DOE/ET/27135--T2

DOE/ET/27135--T2

DE82 012498

# GEOTHERMAL ENERGY:

# OPPORTUNITIES FOR CALIFORNIA COMMERCE

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PHASE I REPORT

DECEMBER, 1981

PREPARED BY:

LAHONTAN, INC.
ALTERNATIVE ENERGY SYSTEMS
1718 - 3RD STREET
SACRAMENTO, CALIFORNIA

ALFRED B. LONGYEAR
PRESIDENT

EDITOR

PREPARED FOR:

CALIFORNIA ENERGY COMMISSION
DEVELOPMENT DIVISION
1111 HOWE AVENUE
SACRAMENTO, CALIFORNIA 95825

JUSTIN N. TIERNEY
CONTRACT MANAGER

LEON G. VANN, JR., MANAGER
OFFICE OF SMALL POWER PRODUCERS

RONALD W. KUKULKA, CHIEF
DEVELOPMENT DIVISION

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

## DISCLAIMER

**This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.**

**DISCLAIMER**

**Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.**

## ACKNOWLEDGEMENTS

This document has been prepared by Lahontan, Inc. for the California Energy Commission under Phase I of Contract 500-80-130. Funding for the contract was made possible through an Energy Commission Cooperative Agreement, Number DE-FC03-79ET27135, with the Department of Energy. Special assistance and overall guidance has been provided by Mr. John E. Crawford, Department of Energy, Program Officer and Ms. Hillary Sullivan, Geothermal Energy Division staff.

The work was performed under the direction of the following California Energy Commission, Development Division, staff: Ronald W. Kukulka, Chief; Leon G. Vann, Jr., Manager of the Small Power Producers Office; Ralph Chandler, Geothermal Program Manager; and, Justin N. Tierney, Contract Manager. Other key geothermal staff that provided technical assistance were: Susan Brown, Andy Coughanour, Michael Smith, Edward Ennis and Davis Hill.

The Lahontan Project Manager was Mr. Alfred B. Longyear, President. Key Lahontan contributors were Mr. Peter Klaussen and Mr. Philip Edwardes. Administrative and publication services were provided by Ms. Judie Houston.

Throughout Phase I, the Lahontan effort was supported by a number of contractors. Their contribution and timely performance made it possible to complete the Phase I objectives. The subcontractors and the principal investigator for each company are: Mr. Frederick A. Tornatore, Energy/Environmental Planner; Mr. A. H. (Monte) Koepf, Koepf & Lange Consulting Engineers; and Mr. Brian Duffy, Pencraft Design Studios, Inc.

## Legal Notice

This report was prepared as the result of work sponsored by the Department of Energy and the California Energy Commission. It does not represent the views of the Department or the Commission, their employees, the United States Government or the State of California. The U.S. Government, Department of Energy, State of California and the Energy Commission, employees, contractors, and subcontractors make no warranty, express or implied; assume no legal responsibility for the information in this report; nor does any party represent that the use of this information will infringe upon privately owned rights.

TABLE OF CONTENTS


| | Page |
|---|---|
| Summary | 1 |
| Introduction | 10 |
| Methodology and Results | 13 |
| Phase I Assessment | 57 |
| Regions & Areas | |
| A. Geysers | 57 |
| B. San Francisco Bay Area | 58 |
| C. Sierra-Cascades | 61 |
| D. Imperial-Desert | 71 |
| E. South Coast | 78 |
| Applications | |
| I. District Heating & Cooling | 84 |
| II. Commercial & Public Facilities | 85 |
| III. Intensive Confined Growing | 86 |
| IV. Waste Processing & Methane Generation | 88 |
| V. Food and Kindred Products | 89 |
| VI. Lumber & Wood Products | 90 |
| VII. Selected Paper Products | 91 |
| VIII. Selected Chemicals & Allied Products | 91 |
| IX. Geothermal Electric Effluent Resource | 91 |
| Conventional Energy Displacement | 92 |
| Recommendations and Conclusions | 95 |
| Bibliography and References | 97 |
| Glossary | 105 |
| Contacts | 107 |

## SUMMARY

This Phase I report assesses the potential geothermal direct-use energy market and its application to projects in California. Project identification effort is to be focused on those that have the highest probability for near-term successful commercial operations. Near-term herein means 2 to 5 years for project implementation. Phase I, of a two phased effort, has been focused on defining and assessing: (a) the geothermal direct-use resources that are suitable for near-term utilization, and (b) the generic applications (municipal heating districts, horticultural greenhouse firms, laundries, etc.) that are suitable for near-term projects.

Phase II will focus on definition and analysis of specific applications at specific sites. Emphasis will be given to near-term projects with the potential for replication over a broad geographic distribution in the state.

The report builds upon prior and recently completed market analyses and surveys. It emphasizes the economic development aspects of direct use projects. In addition to the previously extensively studied industrial sectors, it includes consideration of intensive growing and raising of agricultural products, district heating and cooling and waste processing. Also considered are geothermal power plant effluents as an energy source.

Agriculture is the most important industry sector of application for geothermal direct energy projects. For this study, the generic scope of agriculture includes all growing, raising and processing in the entire food chain, forestry and horticulture. Its importance is based upon:

- Being first or second in its portion of the gross state product (GSP)
- Best fit with most geothermal resources in that the agri-industry process and space conditioning requires low-to-moderate temperatures - geothermal fluids in range of 27 - 150°C (80 - 300°F).
- Agriculture exists in every county and hence has the best chance for co-location with geothermal resources.

- Agriculture has the most need for an economic assist, such as is possible through use of low-cost geothermal energy.

Following closely on agriculture, District Heating and Cooling (DH&C) and its sub sets of related applications is a high priority application. It is necessary for the economic development and use of a hot water energy resource. DH&C, with its multiple applications, permits the orderly use of "cascaded" energy and the consequent full use of a given resource in an optimum economic manner.

The report has been prepared as a reference document for use by the California Energy Commission staff, other state and local agencies, developers of commercial/industrial complexes and energy/utility systems, and local agencies contemplating geothermal development. It should be noted that the relative remoteness of most economic useable sites is a serious detraction that must be compensated for in the economic development associated with the use of this resource.

Five economic development regions in the state, containing recognized geothermal direct-use resources, have been defined. Thirty-eight direct use resources have been evaluated in these regions. After assessment against pre-selected criteria, twenty-seven have been rated with a priority of I, II or III, thereby qualifying them for further marketing effort. The five areas with a priority of I are summarized in Table 1. These areas have no perceived impediments to near-term development.

Twenty-nine generic categories of applications were assessed against previously selected criteria to determine their near term potential for direct use of geothermal fluids. Some twenty industry, commercial and institutional application categories were rated with a priority of I, II or III and warrant further marketing efforts. The seven categories with a priority of I are listed in Table 2. These categories were found to have the least impediments to <u>near-term</u> application projects.

The total results of Phase I are summarized in Figure 1 and Table 3. Figure 1 describes the regions and areas with their priorities. Table 3 lists the generic application sectors and their priorities.

TABLE 1

PRIORITY I RESOURCE AREAS

| Region/Area | Rationale |
|---|---|
| Sierra-Cascades | |
| C-5 Susanville | City of Susanville is the community with the most advanced stage in moderate-to-low temperature developments in California. |
| C-7 Litchfield | Largest direct-use project under construction in California, plus planned industrial development. |
| Imperial-Desert | |
| D-9 Salton Sea Field | Calipatria has pre-zoning, a moderate temperature well, letters for hookup from existing industry and a project initiator. |
| South Coast | |
| E-2 Ontario Hot Springs | Good resource, plus transportation, industry and community services. |
| E-7 Lake Elsinore | Good resource in the city, plus nearby industry and industrially-zoned land. |

TABLE 2

PRIORITY I GENERIC APPLICATIONS

| Application Categories | Rationale |
|---|---|
| I. District Heating & Cooling (DH&C) | |
| 1. Intra-Community Systems | One of two necessary foundations for large scale utilization. |
| 2. Parks of Commerce | The second necessary foundation for large scale utilization. |
| II. Commercial | |
| 1. Retail Sales | These are sub-sets of DH&C that lend themselves to different schemes of implementation such as "mini-districts" and public-assisted financing. |
| 2. Retail Services | |
| 3. Public Facilities | The retail sales and services areas offer the opportunity for significant expansion of a DH&C system through private financing. |
| III. Intensive Confined Growing | |
| 1. Horticultural Products | State-wide growth industry; extremely energy sensitive with peer groups entering geothermal use; world-wide geothermal utilization. |
| IV. Waste Processing & Methane Generation | Use of geothermal heat can double methane yield. Possibility for geothermal cogeneration. San Bernardino demonstration planned. |

# GEOTHERMAL ENERGY

## OPPORTUNITIES FOR CALIFORNIA COMMERCE

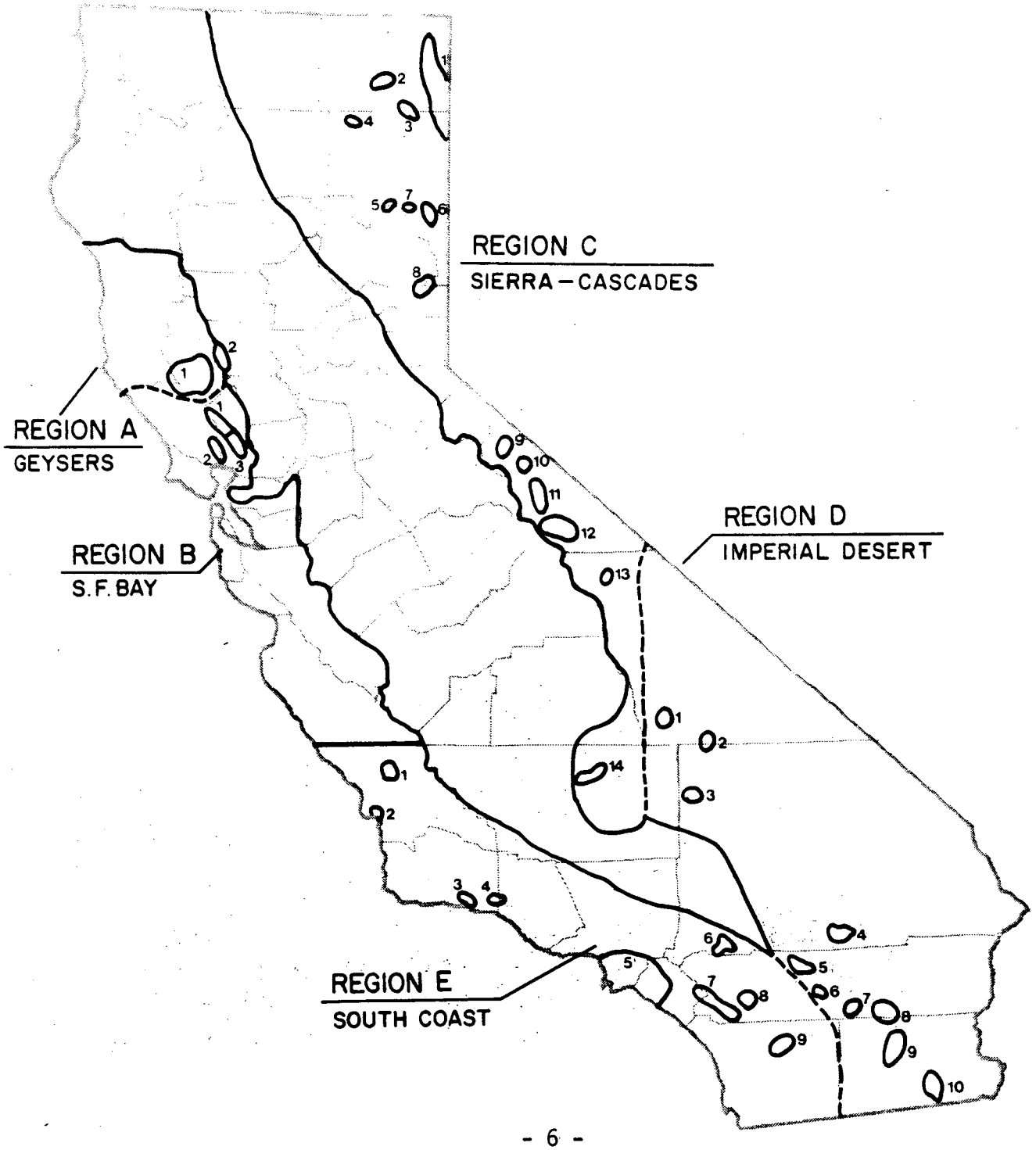

FIGURE I

GEOTHERMAL REGIONS & AREAS

| Regions/Areas | | Priority |
|---|---|---|
| Region A - Geysers | | |
| A-1 | Clear Lake | IV |
| A-2 | Wilbur Hot Springs | V |
| Region B - San Fran. Bay Area | | |
| B-1 | Calistoga | II |
| B-2 | Sonoma-Valley of the Moon | II |
| B-3 | Napa Valley | III |
| Region C - Sierra Cascades | | |
| C-1 | Surprise Valley | III |
| C-2 | Kelley Hot Spring | II |
| C-3 | Likely | III |
| C-4 | Bassett-Kellog Springs | III |
| C-5 | Susanville | I |
| C-6 | Wendel-Amedee | II |
| C-7 | Litchfield | I |
| C-8 | Sierra Valley | II |
| C-9 | Fale's Hot Springs | IV |
| C-10 | Bridgeport | II |
| C-11 | Mono Basin | V |
| C-12 | Mammoth Lakes | II |
| C-13 | Keough Hot Springs | V |
| C-14 | Lake Isabella | II |

| Regions/Areas | | Priority |
|---|---|---|
| Region D - Imperial-Desert | | |
| D-1 | Coso Hot Springs | V |
| D-2 | Trona | II |
| D-3 | Randsburg | IV |
| D-4 | Twenty-nine Palms | III |
| D-5 | Desert Hot Springs | II |
| D-6 | Palm Desert | IV |
| D-7 | Mecca | II |
| D-8 | North Shore | V |
| D-9 | Salton Sea Field | I |
| D-10 | East Mesa Field | II |
| Region E - South Coast | | |
| E-1 | Paso Robles | II |
| E-2 | Ontario Hot Springs | I |
| E-3 | Aqua Caliente | V |
| E-4 | Ojai | V |
| E-5 | L.A.-Huntington Beach | II |
| E-6 | San Bernardino | II |
| E-7 | Lake Elsinore | I |
| E-8 | Winchester Area | III |
| E-9 | Warner Hot Springs | III |

LEGEND

Region Boundary

Indistinct Region Boundard

Geothermal Area

TABLE 3

GENERIC APPLICATIONS AND THEIR PRIORITIES

| | Generic Applications | Priority |
|---|---|---|
| I. | District Heating & Cooling | |
| | 1. Intra-Community Systems | I |
| | 2. Parks of Commerce - Space Htg., Process Energy | I |
| | 3. Small Scale Electric | II |
| II. | Commercial & Public Facilities | |
| | 1. Retail Sales | I |
| | 2. Retail Services | I |
| | 3. Public Facilities | I |
| III. | Intensive Confined Growing | |
| | 1. Horticultural Products | I |
| | 2. Red Meats - Pork & Beef | II |
| | 3. Poultry & Eggs | II |
| | 4. Solid Vegetables | II |
| | 5. Fresh Milk Dairy (including pasteurizing) | II |
| | 6. Aquaculture | V |
| IV. | Waste Processing & Methane Generation | I |
| V. | Food & Kindred Products | |
| | 1. Meat Products | III |
| | 2. Dairy Products | III |
| | 3. Fruit & Vegetable Processing | II |
| | 4. Animal Feed Processing | III |
| | 5. Bakery Products | V |
| | 6. Beverages | IV |
| VI. | Lumber & Wood Products | |
| | 1. Sawmills & Planing Mills | IV |
| | 2. Furniture & Wood Products | II |

VII. Selected Paper Products PAPER PROCESSING

1. Paperboard Containers II
2. Paperboard Mills II

VIII. Selected Chemicals & Allied Products

1. Agricultural Chemicals V
2. Industrial Inorganic (salts) IV
3. Industrial Organic V
4. Plastics, synthetics V
5. Minerals, ground or treated IV

IX. Geothermal Electric

1. Effluent Resource III

## INTRODUCTION

The State of California has more geothermal resources identified to date than any other state in the U.S.[44,52*] A major portion of these are hydrothermal in nature and most suitable for direct utilization of heat energy. Based upon historical and pilot projects currently underway, it is expected that development and use of a significant number of resource sites will be environmentally acceptable and that such projects can be developed in the near term. Extensive utilization of this alternative energy resource will be paced in part, by successful commercial demonstration. Acceleration of such utilization is a goal of the California Energy Commission activities in marketing this resource. This study focuses on identifying those resource sites and those applications that can be combined into near-term direct use projects. For this study, two to five years for project start is considered near term.

This report builds upon prior and recently completed market analyses and surveys[4,7,35,38,75] and emphasizes the economic development aspects of direct use projects.

The nature of geothermal direct energy - a hot water resource - requires an economic development approach[70] to the establishment of the energy supply system. The cost effective requirement for cascading of the hot water energy through multiple applications, either in a large single entity complex or in several individual entities in a "park of commerce" (industrial park), results in a conventional commercial development venture.

In addition to the industrial sector, the report includes consideration of intensive growing and raising of agricultural products, district heating and cooling, waste processing and also considers power plant effluents as an energy source.

---

* Bibliography, References and Contacts Numbers

This form of energy fits well with most agricultural processes; especially with intensive, confined growing of crops and livestock under controlled environmental conditions. Greenhouse operations, confined raising of premium pork, poultry raising and aquaculture are examples. These applications require experienced, high technology personnel and management that has an in-depth knowledge of the business and their product markets. One must caution that this report is not intended to encourage entrepreneurs to enter into a new business and simultaneously to take on the development of a geothermal resource. This form of double jeopardy normally discourages financiers and historically has resulted in numerous business failures.

For near-term development, it has been found that decision making within firms considering alternative energy resource sites is primarily concerned with economic development factors[70] beyond the technical aspects of resource selection.[38]

The marketing of geothermal direct use must be factual and assertive. It must be recognized that the overall geothermal program will be influenced by the current status of the U.S. economy. On the other hand, the relatively low cost of geothermal direct energy combined with the alternative energy financing available through the California Financing Authorities (and other sources outlined in References 86 and 92), plus the alternative energy tax incentives can permit new projects to move forward. The forth-coming de-regulation of natural gas can become a significant forcing function in this area.

For a successful project, an "initiator" person must be responsible for the definition and development of the project. This person must be highly motivated, a problem solver, and be persistent, dedicated and committed (preferrably financially tied by investment, salary or other lock). This all-out commitment is required to assure a sound definition, project focus and the ability to keep the project alive during the startup phase.

This report covers the first phase of a two-phase project. The Phase I effort has been focused on evaluating the direct use geothermal resources in the State and selecting and assessing those generic applications that, when combined with a suitable resource, can become a near-term project. The Phase II effort will be directed to refine the higher priority applications and to identify and define candidate projects.

It should be noted that the effort is focused to select near term opportunities rather than to identify all possible opportunities. It is planned that all raw data in terms of sites and applications considered be filed in the geothermal information center being established at the California Energy Commission, which will permit the extension of this marketing effort as an ongoing activity in support of the longer term opportunities.

The California Energy Commission has a wide variety of energy publications concerning conservation and alternative energy technologies. For a publications catalog, contact:

California Energy Commission
Publications Unit - MS#50
1111 Howe Avenue, Suite 613
Sacramento, CA 95825

To order by telephone, call (916) 920-6216

For further information regarding geothermal direct-use and small scale electric development in California, contact:

Justin Tierney
Geothermal Program
California Energy Commission
(916) 924-2618

## METHODOLOGY AND RESULTS

The purpose of Phase I of this two-phase effort is to identify California's geographic areas and end-use applications with the greatest potential for near-term successful geothermal direct-use development. The results of Phase I are to be used to help focus government and industry development of the State's abundant geothermal resources suitable for direct-use applications. The Phase I effort includes:

- o A literature search and assessment of recent related market analyses.
- o A geographic grouping of potential geothermal direct-use resources.
- o Development of screening and rating criteria and use of them in assessing the potential resource sites.
- o Development of screening and rating criteria and use of them in assessing end-use applications for near-term project potential.

Based upon prior industry contacts and survey efforts,[7,19,38] economic development factors[70] have been emphasized in screening and rating criteria in this report.

In performing Phase I, the state has been divided into economic development regions, geothermal areas and specific sites. Criteria for eligibility as near-term sites were developed and the areas and sites have been assessed against this criteria. An overlay map of the state has been prepared, Figure 1, and field surveys conducted. An aerial photo survey of the areas and most sites was conducted to record the geographic characteristics as well as the location of existing local agribusiness, industry and commerce in the area. State and county agencies were contacted to obtain data on the current economic and institutional posture of the counties containing potential sites.

To identify potential applications, prior market analyses were reviewed and contacts with state agencies and trade associations were initiated. In addition to the Standard Industrial Classifications pertinent for near term, direct-use applications, district heating and cooling,

commercial services, intensive growing of agricultural products and waste processing were added to the applications. Economic development-oriented criteria has been developed and the applications have been assessed in preliminary form. Initially, it was believed that generic applications could be assessed based upon an analytic approach and that matching to potential sites could be conducted during Phase I. For graphic reasons, as well as Phase I limitations in knowledge of all siting requirements for individual industries, assignment of industry to sites or areas is being deferred to Phase II. In Phase I the effort has been focused on the rating of the generic applications and identification of meaningful characteristics to guide the effort in Phase II.

For assistance in the CEC's compliance with the Biennial Report requirements, an estimation of the potential for conventional energy displacement and general trends relating to California's future energy picture has been made. It should be cautioned that such displacement estimates are very sensitive to time and circumstance related factors, such as actual rate of deregulation of natural gas, foreign oil supply rates and prices, the overall health of the economy and cost of financing as well as the relative degree of conservatism of the estimator.

## Geothermal Direct Use Resources

### Regions

The regions have been selected on the basis of grouping pertinent direct use resources in geographic segments that have common economic development conditions. The economic development regions are:

Region A - Geysers - Principally Mendocino and Lake Counties and the Wilbur Hot Springs Area in Colusa County.

Region B - San Francisco Bay Area - Sonoma-Napa counties north of San Francisco, Contra Costa and Alameda counties south to include Monterey and those coast range areas bounded on the east by I-5 and on the west by the Pacific Ocean.

Region C - Sierra-Cascades - From the northern Kern County-Lake Isabella area north, along the eastern side of the Sierra Crest, but west of Coso Hot Springs, including the livestock raising areas in Mono and Inyo counties to the Oregon border, bounded on the west by the Sierra, including Sierra Valley, Lassen Park, Mount Shasta and I-5 to the Oregon border.

Region D - Imperial-Desert - The area east of the south coast region to the Nevada border and north along the eastern side of U.S. 395 up to and including Death Valley National Monument.

Region E - South Coast - San Luis Obispo to San Diego counties, bounded on the east approximately by I-5 and the San Bernardino-to-Santa Rosa Mountains Wilderness Areas.

### Areas

Geothermal direct-use resource areas within each region have been selected for evaluation on the basis of potential near term development. In general terms, the selected areas will have identified or authoritatively projected resource characteristics that meet or exceed the following energy supply criteria that emphasize cost effectiveness.

1. Reservoirs with fluid temperatures of greater than 50°C (122°F). Preferred temperatures are greater than 60°C

(140°F); however, heat pumped systems can operate at lower temperatures for certain applications. Currently the IRS will not grant tax incentives for fluids below 50°C or for the use of heat pumps. However, a commercial greenhouse production of seedling conifers for reforrestation has operated successfully using a 28°C (83°F) geothermal resource. Fluid temperatures in the range of 27-38°C (80-100°F) can be used for convective heating, sewage pond heating, etc. This is especially true if these low temperature fluids are at the bottom end of a cascade. However, one must recognize that these lower temperatures require larger heat exchangers (increasing capital cost) for a given thermal load. A site with low temperatures would not be able to be cost competitive with a site that has fluids above 50°C and can offer the tax advantages and have lower capital and operating costs.

2. Well depths of less than 760m (2,500 ft.). Preferred well depths are 460m (1,500 ft.) or less, which permits use of more conventional water well drilling equipment.
3. Geothermal fluid total dissolved solids of less than 5000 ppm. It is desirable that fluids contain less than 1000 ppm and are of agricultural quality for consumption or surface disposal. Primary heat exchangers will probably be required for fluids having over 4000 ppm.
4. Resource/well sites less than 1.6 km (1 mi.) distance from a potential or actual application site.
5. Short term local permitting process. Exploratory well actual permitting of less than 90 days and total project actual permitting of less than 9 months.

Communities contemplating development of nearby resources should recognize that the above criteria can already be met by a number of geothermal areas. Hence, those communities not meeting one or more of these criteria will not be competitive in terms of cost of development/price of energy, attraction of industry users and state support.

The potential areas have been further assessed against the following economic development factors[70]:

1. Proximity to an adequate labor base. This implies a population center with trainable, employable personnel in quantities adequate for potential end users.
2. Adequate transportation in terms of truck routes, air freight terminals under 100 miles distance and/or, to a lesser extent, rail services. Distances of over 100 miles from major markets, trade centers or distribution centers is a serious site limitation. Remoteness of most resources requires an energy pricing tradeoff with the added transportation costs.
3. Proximity to community services. The resource site falls within a reasonable response time for police and fire protection, hospital services, utilities including adequate consumptive or process water supplies, employee training facilities, etc. These are typical community services expected by commercial, industrial or agri-business firms when siting a new facility.[38,70]
4. Local sources of raw materials, such as crop lands capable of competitive production of crops that will be consummed or processed by the application entity, timber for sawmill operations, solar insolence (sunlight) for greenhouses, feed crops for livestock and dairies.
5. For district heating, an adequate, concentrated heating (or cooling) load in excess of 400,000 therms/yr. Preferrably the annual load should be 600,000 therms or greater. The lower the district heating load the more important the commercial/industrail load becomes.
6. For energy-sensitive applications, reasonable utility rates for electricity, water and sewer are required. The geothermal supply system must be designed and operated to assure a non-interruptible supply of heat.
7. Competitive reasonable land costs for new plant sites.
8. A favorable business climate and community attitude, with local

government institutional capacity that is conducive to the development of both the resource and the applications' facilities.

9. Attractive living conditions (e.g., housing, shopping facilities, schools, medical facilities) and recreational opportunities.
10. Local financial institutions with the ability to develop competitive financing and/or service the project financing that is developed at major financial centers. These are at least branch banks or branch savings and loan facilities.
11. Other regional and site specific factors that can affect economic development decisions. A by-product stream from an existing plant that could be used to attract a new plant is a positive factor. An otherwise attractive resource that topographically may have very limited areas for siting of a user facility is a negative factor.

These factors are relative from area to area. When applied to specific sites, they are a measure of that sites' relative competitive position with other sites.

In assessing the candidate areas, a factor is rated "+" if it is fulfilled or in place at the specific site. If the factor does not exist in the area or is significantly deficient, it is rated "--". If data on a factor for a site is not available or if the data are somewhat marginal, the factor is rated "0".

After all areas were assessed using the criteria and economic development factors, the areas were tabulated and an overall priority rating assessed. This priority rating reflects the +, --, 0 ratings, relative importance of specific factors, specific knowledge of the area and any overriding factors. The ratings were reviewed by CEC and other state agency staffs and a conference convened to discuss the findings. The current priority ratings reflect this review process. Data for each site were obtained from literature, cognizant state agencies, local governmental entities, site visits and the aerial survey.

## Rating of Areas

The following charts identify the areas by regions, their location by county and the pertinent wells and springs using the county code numbering system of the California Division of Mines and Geology Geothermal Resources of California Map, 1980.[30] The highest published temperature source up to 150°C (300°F) is listed. Temperatures listed at variance from the CDMG Map have been obtained from more recent sources of data. It is expected that sources at temperatures above 150°C will be reserved for electric power generation and that, at best, direct use applications will be able to utilize such sources only as a cascade from the power plant. This is most likely to be possible, initially, in the Imperial-Desert or Geysers Regions. To date there have been institutional impediments to such utilization. The range in well or resource depths is listed. The highest published brine content in terms of parts per million of total dissolved solids is listed. In most cases the DMG Map is the data source. The economic development factors are rated with +, -- or 0 as explained above. Comments regarding specific limitations, assets or required mitigating actions are included. Finally, as explained above, an overall rating from "I" to "V" is given, with a "I" being a top priority resource in general terms without special considerations for specific applications.

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS



| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. Geysers Region | | | | | | | | | | | | | | | | | | |
| 1. Clear Lake | LK 8-24 (except LK9) | 150 (302) | 424 (1391) | 385-3000 | + | — | + | 0 | 0 | 0 | — | — | + | + | — | yes | Potential exists for cascading from electric generating facilities planned for area. Historic institutional barriers. | IV |
| 2. Wilbur Hot Springs | CO 2-7 | 61-69 (142-56) | N.A. | 25,000 to 28,900 | — | — | — | — | — | 0 | + | + | — | — | + | yes | Community attitude in the immediate Wilbur Hot Springs towards geothermal use other than spa/medicinal uses has been negative in the past. | V |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B. San Francisco Bay Region | | | | | | | | | | | | | | | | | | |
| 1. Calistoga | NA 3-6 | 24-137 (75-280) | 46-350 (151-1148) | 660-710 | + | + | + | 0 | + | 0 | — | 0 | + | + | — | yes | Historical use for space heating and health spas. Desire wine processing. Heating district for city has potential. Permitting can be lengthy. | II |
| 2. Sonoma - Valley of the Moon | SN 7-13 | 21-46 (70-115) | 91-(298) | 260-650 | + | + | + | 0 | + | 0 | — | 0 | + | + | 0 | yes | Although temperatures are<50°C(122°F), the resource is generally at shallow depths and well situated for co-located applications. Desire wine related applications. Resource is in basic exploratory phase of development. | II |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS



| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3. Napa Valley | NA 9-19 | 21-36 (70-97) | 5-184 (16-604) | 355-700 | + | + | + | 0 | + | 0 | — | 0 | + | + | — | yes | Although temperatures are<50°C(122°F), the resource is generally at shallow depths and well situated for co-located applications. Community no-growth attitude in general, but some benign, acceptable applications (i.e. space conditioning, wine processing, agricultural uses,etc.) may be of interest. | III |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. Sierra-Cascades | | | | | | | | | | | | | | | | | | |
| 1. Surprise Valley | MD 4-18 | 25-198 (77-208) | 12-194 (43-636) | 260-1210 | 0 | — | — | + | — | + | + | + | 0 | — | + | yes | A 160°C (320°F) well at a depth of 1508 M (4948') exists in this area and could be available for use (MD-8). A CEC-sponsored geothermal assessment project is in progress at the Ft. Bidwell Indian Reservation. | III |
| 2. Kelley Hot Spring | MD 30-33 | 27-166 (81-240) | 1035 (3400) | 900 | — | + | — | + | — | + | + | + | 0 | 0 | + | yes | A 116°C (240°F) well at a depth of 1035 M (3400') exists in this area and could be available for use (MD-33). Archeological restrictions. Greenhouse in operation. Available wells. | II |
| 3. Likely | MD 23-26 | 24-77 (75-171) | 38-62 (125-203) | 230-1220 | — | + | 0 | + | — | + | + | + | 0 | — | + | yes | Fertile valley. Very small community. | III |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. Sierra-Cascades (Continued) | | | | | | | | | | | | | | | | | | |
| 4. Basset-Kellogg Springs | LS 3-4 | 78-79 (172-174) | N.A. | 820-880 | — | + | 0 | + | — | + | + | + | 0 | — | + | yes | Also known as the Big Valley area Cattle and timber are major industries in this large area of forests and fertile ranch lands. | III |
| 5. Susanville | LS 6-13 | 27-63 (81-145) | 42-190 (138-623) | 230-690 | + | + | + | + | + | + | + | + | + | + | + | yes | City of Susanville has ongoing geothermal energy projects, including district heating & parks of commerce. | I |
| 6. Wendel-Amedee | LS 17-22 | 28-107 (82-224) | 92-334 (305-1096) | 280-1040 | 0 | + | — | + | + | + | + | + | — | + | + | yes | Current site of geothermal-heated greenhouse - 25 mi. east of Susanville | II |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. Sierra-Cascades (Continued) | | | | | | | | | | | | | | | | | | |
| 7. Litchfield | LS 14 | 82 (180) | 447 (1440) | 241 | + | + | 0 | + | + | + | + | + | 0 | + | + | yes | Largest direct-use project in California under construction. Successful well drilled and tested. CEC is sponsoring design phase. Construction funds authorized by State Legislature. Cascading of geothermal fluids to a Park of Commerce is planned. Resource data presented is from recent U.S. Bureau of Reclamation investigations. | I |
| 8. Sierra Valley | PL 10-19 | 28-93 (82-199) | 7-335 (23-1099) | 190-1600 | 0 | + | 0 | + | — | + | + | + | 0 | 0 | + | yes | Undeveloped fertile valley, ranching. | II |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. Sierra-Cascades (Continued) | | | | | | | | | | | | | | | | | | |
| 9. Fales Hot Springs | MO 4-5 | 38-82 (100-180) | 126 (413) | 1230-4390 | — | + | — | 0 | 0 | 0 | + | + | — | — | + | yes | For sale on U.S. 395, 6 mi. from Marine Base. | IV |
| 10. Bridgeport | MO 6-9 | 45-82 (113-180) | 300 (984) | 1230-4390 | 0 | + | + | + | + | — | + | + | 0 | + | + | yes | Feasibility study under way in area for heating district and possible small electric-generating capabilities. | II |
| 11. Mono Basin | MO 12-18 | 31-86 (88-187) | 743-1220 (2437-4002) | 1600-25,000 | — | + | 0 | 0 | — | — | 0 | + | — | — | + | yes | Limited private land mostly owned by federal government and the City of Los Angeles. Area around and south of Mono Lake was purchased by L.A. to acquire and protect water rights for its aqueduct system. | V |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. Sierra-Cascades (Continued) | | | | | | | | | | | | | | | | | | |
| 12. Mammoth Lakes-Long Valley | MO 11-30 | 22-178 plus (72-352) | 324 (1063) | 510-1700 | 0 | + | + | + | + | — | — | + | + | + | 0 | yes | District heating in the town of Mammoth Lakes has been proposed for several years. Energy companies have been active in area exploring geothermal resources for electrical generation. This area is considered environmentally sensitive with institutional barriers. Tourism-oriented. USGS has projected an extremely large potential geothermal resource. | II |
| 13. Keough Hot Springs | IN 1 | 51 (124) | N.A. | 510 | + | + | — | + | — | — | — | 0 | — | + | — | yes | Limited private land is available in area. Most land is federal or City of Los Angeles ownership. | V |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. Sierra-Cascades (Continued) | | | | | | | | | | | | | | | | | | |
| 14. Lake Isabella Area | KR 1-6 | 44-56 (111-133) | N.A. | 420 | + | 0 | + | 0 | 0 | – | + | + | 0 | + | + | no | Retirement/residential and cattle grazing area. Major resource site of Lake Isabella is located near commercial residential and institutional application sites. High potential for new application sites adjacent to resource (KR-2). | II |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. Imperial-Desert | | | | | | | | | | | | | | | | | | |
| 1. Coso Hot Springs | IN 10-12 | 97 (107) | N.A. | 2500 | – | + | – | – | – | 0 | + | + | – | 0 | + | no | Remote desert with very limited population. Energy companies are currently exploring area's geothermal resources for potential electrical generation. Private land is limited in area due to federal ownership. Resources presently identified are located on U.S. Navy withdrawn property. Eventually power plant cascade for military applications. | V |
| 2. Trona | IN 14-16 | 33-58 (91-136) | 91-183 (298-600) | 230-53,900 | + | + | + | + | + | 0 | + | + | 0 | + | + | yes | The Kerr-McGee chemical facility has investigated the use of the area's geothermal resources. Potential Kerr-McGee projects. | II |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. Imperial Desert (Continued) | | | | | | | | | | | | | | | | | | |
| 3. Randsburg | SB 4 | 116 (241) | 236 (774) | N.A. | — | + | 0 | + | — | 0 | + | + | — | — | — | no | Remote desert community once a prosperous mining area, now inactive. Mineral application, if any. KGRA leases have been recently sold. Not near term. | IV |
| 4. Twenty-nine Palms | SB 15-17 | 53-63 (127-145) | N.A. | 700-1000 | + | 0 | + | — | — | 0 | + | + | 0 | + | 0 | yes | Small desert community on extreme eastern edge of the rapidly growing Yucca Valley region. Major military training base north of town. | III |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. Imperial-Desert (Continued) | | | | | | | | | | | | | | | | | | |
| 5. Desert Hot Springs | RV 65 | 93 (199) | 101 (331) | N.A. | + | + | + | 0 | + | 0 | — | + | + | + | + | yes | More than 50 hot water wells are known in area. Temperatures range from 35° to 70°C (95° to 158°F) at depths of 30 to 75 meters (98 to 246 feet). Predominant use is for spas. Feasibility studies completed. Heating/cooling district determined not economic at this time. Need initiator. | II |
| 6. Palm Desert | RV 32 | 83 (181) | 109 (358) | 290 | + | + | + | — | + | + | — | 0 | + | + | 0 | yes | Generally wealthy residential/resort community near Palm Springs. Industrial development would be difficult, considering its resort nature. Indications from CDMG that temperature data for RV-32 are grossly overstated and actual temperature is in 20°-25°C(68°-77°F) range. | IV |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. Imperial-Desert (Continued) | | | | | | | | | | | | | | | | | | |
| 7. Mecca | RV 33 | 32 (90) | N.A. | 190 | + | + | 0 | 0 | — | + | + | + | — | + | + | yes | Both horticulture and aquaculture activities using geothermal resources have recently located in this area. Temperatures identified are low, but shallow. | II |
| 8. North Shore/ Fountain of Youth Resort | RV 66-67 IM 20-23 | 60-82 (140-180) | 75-192 (246-630) | 2920-4670 | — | + | — | — | — | 0 | + | + | — | 0 | — | yes | Recreational-vehicle oriented spas occur in this area. There has also been unsuccessful attempt at aquaculture using geothermal resources. Failure was business related rather than geothermal. | V |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. Imperial-Desert (Continued) | | | | | | | | | | | | | | | | | | |
| 9. Salton Sea Field | IM 34-51 | 38-360 (100-680) | 46-2470 (151-8102) | 1600-390,000 | + | + | + | + | + | 0 | + | + | 0 | + | + | yes | Much of the geothermal resource in this area is deep and high in TDS. Active exploration by energy companies is occurring throughout the area and several power plants are planned. Recently, a comprehensive environmental document was completed on the Salton Sea KGRA geothermal overlay. The community of Calipatria is currently attempting to become part of the geothermal overlay zone. 82°C (180°F) well (depth unreported) in city, very positive attitude. | I |

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. Imperial-Desert (Continued) | | | | | | | | | | | | | | | | | | |
| 10. East Mesa* | IM 135 142 | 33-202 (91-396) | 46-2426 (151-7957) | 2080-3280 | + | + | 0 | + | 0 | 0 | + | + | — | + | — | yes | | II |

Most of the area is under federal ownership and leased to energy companies which are exploring and developing the resource for electrical generation. Their explorations of the East Mesa reservoir have brought in resources with 2,000 to 50,000 ppm TDS at 190°C+ (374°F+). Area west of E. Highline Canal ready for project, power plant cascade is potentially available.

* In addition to the East Mesa and Salton Sea KGRAs, there are several other KGRAs which are experiencing geothermal exploration and development activities. These include the Westmorland, Brawley and Heber KGRAs and an ongoing space conditioning project in the City of El Centro. Many agribusiness projects have been proposed for these other geothermal resource areas, but none are as yet on-line. The Brawley KGRA is the site of a 10 MW power plant, the only fully-operational geothermal power plant in Imperial Valley.

These areas outside of the East Mesa and Salton Sea KGRA generally did not meet the rating criteria for direct-use applications primarily due to very deep well depths and high salinities. However, the possibility of cascading from the Brawley 10 MW or another power plant should not be discounted as a near-term direct use.

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E. South Coast Region | | | | | | | | | | | | | | | | | | |
| 1. Paso Robles | SL 1-8 | 31-47 (88-117) | 122-316 | 630-2300 | + | + | + | 0 | + | 0 | 0 | 0 | + | + | 0 | yes | Although geothermal temperatures are low in this area, the resource continues to be utilized for applications which only need low temperatures. | II |
| 2. Ontario Hot Springs | SL 12 | 57 (135) | 14 (46) | 815 | + | + | + | + | + | 0 | + | 0 | + | + | 0 | yes | Oil shipping/storage facility, good transport, needs initiator. | I |
| 3. Aqua Caliente | SA 12 | 56 (133) | N.A. | 690 | — | — | — | — | — | 0 | 0 | 0 | — | 0 | — | yes | Very isolated in rugged mountains of the Los Padres National Forest north of Santa Barbara. | V |
| 4. Ojai | VN 4-7 | 39-51 (102-124) | N.A. | 250-7770 | 0 | — | — | — | — | 0 | 0 | — | 0 | + | — | no | Relatively isolated in the rugged mountains of the Los Padres National Forest northwest of Ojai. | V |

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E. South Coast Region (Continued) | | | | | | | | | | | | | | | | | | |
| 5. Los Angeles - Huntington Beach | OR 3-7 | 36-218 (97-424) | 2777 (9109) | N.A. | + | + | + | + | + | + | — | + | + | + | — | no | Hot water discoveries in this area were in conjunction with oil drilling OR-3. High temperature of 218°C at 2777 meters (424°F at 9108 feet). Division of Mines and Geology recently completed a survey of oil wells in Los Angeles and has identified a large number containing hot water of sufficient quantity for direct use projects. Salinities high: 25,000-30,000 ppm. Institutional barriers to geothermal direct-use may exist. Permitting agencies in this large metropolitan area historically accept and process required environmental and permitting information at a slow rate. Needs initiator. | II |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E. South Coast Region (Continued) | | | | | | | | | | | | | | | | | | |
| 6. San Bernardino | SB 23-36 | 38-90 (100-194) | 42-297 (138-974) | 300-1150 | + | + | + | + | + | + | — | + | + | + | 0 | no | The City of San Bernardino Water District has completed drilling for geothermal waters to be used in its sewage treatment facility. It is also initiating a heating district study in south part of city. Both studies are CEC sponsored. City lacks in-house expertise. | II |
| 7. Lake Elisinore | RV 14-25 | 52, 56 (126), (133) | N.A. | 300, 750 | + | + | + | + | 0 | + | 0 | + | 0 | + | 0 | yes | RV-14 is located near the center of the town of Lake Elsinore, a residential/resort community with several spas. Needs initiator. | I |

TABLE 4 - RATING OF GEOTHERMAL RESOURCE AREAS

| GEOTHERMAL DIRECT-USE REGIONS AND AREAS | COUNTY CODE NUMBERS | TEMPERATURES °C (°F) | DEPTH IN METERS (FEET) | TOTAL DISSOLVED SOLIDS (MG/LITER) | LABOR BASE | TRANSPORTATION | COMMUNITY SVCS. | RAW MATERIALS | HEAT LOAD | UTILITY RATES | LAND COSTS | BUSINESS CLIMATE | LIVING CONDITNS | FINANCING | PERMITTING | PHOTOGRAPHS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E. South Coast Region (Continued) | | | | | | | | | | | | | | | | | | |
| 8. Winchester | RV 15-20 | 25-29 (77-138) | 5-40 (16-131) | 470-2260 | + | + | — | 0 | 0 | 0 | — | + | 0 | + | — | yes | Zoned large parcel agriculture. "Horse country", expensive land costs. Greenhouse siting potential. | III |
| 9. Warner Hot Springs | SD 4 | 59 (138) | N.A. | 350 | 0 | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | + | yes | Extensive redevelopment of the Warner Hot Springs resort spa is planned. A large subdivision and recreation project is planned. The developer intends to maximize use of geothermal resources present. | III |

## Applications

The applications have been selected primarily on the basis of their fit with geothermal direct use energy and their potential for near-term application. First, prior studies were screened for candidates.* The industry selections in the previous geothermal marketing studies have concentrated on businesses that are quantified under the Standard Industrial Classification codes, that are energy sensitive and potentially compatible with geothermal direct use. The industries selected from the prior studies have been screened to exlude: high temperature applications, industries with limited opportunities in California, and industrial processes that have a low energy sensitivity.

Additional applications that do not have an SIC code designation, but that are pertinent to geothermal direct use have been included. These include: Heating Districts for heating and cooling of buildings; intensive (confined) growing of horticultural, solid vegetable and livestock products; waste processing for municipal, agricultural and food products wastes; small scale electric power plants (<10MWe); and commercial services; i.e., laundries, cold storage facilities, ice plants, motels, retail sales outlets, office buildings, hospitals and public facilities, etc.

Where a resource has temperatures in the range of 120°-150°C (250°-300°F) small scale electric - "well head generators" - have been considered as a thermal load. This is emerging binary-cycle technology that can be considered,especially where a summer thermal load is required. These systems, to be cost effective, will most likely require a cascaded thermal load downstream of the generator - a heating district and/or park of commerce.

Aquaculture has been extensively considered for direct-use geothermal. A number of research and prototype installations are in operation. Trout hatcheries in Idaho and California are using some geothermal fluids.

---

*Ref. 1-4,7,9-20,22-25,28,31,35-40,43,45,51,54,57,58,60,65-69,71-73,75, 82-85,88,89,91.

A commercially successful catfish farm is using a very unique artesian resource at Buhl, Idaho. However, the owner has stated that if he had to depend on pumped fluids, he would not be able to stay in business. Flow through his very congested, commercial scale ponds is by gravity from his artesian flow from a unique elevated resource. The technology for geothermal aquaculture is still emerging, requiring a very high degree of experience and expertise to operate a commercial scale business. There is a very high business mortality rate (75%) in the U.S. in certain sectors of aquaculture (catfish farms). Relative to solid vegetables and other intensive agriculture, the markets for aquaculture products are emerging at best, hence replication can be limited by markets and lack of experienced, professional management personnel. It is estimated that the resources that would qualify for raising edible aquaculture products will be limited in number and location. These factors would indicate a low priority for aquaculture as a near-term application.

There have been numerous propositions for the use of geothermal energy for the production of fuel grade alcohol (ethanol and methanol). However, the market is heavily government regulated and controlled. It is an undeveloped market in the U.S. and major firms are closing down production facilities. The technology for low cost alcohol production is not widely accepted as a commercial venture. Hence, alcohol production has not been included in this project for near-term applications.

District heating and cooling warrants special consideration, in that these systems reflect the organized development and use of geothermal direct-use energy on a commercial scale. These systems are required for efficient and economic use of the resource through cascading. Most PRDA and PON studies[65-69] have indicated the need for a commercial or industrial load to make heating districts cost effective. Results of prior industry surveys[7,19,38] indicate a general reluctance on the part of business executives to participate in utility systems exploration and development, along with their branch plant expansion. Rather,

a preference was stated for "hooking up to a meter" provided the energy was incentively priced and non-interruptible service could be assured. This leads one to the heating district concept for an organized utility approach. District heat loads should be on the order of 600,000 to 1,000,000 therms/year or greater to commercially support energy supply and distribution system development. This category of application is therefore special and automatically warrants a priority rate of I.

Spas have not been given enough priority to be considered for near-term commercial ventures by themselves. The mortality rate in this business does not warrant adequate priority. Again, professional, experienced management with adequate financing and a sound, multi-state marketing effort would be required to properly develop and operate a commercially successful spa. Also, it should be noted that tourism requires about 1000 visitor days per single full time employee; hence, a large scale enterprise is required to cause a significant economic impact that warrants local community support.

The generic application sectors considered as candidates for near-term direct-use are:

I. District Heating & Cooling
   1. Intra-community systems
   2. Parks of Commerce (agri-business and industrial parks, either separate or contiguous to a community.
   3. Small Scale Electric (binary cycle) as part of a district heating load.

II. Commercial & Public Facilities
   1. Retail Sales
   2. Retail Services
   3. Public Facilities

III. Intensive Confined Growing
   1. Horticulture - cut flowers, potted plants, plant materials and seedling conifers

2. Red Meats
3. Poultry and Eggs
4. Fresh Milk Dairy
5. Solid Vegetables (cucumbers, tomatoes, fruits, etc.)

IV. Waste Processing & Methane Generation
1. Animal Wastes (including rendering)
2. Food Process Wastes
3. Municipal Wastes

V. Food and Kindred Products (SIC 20)
1. Meat Products (201)
2. Dairy Products (202)
3. Fruit & Vegetable Processing (203)
4. Animal Feed Processing (204)
5. Bakery Products (205)
6. Beverages (208)

VI. Lumber & Wood Products (SIC 24)
1. Sawmills & Planing Mills (242)
2. Furniture & Wood Products (251)

VII. Selected Paper Products (SIC 26)
1. Paperboard Containers & Boxes (265)
2. Paperboard Mills (263)

VIII. Selected Chemicals & Allied Products (SIC 28)
1. Agricultural Chemicals (287)
2. Industrial Inorganic Chemicals (281)
3. Industrial Organic Chemicals (292/286)
4. Plastics, Synthetics (286)
5. Minerals, Ground or Treated (329/327)

IX. Geothermal-Electric Effluent Resource

Applications Rating Criteria

The generic applications have been screened against a set of criteria designed to be used in selecting those applications most likely to be near term. Data on all viable generic applications should be

maintained in the CEC geothermal information center for longer term followup. The ratings have been summarized in an overall rating of I to V, to be used in focusing and prioritizing the Phase II and subsequent CEC activities. The ratings were developed and applied in a manner similar to that used for the geothermal resources. These ratings should only be used as a guide. Any established business that has a sincere, expressed desire to convert to alternative energy sources should become a rating of "I". The rating criteria used in this project are as follows for Phase I:

Economics - Overall economic outlook for the generic business in California; e.g., projected relative strength of the product or service market and ability to resist pressures from intrastate, interstate and international competitive forces. Applications were assessed, relative to other applications, for this factor in terms of rate of growth of the generic industry, extent of and stability of the market.

Energy Sensitivity - The energy sensitivity of the business in terms of energy supply impacts on business operations and energy cost impacts on product costs including seasonal factors (see Glossary).

Replication - Potential for transfer of the technology and economics of an application project to other potential sites with similar applications - both within the generic business sector as well as for a broad geographic distribution within the state. Greenhouse operations can fit many resource sites throughout the state; hence, this sector would have a high replication factor. Sugarbeet processing is in a shrinking U.S. market and there are only one or two sites suitable for plants; hence, this sector would have a low replication factor.

Geothermal Compatibility - The degree of fit between the overall energy needs, by quality and quantity, of a generic business and that portion that can be supplied by geothermal direct energy (below 150°C (300°F). This is an important aspect of application matching to geothermal areas.

Economic Development - Economic development factors (adequate labor supply, raw material supplies, transportation and competitive distances to market/distribution centers, permitting factors, municipal services, etc.) as needed by each generic application, which can constrain site selection.

Historical Use - Historical and current use of geothermal in the generic business (throughout the world).

Branch Plants - Potential and propensity within the business sector to expand through new branch plants, or a willingness to locate new facilities on geothermal sites that are otherwise satisfactory for the business.

Overriding Factors - Traditional, intra-industry practicies; i.e., plant size limits, specific market constraints, growth trends elsewhere in U.S., etc., as overriding factors. These can be positive or negative factors or not applicable (N.A.).

## Rating of Applications

The following charts identify the applications by category and sub-category. The temperature factor defines the required geothermal fluid temperature (1) or the process or environment temperature (2) or range in temperatures as required by the application. This factor is stated in general terms from published data and will vary for specific applications. Note: Most resource temperatures can be increased through heat pumps. However, a site- and application-specific analysis would be required for considering such use. At this time, the IRS does not grant tax incentives to the use

of heat pumps. Hence, heat pumps are not considered further in this more generic phase of the Project. The economic development and siting factors are assessed in +, --, 0 ratings and an overall priority rating from I through V is given in a manner similar to that used to rate the resources. A "+" indicates that the economy (product market) is growing, the process or product is energy sensitive and hence needs a reliable, low cost source of energy, the process lends itself to many sites in California, that there are no unusual economic development requirements for installing the application at most sites, that there has been some demonstrated commercial use of geothermal in the application somewhere in the world and that there are no overriding negative factors. Such an application would rate a priority of "I".

A "--" indicates the factors would be negative or opposite to the positive factors described above, and the application would receive a priority of "V". A "0" would indicate that there were some limitations in the factors bearing the "0" rating. Priorities were assessed by an overall review considering the number of "+" or "--" ratings and in particular special overriding factors.

TABLE 5 - RATING OF APPLICATIONS



| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I. District Heating & Cooling | | | | | | | | | | | |
| 1. Intra-Community Systems | 60-91°C (140-195°F) (1) | 0 | + | + | + | 0 | + | N.A. | N.A. | Municipal systems have sensitive economics Require commercial industrial load. | I |
| 2. Parks of Commerce | | | | | | | | | | | |
| Space Heating | 60-91°C (140-195°F) | + | + | + | + | + | + | + | 0 | Immaturity of resource can slow large development financing. | I |
| Process Energy | 43-121°C (110-250°F) (1) | | | | | | | | | | |
| 3. Small Scale Electric | >82°C (>180°F) (1) | 0 | + | + | + | + | — | N.A. | + | Economic systems may still require fluid temperatures >121°C (>250°F). Emerging technology must be demonstrated to be economic in order to be "near term". Overall interest in these systems is increasing. | II |

TABLE 5 - RATING OF APPLICATIONS



| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| II. Commercial/Public Facility | | | | | | | | | | | |
| 1. Retail Sales<br>2. Retail Services: Laundry, car wash, etc. | 24 (75)<br>82 (180)<br>(2) | + | — | + | + | + | + | 0 | N.A. | Same as Community District Heating. | I |
| 3. Public Facilities | 24 (75)<br>(2) | + | — | + | + | N.A. | + | 0 | N.A. | Assumes existing heating system is backup and geothermal is retrofitted. | I |

TABLE 5 - RATING OF APPLICATIONS



| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| III. Intensive Confined Growing | | | | | | | | | | | |
| 1. Horticultural Products | 15-24 (60-75) (2) | + | + + | + | + | + | + | + | + | 3 firms have branch plants near Salton Sea for geothermal application. High temp can be used for cold storage. Highest priority industry. Requires redundancy or other backup. | I |
| 2. Red Meats | 18-39 (65-120) | + | + | + | + | + | 0 | 0 | 0 | Premium fresh pork, energy failure affects quality; however, energy is approaching 30% cost of sales. Industry is slow to change. Large, growing market. Agri-engineering and economic analysis of sheltered feed lots heated with geothermal indicate benefit to cattle feeding. | II |
| 3. Poultry & Eggs | (2) | + | + | 0 | + | 0 | + | 0 | N.A. | Energy sensitive in cold climates. | II |
| 4. Solid Vegetables | 88-121 (190-250) (1) | + | + | + | + | + | + | + | 0 | Confined market periods for tomatoes; emerging market for European cucumbers; growers tend to be smaller operations than horticulture. | II |
| 5. Fresh Milk Dairy (including pasturizing) | 21-77 (70 - 170) (2) | 0 | + | + | + | + | + | 0 | 0 | Reduction in milk subsidies can reduce number of operators and overall production. Energy sensitivity only in processing. Studied under PRDA. | II |

TABLE 5 - RATING OF APPLICATIONS



| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| III. Intensive Confined Growing (Continued) | | | | | | | | | | | |
| 6. Aquaculture | 27 (80) (2) | — | + | 0 | + | 0 | 0 | — | — | 75% mortality to catfish farm businesses. Commercial operations technology still in development; limited supply of technical staff; underdeveloped commercial markets. Limited resources for high production commercial operations. | V |

TABLE 5 - RATING OF APPLICATIONS



| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IV. Waste Processing & Methane Generation | 38-55 (100-131) & 93 (200) (2) | + | + | + | + | + | — | 0 | 0 | Expanding market, but no geothermal experience - assessed on PRDA's. High temperature (200°F) required for rendering. San Bernardino is planning a project for geothermal. Applied to municipal waste processes.<br><br>San Bernardino Water Dept. is preparing to drill well to convert waste water treatment plant to use geothermal heat.<br><br>Experienced operator is considering a continuous cooker rendering plant in Imperial Desert region for production of animal feed protein. | I |

| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| V. Food & Kindred Products | | | | | | | | | | | |
| 1. Meat Products | 60-68 (140-155) (2) & 115 (240) (2) | + | + | 0 | + | + | 0 | 0 | + | California needs additional slaughter and process to meet regional demand for pork. Requires reliable system with some back-up. Steady growth market. Industry will require extensive education. Probably limited to Imperial-Desert region. Can use high temp. for refrigeration. | III |
| 2. Dairy Products | 38-93 (100-200) (2) | 0 | + | + | + | + | + | 0 | 0 | Dairy industry evolving in location away from high priced land, but to larger operations. More knowledge required of industry needs. Market tied to population growth; economics impacted by milk subsidy. | III |
| 3. Fruit & Vegetable Processing | 60-140 (140-284) (2) | + | 0 | 0 | 0 | + | + | + | 0 | Vegetable processing for Imperial. Fruit drying more widely distributed. Highly seasonal, but large load. Requires integration with winter load. Onion and potato processing can be located at moderate-high temperature sites. Brady H.S. plant raises priority to a II; however, number of replications will not be large but energy demand per plant is high. | II |

TABLE 5 - RATING OF APPLICATIONS

| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| V. Food & Kindred Products (continued) | | | | | | | | | | | |
| 4. Animal Feed Processing | 38 (100), 93 (200), 115 (240) (2) | 0 | 0 | + | + | + | + | 0 | 0 | Prior PRDA/PONS; application integrates in Bio- and thermal cascades within animal raising operation. Essential for competition with midwest. Some traditional resistance, needs agri demonstration. Can use some chilling. Can be integrated in an alchohol process | III |
| 5. Bakery Products | 38 (100) (2) | 0 | 0 | 0 | — | + | — | 0 | 0 | Limited portion of energy use in application. Primary baking temperatures compete with electric production. | V |
| 6. Beverages | 77 (170), 100-143 (212-290), 150 (300) (2) | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | Malt beverages, distilled liquor and soft drinks. Wide range of temperatures. Matching resource site to raw material and end product distribution required. Considerable industry contact work required for this multi-faceted industry. Prior studies at OIT on malting industry. | IV |

TABLE 5 - RATING OF APPLICATIONS



| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VI. Lumber & Wood Products | | | | | | | | | | | |
| 1. Sawmills & Planing mills | 93-121 (200-250) (2) | — | 0 | + | + | + | — | 0 | — | Overall industry in prolonged slump tied to housing. Historic reluctance to convert to geothermal found in prior studies. Mills are tied to raw material supply. Expanding market for wood waste as fuel can affect industry decision. Most likely requires co-located mill and resource at some unknown site for near term. | IV |
| 2. Furniture & Wood Products | 21-66 (70-150) (2) | + | 0 | + | + | + | — | 0 | N.A. | A plant was considered for Susanville for geothermal; realtors priced land out of reason. Expansion tied to economy. | II |

| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VII. Selected Paper Products | | | | | | | | | | | |
| 1. Paperboard containers | 66-188 (150-370) | + | + | + | + | + | + | 0 | N.A. | Growth market, good prices for recycled material. Sector needs additional study. | II |
| 2. Paperboard Mills | (2) | | | | | | | | | | |

TABLE 5 - RATING OF APPLICATIONS

| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VIII. Selected Chemicals & Allied Products | | | | | | | | | 0 | Energy costs are rising and are 10% - 85% of operating costs. This is generally a depressed, slow growth industry. | |
| 1. Agricultural Chemicals | 143-191 (290-375) (2) | — | + | 0 | — | + | — | — | 0 | Declining U.S. markets. Requires high temperatures. Limited number of plants. | V |
| 2. Industrial Inorganic (salts) | 138-171 (280-340) (2) | 0 | + | — | — | — | — | — | + | Table salt production, with major redesign to operate at lower temperatures, is one potential product. Overriding factor is Kerr McGee operation at Trona, who has been studying geothermal use in their facility. | IV |
| 3. Industrial Organic | Up to 121 (250) (2) | — | + | + | + | + | — | + | — — | Alcohol production for fuel and intermediates does fit geothermal use. Government controlled, declining market. Not near term as an independent facility, but can be integrated into a feed mill and livestock operation. | V |
| 4. Plastics, Synthetics | 121-177 (250-350) (2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | — | Believed primarily located in Eastern U.S. Further industry contacts required. | V |

TABLE 5 - RATING OF APPLICATIONS



| APPLICATION CATEGORIES | TEMPERATURES °C (°F) | ECONOMICS | ENERGY SENSITIVITY | REPLICATION | GEOTHERMAL COMPATIBILITY | ECONOMIC DEVELOPMENT | HISTORICAL USE | BRANCH PLANTS | OVERRIDING FACTORS | COMMENTS AND OVERRIDING FACTORS | OVERALL RATING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IX. Geothermal Electric Effluent Resource | <150 <(300) (1) | + | + | 0 | + | + | — | N.A. | — | Institutional barriers exist for developers and electric utilities to enter field of direct-use, economic development project; developers of geothermal electric resources (predominently oil companies) do not wish to enter into the utility business. Electric utilities are not normally in the business of hot water heating districts. Neither has an in-house capability for the economic development disciplines required for direct use systems, and finally, a direct use project is a relatively small scale effort for either entity. This should be worked on in Imperial and to lesser extent at Geysers. Needs initiator. Importance warrants a priority of III, but is probably not near term. | III |

## PHASE I ASSESSMENT

### Geothermal Regions and Areas

Region A - Geysers

1. Clear Lake

The Clear Lake area is well known for its many hot springs and close proximity to The Geysers, the world's largest producing field of geothermal electrical energy - approximately 900 MWe. The use of the area's extensive geothermal resource has been the subject of public and institutional controversy. The area investigated for this study excludes the present Geysers area of steam production and electrical generation.

Although population is increasing, the Clear Lake area is predominantly a retirement area with a majority of the citizens over 55. Additionally, transportation systems into the region are limited to two-lane state highways (20, 29 and 175) with no rail lines. Exploration for geothermal resources sufficient for electrical generation is continuing in the Clear Lake area. Several wells have been drilled and although judged insufficient for large-scale electrical generation purposes at this time, they could possibly be used for direct-use applications. Temperatures and resource quantity and quality may allow small-scale electric applications in the Clear Lake area. Cascading from electrical power plants may also be a possibility, but doubtful for near term. If institutional barriers can be overcome, near-term applications would largely be agriculturally oriented; i.e., fruit dehydration, greenhousing, etc.

A shallow geothermal resource exists at the Sulphur Bank Mine area located north of the city of Clear Lake. However, salinities of the springs and old geothermal exploratory wells are high. A high concentration of boron in the geothermal resources is a major problem. TDS of the Sulphur Bank springs is 8,000 ppm.[30]

The Clear Lake geothermal area receives a low priority rating of IV, due in large part to the area's well known public and institutional controversy over geothermal development. The historic lengthy permitting times, as well as a significant faction of the population opposed to increased use of the geothermal resources and industrial and commercial development accompanying such use, are prime factors decreasing the area's competitiveness for applications.

2. Wilbur Hot Springs

This is the site of an operating resort. It is located in rugged terrain at the western edge of Colusa County. The resort is located over five miles on an unpaved road from State Highway 20. The Wilbur Hot Springs area was the site of intensive mining, now inactive. An exploratory geothermal well was recently drilled near Wilbur Hot Springs for potential electrical generation and other exploratory wells are contemplated.

Aside from the historic mining activity, the area is relatively pristine and remote. However, there are indications that mining activity could resume in the future.

Community attitude in the immediate Wilbur Hot Springs area towards geothermal use, other than spa/medicinal uses, has been negative in the past.[99] Coupled with many negative constraints identified, this area receives the lowest priority rating of V.

Region B - San Francisco Bay Area

1. Calistoga

Calistoga is a northern California community long known for its geothermal spas and use of mineral springs for bottled water. It is located at the north of the Napa Valley, a region famous for its vineyards and premium wine production. It is serviced by

State Highway 128 and a branch rail line. A major constraint to geothermal direct use utilization may be disposal of waste geothermal water, (G.R.I.P.S.).

Potential direct-use applications are present within Calistoga and surrounding areas and an expansion of existing uses is contemplated. District heating of homes and businesses has been targeted as a prime candidate for use of the Calistoga area resources. Studies have been completed by the California Division of Mines and Geology (CDMG) to determine the character and extent of the geothermal resource underlaying the area. However, there is a fear by local business groups (i.e., bottled water companies) of contamination of their producing aquifers by geothermal fluid disposal. The California Division of Oil and Gas is examining this potential problem.

Although Calistoga has a good quality resource and significant historical direct-use applications, there are potential constraints. Such constraints as high land costs, an ambivalent attitude for further direct-use applications and length of permitting times lower Calistoga's priority rating to II.

2. Sonoma - Valley of the Moon

Although the identified geothermal resources of the Valley of the Moon area of Sonoma County have relatively low temperatures (21°C to 46°C), it is a shallow reservoir with many potential co-located application sites.

The Valley has several communities located in it along State Highway 12, most notably the City of Sonoma, and it is experiencing significant population growth expansions, mainly from the San Francisco Bay area. In addition to increasing residential development, the Valley is famous for its vineyards and wine production. Hot springs

resort/spas were once common to the area, but have decreased significantly in activity over the years.

The CEC is sponsoring the CDMG to conduct gravity, magnetic and resistivity surveys in the Sonoma-Valley of the Moon and Rohnert Park areas. Potential applications are also being identified or in the planning stages. Those include use of identified geothermal resources at Sonoma State University (Rohnert Park) and Sonoma State Hospital (Valley of the Moon). The geothermal heating of a condominium project at Boyes Hot Springs is also in the planning phase.

Using the criteria presented in this study, the identified low temperatures of Sonoma-Valley of the Moon area would reduce its priority. However, based on the work being accomplished in the area, the near-term availability of co-located applications and the interest exhibited in the area by the CEC, OIT, GRIPS and others, it has been given a priority rating of II.

3. Napa Valley

The Napa Valley is a world-renowned wine production area. Both highway and rail transportation are located in the Napa Valley area, with the business community oriented to grape growing, wine production and tourism. Applications in this area would reach their greatest potential, if agriculturally-oriented.

The use of the geothermal resource in the Napa Valley is also limited by its lower temperatures. However, the resource is generally at shallow depths and co-located potential applications and sites are present throughout the Valley. The lower resource temperatures along with high land costs and uncertainties regarding acceptable applications in Napa Valley, lowers its priority. However, the shallow depths of the resource and the numerous co-located potential applications (vineyard, wineries, resorts, etc.) warrant at least a priority rating of III.

Region C - Sierra-Cascades

1. Surprise Valley

Surprise Valley is located in the remote corner of northeastern California in eastern Modoc County. Population is very low in this largely cattle-raising and forest products region. In addition to several hot springs, many wells of high temperatures at shallow depths are known to the area, which may allow for potential small-scale electrical applications. However, the sparseness of the area's population precludes most applications other than indigenous agriculture. Currently, the Fort Bidwell Indian Reservation, located at the northerly end of the identified geothermal resources, is investigating the use of geothermal fluids for space heating, agriculture and greenhouse operations. (CEC sponsored)

The Surprise Valley, based on its abundant good quality geothermal resource, although tempered by its relative remoteness and low population, is given a priority rating of III.

2. Kelley Hot Spring

Kelley Hot Spring is located in the northeastern corner of California. It is a very rural area, known primarily for its livestock, feed crops and forest products. Situated approximately 15 miles west of the Modoc County seat of Alturas, it is served by both highway and rail line. Population near Kelley Hot Spring is very limited and any labor needed would most likely derive itself from Alturas, which has a high unemployment rate.

The Kelley Hot Spring area is a site of both ongoing and near-term geothermal direct-use applications. Greenhouse operations are presently occurring and a pork feedlot has been designed under a PON. This feedlot will be a totally confined system using geothermal fluids to supply heat to the confined swine raising operations. However, this project has been delayed due to environmental (archaeo-

logical) restrictions. Extensive geothermal exploration, including two wells, has been conducted. This has been rated as one of the best hydrothermal resources in the state. Kelley Hot Spring is the second largest boiling hot spring in the United States.

A priority rating of II is given to Kelley Hot Spring, due to its abundant good quality resource, coupled with it being a site of both ongoing and near-term applications. The archaeological impediments, lack of employment base and community services reduces the priority from a "I".

3. Likely

Likely is a rural, livestock (cattle) raising area south of Alturas on U.S. Highway 395, near the Modoc-Lassen County line. It lies in a very fertile valley that contains the headwaters of the Pit River. Alfalfa for cattle feed and peat fields are its primary resources. Communities in this area, such as Likely, are quite small and have a very limited labor base.

The identified geothermal resource is generally at a lower temperature over most of the area. However, it is relatively shallow-to-very shallow, with the deepest identified resource at around 200 feet.

A priority rating of III is given to the Likely area. Moderate temperatures at shallow depths, coupled with agricultural activities that could utilize such resources, warrant this rating.

4. Bassett-Kellog Springs

The Bassett-Kellog Springs area of northwestern Lassen County is better known as the Big Valley area. Located along State Highway 299, it is a fertile valley, where cattle raising and lumber

mill operations are the major businesses. Although population of the area is small, it is the only other significant population center outside of the Susanville area in Lassen County. A rail line traverses the western side of Big Valley. No geothermal wells above 50°C (122°F) are identified in the Bassett-Kellog Springs areas. The identified resource[30] is limited to hot springs of 172°F to 174°F range. (Note: Information from the CDMG indicates there are some hot wells in the 170°F range north of Bassett Hot Springs.) Although the Bassett-Kellog Springs area has a limited identified resource, there are several factors which warrant a priority rating of III. These include potential near-term agribusiness application, good rail and highway transportation, inexpensive and buildable land, and general support of local government.

5. Susanville

The Honey Lake Valley in Lassen County contains three major direct use project areas: Susanville, Litchfield and Wendel-Amedee. This area is the most advanced, in terms of geothermal direct-use project construction and operations in the state.

Susanville, the county seat of Lassen County, is well known for its progressive activities in the direct use of geothermal resources. District-wide heating system of public buildings, funded by the U.S. Department of Energy, U.S. Bureau of Reclamation, private industry, Lassen County and the City, will be on-line during the winter of 1981-82. This project will be expanded to include a 126-home complex and commercial buildings (sponsored by the U.S. Department of Housing and Urban Development and the Farmers Home Agency), as well as a park of commerce south of the central business district.

The City of Susanville is underlain by a clean geothermal resource of moderate temperature. Combined with being the only significant

population center in northeastern California and traversed by highways (U.S. 395 and California 44) and a rail line spur, this area has a high potential for near-term expanded use of geothermal resources. Additionally, the geothermal resources under Susanville are shallow, of very low TDS and of adequate volume. Economic development activities are underway for geothermal applications for the Susanville Parks of Commerce and the Litchfield site.

Susanville warrants a priority rating of I since, in addition to numerous on-going and planned direct-use applications, it meets or exceeds all criteria necessary for near-term direct-use applications.

6. Wendel-Amedee

The Wendel-Amedee area is the location of one of California's largest geothermal direct-use commercial applications. Currently, some 30 greenhouses on 10 acres are producing tomatoes and European cucumbers, utilizing geothermal fluids from Wendell Hot Springs. Additionally, another direct-use project planned is a hybrid power plant which plans to use geothermal waters and wood waste to generate 55 megawatts of electricity. Both of these projects are located in the Wendell-Amedee KGRA.

This area is located approximately 25 miles from Susanville, near U.S. Highway 395 on the northeastern shore of Honey Lake; a large, shallow, alkaline body of water. The Sierra Army Depot is located directly to the south. Reno, Nevada is located approximately 75 miles south. The Wendel-Amedee area is also traversed by a major Southern Pacific rail line. Ample amounts of flat, buildable land further characterize the area. The main population center, Susanville-Johnstonville, is 20-25 miles to the west.

Although Wendel-Amedee is the location of one of California's largest direct-use application and others are planned, there are constrain-

ing issues in the immediate area (i.e., lack of community services, housing and labor base) which lower its priority rating to II.

7. Litchfield

The Litchfield geothermal area is located approximately ten miles from Susanville. Although the CDMG has identified no geothermal well or hot springs in the immediate Litchfield area, recent investigations by the U.S. Bureau of Reclamation has indicated a relatively high temperature resource with a potential for a large volume of geothermal fluids. This resource will be used to supply heating needs of the California Correctional Center at Litchfield. It will displace approximately 550,000 gallons of the 750,000 gallons of oil now used annually by the facility. Cascaded fluids from the facility will be used for a planned park of commerce on adjacent private lands. The resource is under lease to the City of Susanville, and the supply system is being developed by Carson Development Co. of Sacramento. All energy will be sold by the City at incentive prices. The area has livestock and feed crops as principal products. The site is serviced by Lassen County Route 27, which connects to U.S. 395. A rail siding is on the site. Adequate labor base resides within 1 - 8 miles of the site.

The Litchfield area has similar qualities as the nearby Susanville area, thus rating a priority of I. The recent drilling and consequent indications of a high quality resource reinforce this rating.

8. Sierra Valley

The Sierra Valley, located in the Eastern Sierra region of Plumas and Sierra Counties, is a rural area of small isolated

communities and large cattle ranches. It is the principal agricultural center of Plumas County. This area is located approximately 40 miles northwest of Reno, Nevada near U.S. Highway 395. Major rail lines are located in and adjacent to Sierra Valley.

Numerous direct-use applications are possible for this relatively shallow, hot geothermal resource. Agricultural applications have a great potential in this area, as well as possible district heating of the small towns in the valley. The City of Santa Clara has purchased 10,000 acres of geothermal property in the area.

The Sierra Valley has a priority rating of II. It is a relatively large area of good quality geothermal resources with minimal constraints and potentially numerous applications; however, it has limitations in labor base, community services and no large heat load requirement.

9. Fales Hot Springs

Fales Hot Springs is an inactive hot springs resort directly adjacent to U.S. Highway 395 in northern Mono County. Although located in the Toiyabe National Forest, Fales Hot Springs is on private land with other private land nearby. The resort and land are currently for sale. The nearest community is Bridgeport, 14 miles to the south. Six miles to the west is a military base, the U.S. Marine Corps Mountain Warfare Training Center. Three and one half miles north is the Cal Trans Sonora Junction highway maintenance yard.

The area around Fales Hot Springs is primarily utilized for mountain recreation activity and hunting. Population, as well as most development,is very limited.

The relative remoteness and other limitations of Fales Hot Springs severely restricts potential applications. Priority rating is IV. It should be a V, except that, under proper development with the right application, the excellent resource (82°C (180°F) ) would warrant the higher priority of IV.

10. Bridgeport

Bridgeport is located on U.S. Highway 395 in the relatively remote Eastern Sierra region. Cattle raising and tourism/outdoor recreation are the dominant commercial activities in the region. Although the county seat of Mono County, it only has a population of 500. However, Bridgeport is close enough to a significant geothermal resource to consider a district heating system. Currently, a CEC sponsored feasibility study is underway in the area for the use of geothermal fluids for a heating district and possible small electric-generating capabilities. The resource to be utilized for such applications will be explored, tested and developed by private financing. This resource assessment and development will be initiated in 1982, provided the BLM non-competitive leases are released.

Bridgeport receives a priority rating of II, since it meets most of the criteria necessary for a high rating, but limitations in labor base and high utility costs prevent a higher priority.

11. Mono Basin

The identified geothermal resources in the Mono Basin are situated in and along the shore of Mono Lake, an ancient saline lake in Central Mono County along U.S. Highway 395. Similar to other resource areas in the Eastern Sierra region, nearly all of the land is under federal or City of Los Angeles ownership. Additionally, there is some state-owned land near the lake.

Mono Lake has been a recent environmental concern, as it continues

to recede due to water diversions by the City of Los Angeles Department of Water and Power. Mono Basin is an important wildlife area and is environmentally sensitive. Lee Vining is the only community in the area which is sparsely populated. Recreation and highway-commercial are the primary industries in the area.

12. Mammoth Lakes - Long Valley

This area of southern Mono County is actively being investigated by energy companies for its potential to produce electricity. Most of the attention is in the Long Valley and Casa Diablo areas, where numerous hot springs and fumaroles exist. Potential direct use application sites are numerous in this area, and some have already been demonstrated. The CEC has funded a direct-use project heating a lumberyard storage shed and hardware store near Casa Diablo. The California Department of Fish and Game geothermally heat their Hot Creek Fish Hatchery trout ponds. Such heating allows year-round production of rainbow trout.

A district heating system has been investigated for the community of Mammoth Lakes. The DOE sponsored study (DOE Report SAN/1316-4) determined that a district heating system for Mammoth Lakes was technically feasible.

The area, located along a very scenic portion of U.S. Highway 395, experiences very cold winters and a major ski resort is found at Mammoth Mountain. The area is a major tourist attraction and recreational center, as well as being environmentally sensitive. Additional constraints would include the lack of available private lands. Most land is under federal or City of Los Angeles ownership.

13. Keough Hot Springs

Keough Hot Springs is a privately-owned hot springs in northern Inyo County, adjacent to U.S. Highway 395 in the Owens Valley, (8 miles south of Bishop). Development in the immediate area is limited to a very small community surrounding the developed hot pools. Outside of the community, lands are under federal and City of Los Angeles ownership. Available land for development is extremely limited, since all federal and City of Los Angeles land has been withdrawn from development for watershed protection. Other necessities for commercial or industrial development are almost completely lacking. Keough Hot Springs is given a low priority rating of V. Lack of available land, community services and housing, combined with watershed protection policies, severely limit additional direct use applications.

14. Lake Isabella

Little is known about the geothermal resources of the Lake Isabella area, other than they have been historically utilized for spas. Located in the Kern River Valley on State Highway 178, the area is residential/recreation-oriented with livestock grazing as major land uses.

Main activities are tourism (fishing and boating on Lake Isabella) and cattle raising. There is also a substantial service/commercial base to serve the residential community, which is characterized as a retirement area. Manufacturing is absent from the area; however, there are indications that the community would like to attract industrial development (Kern County Planning Department). Most land in area of KR-2 (site of the defunct Scovern Hot Springs Resort) is zoned for agriculture and some commercial along the old State Highway 178. The recently updated Kern County General Plan has changed much of the agriculturally zoned land to residential. Commercial, institutional and residential development exists both to the north and south within one-half mile of KR-2. A priority

rating of II is given to the Lake Isabella area. Uncertainties regarding available resources and meeting other criteria limit its priority.

Region D - Imperial-Desert Region

1. Coso Hot Springs

Coso Hot Springs is located in a remote desert area of southern Inyo County near U.S. Highway 395. The identified geothermal resources are located within the U.S. Navy's China Lake Naval Weapons Center and are withdrawn from public use. However, the U.S. Navy has contracted with an energy development company to develop the area's resources for electrical generation.

Nearly all of the lands outside the naval reservation, but within the Coso Hot Springs KGRA, are under federal ownership. Population in the immediate area is very low and community services and adequate housing are absent.

Coso Hot Springs' remoteness and lack of available private land near identified resources result in a priority rating of V. Although power plant cascade is a possibility, it is doubtful that it could be near term.

2. Trona

Trona is located in northern San Bernardino County on the border with Inyo County in the Searles Dry Lake area. This company town primarily exists due to presence of the Kerr-McGee chemical plant. Most of the area's population work at this plant which produces potash, borax, salt cake, sodium carbonate, sodium bicarbonate and other minerals from the Searles Dry Lake ancient marine deposits. Kerr-McGee has investigated the use of the nearby geothermal fluids for process heat, as well as actually recovering the chemical compounds in the geothermal brines. The fluids found in wells drilled are generally of high TDS.

Although remotely located in the Mojave Desert, Trona is well established due to the large chemical industry there. It is regu-

larly serviced by rail, which transports the processed chemicals out of the region. Potential applications at the Kerr-McGee facility were briefly addressed in a BLM prepared Environmental Analysis Record for non-competitive geothermal leases in the Trona area. Applications included hot water for mineral processing and use in the solar ponds to increase evaporation.[100]

Trona has a priority rating of II. Although it meets most of the criteria for higher priority, it is single-project-oriented (direct-use applications for the Kerr-McGee facility) in the planning phase.

3. Randsburg

The Randsburg area is an isolated area in northwestern San Bernardino County. There are three small, distinct communities in this portion of the Mojave Desert: Randsburg, Johannesburg and Red Mountain. These were once prosperous mining towns, but have deteriorated with the closing of mining activities. The identified resource in the area is located east of these communities in the Randsburg KGRA, which is further isolated. Competitive leases in the KGRA have recently been sold by the BLM, but near-term development will be resource assessment for electrical generation.

The Randsburg area is located along U.S. Highway 395, approximately 100 miles north of San Bernardino. The nearest rail line is 10 miles north. Services and existing housing are severely limited in the area, but desert recreational activities are abundant.

Randsburg has a priority rating of IV, based in part on its remoteness and general lack of applications other than mining, which is presently inactive on any large scale. Cascading from power plants may be possible should any plants be constructed, but this is not near term.

4. Twentynine Palms

The Twentynine Palms area is located near the eastern edge of the rapidly developing Yucca Valley in southern San Bernardino County. It is a small urban/rural desert community which serves as the civilian entrance town to the Twentynine Palms Marine Corps Base, approximately 5 miles to the north. The community is mostly service-oriented, servicing the retirement and military sector in the area. Agriculture is almost non-existent in the area and most of the surrounding region is desert, with desert recreational activities predominantly. Southern California Edison has plans for a coal-fired power plant in the region.

The community can only be reached from the Los Angeles metropolitan area by State Highway 62. No rail line is located near Twentynine Palms.

Although the published resource data appear promising, there are uncertainties regarding the geothermal resource in the Twentynine Palms area. This, along with the limited potential applications of the resource, results in a priority rating of III.

5. Desert Hot Springs

Desert Hot Springs is the fourth fastest growing community in California (Riverside County Department of Development). It is well known for its extensive geothermal resources, which directly underlie the city and are presently used for the numerous health spas found there. Although the resource has been studied in depth for its possible use in district space heating and cooling, aquaculture, and greenhouses, such projects have yet to be implemented. Recently the city of Desert Hot Springs has established an Energy Commission in an attempt to correct this shortcoming and attract potential users for the area's geothermal resources.

Desert Hot Springs is a desert recreation-oriented community near Interstate 10, ten miles north of Palm Springs and 70 miles from the center of the Los Angeles-San Bernardino metropolitan area. Manufacturing and industrial enterprises are nearly absent in Desert Hot Springs, with over 90% of the land zoned for industry within the city limits presently vacant (Riverside County Department of Development). A Southern Pacific main rail line is located 5 miles to the south.

Uncertainties regarding resource definition and economics of potential uses were weighed against positive factors, resulting in a priority rating of II for Desert Hot Springs.

6. Palm Desert

Palm Desert is located in the exclusive Palm Springs region of Riverside County. It is a major resort area with expensive second-home and condominium developments. Industrial development is absent, with residential and office-commercial development stressed in the area. Housing and land costs are high.

There is only one geothermal resource identified for the Palm Desert area; a well designated RV-32 by the CDMG. While the data presented for this well is within the criteria, the resource is uncertain and there is indication that the identified resource temperatures are grossly overstated. Preliminary recent investigation by CDMG indicates that the Palm Desert area resource is only in the 20° to 25°C (68° to 77°F) range.

Palm Desert is located on State Highway 111 near the rich agricultural area of the Coachella Valley. Interstate 15 and 2 major rail lines are located 5 to 6 miles north.

Uncertainties regarding the Palm Desert resources and the possibility

that the resource temperature is actually quite low warrant a priority rating of only IV.

7. Mecca

The Mecca area is located on the northwestern side of the Salton Sea in the agriculturally rich Coachella Valley of Riverside County. The Coachella Valley is a prime agricultural area serving the southern California market. It is amply supplied with imported Colorado River water via the Coachella Canal. Although over 100 miles from the metropolitan Los Angeles area, transportation systems are well established. State Highway 111 connecting to Interstate 10 and a main Southern Pacific rail line traverse the Mecca area.

Although geothermal resource temperatures are relatively low, the resource is shallow and is already being applied to agricultural and aquacultural projects. Recently a greenhouse operation using geothermal fluids has located in the Mecca area. An aquaculture operation using geothermal fluids for the raising of prawns has been recently located in the Mecca area.

Although temperatures are low in the Mecca area, it received a priority rating of II. This is based on several factors, such as low land costs, shallow depths and the recent siting of horticultural and aquaculture activities in the area with continuing interest by others to locate there.

8. North Shore/Fountain of Youth Resort

This remote desert area is located on the northeast side of the Salton Sea on the Riverside-Imperial County border. It is presently an area of resort/medicinal spas frequented primarily in the winter months by traveling retirees. The permanent year-round population is low, but is increasing as mobile home parks are

being established. Unsuccessful attempts at aquaculture using geothermal fluids were made here; however, failure was for business reasons and not attributable to the geothermal resource.

The North Shore/Fountain of Youth Resort area lacks a community infrastructure and available housing. Although located near State Highway 111, it is relatively isolated from any population centers. Combined with other identified constraints, it warrants priority rating of V.

9. Salton Sea Field

The Salton Sea Field is a large geothermal resource area in the Imperial Valley which is currently receiving much attention for both electrical generation and direct-use applications. Several energy companies are actively exploring and developing geothermal resources for several power plants planned for the area. Temperatures are high, but there are high salinities which cause engineering and waste disposal problems. The Salton Sea Field is in the Salton Sea KGRA. It was recently the subject of an environmental document which would allow the designation of a geothermal overlay zone to permit geothermal development.

Rich in agriculture, the Salton Sea Field offers many potential direct-use applications. Potential applications include agribusiness-oriented parks of commerce, livestock rendering, greenhouses, crop dehydration, and other agriculturally related applications. The Imperial Valley is a well-established agricultural center, with major highways and rail lines.

The city of Calipatria has conducted pre-zoning activities, identified local industries with expressed interest in retrofitting, has a local "initiator" and owns a moderate temperature well. These factors warrant a high priority of I.

10. East Mesa

The East Mesa area is located on the eastern edge of the Imperial Valley near the Mexican border. Although most of the KGRA in which this geothermal area is located is on desert lands, a significant portion is located in agricultural fields. Opportunities are similar to the Salton Sea Field, however salinities of identified geothermal fluids are considerably lower than the Salton Sea Field and the geothermal areas of the Imperial Valley. It is reported that some local private home space heating is being done with geothermal hot water sources.

The lower salinities and high temperatures warrant a priority rating of II. This is further augmented by available agricultural land and the possibility of cascading from existing and planned power plants (MAGMA and Republic Geothermal, Inc.).

Other areas in Imperial Valley, due to high salinities and very deep location of reservoirs in the other geothermal areas in the Imperial Valley (i.e. Westmorland, Brawley, Heber and El Centro), these areas did not meet the criteria for near-term economic direct-use development as outlined in this study. However, the possibility of cascading from existing and planned power plants and use of abandoned wells should not be ignored for longer term development.

Region E - South Coast

1. Paso Robles

The Paso Robles area is located adjacent to U.S. Highway 101 in northern San Luis Obispo County. It is primarily a rural agricultural area with the City of Paso Robles (population 9,163) as the major community. Paso Robles is known for its hot water spas and there are some agricultural applications currently using the low temperature geothermal resources found there (Source: San Luis Obispo Planning Department).

The town of Paso Robles is located along a major Southern Pacific rail line. It also has access to the Central Valley via Highway 46.

The potential for co-located applications of the shallow low temperature resource is great enough to warrant a priority rating of II.

2. Ontario Hot Springs

Ontario Hot Springs is located near the Pacific Ocean, adjacent to U.S. Highway 101, ten miles south of San Luis Obispo and 5 miles north of Pismo Beach. Little is known about Ontario Hot Springs, other than its use as a spa. Most of the land use in the immediate area appears to be residential, some agriculture and open space. An oil shipping facility is a few miles to the west. A major rail line traverses the area.

Although information on this resource is limited, its strategic location coupled with potential co-located activities, good transportation and lack of any perceived major constraints warrants a priority rating of I. However, an "initiator" is needed if the resource is to reach its potential.

3. Aqua Caliente

Aqua Caliente hot springs are located in the rugged Santa Ynez

Mountains of Santa Barbara County. There are no paved access roads to this area situated in the Los Padres National Forest. The ruggedness and remoteness of this site excludes it from any foreseeable development of the geothermal resources for the near term.

The isolation of this resource in the Los Padres National Forest severely limits its potential. Priority rating is V.

4. Ojai

The identified Ojai area geothermal resource lies approximately 6 to 10 miles northwest of the town of Ojai in Western Ventura County. Access to the identified resources is limited and they are located within the boundaries of the Los Padres National Forest.

Similar in constraints as Aqua Caliente, Ojai's priority rating is also V.

5. Los Angeles - Huntington Beach

Geothermal resources have been discovered in the Los Angeles Basin while drilling for oil. Several wells in the Huntington Beach area have very high water temperatures and potential applications exist nearby. The County of Los Angeles and the CDMG are currently investigating the hot water resources found in many oil wells in Los Angeles County.

The Los Angeles Basin is one of the largest metropolitan areas in the United States and has many varieties of potential applications for geothermal fluids co-located with its oil fields. Interest by local agencies in the area is increasing as the potential use of hot water oil wells is being examined. However, there may exist institutional barriers at this time which may limit the near-term potential of use of the geothermal resources.

The major barrier may be the permit processing time in this area. Although it varies from one local jurisdiction to another, the time necessary for permitting can be relatively slow, thus inhibiting the near term application of geothermal resources. Additional institutional barriers may delay direct-use due to uncertainties regarding ownership and right-to-use of hot water from an oil well. Oil companies do not wish to be classed as utilities. These factors rate a priority of II.

6. San Bernardino

The San Bernardino area is a large metropolitan area generally associated with the larger Los Angeles metropolitan area. Population growth is occurring rapidly in San Bernardino, as is commercial development. The two identified geothermal resource areas are located on the north and south sides of the City of San Bernardino. Occurrence of the geothermal resources correspond to the major faults transecting the San Bernardino area (San Jacinto and San Andreas Faults.) There are indications that the occurrence of usable geothermal resources is localized along these faults and may be of limited use (CDMG, 1981). The CDMG, under DOE sponsorship, has also investigated the San Bernardino geothermal resource area. This report, to be published in 1982, will address geology, geophysical investigations, shallow and moderately deep hole temperature surveys, hydrology, geo-chemistry, seismicity, exploratory drilling and resource evaluation of the San Bernardino area (CDMG, 1981).

The southern resource area is located near the intersection of Interstates 10 and 15, and it is currently under investigation (funded by the CEC) for utilization in the San Bernardino Water District waste treatment plant. The City of San Bernardino is also conducting a feasibility study for a geothermal heating district (also funded by the CEC). The northern resource is located in the foothills of the San Bernardino Mountains in an area of

continuing residential development.

The potential applications in the San Bernardino metropolitan area are numerous. There are numerous commercial and industrial enterprises, as well as residential and institutional units, which are near the hot water resources.

Priority rating of II was given to the San Bernardino area. However, given the current activities taking place in the area, i.e., resource assessment and applications feasibility study, it could be elevated to a priority I if activities result in development in the near term. A strong initiator must be given a clear charter with full support of the local government.

7. Lake Elsinore

The Lake Elsinore community is a fast-growing area situated in southwestern Riverside County, 50 miles from the Los Angeles-Orange County metropolitan area. There is an extensive amount of commercial and industrial zoned parcels within the city limits, (Riverside County Department of Economic Development). Northeast of the city center is an area known as Warm Springs Valley, much of which is zoned for manufacturing. It is directly adjacent to Interstate 15 and a Santa Fe branch rail line. The area north of Lake Elsinore (4+ miles) is the site of clay mines and the manufacturing of brick, tile and other clay products. Geothermal resources may exist in this area as well.

The community is aware of its existing geothermal resource, which has historically been used for resort and spa activities in the city of Lake Elsinore and in the general region. An identified spring, low in TDS with a temperature >50°C, exists near the city center. There are additional hot springs (>50°C) to the north and south. Glen Ivy Hot Springs, to the north, and Murrieta Hot Springs, to

the south, may also have potential direct-use applications (other than as resort spas). Murrieta Hot Springs is located near the rapidly growing communities of Temecula and Rancho California.

Lake Elsinore holds significant promise as a near-term target area and has been given a priority rating of I.

8. Winchester

The Winchester area is located approximately 6 miles south of the city of Hemet in western Riverside County. It is approximately 75 miles from downtown Los Angeles and 30 miles from the Riverside-San Bernardino metropolitan area. Hemet is a well-known southern California retirement community and a west coast center for mobile home and recreational vehicle manufacturing. The surrounding region is a productive agricultural area. The area is serviced by major highways and a Santa Fe branch rail line is present.

The Winchester area is primarily large parcel agricultural lands. Much of the uplands areas have been subdivided into large parcel residential (5 acres-plus) lots. There is an abundance of flat buildable land intermingled with uplands and hilly areas.

Predicted growth patterns in the Winchester area may inhibit geothermal applications outside of greenhousing or other compatible agricultural uses. Increasing land costs further lower its priority to a rating of III.

9. Warner Hot Springs

Warner Hot Springs is a relatively isolated area in northern San Diego County. It is located along State Highway 79, a two lane road traversing the Laguna Mountains. The community of Warner Hot Springs is small, composed of many vacation homes. Local business

revolves around tourism and recreational activities. Warner Hot Springs is physically set on a hillside/canyon area on the west side of a large valley in which Lake Henshaw is also located. The elevation is 3132 feet and it may experience snow in the winter months. A small dirt airstrip is located west of the community and no rail line enters the region.

A major residential/commercial development is currently planned for the Warner Hot Springs area. Extensive redevelopment of the Warner Hot Springs resort is underway along with a geothermal resource assessment program at the hot springs. A large subdivision project is planned and the developer intends to maximize use of the geothermal resources. Along with the subdivision, the development plan includes a 150-room hotel, 500-seat indoor/outdoor theater/cultural center, medical clinic and community support businesses. (Source: CEC Staff). If the geothermal resources in the area prove sufficient to be economically utilized for the planned development, fossil fuel displacement could be substantial.

The extent of the proposed development creates a situation warranting a high priority. This is tempered by the fact that the projects are in planning and that economic feasibility will depend on load utilization factors and capacity of the resource, both of which are yet to be defined. These, plus the aforementioned limitations set a priority of III.

## Applications Assessment

### I. District Heating & Cooling

Most single applications cannot economically utilize all of the commercially valuable energy in a geothermal direct energy supply system. This leads one to consider at lease mini-heating districts with multiple or cascaded applications. In heating districts with utilization factors of 20 - 25% for space heating, it has been found that the addition of commercial/industrial loads, with utilization factors up to 80%, can improve the overall economics of a direct energy system by a factor of two or more. Without the encouragement of the organized development of heating districts, large scale utilization will be hampered, especially for individual small businesses. Therefore, this category of application must have the highest priority for marketing of this resource.

1. Intra-community systems show an "0" in the Economics and in the Economic Development factors reflecting the lower economics of a pure heating district without a commercial/industrial load. The economic development occurs when commercial/industrial loads are added. Branch plants is not an appropriate factor for DH&C, hence is not rated. The overall importance of a community heating district warrants a top priority of I.

2. Parks of Commerce - These systems are the most ideal use of a geothermal hot water resource. The space heating application requires fluid temperatures in the range of 60 - 90°C (140 - 195°F). It is dangerous to transmit fluids above 195°F through municipal pipelines, wherein the public may gain access to such fluids. Process temperatures of 43 - 121°C (110 - 250°F) cover the major applications suitable for this resource. This warrants a priority of I.

3. Small Scale Electric - In this project, SSE is handled as a thermal load requiring fluid temperatures of at least 82°C (180°F) for

Israeli salt pond technology (Ormat turbine)[93] to over 150°C (300°F) for other organic turbine technologies. These systems can furnish a good year-round load with a utilization factor on the order of 85%. To be economic, at small scale (<10MWe), the effluent fluids must be cascaded into an additional thermal load, such as a heating district.

These systems have the potential of permitting a small community to get into cogeneration and achieve a degree of local energy independence. These units can put electricity into the grid, sold at PURPA rates, with buy back at conventional rates. It permits local power generation in the event of power outages in the grid. This concept may become the bridge between large scale geothermal electric generation and direct utilization projects. The state of the art is being assessed by the CEC. Limitations in technology demonstration limit the priority to a II.

II. Commercial & Public Facilities

Commercial includes: retail sales entities, such as drug stores, markets, car dealers, etc.; and retail services such as car washes, laundries, cold storage plants, etc. Public facilities include schools, hospitals, local government buildings, etc. The latter is combined with commercial, since both are usually co-located and require similar unit thermal loads and temperatures. They are separated to reflect the possible differences in financing hookup/retrofits.

This area is separated from intra-city heating district in recognition that for private businesses, different project development options are available for pipelines and retrofitting; i.e., the mini-district along main street. It is not expected that commercial and public facilities will directly lead to "branch plant" expansion; however, replication will be aided by demonstrations such as Susanville's public building heating district. This stable multi-user load warrants a priority of I.

## III. Intensive, Confined Growing

This area warrants the highest business application priority. The markets for most intensive or confined grown products is growing; the energy sensitivity to energy interruption and cost impacts on cost of sales is one of the highest. Confined growing in greenhouses is believed to be practiced in every county containing geothermal resources, hence replication can be high. Confined growing and raising of crops and livestock has a close temperature fit with available resources and there is international historical experience for this application. There already are three branch plants in the Imperial-Desert Region. However, one must recognize that experienced, highly qualified technicians are required in confined growing, as well as a thorough knowledge of the confined-grown-product market and all of the national and international forces that play on that market. This requirement applies to red meats, poultry, horticulture and the rest of this area of application.

1. Horticulture - This segment of confined growing is the most suited for geothermal application. The move has already started by three operations in the Imperial-Desert Region. Also, commercial greenhouse operations occur in most of the geothermal counties in California. The California and U.S. markets continue growing. Again, it is a high technology business and requires good marketing expertise.

Though energy sensitive, a large operation is required to fully utilize even a small-scale direct-use energy source. The unit heat load in California amounts to 1 to 1.5 therms/yr/sq.ft. of greenhouse. It would require on the order of 1,000,000 sq. ft. of "glass" to fully utilize a 1500 gpm well at 180°F. This requires an organized, multi-application development to achieve optimum economics. The industry is typically: family owned and operated, conservative business people that know their business. Based upon direct contacts,[7,38]

the owners generally exhibit a reluctance to diversify into geothermal development, as well as greenhouse plant expansion. There is evidence that there is lack of expertise for attempting to accomplish both for large scale commercial operations. This indicates that communities desirous of attracting these industries must be prepared to either directly develop the geothermal utility or to have it done through a franchise with a developer.

Besides potted plants and cut flowers, raising of seedling conifers for reforestation is included in this category. The Boise-Cascade operation in Cove Fort, Oregon has commercially demonstrated a 16-fold improvement in production and survival rate (4 each) for geothermal-raised seedling conifers. Horticulture carries the highest priority of I.

2. Red Meats - The most common confined-raised red meat is fresh premium pork and Danish, European and Canadian bacon and other premium processed pork. Sausage pork need not be of this premium grade. From past PRDA and PON engineering and economic analyses, it has been found that there is a growth market in the U.S. for confined raised pork. Over 90% of California's 1.5 million annual pork carcass consumption is imported primarily from the midwest. Traditionally, pork has been raised in the U.S. on corn. In Canada and Europe, premium pork is raised on barley. Barley is a premium red meat feed that, when compared on a $/lb. of meat produced, can compete with corn. A confined pork raising facility with a feed mill using barley as the grain base, can compete in California with the midwest. Education and demonstration, beyond the current very small efforts, will be required to accelerate this application. Additional slaughter facilities (also a potential geothermal application) are required for a large scale-up in California pork production to meet the existing market and potential Far East market. Financing through the California Financing Authorities must be held under 15% for this and most successful agricultural enterprises.

Cattle raising or extended growing in the colder cattle counties using geothermal energy has been studied and found analytically to pay for the capital required. However, education and demonstration will be required to promote a large scale replication. Potential projects in this area are in evaluation by members of the industry. This area warrants a priority of II.

3. Poultry and Eggs - Have been raised on geothermal heated systems in Hungary. Energy sensitivity requires application in the colder climates. U.S./California demonstration will be required for large scale use. Replication in this industry isn't expected to be as high as it is possible in the red meat industry, since most poultry ranches are located in the central valleys. A priority of II is assigned to this area.

4. Solid Vegetables - Such as tomatoes and cucumbers fit geothermal energy very well. This area does not enjoy the same market maturity nor the size of operations that horticulture does, hence it carries a priority of II.

5. Fresh Milk Dairy - This area has been studied on PRDA's and milk pasturization using geothermal heat has been practiced in Klamath Falls, Oregon. The economics are government regulated through controversial price supports, and there is some consolidation into larger operations with a consequent reduction in the number of smaller operations, hence this area rates a priority of II.

IV. Waste Processing & Methane Generation

Waste processing and methane generation from wastes can use low grade energy from the end of a geothermal cascade. Treatment ponds can double their capacity, thereby deferring pond expansion. Methane generation has been economically marginal at best. Usually about 1/2 of the methane generated has to be burned to furnish the heat required for commercial production of methane. In PRDA and PON studies, the

use of geothermal tail waters can result in a commercially viable methane operation. This permits efficient cogeneration from low grade geothermal resources. It is best that this system be integrated with the source of the waste stream. In Modesto, the water district fuels their vehicles with methane generated from packing plant wastes (a non-geothermal system). San Bernardino's project can be a demonstration of geothermal applied to waste processing. Limited demonstration restricts the priority of this area to a II.

V. Food & Kindred Products

This sector has been studied under a PRDA in Louisiana.[2]

1. Meat Products - Meat processing lends itself to geothermal application. A PRDA studied geothermal refrigeration for meat packing.[28] As stated before, California needs, simultaneously, additional pork raising and pork slaughter capacity. Generally, however, additional facilities are being planned for the midwest and southeast. California labor costs are excessive for this industry. It is hoped that rising transportation costs can counter this limitation. This warrants a medium priority of III.

2. Dairy Products - Limitations in this industry are tied to the fresh milk subsidy mentioned before. Siting is tied to large, nearby markets, but distance from those markets is being extended by high land costs. This also carries a priority of III.

3. Fruit & Vegetable Processing - Like Brady Hot Springs, an onion drying facility, onions and potatoes can be shipped to the processing for up to 400 - 500 miles. Some processes are high temperature and will require cascading from an electric power plant. This is a highly seasonal business. Astute planning and buying are required to result in a reasonable load factor from extended operations. This area carries a priority of II based upon the Brady H.S. facility.

4. Animal Feed Processing - Previous PRDA[39] and PON[40] efforts have studied and designed systems integrated into pork raising operations. Local feed production for medium to large scale operations can reduce feed costs by 20%.[20,21] There is livestock feeding resistance to use alfalfa dried at geothermal temperatures in the U.S., even though such is practiced in New Zealand. Demonstration of new feed systems[20,21] is required. This area has a priority of III.

5. Bakery products - Baking temperatures are in the range of geothermal-electric production. Bakeries are usually located in metropolitan areas. These limitations result in a low priority of V.

6. Beverages - Malting, using geothermal, has been studied in Oregon.[36] It is believed that considerable matching of resource site to raw material and end-product distribution will be required. This industry sector will have to be studied in Phase II before a higher priority can be assigned. This has a priority of IV.

VI. Lumber & Wood Products

1. Sawmills & Planning Mills - This industry is not in an expansion mode, and historically has resisted capital expenditures.[4,7] Mills are sited near timber supplies. Systems studies have been conducted and there is a fit with geothermal energy.[4] Early demonstration probably requires co-location with a geothermal site. It should be noted that many modern mills are already alternative energy-fueled and some are co-generators; hence, priority for geothermal marketing need not be high in this application; This area carries a priority of IV.

2. Furniture & Wood Products - Contrary to 1. above, this area has a better fit, except for lack of historical experience (other than in Klamath Falls). A previous branch plant attempt was made in Susanville. The community's inexpertise in economic development, at that time, resulted in no geothermal application. Energy sensitivity is relatively

low. This has a priority of II.

VII. Selected Paper Products

Kraft paper and paper board containers is a growth market with high prices at recycle centers. This application warrants further study in Phase II. Paper board mills may fall in the same category. Paper pulp trees are very limited in California; hence, paper pulp mills are scarce and environmentally difficult to site. Pending further study, this area carries a priority of II.

VIII. Selected Chemicals & Allied Products

This area has been previously studied.[7] It was found that table salt was one of the few potential products. Such application would require significant redesign of drying equipment. The fertilizer industry, for some time, has not been able to compete with foreign prices and hence is not in an expansion or capital expenditure mode. Energy intensity of product warrants maintaining a surveillance of this industry. This group carries priorities of IV and V.

IX. Geothermal Electric Effluent Resource

This resource potential is extensive in total thermal capacity at the Geysers and potentially in Imperial Valley. However, the current institutional barriers preclude it occurring in the near term. These barriers include the inability of oil companies to act as a hot water utility and likewise for electric utility companies to enter into the business of development and operation of hot water systems. Most hot water systems are small-to-medium enterprizes ($1 to $10 million) which normally is too small for large resource developers or large utilities.

## Conventional Energy Displacement

For the California Energy Commission's compliance with the Biennial Report requirements, an estimation of the potential for conventional energy displacement and general trends relating to California's future energy picture has been made. The estimated projection of annual fossil fuel displacement after 10 years of development is presented in Table 6.

Industry sectors had to be selected on the basis of pertinent energy data availability. These were selected and adjusted to fit the "Applications" previously described. A measure of the industry size or level of production in 1980 is presented as a means of establishing total energy consumption for the sector. It has been assumed, in most cases, that natural gas consumption is the major fixed facility space conditioning and process energy form. This is conservative, since diesel fuel and propane are consumed in remote areas for these heating requirements. This annual energy consumption in million therms is listed. It was then assumed that the de-regulation of natural gas, the lower price of alternative energies and successful demonstrations by peer firms would become an incentive to a significant portion of industry to seriously consider an alternative energy application project. This could be either a retrofit from a nearby source or a new facility at an alternative energy resource site. The percentage penetration in 10 years was estimated between about 5 to 10%, depending upon the viability of the industry and its fit with geothermal. One will not be able to force use of geothermal energy; however, successful geothermal demonstrations, now underway, can, "like lemmings", induce industry to adopt geothermal and biomass or other price-competitive thermal energy resources. Geothermal can be the bellwether, but site restrictions may cause certain firms to seek similar but other forms of alternative thermal energy.

Geothermal direct use has the potential of doubling the net production of methane from animal, human and food process wastes. This not only conserves fossil fuels, but produces same and offers the possibility of economic cogeneration using a moderate grade of geothermal heat. The total estimated annual displacement of 72 million therms amounts to over 50 million barrels of oil per year.

Table 6 - Estimated 10 Year Projection of Fossil Fuel Displacement

| Industry | California Production Capacity 1980 | Annual Energy Consumption ($10^6$ therms) | Potential Annual Fossil Fuel Displacement ($10^6$ therms) |
|---|---|---|---|
| Heating Districts (1) | N.A. | N.A. | 5 |
| All Greenhouses | 3,260 acres | 178 | 18 |
| Pork Raising & Processing | 1,500,000 carcasses (2) | 45 | 4.5 |
| Poultry & Eggs | $721 \times 10^3$ ton | 13.94 | 1 |
| Cattle | $1.74 \times 10^6$ ton | 18.97 | 2 |
| Dairies | $5.2 \times 10^6$ ton | 68.42 | 7 |
| Waste Processing | N.A. | N.A. | 1.5 (3) |
| Food & Kindred Products | $\$14.85 \times 10^9$ | 267 (4) | 13 |
| Wood Products | N.A. | 36.5 (4) | 2 |
| Selected Paper Products | N.A. | 103 (4) | 10 |
| Selected Chemicals | N.A. | 164 (4) | 8 |
| PROJECTED TOTAL ANNUAL DISPLACEMENT - - - - - - | | | 72 |

(1) Includes Commercial, but no industrial load.

(2) California Consumption in Carcasses; assumes displacement by intrastate development and use of alternative energy source.

(3) Produced methane from livestock wastes only.

(4) Approximate consumption of natural gas for sectors considered in report.

## RECOMMENDATIONS & CONCLUSIONS

1. It is recommended that this information and the data and contacts developed in producing this document be utilized to focus the CEC geothermal marketing program.

2. To accomplish a successful marketing effort, the CEC must establish a geothermal information center with inter-ties with other cognizant state agencies, academic institutions and appropriate research and information entities. The data and information must be maintained in a useful form and kept up to date.

3. This information will be used to focus Phase II to contact agencies, associations and business firms in the top three priorities. Within remaining funds, the effort will be directed to identify and initiate definition of specific projects.

4. The areas and applications with priorities of I, II and III should be focused on in the near-term marketing effort. The other areas should be entered into the data bank and as conditions within the areas and applications change, the priority rating should also be updated. Remember, a viable firm with a clear need and an intent to use alternative resources automatically warrants a priority of I. These firms must receive the right information and technical assistance to assure that a project does not fail through ignorance or inexpertise.

5. Geothermal supply systems must be developed in a most cost effective manner. Remoteness of most geothermal sites is one factor that must be considered in marketing geothermal direct energy. Geothermal is not found in an economic form in the great central valleys - the bread basket of the State. Rather, it is found along the coast and along the eastern slope of the Sierras. (Clean, economic forms of this energy are projected to be a very small portion of the total

geothermal energy found in the fertile Imperial Valley.) Hence, geothermal direct energy supply systems must produce energy at a price that is less than competing forms of energy. From horticultural industry contacts, it has been found that this lower cost energy must, in turn, be used as a counter balance to the higher cost of transport from these more remote sites to metropolitan trade and (product) market centers. This compensation for increased transportation requires that direct-use geothermal supply systems must be most cost effective in design, and construction and operation.

## REFERENCES & BIBLIOGRAPHY


1. Anderson, D. N. and J. W. Lund, Editors, "Direct Utilization of Geothermal Energy: A Technical Handbook", Geothermal Council Special Report No. 7, 1980.

2. Arnold, A. J., P.I., "Inventory and Case Studies of Louisiana, Non-electric Industrial Application of Geopressured Geothermal Resources," deLaureal Engineers, Inc., IDO/1629-4, Feb., 1978.

3. Bartmettler, E., PhD., "Controlled Environmental Livestock Production System Computer Simulation Analysis (Dairy)," CLR Consortium, PRDA, 1977.

4. Basse, B. B., D. A. Edson and A. B. Longyear, "Economic Study of Low Temperature Geothermal Energy for Lassen and Modoc Counties, California," VTN-CSL, 1977.

5. Bell, J. M., "Pig Feeding," Canada Department of Agriculture Publication 1126; Ottawa, 1965.

6. Berry, G. W., P. J. Grim, J. A. Ikelman, "Thermal Springs List for the United States," NOAA, Boulder, Colorado, 1980.

7. Bressler, S. A., and W. M. Hanemann, "Geothermal Commercialization Project," UC/B - Earl Warren Legal Institute, 1980: Prospects for Geothermal Commercialization in the (a) Chemical Industry, (b) Lumber Industry, (c) Greenhouse Industry, (d) Potato and Onion Industry.

8. Boersma, L. L.; Gasper, E.; Miner, J. R.; Oldfield, J. E.; Phinney, H. K.; and Cheeke, P. R., "Management of Swine Manure for the Recovery of Protein and Biogas;" Oregon State University Agricultural Experiment Station; Corvallis, Oregon; May, 1978.

9. Boersma, L., and Gasper, E., "Methods for the Recovery of Nutrients and Energy from Swine Manure," Oregon State University; Corvallis, Oregon; unpublished.

10. Boersma, L., Davis, L. R., Resitad, G. M., Ringle, J. C., and Schmusseur, W. E., "A Systems Analysis of the Economic Utilization of Warm Water Discharge from Power Generating Stations," Oregon State University Engineering Experiment Station; Corvallis, Oregon, November, 1974.

11. Bloomster, C. H.; Faubender, L. L.; and McDonald, C. L., "Geothermal Energy Potential for District and Process Heating Applications in the U.S. - An Economic Analysis," Battelle Pacific Northwest Laboratories, August, 1977.

12. Cervinka, V., PhD, "Energy Requirements for Agriculture in California," CA Dept. of Food and Agriculture, January, 1974.

13. Christiansen, C. C., "Direct Use Applications of Geothermal Resources at Desert Hot Springs, CA," CA Energy Commission/U.S. DOE/SAN/1329-4, July, 1978.

14. Cothern, Dr. James H., "Northern California Cattlemen's Dilemma in 1976," U. C. Davis, California, 1977.

15. Cothern, Dr. James H., "Management Alternatives for California Beef Cattle Ranch Operators," U. C. Davis, paper presented at Orland, California, January 23, 1973.

16. Cothern, Dr. James H., "A View of the Future of Cattle Feeding in the Western United States," U. C. Davis, paper presented at Moscow, Idaho, July 24, 1974.

17. Cothern, James H., "Economic Problems and Opportunities for California Pork Producers," paper presented at the California Pork Producers' Annual Meeting and Sale, Visalia, California, January 25, 1974.

18. Cothern, James H., 1977, "California and Inter-Regional Competition in the Pork Business," paper presented at the California Livestock Symposium, Fresno, California, May 26-28, 1977.

19. Davey, J. V., "Survey Report: Study of Information/Education Discussions with Private Industries and Public Institutions on the Direct-Heat Utilization of Geothermal Energy," UC/S, Lawrence Berkeley Laboratory, 1977.

20. Ensminger, M. E.; and Olentine, C. G., Jr., "Feed and Nutrition Complete," The Ensminger Publishing Co., Clovis, CA, First Edition, 1978.

21. Ensminger, M. D., "Swine Science," Clovis, CA.

22. Fogleman, S. F., L. A. Fisher and A. R. Black, "Total Energy Recovery System for Agribusiness: Lake County Study," International Engineering Co., Inc., SAN/1327-5, April, 1978.

23. Freeman, Christina, and Pyle, Leo, "Methane Generation by Anaerobic Fermentation: An Annotated Bibliography," Intermediate Technology Publications, Ltd., London, England, 1977.

24. Geonomics, Inc., "Alternate Agribusiness and Industrial Uses for Exhaust Heat from Geothermal Waste Fluid," PRDA, Berkeley, California, 1977.

25. Goldblith, S. A.; Joslyn, M. A.; and Nickerson, J. T. R., "Introduction to Thermal Processing of Foods," The AVI Publishing Co., Inc., Westport, Conn., 1961.

26. Gratten, J. P. and Hansen, D. P., "A Blueprint for Financing Geothermal District Heating in California," Derek Hansen and Associates, Inc., March, 1981.

27. Hannah, J. L., "The Potential of Low Temperature Geothermal Resources in Northern California," CA Div. Oil and Gas, TR13, 1975.

28. Harris, R. L.; Olson, G. K.; Mah, C. S.; Bujalski, J. H., "Geothermal Absorption Refrigeration for Food Processing Industries," United States Department of Energy, November, 1977.

29. Hashimoto, A. G.; Chen, Y. R.; Prior, R. L., "Thermophilic, Anaerobic Fermentation of Beef Cattle Residue;" "Energy from Biomass and Wastes," Institute of Gas Technology, Chicago, December, 1978.

30. Higgins, C. T., etal, Map, "Geothermal Resources of Califonia - 1980," Division of Mines and Geology/NOAA/DOE.

31. Howard, J. H. (Editor), "Present Status and Future Prospects for Non-electric Uses of Geothermal Resources," Lawrence Livermore Laboratory, University of California; ERDA/NATO UCRL-51926, Livermore, California, October 15, 1975.

32. Huggins, R., Fred Longyear, etal, "Northeast Oregon Geothermal Project," Eastern Oregon Community Development Council, January, 1978.

33. Jordan, Richard C; Priester, Gayle B., "Refrigeration and Air Conditioning," Second Edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1956.

34. Joslyn, Maynard A; Heid, J. L., "Food Processing Operations," Volume One, The AVI Publishing Co., Inc., Westport, Connecticut, 1963.

35. Larson, T. C., "Market Survey for Direct Utilization of Geothermal Energy in California," Science Applications, Inc., SAI-444-80-358-LJ, May, 1980.

36. Leinau, P. J., "Agribusiness Geothermal Energy Utilization Potential of Klamath and Western Snake River Basins, Oregon," Oregon Institute of Technology, IDO-1621-1, 1978.

37. Leinau, P. J., Editor, "Geo Heat Center - Quarterly Bulletin," Oregon Institute of Technology/DOE, Quarterly.

38. Longyear, A. B., "Survey of Selected Industries for Potential Branch Plants - Susanville Geothermal Energy Project," Fred Longyear Co., April, 1978.

39. Longyear, A. B., etal, "Mountain Home Geothermal Project," EMMA/Lahontan, Inc., DOE/ET/28442-1, February, 1979.

40. Longyear, A. B., Editor, "Kelley Hot Spring Geothermal Project," Geothermal Power Corp./Lahontan, Inc., DOE/ET/27041-1, August., 1980.

41. Longyear, A. B., "Replicable Communities," CSL Associates (Unpublished), 1974.

42. Longyear, A. B. and Jeskey, J. C., Editors, "Susanville Geothermal Energy Project - Workshop Proceedings," City of Susanville, SAN-1077-4, July, 1976.

43. May, S. C., etal, "Applications of Geothermal Resources in the Evaporation and Crystallization Industry," Bechtel Corporation, SAN/1328-1, Oct., 1977.

44. Muffler, L. J. P., Editor, "Assessment of Geothermal Resources of the United States - 1978," USGS Circular 790.

45. Nix, James, E., "World and U.S. Outlook for Livestock and Poultry," printed in "1980 Agriculture Outlook," U.S. Government Printing Office (Washington, 1979), p. 275-287.

46. Olson, G. K., etal, "Multi-Use Geothermal Energy System with Augmentation for Enhanced Utilization," Aerojet Energy Conversion Co., DE-AC03-78ET28447.

47. Reed, M. J., "Chemistry of Thermal Water in Selected Geothermal Areas of California," CA Div. Oil and Gas, TR15, 1975.

48. Reistad, Gordon M.; Schmisseur, Wilson E.; Shay, J. Ralph; and Fitch, James B., "An Evaluation of Uses for Low to Intermediate Geothermal Fluids in the Klamath Basin, Oregon," Oregon State University Engineering Experiment Station, Corvallis, Oregon, March, 1978.

49. Sims, Anker V. and Racine, W. C., "Feasibility of Geothermal Space/Water Heating for Mammoth Lakes Village, California," United States Dept. of Energy, December, 1977.

50. Waring, G. A., "Thermal Springs of the United States and Other Countries of the World - A Summary," U.S.G.S. Professional Paper 492, 1965.

51. Talburt, William F., and Smith, Ora, "Potato Processing," The AVI Publishing Co., Inc., Westport, Conn., 1959.

52. White, D. E. and Williams, D. L., Editors, "Assessment of Geothermal Resources of the United States - 1975," USGS Circular 726.

53. Wright, Thoms C., "The Use of Low Quality Geothermal Heat in Grain Drying and Related Agricultural Applications," PRDA, The Futures Group, Glastonbury, Conn., 1977.

54. VanArdsdel, Wallace B., and Coplay, Michael J., Editors, "Food Dehydration," The AVI Publishing Co., Inc., Westport, Conn., 1963.

55. McDonald, Stephen E.; Austin, Carl F.; Lott, James R, "Potential for Heating Western Tree Seedling Greenhouses with Geothermal Energy," Published by the USDA Forest Service Equipment Development Center, November, 1976.

56. Sherwood, P. B. and Newman, K. L., "Engineering and Economic Feasibility of Utilizing Geothermal Heat from the Heber Reservoir for Industrial Processing Purposes at Valley Nitrogen Producers, Inc., El Centro Agricultural Chemical Plant," Final Report under Contract No. EY-76-C-03-1323, U.S. Dept. of Energy, September, 1977.

57. Sims, Anker V. and Rachine, W. C., "Feasibility of Geothermal Space/Water Heating for Mammoth Lakes Village, California," Final Report under Contract No. EY-76-C-03-1316, U.S. Department of Energy, December, 1977.

58. American Society of Agricultural Engineers, "Environmental Control for Animals and Plants," Handbook, Chapter 31.

59. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., "ASHRAE Handbook of Fundamentals," ASHRAE, New York City, various editions.

60. Biomass Energy Institute, Inc., "Biogas Production from Animal Manure," Winnipeg, Manitoba, Canada, March, 1978.

61. Department of Agriculture, "Confined Swine Housing," Alberta, Canada, Publication 1451-79.

62. Maryland Environmental Services, "Feedlot Management," Crestline, Ohio.

63. Anonymous, "New Feed for Cattle," "Animal Nutrition and Health," Vol. 29, No. 4, April, 1974.

64. Anonymous, "Nutrient Requirements of Swine," Printing and Publishing Office, National Academy of Sciences, Washington, D. C., 1973.

65. "Direct Heat Application Program Summary," U.S. DOE, September, 1979.

66. "Direct Utilization of Geothermal Energy: A Symposium," Geothermal Resources Council, February, 1978.

67. "Geothermal Demonstration Project Workshop," U.S. DOE/EG&G Idaho, Inc., October, 1978.

68. "Geothermal Direct Heat Application Program Summary," U.S. DOE, Nov., 1980.

69. "Geothermal State of the Art," Geothermal Resources Council, Transactions, Vol, 1, May, 1977.

70. "How to Improve Your Community by Attracting New Industry," U.S. Dept. of Commerce, Economic Development Administration, Jan., 1972.

71. "Regional Hydrothermal Commercialization Plan - Rocky Mountain Basin and Range Region," DOE/EG&G Idaho, Inc./U. of Utah, July, 1978.

72. "State of the Art Waste-Heat Utilization for Agriculture and Aquaculture," TVA/Electric Power Research Institute, EPRI EA-922, October, 1978.

73. "Expanding the Geothermal Frontier - Transactions, Volume 3," Geothermal Resources Council, Annual Meeting, 24-27 September, 1979, Reno, Nevada.

74. "Site-Specific Analysis of Geothermal Development - Data Files of Prospective Sites, Vol. III," U. S. Department of Energy, Division of Geothermal Energy, Feb., 1978.

75. "California Market Potential for Direct Heat Use of Geothermal Energy," prepared for U.S. Dept. of Energy by Resource Planning Associates, Inc. RPA Ref. No. RA79-0541, 9-26-79.

76. "Final Report for Measurement of Attitudes Toward Commercial Development of Geothermal Energy in Federal Region IX," submitted by Market Facts, Inc., Arlington, VA, Contract No. DE-AC03-80SF10854, June, 1981.

77. "California Energy Prices, 1980-2000," Staff Report, California Energy Commission, Biennial.

78. "Interrelationships of Energy and the Economy," A Supplement to the National Energy Policy Plan, DOE-PE-0030, U.S. Dept. of Energy, July, 1981.

79. "Energy Projections to the Year 2000," DOE-PE-0029, U.S. Department of Energy, July, 1981.

80. "Report on the Status of Development of Geothermal Energy Resources in California," 5040-25, Rev. A, 6/30/76. Jet Propulsion Laboratories, CIT, Pasadena, CA.

81. "California Dairy Industry Statistics, 1980," CA Department of Food & Agriculture by J. H. McEwen, annual report.

82. "California Agriculture, 1980," CA Department of Food & Agriculture, annual report.

83. "California Livestock Statistics, 1980," U.S. Dept. of Agriculture Statistical Reporting Service, annual report.

84. "Production & Marketing - Eggs, Chickens & Turkeys, 1980," CA Crop & Livestock Report Service, annual report.

85. "Summary of County Agricultural Commissions' Reports," Gross Values by Commodity Groups, Federal-State Marketing News Service, Bi-annual report, prepared and published by CA Crop & Livestock Reporting Services.

86. "Geothermal Development Grant Manual for Local Governments," California Energy Commission Staff, October, 1981.

87. "Energy Tomorrow: Challenges and Opportunities for California: 1981 Biennial Report," California Energy Commission.

88. "Geothermal Energy: Opportunities for California Business," California Energy Commission, September, 1981.

89. "A Demonstration of Thermal Water Utilization in Agriculture," EPA-660/2-74-011, Office of Res. & Dev., U.S. EPA, Washington, D.C., 20460, April, 1974.

90. State of California California Permit Handbook, Office of Planning and Research.

91. "Geothermal Development Program," Direct Use Project Summaries, California Energy Commission, September, 1981.

92. "A Guide to Financial Assistance for Geothermal Energy," California Energy Commission, September, 1981.

93. "Solar Salt Pond Generating Facility: A Feasibility Study for California," California Energy Commission, August, 1981.

94. Chapman, R. H.; Chase, G. W.; Youngs, L. G., 1980 (in press), "Geophysical Survey, Paso Robles Geothermal Area, California," U.S. Dept. of Energy, California Division of Mines & Geology.

95. Higgins, C. T., 1981 (in press), "Reconnaissance of Geothermal Resources of Los Angeles County, California," California Div. of Mines and Geology, Report for U.S. Department of Energy.

96. Taylor, G. C.; Bacon, C. F.; Majmundar, H. H., 1981 (in press), "Drilling Addendum to Resource Assessment of Low-and Moderate-Temperature Geothermal Waters in Calistoga, Napa County, California," California Div. of Mines & Geology, Report for U.S. Department of Energy.

97. Youngs, L. G.; Bezore, S. P.; Chapman, R. H.; Chase, G. W., 1981 (in preparation), "Resource Investigation of Low-and Moderate-Temperature Geothermal Areas in San Bernardino, California," California Div. of Mines and Geology, Report for U. S. Department of Energy.

98. Chapman, R. H.; Chase, G. W.; Taylor, G. C., 1978, "Preliminary Results of a Gravity Survey in the Kelley Hot Spring Area, Modoc County, California," California Division of Mines and Geology, Open-File Report 78-SSAC.

99. Gennis and Associates, 1979, "Final Environmental Impact Report for the Colusa County Geothermal Exploratory Project," submitted to the County of Colusa, California Planning Department

a. CDMG 1981 - Personal Communication with CDMG (Chris T. Higgins)
b. CDMG 1980 - CDMG Geothermal Map

100. U.S. Bureau of Land Management, 1976, "Environmental Analysis Record, Searles Valley Geothermal Leasing," Bakersfield District Office, BLM.

## GLOSSARY

Cascading - Flowing or stepping down to decreasing levels of effluent temperature in multiple applications

Geothermal - Having to do with the heat of the earth's interior

Direct(heat) use - A geothermal resource used without conversion to another form of energy

Near-term - For this study, two to five years for project implementation

Intensive Growing - Grown in an articially controlled environment to increase yield, such as a greenhouse

Geothermal Resource - An identified hydrothermal production site as shown by hot springs or wells or high heat flow

Hydrothermal - A geothermal resource that is wet steam or hot water

KGRA - Known Geothermal Resource Area

Park of Commerce - An industrial park of several individual entities

Initiator - A responsible, committed project leader with the ability to carry forth aggressively, a direct-use project

Low Temperature - Geothermal resources which are identified as being between 50 - 100°C (122-212°F)

Moderate Temperature - Boiling to 150°C (300°F)

TDS - Total Dissolved Solids in mg/l or parts per million

Impediments - Constraints in the way of utilizing geothermal direct heat

Cogeneration - Conversion of geothermal heat into electrical energy and thermal energy

Multiple Use - Several direct heat applications of a single resource through cascading, often in a Park of Commerce

Energy Sensitive - A business or process within a business that will be adversely effected by either an energy interruption or by an excessive increase in energy costs. Energy sensitive businesses usually have either a product that has energy as a signficiant percentage of cost of sales (6 - 80%), or a product that is significantly deteriorated in quality or marketability if subjected to a loss of energy supply. Most greenhouse or other confined, environment controlled raising of livestock fall in this latter category.

Generic Industry - Segment or category of industry; e.g., greenhouse operations, cattle feeding, sugar processing, potato processing, or industries categorized by the first 2 - 3 digits of the SIC code.

PRDA - Program Research and Development Announcement. Announcement to procure engineering and economic analysis studies in the demonstration of geothermal direct-use projects funded by DOE.

PON - Program Opportunity Notice - Announcement of a competitively-procured design and construction of a geothermal direct-use project at a specific site for a field demonstration. Cost-shared funding with DOE.

Small-scale Electric - Electric generators usually under 10 million watts (<10MWe), usually using a binary cycle energy conversion system for use on resources under 150°C (300°F).

Institutional Barriers - Permitting procedures, regulations and environmental activities directed at impeding geothermal development, including direct-use projects.

## CONTACTS - BY REGION

### Region A - Geysers

Stan Walker
Director of Planning, Colusa County
Colusa, CA
(916) 458-7407

### Region B - San Francisco Bay Area

Paula E. Blaydes
Consultant (formerly with GRIPS)
Santa Rosa, CA
(707) 545-1732

Pranab Charrawarti
Planning Director, Sonoma County
Santa Rosa, CA
(707) 527-2412

Michael Cole
Geothermal Planner, Sonoma County
Santa Rosa, CA
(707) 527-2917

Anthony McClimans
Senior Planner, Napa County
Napa, CA
(707) 253-4416

### Region C - Sierra-Cascades

Gordon Ash
Senior Planner, Modoc County
Alturas, CA
(916) 233-2582

Starlyn S. Brown
Senior Planner, Lassen County
Susanville, CA
(916) 257-6177

Jerry K. Grove
Public Works Director, Modoc County
Alturas, CA
(916) 233-3215

Allan Giffen
Planner, Kern County Planning Dept.
Bakersfield, CA
(805) 861-2615

Ted Hilton
Planning Director, County of Inyo
Independence, CA
(714) 878-2411

Al McGreehan
Assistant Planning Director, Plumas County
Quincy, CA
(916) 283-2000

Randy Pestor
Executive Director
Inyo-Mono Association of Governmental Entities
Bishop, CA
(714) 872-4351

Carl Rimbee
Farm Advisor, Cooperative Extension
Susanville, CA
(916) 257-5506

Mark Totten
Planning Director, Lassen County
Susanville, CA
(916) 257-6177

Region D - Imperial Desert
Region E - South Coast

Merle Albright
(formerly with County of Los Angeles
Dept. of Community Development)
Los Angeles, CA

Keith Downs
Associate Planner, County of Riverside
Riverside, CA
(714) 787-6181

Chris T. Higgins
Geologist
California Div. of Mines & Geology

Kerr-McGee (Chemical Corporation)
P. O. Box 367
Trona, CA 93562
(714) 372-4311

C. Lee Kiernan
Planning Director
City of Desert Hot Springs
Desert Hot Springs, CA
(714) 329-6411

Larry Markham (Lake Elsinore, Winchester)
Development Consultant
28690 Front St., Suite 210
Temecula, CA 92390
(714) 676-6672

Richard Mitchell
Planning Dept., Imperial County
(714) 352-8184

David E. Pierson
Director, Public Works
Imperial County
(714) 352-2851

William Sorensen
Newspaper Publisher, City Planner
Calipatria
(714) 348-2246

Steve Wilson
Senior Planner, County of San Bernardino
Environmental Improvement Agency
San Bernardino, CA
(714) 383-1417

Sylvia Woodburne
Economic Research Specialist
County of Riverside Dept. of Development
Riverside, CA
(714) 787-2035

CONTACTS - STATEWIDE

Agricultural Council of California
Sacramento, CA
(916) 443-4887

C. Forrest Bacon
Sr. Geologist
CA Div. of Mines & Geology
Sacramento, CA
(916) 322-9918

Sandra E. Bressler
Earl Warren Legal Institute
U. C. Berkeley
(415) 848-3037

Robert Burt
California Manufacturers Association
Sacramento, CA
(916) 441-5420

California Association of Nurserymen
Sacramento, CA
(916) 448-2881

California Cattlemen's Association
Sacramento, CA
(916) 444-0845

California Financing Authorities
Sacramento, CA
(916) 445-9597

California Grain and Feed Association
Sacramento, CA
(916) 441-2272

California State Florists Association
San Francisco, CA
(415) 495-6780

California Pork Producers Association
Sacramento, CA
(916) 924-4090

Vashek Cervinka
Planning (Energy)
CA Dept. Food & Agriculture
Sacramento, CA
(916) 445-6719

James Cothern
Agricultural Economist
Cooperative Extension Service
U. C. Davis
(916) 752-2092

Jim Davey
Mechanical Dept.
Director Energy Projects
L.B.L./U. C. Berkeley
(415) 843-2340

Ray Hasek, PhD
Horticultural Specialist
Cooperative Extension Services
U. C. Davis
(916) 752-0412

Hunter Johnson, PhD
Vegetable Specialist (Greenhouse)
Cooperative Extension Service
U. C. Riverside
(714) 787-3432

Paul J. Lienau
Director
Geo-Heat Utilization Center
(Technical Assistance)
Klamath Falls, Oregon
(503) 882-6321

Oscar Lorenz, PhD
Chairman
Vegetable Crops
U. C. Davis
(916) 752-1741

Robert Miller
Farm Advisor - Confined Swine Raising
Tulare County
(209) 733-6363

Robert Pearl
Food Science & Technology
Cooperative Extension Service
U. C. Davis
(916) 752-0980

Cecil Pierce
Farm Advisor - Cattle Ranching
Modoc County
(916) 233-2123

Steven M. Ramirez
Director
Dept. of Economic and Business Development
Sacramento, CA
(916) 322-5665

Douglas Stockton
State Geothermal Officer

Richard Thomas
Asst. State Geothermal Officer

Div. of Oil & Gas
Department of Conservation
Sacramento, CA
(916) 445-9686

Lyle Tomlin
Special Projects (Geothermal Office)
U. S. Bureau of Reclamation
Sacramento, CA
(916) 484-4504

George B. E. West, D.V.M.
Animal Pathology
Bureau of Animal Health
CA Dept. of Food & Agriculture
U. C. Davis
(916) 753-2059
(916) 445-4191

Western Greenhouse Vegetable Growers Association
Robert Munion, President (1981-82)
7787 East Jahant Rd.
Acampo, CA 95220

Gary Hickman, Farm Advisor (Secretary)
San Joaquin Co.

(209) 944-3711