Use Overview for California, a model was developed to estimate the demand for direct heat applications of geothermal energy. Data on existing demographic and business patterns were input to project the local potential demand for geothermal heat. The potential uses were correlated with conservative estimates of the potential geothermal resources to achieve a statistical estimate of the volume of resource exploitation which might be achieved.

Most of the Known Geothermal Resource Areas (KGRA's) in California are located in areas remote from many of the potential resource users. The KGRA's were established anticipating high-quality energy usage such as electric power generation. Many direct use applications do not require the higher temperatures associated with electric power generation.

It is estimated that there is a substantial level of lower quality geothermal resources which are located near urban markets. Figure 5 on the following page displays unexplored resource areas whose hot springs and geologic characteristics indicate historical and potential resources. Although the estimates of electric power potential in areas other than the KGRA's are limited, possibilities exist for process heat and space heating. An exploration program to better define the resources available to potential direct heat users is essential to verify the resource, if large amounts of direct use are to be developed. The estimates cited for this market analysis are conservative, based upon low probabilities of resource exploitability. Resource confirmation could increase these probabilities substantially. Demonstration of cost-effective applications of direct use of geothermal energy is the strongest marketing tool that could be used to accelerate direct use development.

Figure 5. Resource Zones from the Direct Use Overview

Estimates of the potential level of usage or market demand were made by using an evaluative process point system of resource indicators. Resource areas were assigned points on the basis of the presence of surface evidence of resources and the presence of potential users. Equal weight was given to resource indicators and user (or market) indicators. Points were assigned for such factors as the presence of thermal wells and springs, surface temperatures, heat flow, population, concentration of industry and agriculture. (A description of the point system is given in the Direct Use Overview).

The more highly populated the area, the greater the market potential. The evaluative process described above highlights areas such as Los Angeles, Long Beach, Santa Barbara, San Luis Obispo, San Diego, and Contra Costa and Santa Clara Counties as focal points for geothermal energy exploration. Markets are given an important weighting. The presence of a market is a crucial consideration in planning for the accelerated growth of geothermal energy, because the energy generally cannot be transported over great distances. Piping of geothermal fluids to distances of over 50 miles is unlikely due to heat loss, friction in the system and excessive capital costs. Demonstrations of geothermal energy in isolated, remote areas are valuable, but the chances of accelerated development in these areas are much lower than in urban and suburban districts.

The geothermal energy discovered to date tends to be located where there are very limited direct use markets. An exploration program for direct use potential should first assess the market possibilities. Even if there is a higher likelihood of finding geothermal resources in rural areas, there is no benefit if a market does not exist for the resource. A balance must be reached between the risk of not finding a resource and the risk of very limited markets. The amount of direct heat utilization, then, is based upon the premise that substantial

direct use development will only be achieved where resources and potential heat applications co-exist.

An overview of the energy usage levels that could be achieved in the near-term for space conditioning and industrial process heating was performed. The result is a conservative estimate of the level of direct use that could be achieved immediately, given sufficient investment. Demand for residential (district) space heating was not considered. Nine groups of applications were considered:

1. hospitals
2. colleges and universities
3. hotels
4. food processors
5. lumber mills
6. paper and pulp manufacture
7. chemicals and allied products
8. petroleum and coal products
9. rubber and miscellaneous plastics

This list does not include all of the possibilities for direct heat applications but does represent some of the major candidates for market development in order to make conservative estimates of direct use viability.

Geothermal resource zones were defined in which geothermal resources have been indicated. The zones are displayed in Figure 5. The zone generally includes the areas labeled as "prospective resource areas" by USGS, but additional areas have been included since some of the direct uses under consideration can be served with relatively low temperatures. Some isolated thermal springs existing outside the zone were not considered.

Each zone was assigned a probability, indicating the chance of finding a resource at a given location for three temperature classes. Then, given

X_{CA} = the number of applications of type A in county C

$P_{Z,T}$ = the probability by zone and temperature

Z = zone

A = applications

C = county

E_{CA} = energy use required for application

then

$\sum_Z \sum_A \sum_C P_{Z,T} X_{Z,C,A} E_{CA}$ = estimated developable usage by all applications.

This estimate is 10^{14} BTU/yr or 0.1 quads. It was estimated that about 450 wells would be needed (assumed pumped, at an average rate of 1,000 gpm), at a cost of \$500 million to develop the wells and distribution systems. Assuming the competitive cost of fuel is presently \$2 per million BTU, private industry would be willing to put up only 25 percent of the capital investment at the present time. This, however, does not mean that geothermal energy is not cost-competitive, because the applications mentioned would consume only about 11 percent, on the average, of the total energy provided. Cascading effects, once the resources are established, would enhance the efficiency of usage and could easily make the resource viable. Also, many applications would already be efficient, using 80 to 90 percent of the total energy recoverable. Figure 6 displays an estimate of the expected number of BTU's on-line, given increasing levels of capital investment.

Figure 6. BTU's in Production Resulting from Capital Investment

5. MARKET FOR DIRECT HEAT APPLICATIONS

5.1 CALIFORNIA

The market analysis for the Direct Heat Applications of geothermal energy for California must be generalized to a large extent because of the volume of business activity presently taking place in the state. With fifty-eight counties in the state and hundreds of cities, it is a substantial task to attempt a detailed study of specific markets for individual goods and services. There are three major categories of direct heat applications which are under consideration. They are:

- o Space Conditioning (heating and cooling)
- o Agribusiness (agriculture and aquaculture)
- o Industrial Use (process heat and mechanical work)

5.1.1 Space Conditioning

In order to use geothermal resources for space heating, temperatures of 80°F must be attained. All of the Known Geothermal Resource Areas (KGRA) in California are capable of providing 80°F water for space heating. A question arises as to need and economics. In Southern California the climate is moderate and the demand for space heating is very low. In Imperial County, where vast amounts of geothermal energy exist, the temperatures reach 100°F over 100 days out of the year. Space cooling needs are greater in Southern California and the air cooling systems have higher temperature requirements. Refrigeration technologies utilizing geothermal fluids are presently in the process of being developed. An economical system has yet to be demonstrated in the U.S. Utilization of geothermal fluids for a refrigeration or cooling system is technically feasible, however, economic systems have not been demonstrated.

Space heating is expected to be developed to a greater extent than space cooling in the near-term and will be a function of heating degree days and population. Heating degree days in Northern California range from 2000°C to 4000°C, while they vary between 1000°C to 2000°C in Southern California. This means that in Northern California, on the average, the temperature must be raised between 5.5° and 11°C each day. In Southern California, the temperature must be raised between 2.7°C and 5.5°C each day.

Economies of scale impact the potential for space heating for many resources. A deep well is prohibitive for a small household or business. Where the resources require rotary drill rigs, a district heating system would be necessary to make the project economical. Such an application might include an industrial park, a large housing or apartment complex, or a series of office buildings and would most likely be required in areas with high population densities. Urban, rather than rural areas, would also be more likely to be developed.

Looking at Figure 5, an output of the direct use overview which displays the potential direct use resource areas, it appears that Areas G,F,K, and L would have the highest potential for a district heating system. Areas A,B,C,D and E in the northeastern portion of the state have the greater heating degree days, however the population density in this area is very low. Space heating might be developed here if the geothermal wells are shallow (less than 1,000 feet), similar to the wells in Klamath Falls, Oregon.

5.1.2 Agribusiness

California leads the nation in the production of forty-four commercial crop and livestock commodities. A wide range of crops is produced with no one crop dominating the state's agricultural economy. Geothermal energy can be used to heat greenhouses, heat crop lands, and for food processing

(dehydration and canning, and potentially for freezing or cooling). Table 9 displays California's share of national agricultural commodities production, along with its national ranking. One important factor to note is that most of the crops have relatively short harvest seasons. This indicates that a food processing plant would require more than one crop for production. Some major crops grown in California which might be likely candidates for utilization of geothermal energy are included in Table 10 along with their respective harvest seasons. Major processing already exists for asparagus, snap beans, green peas, spinach, strawberries, and tomatoes.

Since many of the harvest seasons for crops are relatively short (three months or less), it may be necessary to combine two, three, or four crops into a processing cycle in order to increase the load factor of the processing plant. For example, one likely candidate application is dehydration of onions. The harvest season for onions is from April through October, seven months. The processing season would be even shorter, two to three months. In order to justify the capital expenditure of a dehydration plant it would be necessary to keep the plant in operation 9 to 12 months out of the year. Carrots and potatoes are grown continuously throughout the year and could pick up slack time in the plant. Celery and bell peppers could also be candidates for application. Dehydration temperature requirements are approximately 100°C (212°F). The value of shipments of dried and dehydrated fruits and vegetables (soup mixes, etc.) increased 7% for the nation from 1976 to 1978; market expectations for 1978 project an 8% increase. This would indicate that real production is expected to increase one to 2% for the nation in the coming year. Dehydrated goods are light in weight and can easily be shipped throughout the country. In 1970, there were ninety-eight businesses with 5,274 employees in the food drying and dehydration business and in 1975, there were seventy-nine, with 5,389 employees. It would appear that there has been excess capacity in the state and smaller firms have

Table 9. National Ranking, Share of Production, and Harvested Acreage for California's Commodities

Commodity	National ranking	California's share of U.S. production	Harvested acreage	Commodity	National ranking	California's share of U.S. production	Harvested acreage
Crops	Number	Percent	1,000 acres	Lettuce	1	73.0	151.8
Alfalfa seed	1	35.8	49.0	Winter	—	—	41.5
Almonds	1	99.9 ^d	259.3	Spring	—	—	43.6
Apples	4	7.7	21.2	Summer	—	—	36.4
Apricots	1	96.9	28.0	Fall	—	—	30.3
Artichokes	1	98.4	10.6	Melons			
Asparagus	1	84.0	33.9	Cantaloups	1	65.7	37.2
Fresh market	—	79.3	—	Honeydew	1	78.3	6.8
Processing	—	37.3	—	Persian	1	—	0.3
Avocado	1	66.7	24.9	Watermelons	4	7.5	9.3
Barley	2	15.0	1,010.0	Nectarines	1	98.3 ^c	13.3
Beans, Dry	2	16.3	179.0	Nursery Products ^e	1	18.7 ^d	—
Beans, Green Lima	1	46.1	13.7	Oats	18	1.0	115.0
Beans, Snap	6	3.5	8.0	Olives	1	100.0 ^d	30.3
Fresh market	2	10.0	3.5	Onions	1	24.2	24.4
Processing	3	1.6	4.3	Oranges	2	21.6	197.7
Broccoli	1	96.4	51.5	Navel & Misc.	2	—	114.9
Brussels sprouts	1	100.0 ^d	4.9	Valencia	2	—	82.8
Bushberries	—	—	—	Peaches	1	64.9	73.0
Boysenberries	1	—	4	Clingstone	1	—	51.4
Olallieberries	1	—	4	Freestone	1	—	21.6
Raspberries	1	—	1	Pears	1	43.4	37.4
Cabbage	3	7.5	8.0	Peas, green (proc.)	7	2.3	8.0
Carrots	1	50.3	33.6	Peppers, bell	2	29.7	8.5
Desert	—	—	10.6	Peppers, chili	1	—	5.3
Other	—	—	23.0	Persimmons	1	92.0 ^c	0.5
Cauliflower	1	79.3	27.0	Plums	1	—	24.6
Celery	1	65.9	19.6	Pomegranates	1	99.9 ^c	2.1
Central Coast	—	—	9.1	Potatoes	3	6.8	66.4
South Coast	—	—	10.3	Winter	—	—	3.2
Cherries, sweet	2	30.2	13.3	Spring	—	—	34.2
Corn, for grain	24	5	290.0	Summer	—	—	8.3
Corn, sweet	10	2.0	15.0	Fall	—	—	18.3
Cotton	2	—	—	Prunes, dried basis	1	—	77.6
Lint	2	23.5	1,120.1	Rice	3	20.0	420.0
Seed	2	25.3	—	Safflower	1	89.8 ^d	54.0
Cucumbers	2	12.3	7.8	Sorghum Grain	7	2.2	210.0
Fresh market	—	—	3.0	Spinach	1	57.3	12.0
For pickles	—	—	4.8	Fresh market	1	47.7	2.3
Dates	1	99.4 ^d	4.1	Processing, winter	1	—	9.7
Figs	1	99.5 ^d	14.9	Strawberries	1	73.8	10.8
Flowers & Foliage ^{e,f}	1	22.5 ^d	—	Fresh market	—	—	—
Garlic	1	85.7 ^d	8.8	Processing	—	—	—
Grapefruit	3	10.3	16.4	Sugar beets	1	30.2	312.0
Desert	—	—	9.7	Sweet potatoes	3	8.6	7.8
Other	—	—	6.7	Tangerines	2	25.0	10.6
Grapes	1	88.6	583.4	Tomatoes	1	71.7	263.2
Raisin type	1	—	241.0	Fresh market	2	31.3	29.4
Table type	1	—	64.8	Processing	1	78.3	233.8
Wine type	1	—	277.6	Walnuts	1	99.0	170.1
Hay	2	6.3	1,630.0	Wheat	13	2.8	940.0
Hops	4	4.3	1.3	Livestock			
Ladino clover seed	1	100.0	11.6	Beeswax	2	9.7	—
Lemons	1	86.4	47.4	Cattle & Calves	6	5.4	—
				Chickens	9	4.1	—
				Broilers & fryers	9	3.7	—
				Other	4	6.7	—
				Eggs, chicken	1	13.9	—

Table 10. Harvest Seasons for California Crops

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
CROPS												
Alfalfa seed								•	•	•		
Almonds								•	•	•		
Apples							•	•	•	•		
Apricots						•	•	•	•	•		
Artichokes	•	•	•	•	•	•	•	•	•	•	•	•
Asparagus: Fresh Processing		•	•	•	•	•	•					
Avocado	•	•	•	•	•	•	•	•			•	•
Barley						•	•	•				
Beans, Dry								•	•	•	•	
Beans, Green Lima								•	•	•		
Beans, Snap: Fresh Processing				•	•	•	•	•	•	•	•	•
Broccoli	•	•	•	•	•	•	•	•	•	•	•	•
Brussels sprouts	•	•	•					•	•	•	•	•
Boysenberries						•						
Blackberries						•	•	•				
Raspberries						•	•					
Cabbage	•	•	•	•	•	•	•	•	•	•	•	•
Carrots: Desert Other	•	•	•	•	•	•	•	•	•	•	•	•
Cauliflower	•	•	•	•	•	•	•	•	•	•	•	•
Celery: Central Coast South Coast				•	•	•	•	•	•	•	•	•
Cherries, Sweet					•	•						
Corn, for grain									•	•	•	
Corn, sweet					•	•	•	•	•	•	•	•
Cotton, lint seed									•	•		
Cucumbers: Fresh For pickles			•	•	•	•	•	•	•	•	•	
Dates										•	•	•
Figs						•	•	•				
Flowers & Foliage												
Garlic			•	•	•	•	•	•				
Grapefruit: Desert Other	•	•	•	•	•	•	•					
Grapes: Raisin Table type Wine type						•	•	•	•	•	•	
Hay			•	•	•	•	•	•	•	•		
Hops								•	•			
Ladino Clover Seed												
Lemons	•	•	•	•	•	•	•	•	•	•	•	•
Lettuce: Winter Spring Summer Fall	•	•	•									
Cantaloups					•	•	•	•	•	•	•	•
Honeydew						•	•	•	•	•	•	•
Persian						•	•	•	•	•	•	•
Watermelons					•	•	•	•	•	•		
Nectarines						•	•	•	•	•		
Nursery Products												
Oats						•	•	•				
Olives	•	•									•	•
Onions				•	•	•	•	•	•	•	•	•
Oranges: Naval Valencia	•	•	•	•	•						•	•
Peaches: Clingstone Freestone						•	•	•	•			
Pears						•	•	•				
Peas, green				•	•	•						
Peppers, bell						•	•	•	•	•	•	•
Peppers, chili									•	•	•	•
Persimmons									•	•	•	•
Plums						•	•	•				
Pomegranates									•	•	•	
Potatoes: Winter Spring Summer Fall	•	•	•	•	•	•	•	•	•	•	•	•
Prunes, dried									•	•		
Rice									•	•	•	
Safflower							•	•	•			
Sorghum Grain									•	•	•	
Spinach: Fresh Processing, winter	•	•	•	•	•	•	•	•	•	•	•	•
Strawberries: Fresh Processing		•	•	•	•	•	•	•	•	•	•	
Sugar beets				•	•	•	•	•	•	•	•	•
Sweet potatoes						•	•	•	•	•	•	
Tangerines	•	•	•	•								•
Tomatoes: Fresh Processing				•	•	•	•	•	•	•	•	•
Walnuts									•	•	•	
Wheat												

dropped out of the market. The competitive nature of the geothermal resource will determine if retrofitting or a new plant with locational benefits would be in order.

5.1.3 Industrial Uses

There is a wide variety of industrial uses for process heat. In order to determine the market for process heat in California a county-by-county compilation of energy use was made. The following six major industries were considered:

<u>SIC CODE</u>	<u>INDUSTRY</u>
20	Food & Kindred Products
24	Lumber & Wood
26	Paper & Allied Products
28	Chemicals & Allied Products
29	Petroleum & Coal Products
30	Rubber & Misc. Plastics

These six industries consume the major portion of the process heat used in the state.

To estimate county markets, three market indicators were used for the above industries. They are: 1) yearly energy use per capita, 2) yearly total energy use per county, and 3) yearly energy use per square mile. These statistics are displayed in Figures 7 through 9 for each county. Total energy usage gives an indication of the volume of energy used, Energy Per Capita gives an indication of the energy importance to residents in the county, and Energy Per Square Mile gives a measure of energy intensiveness in the county. In each of the three cases the Bay Area and the Los Angeles area were major markets, as would be expected. The breakdown of energy purchased by counties is displayed in Appendix A, for the six major process heat industries.

Figure 7. Total Energy Purchased for Selected Industries, 1976 (Billion BTU's)

40°

35°

120°

115°

ENERGY USE PER SQUARE MILE*
(BILLION BTU/SQUARE MILE)

1976

2.55 - 59.6	BILLION BTU/SQMI/YR
.57 - 1.86	"	"	"	"	"
.12 - .50	"	"	"	"	"
0 - .11	"	"	"	"	"

*CUMULATIVE YEARLY ENERGY PURCHASES PER SQ. MI.
FOR THE FOLLOWING MAJOR PROCESS HEAT USES:

SIC CODEINDUSTRY

20	FOOD
24	LUMBER & WOOD
26	PAPER
28	CHEMICALS
29	PETROLEUM
30	RUBBER & PLASTICS

Figure 8. Energy Use Per Square Mile for Selected Industries, 1976 (Billion BTU/SQ. MI.)

Figure 9. Energy Use Per Capita for Selected Industries, 1976 (Million BTU Per Capita)

When total energy use is the criterion, Southern California appears to be the more important market. When energy use percapita is the criterion, the counties in the Northern portion of the state are the best markets, due to the importance of the lumber and paper industries. Energy use per square mile is probably the best market indicator. It indicates strong markets along the coast.

Table 11 indicates the top twelve counties under each of the three criteria. Five counties rank in the top twelve in each case using these three criteria: Contra Costa (which would appear by far the best market), Los Angeles, Stanislaus, San Joaquin, and Yolo County. These counties have high energy usage. Some of the lesser developed counties may also hold promise for development. Most of the interest in geothermal to date in California has been with electric power production; direct heat applications have not been demonstrated. Federal involvement in direct heat applications could accelerate development of resources much the same as has occurred in Oregon. Figure 10 displays the projection of BTU's in operation with and without federal assistance.

Table 11

Market Indicators* Top 12 Counties (Billion BTUs)
In California

<u>Total Energy Use (Billion BTU's)</u>	<u>Energy Use Per Capita (Million BTU Per Capita)</u>	<u>Energy Use Per Square Mile (Billion BTU/sq mi)</u>
1. Los Angeles (162,766)	Contra Costa (79.6)	Contra Costa (59.6)
2. Contra Costa (47,596)	Kings (54.1)	Los Angeles (39.9)
3. Orange (20,023)	Yolo (50.1)	Alameda (24.0)
4. Alameda (19,857)	Tehama (45.7)	Santa Clara (9.1)
5. Santa Clara (12,033)	Del Norte (37.5)	Solano (5.5)
6. Kern (8,601)	Stanislaus (34.3)	Santa Cruz (5.4)
7. Stanislaus (7,915)	San Benito (29.8)	San Francisco (5.3)
8. San Joaquin (6,757)	Humboldt (28.6)	Stanislaus (5.2)
9. San Mateo (6,632)	Solano (25.0)	Yolo (5.0)
10. San Diego (6,463)	Kern (24.3)	San Joaquin (4.7)
11. Fresno (6,285)	Los Angeles (23.2)	Sacramento (4.0)
12. Yolo (5,249)	San Joaquin (22.4)	Kings (2.6)

*For SIC Codes 20, 24, 26, 28, 29, 30

Figure 10. Projection of Geothermal MBtu/HR in Operation for Direct Heat Applications in California

Sugar refineries, pineapple canneries, and various processing plants are among the process heat users in Hawaii. Table 13 indicates the process heat requirements, cost per million BTU and energy as a percent of product cost for some of the major process heat using industries in Hawaii. Competitive energy costs in Hawaii range from \$1.56 to \$4.93 per million BTU's.

For comparison, an industrial park at Keaau, near the Puna well on Hawaii, will be exemplified. An estimate of the cost of drilling a well (\$1.5 million) and building an 18-mile pipeline from Puna to Keaau (\$3 million) delivering 4.1×10^{11} BTU per year at an operating cost of \$400,000/year was made. Given a 12% return on investment and 75% debt at 9% interest rate the "GEYSER" Economic Feasibility Model determined that the cost of delivered BTU's would be \$2.03 per million BTU, indicating that geothermal energy would be reasonably competitive and, perhaps, very competitive (depending upon the character of these resources and proximity of the resource to the application relative to other fuels).

Totaling the process heat requirements for the industries in Table 13, we find a total potential of 9.532×10^{13} BTU's per year or 0.095 quads, a possible substantial energy displacement.

Figure 11 displays the projection of BTU's in operation with and without federal assistance for the State of Hawaii.

Looking at the six major process heat users that were highlighted for California, a breakdown of energy usage by county was prepared by using Census of Manufacture data and County Business Patterns for Hawaii displayed in Table 12.

Table 12

Energy Purchased by Six Major Process Heat Using
Industries for the State of Hawaii, by County
1976 (SIC Code trillion BTU's)

County	Food (20)	Lumber & Wood (24)	Paper (26)	Chem (28)	Oil Refining (29)	Rubber & Plastic (30)
Hawaii	1.377	--	--	--	1.032	--
Honolulu	3.666	.174	.240	.469	2.913	.501
Lauai	.495	--	--	--	--	--
Maui	1.186	--	--	--	--	--
State Wide	6.742	.191	.243	.477	3.780	.052

The County of Honolulu accounts for the major share of industry in the Islands. At the present time the only geothermal well is on the Big Island of Hawaii. Comparing Table 12 (1978) with Table 13 (1976), it can be seen that processed heat for the six categories has increased considerably. It should be noted that Table 12 records purchased fuels only and that captive energy supplies exist. Bagasse is burned in the sugar refining process and accounts for a considerable portion of fuel usage.

Table 13. Hawaii State Fixed Industries Process Heat Energy Consumption

	PLANT NAME LOCATION, ISLAND	TYPE OF PLANT	YEAR OF DATA	PROCESS HEAT GROSS BTU x 10 ⁹	COSTS \$/BTU x 10 ⁻⁶	ENERGY % OF PRODUCT COST
1.	HECO (3 Plants) OAHU	UTILITY	1975	48,011	1.56	44%
2.	CHEVRON USA BARBERS PT., OAHU	OIL REFINERY	1977	4,985	N/A	4.5-5%
3.	MECO (2 Plants) MAUI	UTILITY	1975	3,662	2.0	46%
4.	HILO COAST PROCESSING PEPEKEO, HAWAII	SUGAR	1975	3,153	*	*
5.	HAW'N INDEPENDENT REFINERY, INC. EWA BEACH, OAHU	OIL REFINERY	1976	3,041	2.25	N/A
6.	HELCO (7 Plants) HAWAII	UTILITY	1975	2,541	1.84	26%
7.	OAHU SUGAR WAIPAHU, OAHU	SUGAR	1975	2,423	*	*
8.	PUNA SUGAR CO. PUNA, HAWAII	SUGAR	1975	2,333	*	*
9.	HAW'N COM. & SUGAR PUUENE, MAUI	SUGAR	1975	2,323	*	*
10.	HAW'N COM. & SUGAR PAIA, MAUI	SUGAR	1975	1,979	*	*
11.	LEIDE PLANTATION LEIDE, KAUAI	SUGAR	1975	1,960	*	*
12.	WALALUA SUGAR CO. WALALUA, OAHU	SUGAR	1975	1,944	*	*
13.	LAIPAHOE SUGAR CO. OOKALA, HAWAII	SUGAR	1975	1,942	*	*
14.	CITIZENS ELEC. CO. PORT ALLEN, KAUAI	UTILITY	1975	1,780	2.2	39%
15.	KA'U SUGAR CO. PAHALA, HAWAII	SUGAR	1975	1,572	*	*
16.	PIONEER MILL KAIHAULA, MAUI	SUGAR	1975	1,500	*	*
17.	CYPRUS HAW'N CEMENT EWA BEACH, OAHU	CEMENT	1976	1,393	2.9	50%
18.	MERYDE SUGAR CO. KOLA, KAUAI	SUGAR	1975	1,382	*	*
19.	HONOKAA SUGAR CO. HONOKAA, HAWAII	SUGAR	1975	1,264	*	*
20.	KAISER CEMENT NANAKULI, OAHU	CEMENT	1976	1,218	2.9	45%
21.	KEKAHA SUGAR CO. KEKAHA, KAUAI	SUGAR	1975	1,012	*	*
22.	HILO COAST PROCESSING PAPAIOU, HAWAII	SUGAR	1975	956	*	*
23.	OLOKELE SUGAR CO. KAUMAKANI, KAUAI	SUGAR	1975	904	*	*
24.	WAILIKU MILL WAILIKU, MAUI	SUGAR	1975	498	*	*
25.	DOLE PINEAPPLE CO. HONOLULU, OAHU	CANNERY	1977	418	1.99	5%
26.	NAVY POWER PLANT PEARL HARBOR, OAHU	NAVY	1977	369	2.6	N/A
27.	HAWAIIAN WEST. STEEL EWA BEACH, OAHU	STEEL	1977	291	4.93	20-25%
28.	ENERCO OAHU	GAS MAKER	1976	234	N/A	7-3%
29.	MOLOKAI ELECTRIC CO. KAUNAKAKAI, MOLOKAI	UTILITY	1975	232	2.58	43%

NOTE:

Data is derived and/or is estimated from various data sources and the listing presented is a coarse ordering of users. Accuracy of ± 20% can be reasonably assumed only within industries. See Text for discussion.

* Sugar refinery data on energy costs is complicated by the burning of bagasse, a by-product of sugar processing, for the majority of their energy. See Text.

Figure 11. Projection of Geothermal MBtu/Hr. in Operation for Direct Heat Applications in Hawaii

6. MARKET PROSPECTS FOR MAJOR INDUSTRIAL DIRECT USE CANDIDATES(The National Market)

6.1 FOOD AND KINDRED PRODUCTS

Food and beverage processors expect 7% growth in 1978 shipments. Energy, weather, government regulations, and consumer issues impact the food processing industry. The nation had an abundant supply of basic foodstuffs in late 1977 and the outlook for 1978 is bright.

Table 14 displays the percent increase in value of shipments from 1976 to 1977 and the projection from 1977 to 1978 for various processed foods, from the 1978 U.S. Industrial Outlook. Looking at these figures, one should assume a 6% inflation rate. In this light, many of the products appear to have actual reductions in production. Those industries which would appear to have special interest in geothermal process heat are poultry dressing plants, dairy products, canned goods, dried and dehydrated goods, frozen goods, and malt beverages, all of which have expected increased production of over 8% in current dollars.

The food processing industry has become increasingly concerned about shortages of various types of fuel. The canning industry has been motivated to achieve a 9.3% improvement in energy efficiency from 1972 to 1976. The frozen food industry has a target of an 11% reduction in energy consumption per unit of production by 1980. The increase in the concern over energy costs and availability provides an incentive for the food industry to consider geothermal energy.

Table 14. Food and Kindred Products: Trends and Projections
1975-78⁽¹⁾ (Value of Shipments in Millions of
Current Dollars Except as Noted)

SIC code	Industry	1975	1976 ¹	1977 ¹	Percent increase 1976-77	1978 ¹	Percent increase 1977-78
20	Total	172,510	187,308	205,096	9	220,252	7
2011	Meat packing plants	31,310	34,440	38,228	11	42,815	12
2013	Sausages and other prepared meat products	6,610	7,270	8,142	12	9,119	12
2016	Poultry dressing plants	5,060	5,565	6,121	10	6,733	10
2017	Poultry and egg processing	852	904	994	10	1,093	10
2021	Creamery butter	1,011	1,208	1,268	5	1,369	8
2022	Cheese, natural and processed	5,253	5,673	6,107	8	6,657	9
2023	Condensed and evaporated milk	2,637	2,848	3,104	9	3,383	9
2024	Ice cream and frozen desert	1,768	1,945	2,159	11	2,418	12
2026	Fluid milk	12,133	13,344	14,545	9	15,854	9
2032	Canned specialties	2 2,825	2 3,136	2 3,463	10	2 3,775	9
2033	Canned fruits, vegetables, preserves, jams and jellies	2 5,817	2 6,293	2 6,782	8	2 7,294	8
2034	Dried and dehydrated fruits, vegetables and soup mixes	924	975	1,043	7	1,129	8
2035	Pickled fruits and vegetables, vegetable sauces and seasonings and salad dressings	2 1,721	2 1,838	2 1,949	6	2 2,127	9
2037	Frozen fruits, juices and vegetables	2 2,664	2 2,875	2 3,089	7	2 3,383	10
2038	Frozen specialties	2 2,804	2 3,022	2 3,263	8	2 3,570	9
2041	Flour and other grain mill products	4,328	4,458	4,592	3	4,730	3
2043	Cereal breakfast foods	2,028	2,088	2,152	3	2,216	3
2044	Rice milling	1,434	1,450	1,552	7	1,598	3
2045	Blended and prepared flour	1,139	1,173	1,208	3	1,245	3
2046	Wet corn milling	2,142	2,286	2,272	3	2,341	3
2047	Dog, cat and other pet food	2,282	2,465	2,679	9	2,899	8
2048	Prepared feeds and feed ingredients for animals and fowls, n.e.c.	7,333	7,553	8,082	7	8,648	7
2051	Bread and other bakery products, except cookies and crackers	9,047	9,427	9,842	4	10,088	3
2052	Cookies and crackers	2,671	2,770	2,936	6	3,009	3
2061	Cane sugar, except refining	1,016	1,062	1,083	2	1,105	2
2062	Cane sugar refining	3,474	3,543	3,614	2	3,687	2
2063	Beet sugar	1,741	1,776	1,811	2	1,848	2
2065	Candy and other confectionary products	3,540	3,859	4,206	9	4,458	6
2066	Chocolate and cocoa products	1,170	1,287	1,480	15	1,628	10
2067	Chewing gum	481	490	500	2	510	2
2074	Cottonseed oil mills	970	989	1,009	2	1,029	2
2075	Soybean oil mills	6,159	6,282	6,408	2	6,536	2
2076	Vegetable oil mills, except corn, cottonseed and soybean	664	677	691	2	705	2
2077	Animal and marine fats and oils	1,097	1,119	1,141	2	1,164	2
2079	Shortening, table oils, margarine and other edible fats and oils, n.e.c.	3,890	3,968	4,047	2	4,128	2
2082	Malt beverages	5,744	6,241	6,865	10	7,552	10
2083	Malt	591	626	684	9	739	8
2084	Wines, brandy and brandy spirits	1,375	1,620	1,790	10	2,014	13
2085	Distilled, rectified and blended liquors	2,020	2,222	2,411	9	2,664	10
2086	Bottled and canned soft drinks and carbonated waters	8,508	10,009	11,044	10	12,214	11
2087	Flavoring extracts and flavoring sirups, n.e.c.	2,365	2,564	2,801	9	3,064	9
2091	Canned and cured fish and seafoods	1,001	1,101	1,211	10	1,332	10
2092	Fresh or frozen packaged fish and seafoods	1,477	1,625	1,787	10	1,966	10
2095	Roasted coffee	3,162	4,531	7,702	7	6,646	-14
2097	Manufactured ice	126	131	135	3	140	4
2098	Macaroni, spaghetti, vermicelli and noodles	553	586	630	8	677	7
2099	Food preparations, n.e.c.	5,597	5,994	6,474	8	6,953	7

¹ Estimated by Bureau of Domestic Commerce (BDC).

² Establishments in this industry reported value of production, not value of

shipments.

n.e.c. = Not elsewhere classified.

6.2 LUMBER, PULP AND PAPER

In 1978, lumber and plywood production is expected to reach near-capacity levels. Lumber exports should rise, softwood plywood exports should drop. Lumber prices are expected to peak with increased employment and efficiency. Wood residues are increasingly being used as an energy source. Some companies are producing enough energy to meet their own needs and sell it to other industrial firms as well. (Presently, a hybrid system power plant using wood residues and geothermal energy as fuel sources is being considered very seriously near Susanville, California.) A major benefit of using geothermal energy in lumber production would be to free the wood residue for power production. A company in California already sells surplus electricity under a long-term contract to a nearby city. (Lumber output is influenced largely by trends in construction, which is presently at a very high level in California).

The paper and paperboard industry is the fourth largest manufacturing industry in the United States and has the fifth fastest rate of real growth. Virtually all of the northern counties in California are lumber producing, providing raw materials to the pulp and paper industry. Product shipments for pulp, paper and board, and converted products are expected to rise 11% from 1977 to 1978. Paper and board production in 1978 is expected to be 5% over 1977.

Table 15 displays pulp production, annual capacity, and the operating ratio (production as a percent of capacity) for the years 1968 through 1978.

Table 15. Wood Pulp Production: Actual 1968-76; Projections 1977-78 (000 Short Tons)

Year	Pulp production-all grades	Annual capacity ¹	Operating ratio (production as a percent of capacity)	Exports	Imports	Apparent new supply
1968.....	40,892	43,120	94.8	1,915	3,532	42,509
1969.....	42,813	44,834	95.5	2,103	4,040	44,750
1970.....	43,546	45,863	94.9	3,095	3,518	43,969
1971.....	43,903	47,107	93.2	2,175	3,515	45,243
1972.....	46,767	48,731	96.0	2,237	3,773	48,303
1973.....	48,327	50,674	95.4	2,344	3,993	49,976
1974.....	48,417	51,295	94.4	2,806	4,123	49,734
1975.....	43,084	51,927	82.9	2,565	3,078	43,597
1976.....	48,804	53,057	92.0	2,587	3,727	49,940
1977.....	50,300	54,678	92.0	2,760	3,940	51,480
1978.....	52,600	55,933	94.0	2,800	4,000	53,800

¹ API Capacity Survey: 1975-1978 revisions.

Source: Bureau of the Census, American Paper Institute, and BDC.

The new capacity for wood pulp production comes substantially from mill modernization, the addition of on-site incremental capacity, and replacement of older pulping technology with newer processes. New technology developments in the area of thermo-mechanical pulping (TMP) are presently being adopted. This process requires greater amounts of energy and geothermal energy may be able to help serve this need.

Shipments of paper and board are expected to grow at a rate of 4.1% per year until 1982. The U.S. paper industry was expected to spend approximately \$3.5 billion for new plants and equipment in 1977, a 2.4% increase over 1976. Approximately 55% of the capital investment goes into paper mills. This high rate of capital development should provide opportunities for applications of geothermal energy.

6.3 CHEMICALS AND ALLIED PRODUCTS

The chemical industry utilizes the highest amount of energy per unit of output of any industrial sector. Energy is a most important issue, as the industry is dependent upon petroleum and natural gas feedstocks. Energy is important both as a fuel and as a feedstock. Energy consumption in the chemical industry

in 1976 amounted to over 3 quads. Table 16 displays the composition of energy usage for the the industry.

Table 16. Energy Consumption of the Chemical Industry, 1976
January-December

Energy Type	Consumption (10 ¹² BTU)
Gaseous	
Natural Gas.....	1,307.1
Propane.....	13.1
LPG.....	11.3
Other Gas.....	264.8
	<hr/> 1,596.3
Petroleum Liquids	
Distillate Fuel Oil.....	54.3
Residual Fuel Oil.....	191.3
Other Liquids.....	45.2
	<hr/> 290.8
Solids	
Coal.....	279.2
Coke.....	6.5
Other Solids.....	11.9
	<hr/> 297.6
Purchased Steam.....	144.4
Purchased Electric Power.....	769.1
Total.....	<hr/> 3,098.2 <hr/>

The chemical industry is critically dependent upon a stable energy supply, and therefore, plans for energy supplies to a higher degree than other industries, and is very interested in alternative energy supplies. Dow Chemical has been active in securing resources in the Gulf Coast region. Successful demonstration of direct heat application in California could have a formidable impact upon the chemical industry's interest in geothermal resources in California. Table 17 below displays the energy conversion processes used in the chemical industry. Process heat accounts for almost 60% of the energy usage.

Table 17. Energy Consumption by the Chemical Industry
Utilization by Conversion Process

Process	Energy Usage (10 ¹² BTU)
Steam Production.....	1,800
For Shaft Power.....	(400)
For Process Heat.....	(1,400)
Direct Fired Process Heaters.....	450
Kilns, Calciners, Etc.....	250
Electricity.....	380
For Shaft Power.....	(250)
For Electrolysis.....	(100)
Other.....	(30)
Internal Combustion Engines.....	150
Unaccounted.....	70
Total.....	3,100

Table 18 indicates the growth rates for several of the chemicals and allied products. Plastics Materials & Resins is the fastest growing sector, with a 14% growth rate projected for 1978. Chlor-Alkali, Inorganic Pigments, Drugs and Pharmaceuticals, Soaps & Detergents, Paints & Allied Products, Industrial Organic Chemicals, and Pesticides also has high expected growth rates, exceeding 9% per year. Assuming a 6% inflation rate, the real growth for these industries ranges from 3% to 8% for the year.

Table 18. Chemicals and Allied Products: Projections 1976-78⁽¹⁾

SIC Code	Industry	1976 ¹	Percent change 1975-76	1977 ¹	Percent change 1976-77	1978 ¹	Percent change 1977-78
2812	Chlor-Alkali.....	1,800	11	1,900	6	2,100	11
2813	Industrial Gases.....	1,210	10	1,308	8	2,300	7.4
2816	Inorganic Pigments ²	1,150	18	1,200	4	1,310	9
2819	Industrial Inorganic Chemicals.....	7,127	16	7,646	7	7,953	4
2821	Plastics Materials & Resins.....	8,255	15	9,600	9	10,300	14
2822	Synthetic Rubber ²	1,845	25	2,100	14	2,250	7
283	Drugs and Pharmaceuticals ²	12,260	9	13,350	9	14,550	9
2841	Soaps & Detergents ²	5,285	12	5,920	12	6,570	11
2844	Perfumes, Cosmetics ²	5,505	9	5,940	8	6,420	8
2851	Paints & Allied Products ²	5,950	16	6,075	2	6,655	9
2865	Cyclic Crudes & Intermediates.....	4,420	16	4,690	6	5,150	10
2869	Industrial Organic Chemicals.....	19,150	13	21,800	14	24,000	10
2873	Nitrogenous Fertilizers ²	2,100	-13	2,175	4	2,250	3
2874	Phosphatic Fertilizers ²	3,000	9	3,150	5	3,275	4
2879	Pesticides.....	2,635	15	2,900	10	3,200	10

¹ Estimated by Bureau of Domestic Commerce (BDC).

² These industries are part of Chemicals and Allied Products

Natural gas curtailments for 1978 (nationwide) are expected to be over 20%. Because the natural gas is required as a feedstock, alternative fuels must be used as replacements in the future. Geothermal energy will be an ideal substitute, once its reliability is established. The industry recognizes the higher use of petroleum and natural gas as feedstocks and the need to curb the use of these valuable resources as an energy source.

6.4 RUBBER AND MISCELLANEOUS PLASTICS

Table 19 below indicates the growth rates for the seven categories under Rubber and Miscellaneous Plastics. Assuming a 6% inflation rate, synthetic rubber, tires, and inner tubes have slight increases in production. Rubber and plastics footwear and reclaimed rubber have effective decreases in production. Hose and belting, rubber, and miscellaneous products have net increases in production, ranging from 3 to 6%.

Table 19. Rubber and Plastics: Trends and Projections 1975-78
(Value of Shipments in Millions of Current Dollars)

SIC Code	Industry	1975	1976	Percent change 1975-76	1977	Percent change 1976-77	1978	Percent change 1977-78
2822	Synthetic Rubber.....	1,481	1,845	25	2,100	14	2,250	7
3011	Tires and inner tubes.....	7,143	8,450	18	10,200	21	11,000	8
3021	Rubber and plastics footwear.....	566	570	1	575	1	575	0
3031	Reclaimed rubber.....	28	20	-29	20	0	20	0
3041	Hose and belting.....	1,235	1,375	11	1,500	9	1,650	10
3069	Rubber products, n.e.c.....	3,412	3,900	14	4,200	8	4,600	10
3079	Miscellaneous products.....	14,932	18,700	25	20,500	10	23,000	12
	Totals.....	28,797	34,860		39,095		43,095	

Estimated by Bureau of Domestic Commerce (BDC).

n.e.c. = Not elsewhere classified.

Capital expenditures in these industries in 1978 can be expected to be approximately \$1.5 billion nationally.

6.5 PETROLEUM REFINING

Table 20 displays the source of crude oil and the composition of petroleum product outputs for the State of California. Total energy consumption in California in 1976-77

(October through September) was 6.317 quads, of this amount 4.044 quads were supplied by petroleum products. The petroleum product output for California in 1976-77 was 736,802,000 barrels of various products. Assuming an average of 5.5 million BTU's per barrel, this amounts to 4.052 quads, indicating that California can effectively produce and refine enough petroleum to meet its own needs. About 84% of this energy is consumed in California. Out-of-state sales in 1976-77 were 115,367,000 barrels; imports were 52,369,000, for a net export of 8.5% of the refinery output.

The market for petroleum products fluctuates depending upon the amount of fuel in storage and expected prices of foreign crude, but over the long run the market is fairly stable. The critical nature of petroleum products to the national economy ensures that there will be a market for the refined products. There is at the present time a shortage of oil refineries because of siting difficulties due to environmental controls.

In 1976-77, California's feedstocks were heavily dependent upon foreign imports, about 44% of the crude coming from Arab countries, Indonesia, and Venezuela. As mentioned earlier in this paper, Foreign imports were reduced to 22% for the months of August, 1978.

Table 20. California Refineries

ORIGIN or PRODUCT	QUARTER: (JULY thru SEPTEMBER)				FULL YEAR: (OCTOBER thru SEPTEMBER)			
	Thousand Barrels		Percent		Thousand Barrels		Percent	
	1976	1977	Change	Change	1975-76	1976-77	Change	Change
CRUDE OIL RECEIPTS								
DOMESTIC								
California	73187	75375	2188	3.0	300319	310030	9711	3.3
Other States								
Alaska	9364	22946	13582	145.0	40673	43769	3096	7.6
Four Corners Area*	410	249	- 161	- 39.3	4509	995	- 3514	- 77.9
Federal Offshore	745	644	- 101	- 13.6	2105	2688	- 417	- 13.4
Other	87	20	- 67	- 77.0	4817	186	- 4651	- 96.2
Subtotal	10506	23859	13253	125.0	53124	47638	- 5486	- 10.3
Subtotal	83793	99234	15441	18.4	353443	357668	4225	0.12
FOREIGN								
O.P.E.C. Countries								
Arab Countries								
Algeria	0	0	0	0	1307	0	- 1307	100.0
Iran	4801	5649	848	17.7	19743	26793	7050	35.7
Kuwait	336	0	- 336	- 100.0	0	0	0	0
Libya	1452	373	- 1119	- 75.0	2373	877	- 1496	- 63.0
Saudi Arabia	14543	24670	10127	69.6	51227	87751	36524	71.4
United Arab Emirates	1911	1592	- 319	- 16.7	8530	7673	- 907	- 10.6
Iraq, Qatar	2068	5808	3740	180.9	10097	18964	8867	87.8
Subtotal	25151	36092	12941	51.5	93327	142098	48771	52.3
Non-Arab Countries								
Indonesia	36958	29155	- 7803	- 21.1	113989	142936	28947	25.4
Venezuela	175	454	279	159.4	3115	1662	- 1453	- 46.6
Ecuador, Gabon, Nigeria	4623	5900	1277	27.6	5028	19727	14699	110.8
Subtotal	41256	35506	- 5750	- 14.0	126132	163525	37393	29.7
Subtotal	66907	73601	6694	10.0	219459	305723	86264	39.3
Non-O.P.E.C. Countries								
Latin America	3763	1630	- 2133	- 56.7	10911	8147	- 2764	- 24.6
All Other	2214	8065	5851	264.3	7137	24102	16965	237.7
Subtotal	5977	9695	3718	62.2	17948	32249	14301	79.7
Subtotal	72634	83296	10662	14.3	237407	337972	100565	42.4
TOTAL	156677	182530	25853	16.5	590650	695640	104990	17.7
FEEDSTOCK INPUT								
Crude Oil								
Domestic	84775	96312	11537	13.6	346078	356151	10073	2.9
Foreign	71517	85178	12861	18.0	227928	323643	95720	42.0
Subtotal	156292	180690	24398	15.6	574006	679799	105793	18.4
Other Products								
Propane	1	1	0	0	24	6	- 16	- 66.7
Butane	651	829	178	27.3	2955	3611	656	22.2
Natural Gasoline	920	1046	126	13.7	4361	3845	- 516	- 12.2
Plant Condensate	0	0	0	0	184	0	- 184	- 100.0
Other Hydrocarbons	1113	1079	- 34	- 3.1	4250	4730	530	12.6
Unfinished Oil	11094	8615	- 2479	- 22.3	52574	44652	- 7922	- 15.1
Subtotal	13779	11570	- 2209	- 16.0	64318	50246	- 14072	- 21.6
TOTAL	170071	192260	22189	13.0	638324	736645	98321	15.4
PETROLEUM PRODUCT OUTPUT								
Motor Gasoline	72270	80835	8565	11.9	271868	298687	26819	9.9
Aviation Fuel								
Gasoline	836	1070	234	23.2	2980	3052	72	2.4
Kerosene Jet Fuel	3205	3416	211	6.6	13013	14116	1103	8.5
Jet Fuel	14123	16780	2591	18.3	53532	60336	6704	12.5
Subtotal	18230	21226	2996	16.4	69623	77504	7879	11.3
Fuel Oil								
Distillate	19172	21010	1838	9.6	69448	83295	13847	19.9
Low Sulfur Residual	17669	23164	5495	31.1	61105	94887	33782	55.3
High Sulfur Residual	15978	17785	1807	11.3	66774	71485	4711	7.1
Subtotal	52819	61959	9140	17.3	197327	249667	52340	26.5
Other Products								
Asphalt	4382	5477	1095	25.0	15406	18447	3041	19.7
Petroleum Coke	5498	6630	1132	20.6	22405	23828	1423	6.4
Road Oil	155	164	9	5.8	580	759	179	30.9
Petrochemical Feedstock	1431	1639	208	18.7	6354	8038	2264	35.3
Other	13592	16627	3235	23.8	53012	59272	6260	11.8
Subtotal	25058	30797	5739	22.9	97757	110544	13167	13.5
TOTAL	168377	194817	26440	15.7	636577	736802	100225	15.7
COSTS: FEEDSTOCK INPUT								
CRUDE OIL	Million Dollars				Million Dollars			
	1976	1977	Change	Percent Change	1975-76	1976-77	Change	Percent Change
Total Cost	665.8	858.5	192.7	28.9	2614.4	2917.8	303.4	11.6
Domestic	941.8	1155.6	213.8	22.7	3087.8	4470.9	1383.1	44.8
Foreign	1607.6	2014.1	406.5	25.3	5702.2	7360.7	1658.5	29.6
Unit Cost	Dollars per Barrel				Dollars per Barrel			
	1976	1977	Change	Percent Change	1975-76	1976-77	Change	Percent Change
Domestic	7.85	8.91	1.06	13.5	7.55	8.12	0.57	7.5
Foreign	13.17	13.70	0.53	4.0	13.55	13.81	0.26	1.9
Total	10.29	11.15	0.86	8.4	9.93	10.87	0.94	9.5
*Arizona, Colorado, New Mexico, Utah								

7. ALTERNATIVE ENERGY COSTS

The cost of energy to industry and agriculture may vary from supplier to supplier depending upon specific fuel requirements and established contracts. Generally, geothermal energy is competing with natural gas, petroleum products and nuclear fuel. The cost of these fuels can range from below \$1.00 to \$3.00 per million BTU's. Competitive costs of fuel presently are about \$2.20 per million BTU. If geothermal energy can be produced for this cost, it should be considered cost competitive from the government's point of view, although industry might be able to procure cheaper fuel.

An important factor to keep in mind is the current trend of escalation of fuel costs. Table 21 shows the trend of fuel costs for utilities in California and Hawaii (from Moody's Public Utilities Manual). Currently commercial gas prices in the PG&E region range from 21.9¢ per therm to 22.9¢ per therm or \$2.19 to \$2.29 per million BTU, in the SCE region \$1.88 to \$1.98 per million BTU, and in the San Diego region \$2.35 to \$2.45 per million BTU.

Table 22 displays the estimated landed cost of imported crude petroleum from selected countries for the first three months of 1978.

In March, 1978, the refiner acquisition cost of domestic crude petroleum was \$10.45 per bbl; imported crude was \$14.57 per bbl and the composite cost was \$12.23 per bbl or \$2.23 per million BTU before refining. The average cost for all grades of No. 6 residual fuel oil was \$12.63 per barrel or \$2.30 per million BTU in March 1978. Table 23 displays the costs of coal, residual fuel oil, and natural gas from October 1976 to October 1977.

Table 21. Fuel Costs for Major Utilities in California and Hawaii
1971-1976

	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>
<u>Pacific Gas & Electric Company</u>						
Gas (Average cost per MCF)	\$.38	\$.41	\$.47	\$.68	\$1.29	\$1.78
Fuel Oil (Average cost per bbl)	3.13	4.04	5.01	10.88	15.40	14.78
All Fuel (Average cost per million Btu)	.36	.40	.49	1.03	1.60	-
<u>Southern California Edison</u>						
Gas (Average cost per MCF)	.36	.39	.42	.61	.85	-
Fuel Oil (Average cost per bbl)	3.69	4.80	5.93	12.08	16.33	15.90
All Fuel (Average cost per million Btu)	.39	.44	.65	1.19	1.76	1.80
<u>San Diego Gas & Electric</u>						
Gas (Average cost per MCF)	.42	.44	.48	.64	-	1.57
Fuel Oil (Average cost per bbl)	4.15	5.00	5.00	9.87	-	15.21
All Fuel (Average cost per million Btu)	.48	.58	-	-	-	-
<u>Hawaiian Electric Company</u>						
Fuel Oil (Cost per bbl)	3.25	3.32	4.17	5.28	9.76	10.05
All Fuel (Average cost per million Btu)	.51	.53	.67	.84	1.56	1.59

Table 22

Estimated Landed Cost Of Imported Crude Petroleum
From Selected Countries

(\$ per million BTU, assuming 5.49 million BTU
per bbl of oil)

	<u>\$ PER MILLION BTU</u>		
	<u>January</u>	<u>February</u>	<u>March</u>
Algeria	\$2.73	2.71	2.68
Canada	2.61	2.60	2.45
Indonesia	2.65	2.65	2.65
Iran	2.53	2.50	2.56
Libya	2.66	2.70	2.66
Nigeria	2.71	2.71	2.71
Saudi Arabia	2.54	2.54	2.56
U.A. Emirates	2.62	2.56	2.63
Venezuela	2.37	2.36	2.41

Table 23

Cost Per Million BTU For Pacific Region Of U.S.

	<u>Coal</u>	<u>Residual Fuel Oil</u>	<u>Natural Gas</u>
October 1976	\$.76	\$2.312	\$1.690
November 1976	.756	2.341	1.775
December 1976	.745	2.334	1.887
January 1977	.776	2.313	1.968
February 1977	.805	2.310	1.892
March 1977	.740	2.321	1.810
April 1977	.708	2.358	2.045
May 1977	.708	2.352	2.089
June 1977	.712	2.357	2.005
July 1977	.717	2.400	2.110
August 1977	.711	2.401	2.188
September 1977	.713	2.406	2.179
October 1977	.714	2.416	2.197

Table 24 displays the range of electricity costs for lighting, appliances, refrigeration, cooking and water heating for selected cities in California and Hawaii. The ranges are for different usage levels, from 100 kWh and less to 1000 plus kWh, from Typical Electric Bills, 1977 (FPC).

Table 24

Range of Electricity Costs for Selected Cities
in California and Hawaii for Lighting, Refrigeration,
Cooking, and Water Heating, January 1, 1977

<u>CITY</u>	<u>UTILITY</u>	<u>MILL/KWH</u>
Eureka	PG&E	30.5-45.5
Redding	City of Redding Electric Co.	14.6-24.7
San Francisco	PG&E	29.4-40.5
Sacramento	SMUD	18.3-39.5
San Luis Obispo	PG&E	30.6-45.5
Fresno	PG&E	30.2-43.5
Santa Barbara	SCE	37.2-65.5
Bakersfield	PG&E	30.2-43.5
Los Angeles	LADWP	37.2-62.6
Riverside	Riverside Public Utilities	43.3-72.2
San Bernardino	SCE	37.2-65.5
San Diego	SDG&E	42.3-59.0
El Centro	IID	30.9-52.1
Hilo	HELCO	63.5-80.2
Honolulu	HELCO	45.3-80.0
Kahului	Maui Electric Co.	58.6-106.0
Lihue	Citizens Utility Co.	68.9-107.7

8. CAPITAL COST OF SUPPLYING COMPETITIVE GEOTHERMAL FUEL

Geothermal resources will be realized at different costs for each specific location. Some locations will have resources that will be cost competitive with alternative fuels, while others will be marginal, requiring tax incentives to make them competitive with natural gas, fuel oil, coal and uranium.

There are other uncertainties as to the exact character of the geothermal resources in California and Hawaii. The temperatures, depth, chemical composition, and flow rate of resources throughout both states have yet to be assessed. These factors will all have an impact upon the capital costs of development and the operating and maintenance costs once production begins. In light of the vast amount of geothermal resources yet to be assessed, a generic approach will be used to make estimates of the capital costs necessary to develop geothermal energy which will provide heat at a cost competitive with variously priced fuels.

The GEYSER model, developed at SAI, was used to make estimates of the capital costs required. The model was originally designed to calculate the price of a product or return on investment, given the capital and operating costs as well as other economic variables. The model was modified to determine the capital cost requirements given that the competitive cost of energy and required return on investment are known. In this way we can determine approximately the cost limitations of getting a certain amount of BTU's into service. The model was also used to determine the impact of the proposed tax incentives upon the capital cost limitations and the return on investment.

The model was used to determine what the capital costs would be to develop energy at different costs per unit of output. In this case, the cost requirements needed to provide a facility

that would produce 20×10^9 BTU per year were calculated. Table 25 outlines the general economic assumptions used for this analysis.

Table 25

Basic Assumptions For Costing Direct Heat
Applications Of Geothermal Energy

Capital Development Time	1 year
Life of the Investment	20 years
Price of Energy	\$2.20 per million BTU
Volume of Output per Year	20×10^9 BTU
Operating and Maintenance	30% of Yearly Revenues
Depreciation	Double Declining Balance
Debt	50% of Financing
Interest Rate	9%
Depletion Allowance	None
Expense of Intangible	
Drilling Cost	None
Investment Tax Credit	10%
Return on Investment	12%
Escalation Factors	None (Constant Dollars)

The results of the analysis are displayed in Figure 12, which shows a linear relationship between capital costs and price per million BTU's. If the competitive cost of natural gas is \$2.20 per million BTU, a facility generating 20×10^9 BTU per year will have annual revenues of \$44,000. In order to achieve a 12% return on equity (50% of the capital investment is financed by debt at a 9% interest rate), a total capital investment of \$238,574 must be made. The entrepreneur's share of the investment would be \$119,287. An additional \$119,287 would be provided by debt financing.

Figure 12. Capital Costs Associated with Competitive Prices of Alternative Energy (Assuming a 12% Rate of Return, Op. & Maint. Costs = 30% of Yearly Revenue, Producing 20×10^9 BTU's)

9. THE IMPACT OF TAX INCENTIVES

One vehicle the federal government has provided to increase the capital cost limitations for geothermal development is the enactment of tax incentives. The Energy Bill recently passed through Congress provides for three important tax incentives that should have a dramatic impact upon the acceleration of the commercialization of geothermal energy.

The tax incentives include:

1. Percentage Depletion (22% in 1978 declining by schedule to 15% by 1984)
2. Early expansion of intangible drilling costs
3. An additional 10% Investment Tax Credit (totalling 20%)

The tax incentives are retroactive to January 1, 1978. Development activities this year will be able to benefit.

Tax incentives provide for a reduction in the tax liability of the company. The company must be profitable in order to take advantage of the incentives, otherwise there is no benefit. It is a subsidy from the federal government in terms of revenues it will not collect from the developer.

The tax incentives can have a substantial impact on the return on investment, the price of the product, or the capital cost limitations required for development. Following is a description of each incentive.

9.1 DEPLETION ALLOWANCE

The depletion allowance provides for a percentage of total revenues (less royalties) to be written off as an expense,

thus reducing net income before taxes. The impact of the depletion allowance is determined by the effective tax rates. It reduces federal taxes and state taxes in California. Depletion is to the resource what depreciation is to the capital investment. The depletion allowance may not exceed 50% of taxable income.

9.2 INTANGIBLE DRILLING COSTS

While drilling is a capital investment it does not provide a tangible product which has a salvageable value. Allowing the early expensing of intangible drilling costs is effectively a form of accelerated depreciation, allowing for quick recovery of drilling costs. The intangibles may be as high as 70% of drilling costs and include such items as labor, fuel and power, materials and supplies, tool rental, truck and auto hire, repairs to drilling equipment and depreciation upon drilling equipment.

9.3 INVESTMENT TAX CREDIT

The investment tax credit is a direct reduction in tax liability. A 20% investment tax credit allows for 20% of the capital cost of the investment, to be deducted from the tax liability. The amount of ITC that can be used in a given year is limited only by the extent of the tax liability. A company may not have to pay any taxes for several years. If a company has a large tax liability from other operations, it may be able to claim the entire ITC in the first year of operation providing a substantial benefit.

There are different frameworks for evaluating the impact of tax incentives. One view might be to assume that an entrepreneur would be willing to accept a 12% return on investment and that a tax incentive then gives him an extra margin of capital which he might not otherwise risk. Another would be that tax incentives can increase the effective return on investment,

making geothermal energy more profitable and encouraging further development. Another possibility is that the tax incentive could be used to lower the unit energy cost, in which case the benefit could be passed on to the consumer. If the tax break increases the return on investment, the benefit would be retained by the developer. The government might take the view that given the uncertainty as to capital costs (due to varying drilling depths), an additional margin of capital should be invested while assuring that an acceptable return can still be achieved. If a 12% return on investment is a criterion for development, then the capital costs limitation for the developer would be \$216,884 for the example given above. The businessman would not budget more than this amount for development; in fact, he would probably budget much less. If in the course of the development activities he found that it was unlikely that the project could be accomplished for less than this amount, the project might be cancelled. If a 5% return were sufficient, then he could afford to budget \$337,000 for the same endeavor. A private entrepreneur would probably not want to accept such a low return; however, government discount rates are much lower than private enterprise and 5% might be deemed acceptable.

If the entrepreneur cannot accept a lower return, the government can, by utilization of tax incentives, bring about the possible impact of increasing the amount of venture capital the entrepreneur would be willing to invest.

The government is in effect increasing the amount of capital that industry might be willing to venture for geothermal energy. Industry can then develop a larger volume of resources before it reaches the point where it can no longer earn its 12% on the investment. Table 26 displays capital cost limitations for different acceptable returns on investment under the conditions outlined above to produce 20×10^9 BTU per year.

Table 26

Capital Cost Limitation For Rates Of
Return On Investment To Provide 20×10^9 BTU/Yr

(Assumptions Table 25)

<u>RETURN ON INVESTMENT</u>	<u>CAPITAL COST LIMITATION</u>
5%	\$337,224
10%	238,574
12%	263,378
20%	165,351

It can be seen that if a 5% return is acceptable rather than a 10% return, the additional \$98,650 can be allocated towards proving and developing the resource, increasing the capital cost limitation by 41.3%. The impact of tax incentives upon the capital cost limitations is given in Table 27 which follows. For this analysis, it was assumed that the Developer Industry is a large company capable of writing off the tax incentives in the first year of production. The tax liability is not a limiting factor.

Table 27

Impact Of Tax Incentives Upon Capital Cost
 Limitations Of System To Produce 20×10^9 BTU's Per Year

(Assumptions Table 25)

<u>TAX INCENTIVES</u>	<u>CAPITAL COST LIMITATIONS</u>	<u>% INCREASE OVER BASE COST</u>
Base Case (No Incentives, 10% ITC)	\$238,574	--
Depletion Allowance (22% till 1984, then 15%)	314,443	31.7%
Investment Tax Credit (25%)*	346,411	45.2%
Intangible Drilling Cost (50% of Capital)	283,003	18.6%
Depletion, ITC	456,572	91.4%
Depletion, Intangibles	372,998	56.3%
ITC, Intangibles	347,084	45.5%
Depletion, ITC, and Intangibles	457,460	91.7%

*The ITC in the existing energy package is 20% and will go into effect if the bill is signed.

Tax incentives may impact larger companies more favorably than smaller ones. Large companies have greater tax liabilities, spread over many enterprises, while smaller companies may be limited to the immediate geothermal ventures. A large company may be able to claim the entire Investment Tax Credit in a single year, simply because it has a large enough tax liability to accommodate the whole ITC. The larger company then receives its incentive at a faster rate and, depending upon the discount rate, receives a greater benefit. This means that if the larger company wants to pass the tax savings on to the public, it could sell the energy at a lower cost than the smaller company, or if

it prefers to keep the benefit for further exploration and development, it can have more capital available from tax benefit resources. The tables following, 28 and 29, display the impact of the tax incentives under both conditions. The level of tax liability may be a limitation upon the benefit.

Table 28

Impact Of Tax Incentives For A Large Company

<u>Tax Incentive</u>	<u>Cost of Energy</u> <u>\$ per Million BTU</u> <u>(with 12% return on</u> <u>investment)</u>	
BASE CASE	\$2.20	
Depletion Allowance (22%, declining to 15% in 1984)	1.67	24.1%
Investment Tax Credit (25%) *	1.52	30.9%
Expensing Intangible Drilling Cost (50% of Capital)	1.85	15.9%
Depletion Allowance, ITC	1.15	47.7%
Depletion Allowance, Intangibles	1.41	35.9%
Intangibles, ITC	1.51	31.4%
Depletion, ITC, Intangibles	1.15	47.7%

*The ITC in the existing energy bill is 20%.

These large differences in prices are assuming that the company is willing to accept a 12% return on investment and pass the savings on to the market. The large tax incentive in the first year has a dramatic impact when revenues are discounted over time. A dollar benefit in year one is better than a dollar benefit in year two.

In the case of a smaller company that has tax liability limitations, the impact is much more reserved, as displayed in Table 29.

Table 29

Impact Of Tax Incentives Upon A Smaller
Company With A Tax Liability Limitation

	<u>Cost of Energy \$ per Million BTU</u>	<u>% of Reduction</u>
BASE CASE	\$2.20	--
Depletion	2.04	7.1%
Investment Tax Credit (25%) *	2.20	0%
Intangible Drilling Cost	2.14	2.3%
Depletion and ITC	2.04	7.1%
Depletion and Intangibles	2.02	8.2%
ITC and Intangibles	2.15	2.3%
<u>Depletion, ITC, and Intangibles</u>	2.02	8.2%

*The ITC in the existing energy bill is 20%.

Surprisingly, the investment tax credit has no impact. This is because the small company is not able to utilize the existing 10% ITC it already has. The tax liability limitation effectively puts off the ITC for over seven years, at which time it can no longer be claimed. Even if it could be claimed at this time, the tax incentive would only be worth 45% of its initial value after seven years, and then most likely only a small portion could be claimed each year.

10. RECOMMENDATIONS

The market for electric power production in California is adequate to absorb geothermal resources as they are currently projected to come on-line to the year 2000. CERCDC anticipates that an additional 24,000 MWe of installed capacity will be needed by 1995. Utility plans for electric power-on-line include 34,640 MWe by 1995. The estimated geothermal reserves in California are 20,000 MWe. Siting difficulties with alternatively fueled plants have given incentive to plan for more geothermal plants, which can easily be incremented to the energy mix because the lead times before production are shorter and the power plants are smaller. Demonstration of power generation from liquid-dominated resources should further accelerate development activity. Once geothermal energy is proved viable, utilities should plan for more geothermal. Utilities have already displaced existing plans for alternative fuel plants with geothermal.

Recommendation:

DOE support to facilitate the demonstration of liquid dominated geothermal electric power generation until its viability is proven will accelerate development of the resource. Support should include flash, binary and hybrid systems.

Tax incentives in the form of depletion allowance, investment tax credits, and intangible drilling costs write-offs have been included in the existing energy bill. These incentives can have a substantial impact upon lowering the cost of geothermal fuel, increasing the return on investment for a geothermal venture, and increasing the amount of capital which entrepreneurs should be willing to invest. The incentives will have the impact of making many marginal resources economically competitive and in some cases, very competitive. The benefits of the tax incentives should be pointed out to potential industrial users, as well as

the existing developers and utilities.

Recommendation:

Dissemination of tax benefit information to potential beneficiaries with regard to direct heat applications, as well as electric power producers, should have positive effects in accelerating commercial development of the resource.

Six major industries were addressed in the document. Of these, four would appear to be of particular interest:

- 1) Food Processing (a variety of applications)
- 2) Lumber & Wood Processing
- 3) Paper Processing
- 4) Chemical Processing (a variety of applications)

These four industries account for 35% of the purchased fuels and electric energy used for heat and power for industries in California. California leads the nation in the production of over fifty crops and accounts for over 50% of the U.S. production of thirty-six crops. Agriculture and food processing are very important industries in California. Virtually every county in Northern California produces lumber, wood, and paper. The paper and paperboard industry is the fourth largest industry in the country, with the fifth fastest rate of real growth. The chemical industry is the most energy intensive industry, energy accounting for the highest percentage of product cost of any industrial classification. These major industries are prime targets for the use of geothermal process heat and warrant special consideration.

Recommendation:

A DOE-sponsored market analysis of the lumber, wood, and paper industry in Northern California should have positive effects on accelerating resource development.

Recommendation:

A DOE-sponsored study of the chemical industry in California and Hawaii should have positive effects on resource development.

Recommendation:

A DOE-sponsored study of the food processing industry in California and Hawaii should have positive effects on resource development.

Recommendation:

A DOE-sponsored demonstration of direct use applications of geothermal energy in California and Hawaii, with particular emphasis on industrial uses such as the food processing, lumber and paper, and chemical industries should accelerate commercial utilization of the resource.

California contains many industries and many markets. There are fifty-eight counties in California and over 36,000 manufacturing establishments, including over 2,300 food processing establishments, 1,000 lumber establishments, 30 pulp and paper mills, and 1,200 chemical companies. Many of these companies have probably not considered geothermal energy as an alternative. It would be valuable to determine the industrial attitude toward geothermal energy and increase industry's awareness of this energy alternative.

Recommendation:

Sample industrial process heat users to assess attitudes towards geothermal energy and related issues, by authorized marketing research instrument (questionnaire, interview).

The major markets for industrial process heat applications in California center around the San Francisco Bay area and Los Angeles, and other coastal cities. In Hawaii, the Island of Oahu provides the major market. In the case of both California and Hawaii, the proven resources capable of industrial use do not coincide with the urban market locations. Still, there is a great amount of unexplored territory which may hold considerable promise. The Direct Use Overview points to hot springs and geologic characteristics that indicate potential resources which are in the vicinity of the strong urban markets.

Recommendation:

DOE-sponsored exploration and assessment of resources which are located in proximity to major existing markets such as Contra Costa and Los Angeles County in California and the Island of Oahu in Hawaii should have positive effects on accelerating commercialization of the resource.

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APPENDIX A

PURCHASED FUELS AND ELECTRIC ENERGY CONSUMED IN CALIFORNIA COUNTIES FOR SIX MAJOR PROCESS HEAT USING INDUSTRIES (BILLION BTUs)

	<u>Food</u>	<u>Lumber</u>	<u>Paper</u>	<u>Chemical</u>	<u>Oil</u>	<u>Rubber</u>
Alameda	8,068.5	336.8	3,394.6	6,150.7	1,535.4	371.7
Alpine	-	-	-	-	-	-
Amadore	-	271.2	-	-	-	-
Butte	438.7	495.4	-	-	-	12.7
Calaveras	-	18.1	-	-	-	-
Colusa	39.4	-	-	-	-	-
Contra Costa	1,534.4	70.4	2,280.3	3,937.3	39,725.3	48.8
Del Norte	33.4	554.9	-	-	-	-
El Dorado	-	207.6	-	-	-	37.2
Fresno	3,802.5	374.5	166.7	1,034.8	-	74.3
Glenn	282.4	63.5	-	-	-	-
Humboldt	327.2	2,310.2	395.7	-	-	-
Imperial	362.6	-	-	204.4	-	-
Inyo	33.4	-	-	-	-	-
Kern	779.2	75.5	-	325.9	7,332.5	88.6
Kings	459.4	-	-	113.3	3,079.2	159.3
Lake	-	25.8	-	-	-	-
Lassen	-	151.0	-	-	-	-
Los Angeles	31,644.3	3,882.7	16,514.9	30,226.7	73,743.9	6,753.9
Madera	758.5	152.8	-	-	-	10.6
Marin	85.5	-	-	-	-	78.4
Mariposa	-	-	-	-	-	-
Mendocino	93.5	1,116.3	-	-	-	-
Merced	2,437.1	110.3	52.8	-	-	13.2
Modoc	-	53.3	-	-	-	-

Mono	-	-	-	-	-	-
Monterey	2,228.8	34.5	184.7	58.4	-	371.7
Napa	618.9	63.5	-	204.4	-	-
Orange	4,202.5	855.7	4,397.0	6,367.9	1,650.4	1,663.1
Placer	-	280.5	-	-	-	69.0
Plumas	-	299.0	-	-	-	-
Riverside	885.4	691.0	791.4	735.8	-	104.5
Sacramento	2,434.4	510.2	453.7	661.1	-	29.1
San Benito	116.8	-	52.8	438.0	-	-
San Bernardino	1,583.1	373.8	382.0	1,287.1	-	242.6
San Diego	2,973.3	268.9q	317.6	2,047.5	656.9	199.0
San Francisco	3,159.5	136.5	494.9	899.4	-	114.1
San Joaquin	4,350.1	647.4	791.4	869.0	-	99.4
San Luis						
Obispo	101.5	18.1	-	-	410.5	-
San Mateo	2,085.9	103.4	919.1	1,747.3	615.8	631.3
Santa Barbara	1,069.0	39.9	-	-	410.5	37.2
Santa Clara	6,438.6	250.8	1,846.6	2,657.2	410.5	429.6
Santa Cruz	2,185.4	161.1	-	-	-	35.7
Shasta	112.8	974.7	791.4	-	-	10.6
Sierra	-	18.1	-	-	-	-
Siskiyou	46.1	643.8	-	-	-	-
Solano	942.8	54.8	55.9	-	3,079.2	-
Sonoma	1,408.8	516.8	-	-	-	37.2
Stanislaus	6,422.6	179.3	1,086.8	204.4	-	22.5
Sutter	425.3	117.6	-	-	-	-
Tehama	155.6	404.3	395.7	-	-	-
Trinity	-	136.1	-	-	-	-
Tulare	1,149.1	433.7	184.7	-	-	42.3
Tuolumne	-	241.7	-	-	-	-

Ventura	1,197.8	136.5	797.7	210.2	886.8	237.9
Yolo	929.4	321.2	395.7	114.5	-	22.1
Yuba	41.4	221.4	-	-	-	-