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OPPORTUNITIES FOR CALIFORNIA COMMERCE

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GEOTHERMAL ENERGY:

OPPORTUNITIES FOR CALIFORNIA COMMERCE

FINAL REPORT

JUNE, 1982

PREPARED BY:

LAHONTAN, INC.

ALTERNATIVE ENERGY SYSTEMS

SACRAMENTO, CALIFORNIA

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ABSTRACT

This report provides a preliminary engineering and economic assessment of five direct use projects using low and moderate temperature geothermal resources. Each project site and end-use application was selected because each has a high potential for successful, near-term (2-5 years) commercial development. The report also includes an extensive bibliography, and reference and contact lists.

The five projects are: Wendel Agricultural Complex, East Mesa Livestock Complex, East Mesa Vegetable Dehydration Facility, Calapatria Heating District and Bridgeport Heating District. The projects involve actual investors, resource owners, and operators with varying financial commitments for project development. For each project, an implementation plan is defined which identifies major barriers to development and methods to overcome them. All projects were determined to be potentially feasible.

Three of the projects cascade heat from a small-scale electric generator to direct use applications. Small-scale electric generation technology (especially in the 0.5 to 3 MW range) has recently evolved to such a degree as to warrant serious consideration. These systems provide a year-round heating load and substantially improve the economic feasibility of most direct use energy projects using geothermal resources above 200^{o}F.

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I. SUMMARY

This report, which is the final phase of a two-phased study, assesses the potential geothermal direct use market and its applications to projects in California. The effort is focused on those areas and applications that have the highest probability for successful near-term commercial development (near-term means 2 to 5 years for project implementation). Phase I was focused on defining and assessing potential resource sites and generic applications. Phase II analyzes specific applications at specific sites. Emphasis has been given to near-term projects with the potential for replication over a broad geographic distribution in the state.

The Phase I effort was not simply an extension of previous market studies; it has emphasized economic development aspects of direct-use projects that are important to attracting industry to consider geothermal energy. Commercial development and use of geothermal direct energy requires emphasis on economic development efforts in addition to energy development efforts.

The Phase I study confirmed that agriculture is the most important industry sector for application of geothermal direct use energy. District Heating and Cooling (DH/C) (including commercial and institutional heating and cooling uses) is also high priority application, which is necessary for the efficient and economic use of these resources. The study also determined that small-scale electric technologies (less than 10 MWe) have sufficiently evolved to warrant serious consideration. These systems, especially in the 0.5 to 3 MWe range, offer a summer load and improve the economics of most direct use energy systems. Further, they have the potential of accelerating development of many moderate temperature resources.

The results of Phase I are summarized in the "Synopsis of Phase I" section of this report and are reported in full in CEC Report, P500-82-008.[101*]

The Phase II effort is composed primarily of two interrelated activities:

<u>Task A</u>: Candidate Project Selection

Using the Phase I classification of sites and applications, five candidate projects have been selected. To assure broad coverage for project selection, cognizant state agencies, the cooperative extension service and trade associations were contacted (see Contact List). The result is a cooperative effort between the contractor and the CEC staff, who are continuing to identify additional projects as an on-going part of the CEC geothermal program.

<u>Task B</u>: Project Evaluation

To further define each potential project, the principal participants were identified, along with their roles and depth of financial commitment, and the known characteristics of the resource assessed. Then, a conceptual engineering and economic assessment was conducted for each project. Finally, known impediments to developing each project were addressed, including possible mitigation measures; and a project plan, identifying key participants and their required actions, was prepared.

*Superscript numbers refer to Bibliography, References and Contacts Lists.

A summary of the results of Phase II follows. The geothermal regions and areas defined in Phase I that received a priority of I, II or III are shown in the marketing base map (Figure 1). Known on-line or in-development geothermal direct use projects are summarized in Table I and are shown in the overlay of the base map (Figure 2).* These were selected based upon the fact that they were commercial scale operations, displacing fossil fuels and/or have committed financing for immediate development. Projects that stalled after completion of feasibility studies and those without a firm commitment for development have not been included.

The projects have been addressed at the conceptual level in order to determine first-cut, go/no go, and to identify critical next steps. These conceptual studies have been set up so that the CEC Technical Assistance Program could be utilized by the individual project proponents to address key problems and to continue the engineering/economic analysis in a greater depth.

*It should be noted that horticultural nurseries, the highest priority application category, are moving into geothermal applications in the state based upon their high energy sensitivity. Therefore, Figure 2 is valid only through the end of March 1982.

Figure 1

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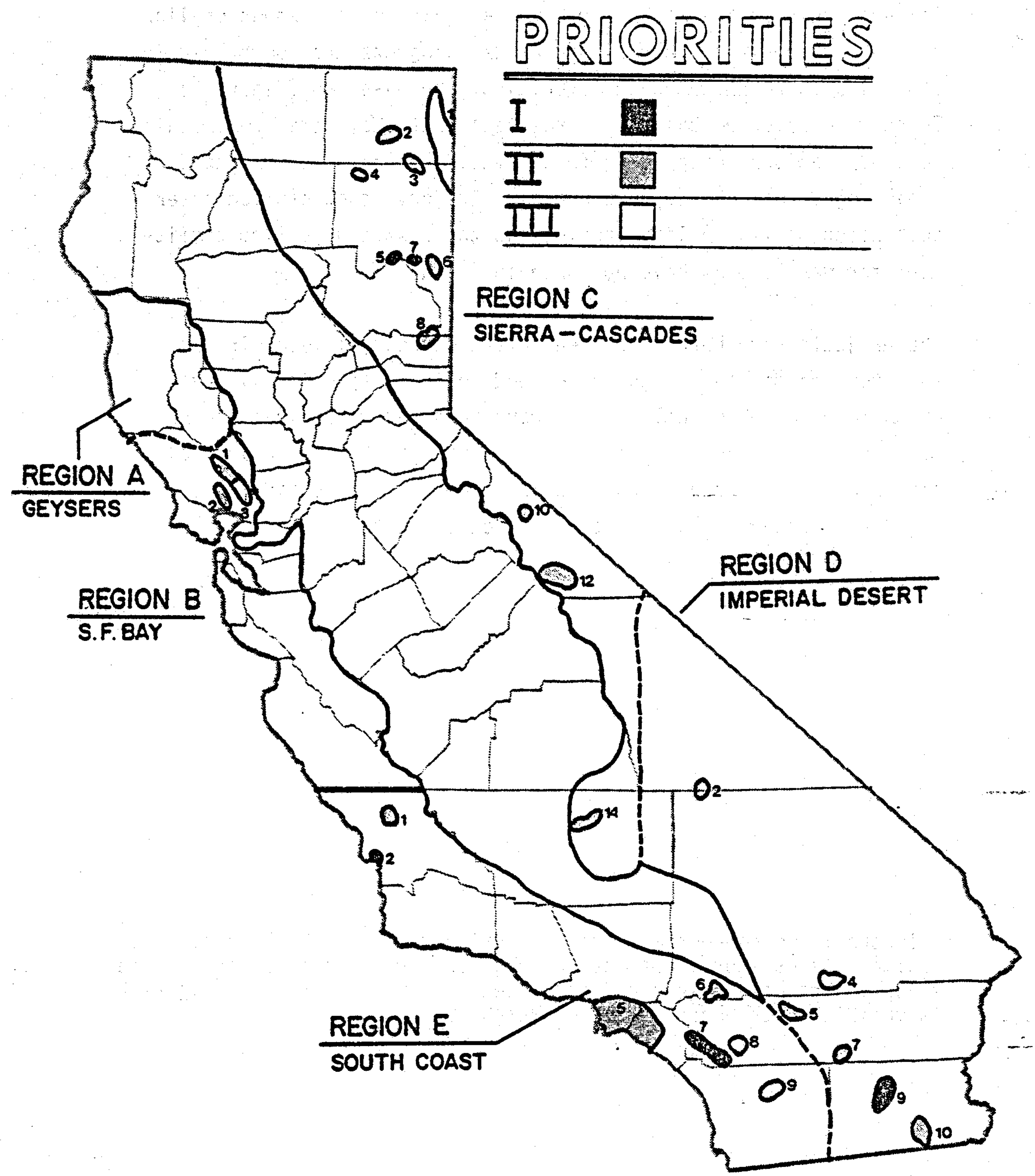

FIGURE I

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

Figure 2

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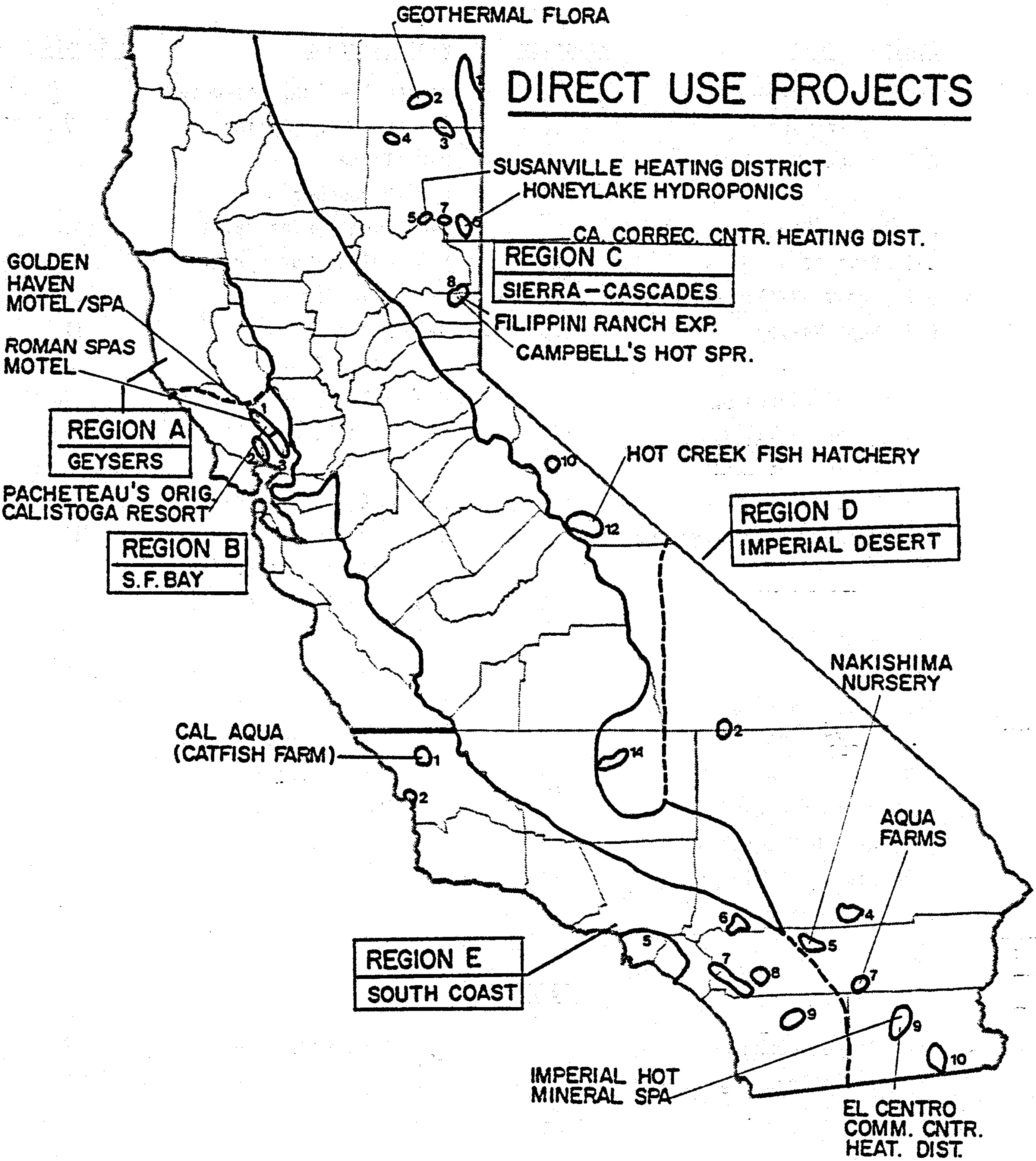

TABLE 1

Geothermal Direct Use Project Status

On-Line or In-Development Projects

Project Title	Location	Description
El Centro Community Center	City of El Centro 1275 Main Street Imperial County	Demonstration of space heating and cooling of City Community Center. Project is under construction, wells were completed 2/82.
Imperial Hot Mineral Spa	10595 Hot Mineral Spa Road Niland, CA Imperial, County	Mineral baths at a mobil home development in operation two years.
Honey Lake Hydroponics	Wendel-Amedee Hot Springs 30 miles east of Susanville Lassen County	Thirty greenhouses operational for several years.
Susanville District Heating System	Susanville, CA Lassen County	Initial phase of district heating demonstration including 17 buildings currently in operational shakedown period. HUD funding is adding 126 homes to the system.
Geothermal Flora	Kelley Hot Spring 4 miles east of Canby Modoc County	Heating of a 4,300 square foot greenhouse currently producing cut flowers. Resource is a 206°F boiling hot spring.
Filippini Ranch Experimental Facility	Sierra Valley Plumas and Sierra Counties	Using an artesian, 140°F resource, have tried a variety of applications such as heating a greenhouse, a barn and prawn farming. Considering development of a five acre greenhouse.
Aquafarms International, Inc.	Mecca, CA Riverside County	Raising fresh water prawns.
Cal Aqua (Catfish Farm)	Creston, CA San Luis Obispo County	Operating catfish hatchery for 9 years and currently expanding.
Campbell's Hot Springs	One mile east of Sierraville Sierra Valley Sierra County	108°F spring used for spa and swimming pool heat.
California Correctional Center	Litchfield 8 miles east of Susanville, CA Lassen County	Successful supply well drilled by private developer under agreement with City of Susanville. Susanville to sell minimum of 600,000 therm/yr to state for space heating center.

TABLE 1 (Cont.)

Project Title	Location	Description
Hot Creek Fish Hatchery	3 miles west of the intersection of State Highway 203 and U.S. 395 Inyo County	Large fish hatchery using nearby hot and cold springs in combination to produce 60° optimum temperature for trout production. Facility has considered space heating.
Nakishima Nursery	In Salton Sea area near Oasis Riverside County	Some nursery greenhouses are heated geothermally.
Golden Haven Motel/Spa	1113 Lake Street Calistoga, CA Napa County	Space heating and water heating for the motel and spa for 20+ years. Owners want to expand the motel and heating system.
Roman Spas Motel	Calistoga, CA Napa County	Swimming pool and domestic water are geothermally heated.
Pacheteau's Original Calistoga Resort	Calistoga, CA Napa County	Resource consists of four wells, three at 160-170' and one at 2,000', all with a temperature of 225°F. Resource is used for space, domestic water, hot baths and swimming pool heating. Owner wants to convert remaining cabins from gas to geothermal heat.

Note: The above table may not include all current on-going direct use projects in California.

Overall Assessment of the Projects

Five projects have been selected, each of which has one or more approaches that are economically feasible at the conceptual level. In all cases, the projects were addressed on the basis of a commercial or conventional approach to financing. However, in some cases it was found that use of direct government assistance (e.g., Local Government Grant Program) may be required to mitigate a high-risk well or long supply pipeline. In three of the projects, feasibility can be achieved through use of a small wellhead generator in order to have an adequate thermal load and to generate enough revenue for overall economic feasibility.

The use of small wellhead generators (0.5 - 3 MWe) can theoretically justify development of many moderate temperature geothermal resources in the state. However, lacking significant commercial demonstration these systems may require unique approaches to financing, cost effective design, strong warranty agreements and unique approaches to operations and maintenance during the early years of demonstration. Until performance, reliability and longevity have been demonstrated, the suppliers should be prepared to participate in these early installations.

The five projects are:

1. Wendel Agricultural Complex - An all private development of an agribusiness park of commerce with a wellhead generator. Owners/developers will build-to-suit for a qualified horticulturist, and a prototype cattle fattening facility is planned by one of the principals.

The following two projects combine to make up the Agribusiness Complex at East Mesa:

2. East Mesa Livestock Complex - An all private development of an animal protein feed production process plus a swine raising complex. The principal has experience in operation of a continuous feed rendering plant and in swine raising. He has a swine raising facility in Imperial County and is familiar with the site.

3. East Mesa Vegetable Dehydration Facility - A generic facility optimized for geothermal application to the food process industry. Conceptual feasibility supports CEC effort under SR24.*

4. Calipatria Heating District - A small community, north of Brawley, Imperial County, has a dedicated initiator with industry in-place that has expressed interest, in writing, to hook up. Much planning, prezoning and institutional effort has been accomplished. Small size probably will require a wellhead generator for an adequate load. Electric generation is desired by the community.

5. Bridgeport Heating District - The Bridgeport Geothermal Project is completing a CEC funded feasibility project, contract #500-81-003. Working relationships and interim agreements are in place between the resource owner, the private developer and the Bridgeport PUD, of Bridgeport, Mono County.

*Senate Resolution 24 requires the California Energy Commission to investigate the use of alternative energy systems in the food processing industry, including geothermal direct use.

This heating district will consider use of a wellhead generator, which is also being considered for Calipatria and a combination of the two East Mesa projects as an integrated complex.

Locations of the five projects are shown in the overlay Figure 3.

Figure 3

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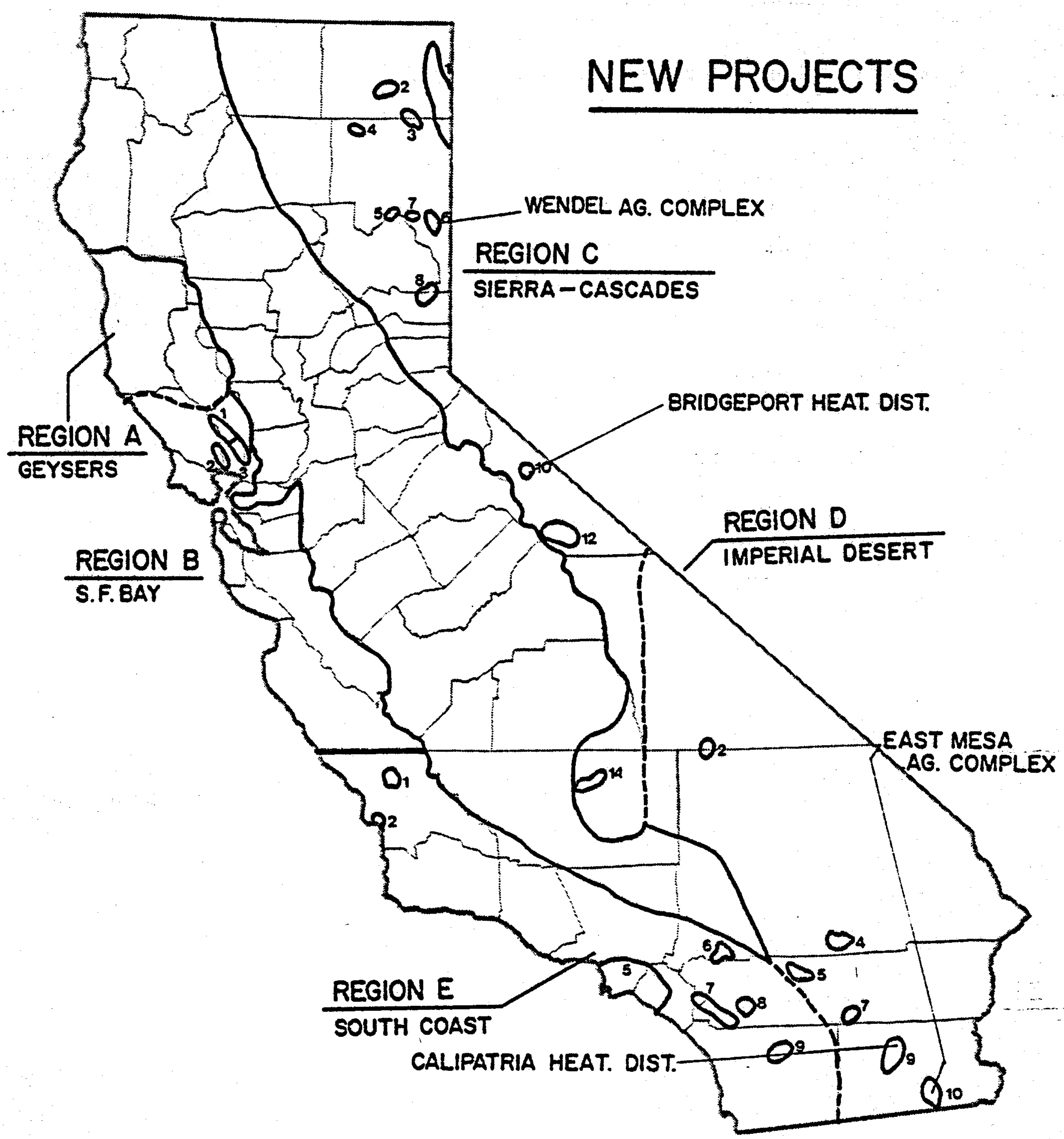


II. INTRODUCTION

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 water dominated (hydrothermal) 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 analysis 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.

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 forthcoming deregulation 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 (preferably 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 second phase of a two-phase project. The Phase I effort focused on evaluating the direct use geothermal resources in the state and selecting those generic applications that, when combined with a suitable resource, could possibly become a near-term project. The results of Phase I are also summarized in the following section. The Phase II effort focuses on selecting specific projects at specific sites. These projects were subjected to a conceptual engineering and economic assessment and a recommended approach to development was prepared.

Five projects were selected for Phase II assessment. In support of the California Energy Commission's effort to respond to SR24, a generic food processing system was included. For this project, a vegetable dehydration process was selected based upon discussions with the California League of Food Processors, the CEC staff and based upon the fit with geothermal direct-use resources.

Two community heating district projects were selected based upon these new projects receiving a high priority in Phase I. The City of Calipatria Heating District is a new project. The Bridgeport Community Heating District project has been undergoing a CEC-funded feasibility study in parallel with this project (CEC Contract #500-81-003).

The two other selected projects are based upon the expressed intent of private entities to carry forward the development. The specific names of these entities are on file with the CEC project office. Fictitious names are used herein to protect the competitive interest of the firms involved.

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

III. SYNOPSIS OF PHASE I

The Phase I effort assessed the potential direct use energy market and its application to California projects. The potential project identification effort has been focused on those opportunities that have the highest probability for near-term successful commercial operations, meaning 2 to 5 years for project construction and start-up. Phase I focused on defining suitable geothermal direct use resources and generic applications that are most appropriate for near-term projects.

This study builds on prior and recently completed market analysis and surveys. It emphasizes the economic development aspects of direct use projects. In addition to the previously studied industrial sectors, it included consideration of intensive growing and raising of agricultural products, district heating/cooling and waste processing. Also considered were wellhead generators as a commercial thermal load and use of geothermal power plant effluents as an energy source.

Emphasis was placed on agriculture as the most important industry sector of application for geothermal direct energy projects. Following closely on agriculture, District Heating and Cooling (DH/C) and its sub-sets of related applications, is a high priority application. The organized utilization, implied in a DH/C system, is necessary for the economic development and efficient use of a geothermal hot water energy 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. Five areas with a priority of I 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. Seven categories with a priority of I were found to have the least impediments to near-term application projects.

The geothermal regions and sites studied in Phase I were shown in Figure 1 along with their priorities. The generic applications studied along with their priority ratings are shown in Table 2.

The Phase I effort along with the definitions of criteria and assessment factors, tabulations of criteria, and assessments for sites and application are contained in the Phase I report,[101] "Geothermal Energy-Opportunities for California Commerce," Phase I, December 1981, CEC report number P500-82-008. Copies are available from the California Energy Commission.

TABLE 2

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	
	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

IV. PROJECT SELECTION AND EVALUATIONS

Project Selection Rationale

The Wendel, East Mesa Livestock and Calipatria projects were selected on the following basis:

a. The site rated a Priority of I or II in Phase I.

b. The application rated a Priority of I or II in Phase I.

c. The principal(s)/owner(s) were involved and committed to carry forward the project if an acceptable feasible approach could be defined.

d. The principal(s) either have a track record for financing projects of the size studied or have the stature and hands-on experience that could qualify them for private/commercial financing, (private/public financing in the case of Calipatria).

e. All projects must have a capable "initiator" involved.

The principals of the Wendel project initiated contact with the contractor of this marketing project seeking a feasibility effort. As a result, they have cost-shared and expanded the Wendel effort. The contractor was also approached by the principal of the East Mesa Livestock project long before this marketing project was initiated.

The Vegetable Dehydration Facility was selected in conference with the California League of Food Processors and the CEC. The selection was based upon the dehydration process match with geothermal resources, prior studies[1,4] and the success of a similar system at Brady Hot Springs, Nevada. While the process does not address the highly seasonal, large energy demand of tomato processors in the Central Valley, it does address a highly energy-sensitive process that is expanding with current trends to dehydrate foods and ingredients, new packaging technology and a declining market for canned goods. It should be noted that this is a generic model with no principal or "initiator" involved. It will remain up to the California Food Processors League and the CEC to promote this application.

The East Mesa Livestock and the Vegetable Dehydration facilities are discussed as an integrated energy system.

The Bridgeport project is to be separately reported in detail under contract #500-81-003. It is included in this report, in summary form, for completeness. All of the principals are in place with a stated intent to carry a feasible project forward. The model is a combination of private equity plus industrial revenue bond debt financing.

The financing for all projects was based upon the financing of the supply system for the Litchfield Geothermal Project, which used private equity financing for the high-risk area (geothermal wells) plus Industrial Revenue bonds to be issued under the California Financial authorities with a substantial bond buyer committed up front. Leveraged leasing and lease/purchase are alternatives for the debt financing.

A. Wendel Agribusiness Complex

1. Project Description

The Wendel Known Geothermal Resource Area (KGRA) is situated on the east shore of Honey Lake in Lassen County at an altitude of 4300 feet. It is twenty-five miles east of the City of Susanville and serviced by State Highway 395 North. The proposed project is to demonstrate the feasibility of utilizing a low temperature geothermal resource of 205°F to produce well-head electric power and then use the cascaded direct heat energy in a greenhouse complex and steer fattening facility.

The Wendel KGRA was selected on the basis that extensive geological work and demonstrated production from existing wells identified that large quantities of hydrothermal fluids in the 180°F - 220°F range were available from shallow wells at 150' to 300'. Low cost land availability and proximity to a major highway, railroad and power line enhances the site for near-term development. Lassen County has a stated commitment to develop its geothermal resources, which greatly facilitates the permitting process for prospective development. The 5,000 acre area under investigation for the purposes of this study is either owned or leased by four local businessmen. These owners participated in the study and have a strong interest in realizing development of the resource in the near-term.

For this project, a measured flow of 600 GPM at 205°F from an existing geothermal well and nearby Hobo Springs is used to supply the energy requirement of a complex consisting of a wellhead generator, five acres of greenhousing and an open air, ground heated steer fattening facility. The Rankine cycle wellhead generator is designed to extract a temperature drop of 50°F from 600 GPM at 250°F to produce a net output of 400 KW on a 310 day per year operating basis, which would go into the power grid. A five acre greenhouse complex will receive the cascaded 155°F fluids. A combination of in-ground and above-ground tubing and fin tube radiators will extract a temperature drop of 55°F to provide 1.5 therms per square foot annually. For six months of the year heating is required on a continuous 24 hour basis and, for the remainder of the year, on a 1/3 to 1/2 time basis. A flow of 210 GPM of cascaded geothermal fluids from the greenhouse operation will be fed through a lattice work of subsurface pipes prior to injection and disposal, for ground heating of a feedlot facility sized to hold 350 head per fattening cycle.

There is a definite need expressed by ranchers in Northern California to develop an economic system for fattening of long calves (650 - 700 lbs.) through to finished yearlings (1000 - 1100 lbs.), however, current low prices in the beef industry are not conducive to encouraging ranchers in geothermal areas to install a demonstration fattening facility. It is generally agreed that should such a facility prove that substantial gains could occur through ground heating with geothermal energy, considerable opportunity would exist for major beef producers to utilize some of the extensive resources areas of Northeastern California for this purpose.

Installation of a lattice work of 3/4 inch piping set 2' below ground would cost approximately $1.70 per square foot. Allowing approximately 110 square feet of heated space per head, a capital cost of $187 per heating space would be incurred. Without a concrete slab cover the life of such a facility might be ten years, which would amount to an annual cost of $34 per fattening space, including financing charges. To this must be added a nominal charge of $10 per space for cascaded energy, resulting in an annual total cost of $44. Since two fattening cycles of 120 - 140 days can be obtained annually, the final estimated cost would be $22 per head. Analysis of the incremental weight gain due to the enhanced food conversion rate resulting from geothermal ground heating is insufficient to justify a capital expenditure of $22 per head per year under current pricing conditions. At best, the project economics appear marginal.

II. Resource Description

There are two existing sources of developed geothermal flow currently available on the property.

- Hobo Springs - Despite several years of near drought conditions, Hobo Springs continues to yield 200 GPM of +206°F geothermal fluids and temperatures as high as 227°F have been recorded by the owner.

- Magma Well - Developed by Magma as a part of a resource exploration effort and left uncased. Honey Lake Farms cased and test pumped this well and ultimately used it as the main production well for their greenhouse facility. The well is 350' deep with main production zones in the 90' - 150' level. Temperature logs show temperatures of 231°F at 95' although the pumped well reflects a temperature of 205°F with a sustained capability of 500 GPM.

Extensive geologic work has been undertaken in the immediate vicinity of the project site since the early 1960's. All available information indicates an extensive resource area with both shallow and deep geothermal aquifers running throughout the area. The Honey Lake Basin has attracted considerable interest from those primarily interested in resource temperatures in excess of 240°F for electrical production, however, these resources have been relatively neglected by developers in the direct use field.

Water quality analysis of the existing geothermal sources described above depict a relatively clean resource in geothermal terms. Available off-the-shelf hardware will handle this fluid without major concern for materials compatibility. However, direct use for agricultural irrigation purposes would not be possible without incorporating a reverse osmosis process that is not now considered cost effective.

III. Project Energy Needs

The project is sized so as to make full use of the existing geothermal output described in the previous section.

IV. Engineering and Economic Assessment

The economics of the project (and the other projects described in this study) are conceptual in nature and arrive at preliminary conclusions. It is recommended that a more comprehensive feasibility analysis be undertaken through the CEC Technical Assistance Program using the services of the Oregon Institute of Technology (OIT).

A block diagram of the proposed Agricultural Complex is shown in Figure 4*. Load 1 (400 KW Rankine Cycle Cogeneration Unit) requires approximately 600 GPM of geothermal fluids at 205°F. The fluids will exit this load at 155°F and enter Load 2 (five acre greenhouse complex) requiring 600 GPM at 155°F under peak load conditions. Load 3 is designed to utilize 210 GPM at 105°F with excess fluids returning directly to the injection facility.

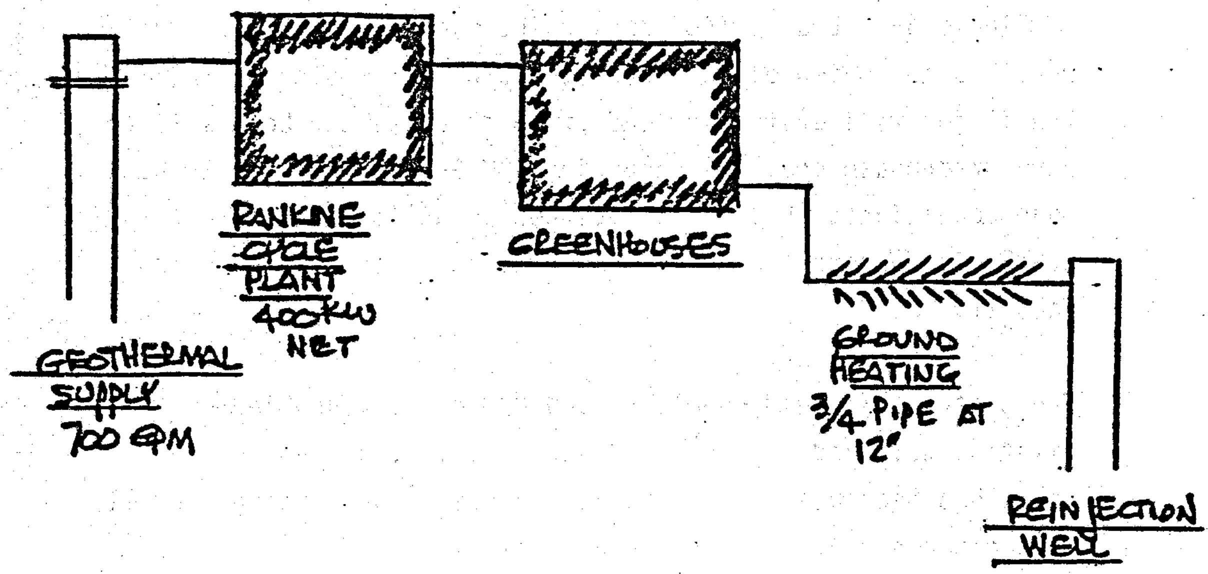
The goethermal fluid supply of 600 GPM can be supplied by the existing well and springs; however, the cost of new supply wells has been used for economic analysis representing overall expenditures required for a new development. The Rankine Cycle Cogeneration Unit is expected to operate at an 85% utilization factor. The greenhouse energy demand fluctuates with the seasons: roughly, November through April - 100% demand, May through July - 60% demand and August through October - 30% demand. The steer fattening facility energy demands coincide with the peak greenhouse demand.

A total first year gross income of $357,700 is projected for the overall project; which is made up of the Rankine cycle unit, the greenhouses, and the cattle fattening facility. The Rankine cycle unit is sized to produce a net output of 400 KW for 310 days per year priced at 8.5 cents/KW or $253,000 per year. The greenhouse complex will require 1.5 therms for each of 225,000 square feet, or a load of 337,500 therms per year. At a proposed selling price of

*All system block diagrams and engineering calculations were prepared by Koepf & Lange, Consulting Engineers, Lafayette, CA.

RANKINE CYCLE, GREENHOUSE, LIVESTOCK GROUND HEATING

FIGURE 4.



GREENHOUSES

5 ACRES = 217000 SF

Q TOTAL = 1.5 THERM/SF/YR (217000)

= 32.55 MMBTU/Y

HEATING GROUND

100' x 400' = 40000 SF

Q TOTAL ≅ 2.6 MMBTU/H (210 GPM AT 25°F ΔT)

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30 cents/therm (50% of the current average cost of natural gas), this will amount to $101,200 per year. While the cattle fattening facility does not now appear able to pay a competitive price for geothermal heat, for the purpose of encouraging a demonstration project, a nominal fee of $5 per animal is proposed which will add $3,500 in annual income.

The engineering estimate, by Koepf and Lange, of the capital cost of wells and wellhead equipment amounts to $830,000, as shown below:

Installed Capital Cost of Geothermal System:

1 x production well of 250' @ $80/ft	$ 20,000.
1x injection well of 250' @ $80/ft	20,000.
Distribution and injection pipeline	40,000.
Wellhead turbine pump	45,000.
Electrical equipment	22,000.
Pumphouse	5,000.
400 KW Rankine Cycle Unit	569,000.
Software costs	109,000.
Total capital cost	$830,000.

Operating costs are projected to be $271,400 in the first year, including estimated financing, managing, operating and electrical costs (plus a royalty of 12% of electrical sales).

The conceptual economic summary of the first year of operation results in a potential net revenue of $86,300 ($357,700 income less $271,400 in costs), representing a return before taxes in excess of 10% of capital invested. These preliminary estimates indicate that the Wendel Agricultural Complex can become a viable concept for private investors. It is determined that the shallow depth of the geothermal resource has a major favorable impact on the overall system economics.

V. Implementation and Impediments

The resource owner/lease holders have indicated their intent to follow up the findings of this report and bring the proposed project to near-term development. Three of the owners wish to install Rankine cycle generators and utilize the cascaded energy for greenhouse plants. The cattle rancher wishes to utilize residual effluent energy in a feedlot situation if a low cost system can be proven to enhance food conversion ratios. All candidates have the capability of raising sufficient financing to develop the proposed projects and are currently attempting to induce greenhouse operators to relocate to the Wendel area.

The following constraints will have to be resolved before any project will advance to commercialization:

a. Engineering evaluation to the Rankine cycle generators is required to establish the integrity of the mechanical components, seals, fluids and thermal cycle along with the capability of the plant to operate at 85% utilization with minimum maintenance cost.

b. The ability of the property owners to persuade experienced greenhouse operators to relocate to Lassen County.

c. Support from a government agency or extension service to assist development of a demonstration geothermally heated feedlot.

Since the Wendel project area is sufficiently distant from any population centers, increased activity caused by new development and expanded productivity should not arouse serious environmental concerns. The proposed activities and developments are compatible with current agricultural land zoning. Increased traffic caused by construction and increased productivity can comfortably be handled by State Highway 395. Geothermal fluids produced from the production well will be injected back into the general geothermal aquifer or disposed of through open evaporation/percolation ponds, depending on the permitting requirements of the Department of Oil and Gas and Lahontan Water Quality Control Board.

B. Agribusiness Complex at East Mesa

1. Project Description - East Mesa KGRA

A private business in Imperial Valley is proposing to use geothermal direct use energy for a combined rendering plant, feedmill and swine production complex. It is estimated that 300,000 cattle were marketed from feedlots in Imperial Valley during 1981. With an average 4% death loss in the feedlots annually, there are expected to be some 12,000 dead cattle at an average carcass weight, less hide, of 500 lbs. Thus, 6,000,000 lbs. of carcass would be available for rendering into high protein feed each year at the current feedlot level. An additional 4,000,000 lbs./yr. of butchered material is estimated to be available locally from a slaughterhouse (currently handling 50 head per day), plus other commercial and restaurant sources, making up a total estimated amount of 5,000 tons per year for rendering from all sources in Imperial Valley.

About 20 lbs of high protein feed (meat and bone meal) can be processed from each 100 lbs of carcass, or a total of 1,000 tons per year, using a small continuous flow rendering plant. This can constitute up to 10% of the complete feed ration for swine and is the most extensive constituent of swine feed.[40] A feedmill, in conjunction with the rendering plant and available locally grown grains, will serve to greatly improve the economics of the swine complex.

The conventional natural gas energy needs for the rendering cooker is in the range of 60,000 therms per year, based on 264 days of operation.

The high protein feed available from rendering, plus supplemental local grain and vegetable by-product feedstock for the other 90%, is sufficient for a 1360 sow complex which can produce 6.7 million pounds of pork annually under ideal confined conditions.

The design and economic analysis of a similarly sized swine complex proposed for northeastern California, using geothermal direct heat, is taken up in detail in the Kelly Hot Spring geothermal project (Reference 40). Some differences are the rigorous climate in Modoc County compared with Imperial Valley and the totally enclosed confinement required there, rather than the generally open shade usage found in Imperial Valley. Also, it is proposed that slab heating only be required in the gestation, farrowing and nursery areas, rather than throughout the complex as in Modoc. Taking these factors into consideration, and based on 365 days of annual operation, the swine facility has estimated conventional natural gas needs of 358,000 therms per year for slab heating.

II. Project Description - Vegetable Dehydration Facility

This generic facility has been selected in support of the CEC effort under Senate Resolution 24.

Several kinds of vegetables are grown in Imperial Valley over a long growing season that can be dehydrated by the application of geothermal direct heat. Although no agricultural candidate has at this time been identified to operate such a food processing facility, a typical modern onion dehydration plant (for which the thermal loads have been previously analyzed[102]) will be assessed. It is assumed that dehydration of other vegetables would have similar thermal requirements.

Low temperature drying in the food processing industry is especially adaptable to geothermal energy as the heat source, because dehydration requires large quantities of low intensity heat. The Geothermal heat is one of the least expensive sources and its temperature is less likely to get out of control to overheat the product. Onion drying fits into this category particularly well because it is an intensive process in which the onions are dried to only 20% of their original weight. One dryer installation of the type described would process the output of 800 to 1000 acres.

Onions, harvested in bulk, are loaded into large bins for curing, where dry air is passed through them to remove the excess surface moisture. The onions are then washed, sliced and moved along the line to the dryers. The dehydrator is a commercially available, highly automated system capable of handling 10,000 pounds of raw onions per hour in a four-stage process.

The temperature levels in the dehydrator are as follows: Stage 1 is at 210°F, Stage 2 at 180°F, Stage 3 at 150°F, and Stage 4 at 135°F. The total requirement is for 350 - 500 therms per hour, depending upon a number of internal and external environmental and product variables. Using an average of 425 therms per hour for 24 hours for a 250 day season projected for Imperial Valley, a total of 2,550,000 therms will be required annually for food drying, which will require a flow of 1000 GPM of geothermal fluids at 250°F.

III. Resource Description - East Mesa KGRA

The North Brawley area is one of the geothermal areas under consideration because it is in the center of feedlot activity and agricultural feedstock growing in Imperial Valley. It is also the location of the North Brawley Field, a KGRA with fluids of high temperatures and salinity at rather deep depths (± 7500 ft). Many private developers have geothermal leases in the area and Union Oil has developed (jointly with Southern California Edison) the Brawley Geothermal Electric Project. This is a single flash plant producing 10 MW of power designed, according to the information brochure, to demonstrate the feasibility of recovering the highly saline geothermal fluids found beneath the Imperial Valley and extracting steam that can power electric generation plants.

A local representative of the resource developer stated that 220 - 350°F waste energy now being vented to the atmosphere and the 115°F tailwaters from the turbine in the Brawley demonstration facility are not available for direct use, because its experimental nature precludes them from being able to assure a dependable supply of direct use energy to potential customers. He said, however, that the high cost of developing these deep wells with high salinity will encourage them to sell primary and cascaded heat to customers in future plants, once the problems of producing electric energy have been solved. This potential availability is expected to be at least three years downstream.

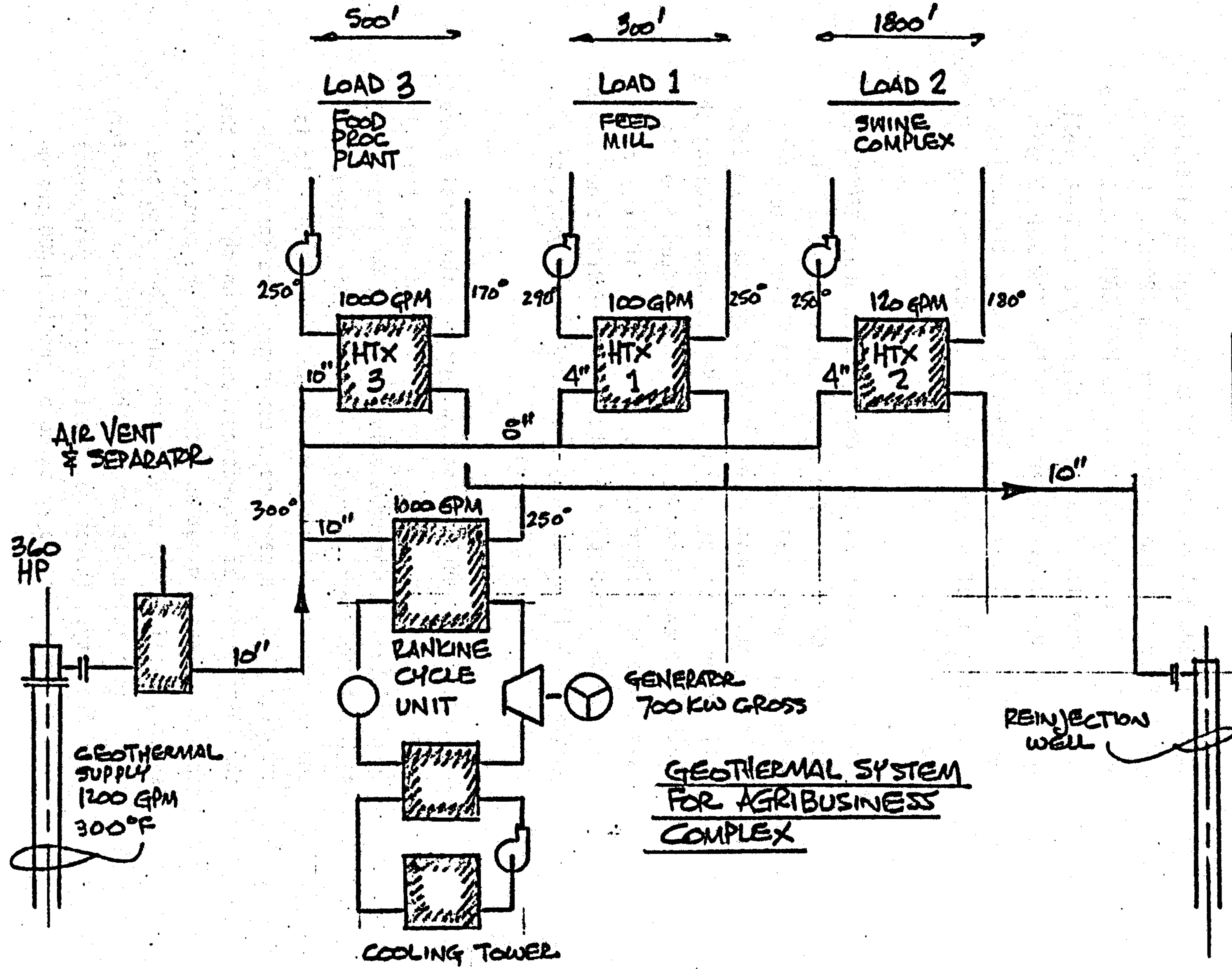
For these reasons, a Brawley location has not been considered for the near-term and an acceptable site has been selected on BLM land leased to Imperial Magma in the East Mesa Field, a KGRA some 30 road miles from Brawley and 20 miles east of El Centro. Environmental concerns in this isolated location should be at a minimum. Although greater trucking distances for carcasses, feed and vegetables will be necessary, it is expected that increased transportation expense will be offset by: low cost usage of BLM lands, availability of an appropriate geothermal resource and shorter permitting time. The resource has been developed by Imperial Magma, which has direct heat cascaded tailwaters in the 160 - 180°F range available in quantity from an existing facility at quite favorable rates (approximately half the cost of natural gas). While slab heating of the swine complex and some dehydrator stages could make excellent use of these tailwaters, the rendering plant cooker requires jacket temperatures of about 290°F and the first stage of the dehydrator requires 210°F.

For these reasons, a new geothermal well is projected for the Agribusiness Complex at East Mesa with 1200 GPM total capacity required, giving at least 300°F at an estimated 2000' depth. Imperial Magma also reports that fluids are expected to be in the 10,000 TDS range, are non-scaling and have a PH of 5.2 - 5.8. Due to these favorable characteristics, heat exchangers are proposed for each of the three processes (rendering cooker, slab heating and food drying) rather than a central heat exchanger at the wellhead.

IV. Engineering and Economic Assessment

The block diagram of the Agribusiness Complex is shown in Figure 5. The injection well is to have the same estimated depth of 2000' as the production well and must be located at least one mile away via an uninsulated line.

FIGURE 5.



GEOTHERMAL SYSTEM FOR AGRIBUSINESS COMPLEX

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Load 1 (Feedmill) requires 100 GPM of geothermal fluids at 290°F, Load 2 (Swine Complex) requires 120 GPM at 250°F, and Load 3 (Food Drying) requires 1000 GPM at 250°F. The total of these loads can be supplied by a 1200 GPM well producing geothermal fluids of 300°F. The overall energy requirement of these three loads, based on the projected hours per year of demand, amounts to approximately 2,968,000 therms annually.

Since only Load 1 requires temperatures above 250°F, at least 1000 GPM can be fed continuously to the Rankine cycle unit, which will lower the 300°F fluids to 250°F. The cogeneration unit is expected to operate on an 85% utilization factor producing 700 KW net output during this period. Revenue from the sale of cogenerated power is assumed to be 7 cents per KWH during the initial year as the "avoided cost" paid by the utility. With a net 700 KW delivered 24 hours per day for 310 days per year, this amounts to $364,600 in revenue.

The cost of conventional natural gas for the total energy demand, currently at approximately 30 cents per therm in Imperial Valley, (an unusually low price) would amount to $890,400 the first year of operation. This natural gas cost is projected to increase by 15% annually.[77] It is expected that the developers can charge the same price the initial year as conventional energy on the basis that they are financing not only the cost of the geothermal system, pipeline and cogeneration unit, but also the entire individual retrofit and heat exchanger costs for each facility. Therefore, the total first year gross revenue income is projected to be the $890,400 charge for direct heat to the Agribusiness Complex, plus the $364,600 sale of cogenerated power, amounting to total revenue of $1,255,000.

A breakdown of the estimated installed capital cost of the entire geothermal system, in current dollars, follows:

GEOTHERMAL SYSTEM CAPITAL COST

Production Well	$ 316,000
Injection Well	201,000
Wellhead Equipment	294,000
Distribution Pipeline	673,000
Retrofits (3)	527,000
Cogeneration Unit	996,000
Subtotal cost	$3,007,000
Software at 15%	451,000
Total Capital Cost	$3,458,000

The cost of the first year of operations is conceptually projected at $936,000, including debt financing, management, operations, power charges and a royalty fee of 7.5% of revenue. When these operating costs are subtracted from revenues of $1,255,000 there remains an estimated net revenue of $319,000 before taxes in the first year. There appears to be sufficient net income generated by the project to warrant lowered geothermal energy charges (perhaps 75% of current natural gas cost, with a limited escalation rate not to exceed 5% annually) in order to induce potential agribusiness to establish suitable facilities at the East Mesa Location. These are tentative economic projections and it is recommended that detailed feasibility analysis be provided by the CEC Technical Assistance Program using the services of OIT.

V. Implementation and Impediments

The geothermal developer must put together a realistic feasibility study, in order to interest experienced agribusinesses to invest in new facilities at East Mesa. At an early stage, he must seek out suitable debt financing investment funds. A limited partnership, with the developer acting as the general partner, is proposed as one method of organization which can make excellent use of the accelerated depreciation and available tax credits.

Permitting activities should also be started at an early stage to assess time and costs required, plus evaluating potential impediments and their mitigations. An engineer would then be retained to develop a basis of design. At the same time, or earlier, an exploratory geothermal well must be drilled to prove out the resource before much risk capital is committed. It may be possible to have an existing geothermal developer supply the well and sell the required energy at a favorable rate, thus saving well development costs. This study does not foresee that possibility as likely and instead includes the full costs of development of a successful exploratory/production well delivering 1200 GPM at 300°F at a depth in the range of 2000 feet with characteristics which will not preclude individual heat exchangers at the user's sites. Once a successful well is assured, then 35% design of the geothermal system and cogeneration facility may be started.

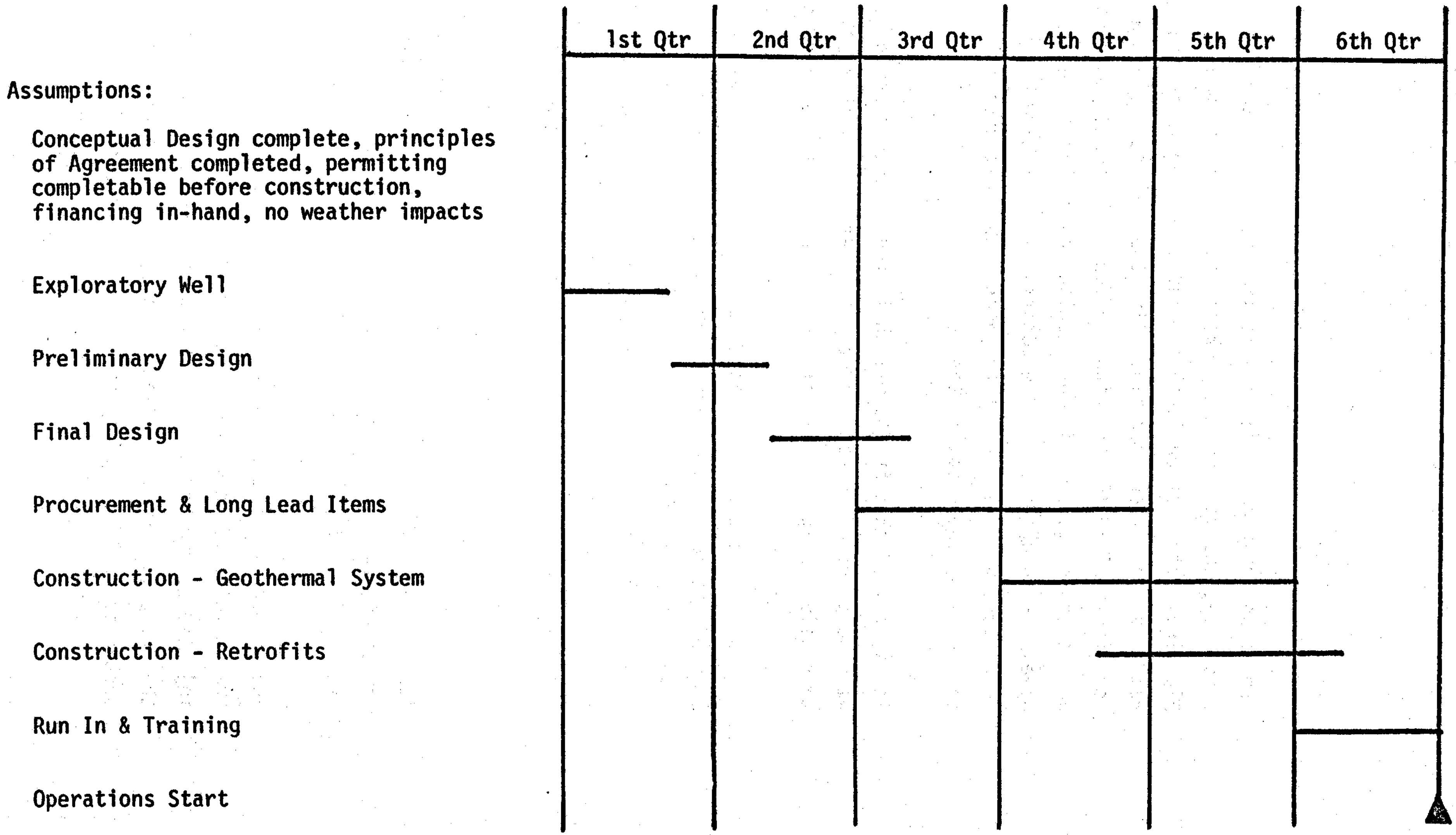
Once preliminary design has been evaluated and a Construction Plan made to determine if cost estimates and scheduling are within favorable limits, then final construction design can be undertaken. Once final design has been reviewed carefully, the various bid packages (wellhead equipment, pipeline, cogeneration facility, retrofits and injection well) can be put out for bid. With the assumption that an acceptable bid will fall within budget estimates, contract awards can be given and construction undertaken. The developer should inspect the construction, or hire an inspector, to be sure that the work is done according to the plans and specifications.

It is assumed that in the meanwhile the Agribusiness Complex will be constructed concurrently so that it will be ready to receive the geothermal fluids within a relatively short time after they are available;otherwise,the developer will lose significant direct heat sales. Should the Agribusiness Complex not be ready to accept any or all of the direct heat energy, the cogeneration facility can still be run at full capacity. While it is assumed that the geothermal developer will fund and install the individual retrofits, including heat exchangers, in trade for a higher price for delivered energy, all retrofit operations and maintenance will be the responsibility of the agribusiness involved. Should the entity wish to provide the retrofit investment as part of its facility, a proportional reduction in the energy pricing can be offered. A Conceptual Schedule of these implementation highlights follows as Figure 6.

Environmental impediments for the East Mesa geothermal system are expected to be minimal. The cascaded fluids must be injected according to local regulations as to distance from the production well (at least 1 mile) and depth (same as production well). Safety from high temperature fluids will

FIGURE 6

Agribusiness Complex at East Mesa - Conceptual Schedule



require burying pipelines and installing safety devices and jacketing as required. Drilling and well completion can be noisy, but it is assumed proper design and scheduling can reduce these to acceptable limits.

The Agribusiness Complex will have potential impediments in terms of truck and employee traffic, odors from rendering and swine raising, the removal of waste products and the disposition of manure. While the vehicle traffic and amount of odor can be minimized, it is assumed that the East Mesa site, which is downwind and well away from residential areas, will serve to minimize serious objections. Increased employment will require additional housing, traffic and services. Some of this impact can be mitigated by a policy of local employment where practical and it is assumed that agricultural related employment (with its local acceptance and its additional income and tax base), will not be conceived as detrimental.

C. Calipatria Heating District

I. Project Description

The Imperial Valley City of Calipatria, population 2,650, is located adjacent to the Salton Sea KGRA and close to the North Brawley KGRA. It is believed that Calipatria would have been within the Salton Sea KGRA except that, as a municipality and residential community, it was excluded to avoid potential institutional problems. Calipatria, through its City Council, wishes to improve its economic welfare by utilizing some of its available land for geothermal wells. It then proposes an electric generation facility be developed in the 50 MW range along with the sale of cascaded direct heat through District Heating & Cooling (DH/C).

The City is soliciting public funding for a feasibility study and if the study is favorable, it plans to drill, or have drilled, a slim-hole well on City property at the airport. Should there prove out to be a resource with potential suitable for electric generation, the City plans to call for proposals in two phases: "(1) Leasing of the resource for electrical generation and (2) Development of the waste heat (or separate system) for direct use industrial and commercial processing, heating and cooling."[103]

Identified in-place potential direct-heat users,[104] with present annual therms of natural gas energy required, are listed below:

1.	Calipatria Unified School District	16,000 therms/yr
2.	Cal-Pat Growers (cotton ginning)	288,000 therms/yr
3.	Producers Cotton Oil (cotton seed oil)	521,000 therms/yr
	Total existing energy use	825,000 therms/yr

The City has been active for several years in preparing itself and its citizens for a potential DH/C and, in fact, has obtained commitment letters of agreement from the three potential users listed above.[104] Prezoning activities have been conducted and admission to the Imperial County Geothermal Overlay has been requested. In addition, Foster Commodities has a vacant plant site in Calipatria and would be approached to proceed with a proposed facility to reclaim cooking oils on the basis that a dependable source of process heat would be available at a lower long-term cost than conventional energy.

Calipatria has stated the expected benefits of developing geothermal energy to be:[103]

"a. TO THE CITY. Source of revenue to offset current and future losses due to restructuring of existing taxes. Potential for subsidizing certain residential energy needs through distribution of excess revenues instead of direct payment to property owners as fair share of resource (royalty) income.

b. TO AREA. Establishing of industry that will use agricultural wastes will improve income of local agricultural economy. New industry will tend to stablize overall economy and improve both unemployment (currently chronic 20% plus) and income levels.

d. TO STATE: Provide demonstration project for statewide application of both geothermal direct use and large-scale agricultural waste utilization for both hydrocarbon processing for fuel and for the chemical industry, i.e., 2-3-4 carbon products."

II. Resource Description

The City of Calipatria is hopeful that the slim-hole well will show temperatures in the 300°F range at not more than 2500 feet depth, with the expectation that the higher temperatures required for electric generation will be available in the 5000 feet range.

Geologists for the Division of Oil and Gas are less optimistic. They report U.S. Geologic Survey data showing the Calipatria area to be in a temperature gradient trough with less than 4°F rise per 100 feet of depth, while the Salton Sea and North Brawley anomalies have highs of over 10°F per 100 feet. They state that electric power developers tend to concentrate on areas with more than 4°/100' for exploratory purposes. Their estimate was that one would have to go to at least 4000 feet to produce 300°F fluids at Calipatria. Further, it is known that few, if any, exploratory wells are being sunk by developers into the extensive geothermal leaseholds in the Calipatria area; indicating that current research is not favorable. For these reasons it would appear that the slim-hole well would have to show at least as good results as are obtained nearer the center of the anomalies in order to arouse the interest of developers for a power plant site.

The local representative of a large geothermal developer expressed the opinion that geothermal development in Imperial Valley, especially for electric power generation, is a quite risky business that should only be attempted by experts with plenty of experience and capital. In addition, good research analysis and a realistic feasibility study are strongly recommended. The high salinities found in the area make technical development, scaling problems and disposal particularly difficult.

III. Development Options from Slim-Hole Exploration

It is assumed that slim-hole exploration by the City will not extend to depths greater than 2500' due to technical and cost limitations. Three options, depending upon down-hole temperatures obtained, are addressed:

1. Temperatures over 300°F at less than 2500' depth:

   The assumption is made that the City's desire of attracting geothermal developers interested in electrical power generation will be realized and that direct heat will be cascaded to industrial processors at favorable energy rates. The developer would pay a franchise fee to the City in the range of 7% of revenue, new industry may be induced to locate in the nearby area to make use of less expensive direct heat and the City will have reached toward its geothermal goals. The feasibility study being applied for by the City will presumably show cost-effective economics which will make the contemplated investment and beneficial use possible.

This study will not address the above scenario as the City's projected feasibility study will be based on this eventuality. Instead, the more likely probability will be addressed, as conveyed by the geologists contacted, that temperatures of interest to such electric power developers are not expected to be found in the immediate Calipatria environs.

2. Temperatures in the 240° - 290°F range at less than 2500' depth:

   This is the temperature range which, at the present state of the art, is below that of interest to electric power developers. However, process industry can make good use of these temperatures as direct heat and there is the distinct possibility of a modern Rankine cycle wellhead generator being able to produce cogenerated electrical power beneficially. The above option will be addressed with the assumption that a private geothermal developer will undertake the project as a profit-making venture under franchise from the City.

3. Temperatures below 230°F at less than 2500' depth:

As these temperatures are below that required by the large existing process industry loads, it is not expected that local space heating and cooling needs will be sufficient for an economic geothermal system. The Unified School District has a relatively small load (estimated at less than 20,000 therms/yr) and requires considerable pipeline costs at its greater distance from the proposed well site and process loads, resulting in expenses which would not appear to be cost effective in the near-term.

IV. Conventional Energy Requirements

The two identified significant heat loads within 1.5 miles of the proposed 20 acre well development site northeast of the airport are now using natural gas for process heat. The Unified Schools have existing air conditioning using electrical systems which would be very expensive to retrofit to geothermal for the relatively small amount of energy involved.

The conventional natural gas energy needs of two existing and one proposed industrial processors are tabulated below:

Load A. Cal-Pat Growers, Inc. Process: Cotton ginning. 4 dryers in 240°F range, 50 therms per hour each, 16 hours per day for 90 days. Estimated energy used annually - 288,000 therms.

Load B. Producers Cotton Oil Co. Process: Cotton seed oil extraction.

1 boiler producing 240°F steam, 65 therms per hour, 24 hours per day for 334 days average. Estimated energy used annually - 521,000 therms.

Load C. Foster Commodities Process: Reclaiming cooking oils.

Assume 240°F at 25% of Load B above, 15 therms per hour, 24 hours per day for 334 days per year. Estimated energy projected annually - 130,000 therms.

Estimated Annual Conventional Energy Load - 939,000 therms

Direct heat flow to process users, of at least 230°F, has been calculated as: Load A - 1330 GPM, Load B - 480 GPM, and Load C - 150 GPM. The system has been designed for a peak of 1000 GPM (75% of Load A), and a 650' pumping depth which will require a 300 horsepower pump motor. As the peak flow for Load A is only used 90 days per year, a Rankine cycle generator is incorporated into the system to cogenerate electric power during the rest of the year and whenever less than peak loads are demanded. Net output of the generator is calculated as 527 KW nominal, which can be sold or wheeled to the utility with the best rate.

Figure 7 is a block diagram of the system described.

First year revenue from process heat sales, assuming the price of geothermal energy would initially be the same as conventional energy (in Calipatria natural gas has the very low cost of

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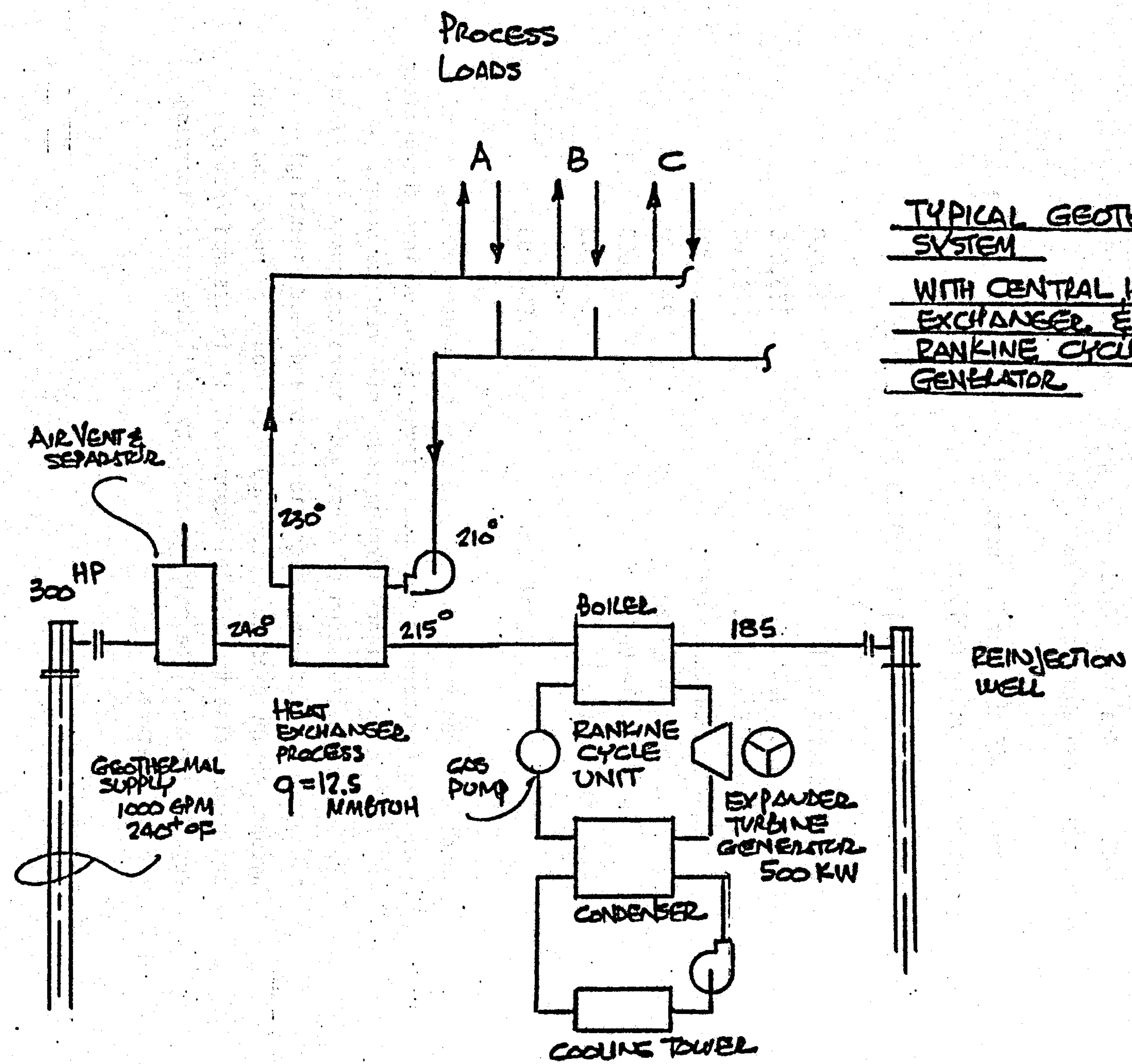

TYPICAL GEOTHERMAL SYSTEM

WITH CENTRAL HEAT EXCHANGER & RANKINE CYCLE GENERATOR

FIGURE 7.

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approximately 30¢/therm), would be $281,700. Sales to the utility power grid, assumed at 7¢ per KWH for a 527 KW Rankine cycle unit with a 75% utilization factor, would amount to $242,300. The total first year gross revenue would be the sum of these two amounts, or $524,000.

Estimates of the overall installed capital costs of the geothermal system follows:

Conceptual Installed Capital Cost

Production Well	$ 262,000
Injection Well	135,000
Wellhead Equipment	248,000
Central Heat Exchanger	114,000
Distribution System	971,000
Rankine Cycle Unit	835,000
Software (at 15%)	385,000
Total Cost	$2,950,000

Conceptual generating costs have been based upon making use of a Limited Partnership that would invest $600,000 into the project and finance the balance through industrial revenue bonds. A preliminary calculation of first year operating costs (including management, operations, electric power and debt financing) amounts to approximately $535,000. It should be noted that, in order to assist the initial economics, it is assumed that no royalty fees will be paid to the City until the debt financing has been retired.

Revenues of $524,000 less operating costs of $535,000 would result in a projected net revenue cost of $9,000 in the first year of operation. Net revenue gain is expected during the second year. For a detailed feasibility study, it is highly recommended that the CEC Technical Assistance program, using the services of OIT, be sought. It should be kept in mind that the economics and conclusions reached here are definitely conceptual in nature.

Retrofit costs to the process users (estimated in the range of $260,000) are not included as part of the system cost in these calculations, since they will be built into the existing plants. These costs are to be born by the users and may be substantially reduced by available tax credits, write-offs and potential direct government assistance (e.g., CEC Grant Program).

It is conceptually estimated that first year operating costs (including management, operations, electric power and debt financing) would amount to approximately $620,000. No royalty fees have been included to the City, at least until debt financing has been paid off, in order to assist the economics. Conceptually an operating cost of $95,900 in net revenue before taxes is calculated for the first year.

VI. Implementation and Impediments

Calipatria has already applied for public funding of a Basis of Design and for a slim-hole exploration well. It is assumed that these efforts will be rewarded. The detailed Basis of Design should be based on technical information available from the exploration. The scenario addressed here is that resource temperatures, although below those of interest to electric power developers, will be suitable for the process heat loads (240+°F) at depts in the 2000' range.

A direct heat developer would then negotiate with the City for geothermal leases and rights of way and with the process users to supply them with geothermal energy. He would develop his own Basis of Design, which would contain conceptual engineering design and projected cost estimates. Based on favorable long-term economics resulting from the study, the developer would put together a limited partnership as one form of investment vehicle and seek out an assured source of acceptable debt financing through industrial revenue bonds or equivalent debt financing.

At this point, the permitting time and seriousness of potential impediments should be evaluated, permitting activities undertaken and 35% engineering design authorized. Implementation steps will then follow the same format previously described for the Agri-business Complex at East Mesa. The final link will be an interface connection to the retrofits installed by the process users. If the geothermal system is on line before the process users are ready, the Rankine cycle unit can be run at full capacity to cogenerate electrical power in the meanwhile. A conceptual implementation schedule will be quite similar to that of the East Mesa Agri-business Complex shown in Figure 6.

The major impediment to the Calipatria DH/C project is the questionable quality of the City's resource. This must be resolved through drilling and testing one or more slim-holes. Once the resource has been established, adequate direct heat loads must be committed and/or new ones developed. A development team must be put together, consisting of City officials and private entities, to deal with the technical, economic and institutional tasks involved.

Since the site proposed by the City is adjacent to residential areas, noise and emissions from the drilling well completion and from the cogeneration facility must be carefully controlled to permitted levels. Construction will result in traffic, noise and street disruptions while the pipeline is being laid. While careful planning can mitigate these somewhat, a certain amount of temporary inconvenience is inevitable. All pipelines will be buried for safety and protection; however, an unavoidable crossing under the Southern Pacific railway right-of-way may pose some special consideration.

D. Bridgeport Heating District

The Bridgeport project has not completed the formal feasibility effort. A summary is included here only to scope the project, for completeness of this report. Final feasibility data is to be presented in the Final Report under contract #500-81-003.

I. Project Description

The project, as defined at this stage, is based upon interim agreements for sublease of geothermal direct energy rights and for participation in the feasibility study. The principals include the private resource "owner" that holds the major federal non-competitive lease applications at the site, the private developer committed to carry forward the development of financing and the project, and the Public Utility District with the expressed interest in owning and operating an economic, self-supporting energy system. Excellent encouragement and support is being rendered by the county officials and staff.

The project assumes at least one supply well, nominally 2000 feet depth, and a transmission line to a utility complex. Also included are a primary heat exchanger, provisions for a wellhead generator, system controls and a reinjection well. Secondary fluids (boiler quality water) from the primary heat exchanger transmit heat energy to the principal public buildings in town. Major private buildings will be encouraged to hook up during the initial capital construction. All public buildings but the school are boiler/hot water systems, enabling simple water-to-water retrofits, with present boilers to be left available for standby and peaking, if required.

A nominal 600 GPM flow of 205°F geothermal water is required for the design load, including a nominal reserve for growth. To assure adequate margin for wellhead generation and significant retrofit of all active buildings in the town proper a target of 1000 GPM is desired. The fluid quality in the springs is 4300 ppm TDS; hence, a primary heat exchanger at the utility complex has been chosen. The total public building load has been calculated at 1.6×10^{10} BTU/year.

Conventional Energy - For heating, the conventional energy is propane piped through a utility system; plus some electric heat. Propane was deregulated in 1980 and cost $.87/therm in January 1982. Electric power at the end of 1981 cost $0.088/KWH. A 26% electric power rate increase was to be effective in March 1982.

The Energy System Description - The system block diagram is included as Figure 8.

II. Conceptual Economics

The Heating District including wells and major retrofits is estimated to cost $2.5 million and the wellhead generator (400 KW) another $1,000,000. In one economic model the project achieves a positive cash flow in the sixth year of operations and has an Internal Rate of Return of 27%. It has been noted that several elements make the economics very sensitive:

1. The supply well is deep and expensive to drill
2. The supply line has to be insulated steel and hence is quite expensive.
3. A small increase in fluid temperature (~10°F) will have a significant impact in electric power revenues. If the resource comes in at 240+°F the electric and heating district can operate independently from each other and hence the electric power can be generated year around.

It must be clearly understood that this project depends entirely upon the success of drilling a useful supply well.

GEOTHERMAL SYSTEM
BRIDGEPORT, CALIF

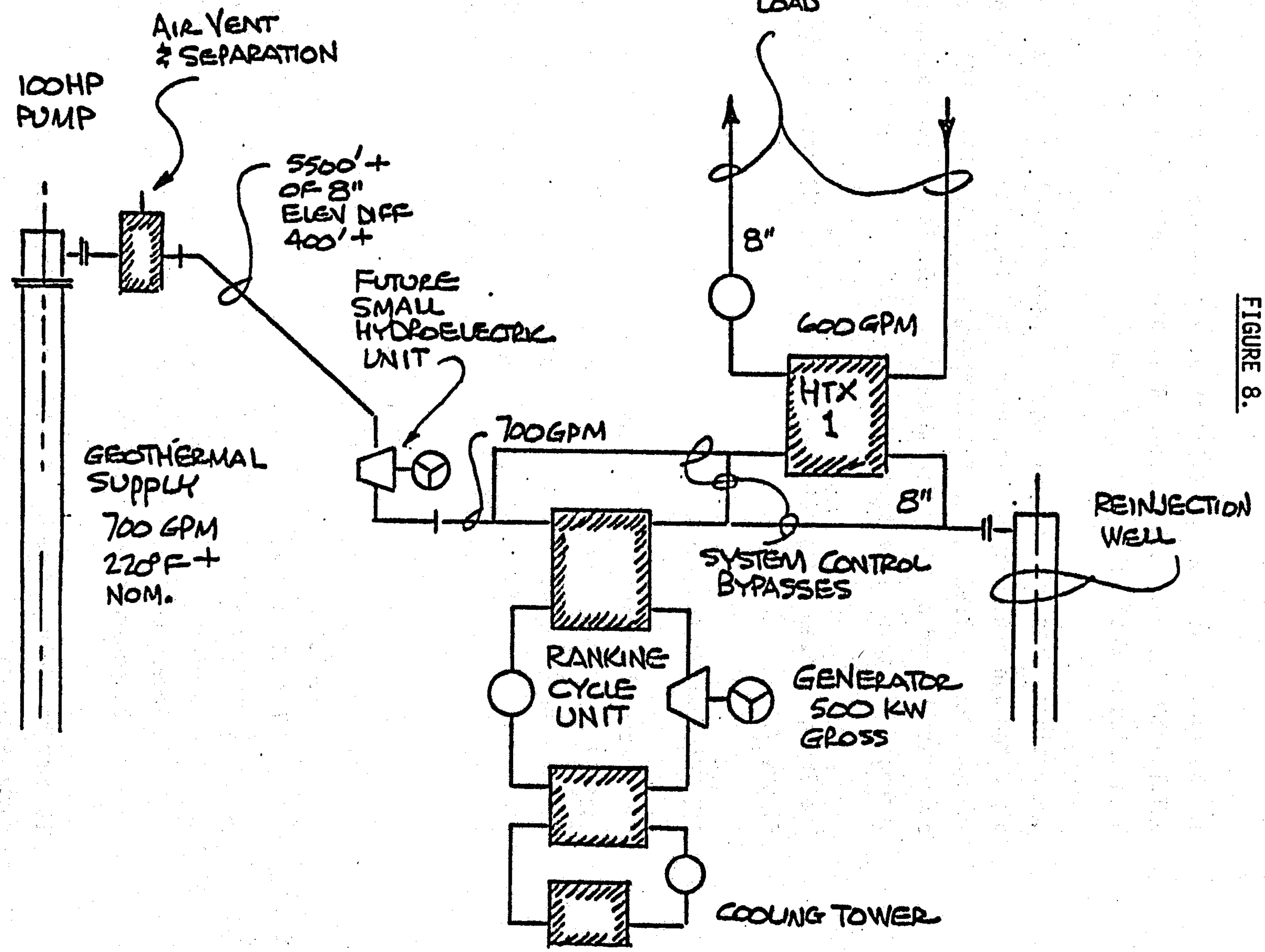

FIGURE 8.

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871 DEWING AVENUE
LAFAYETTE, CALIFORNIA 94549
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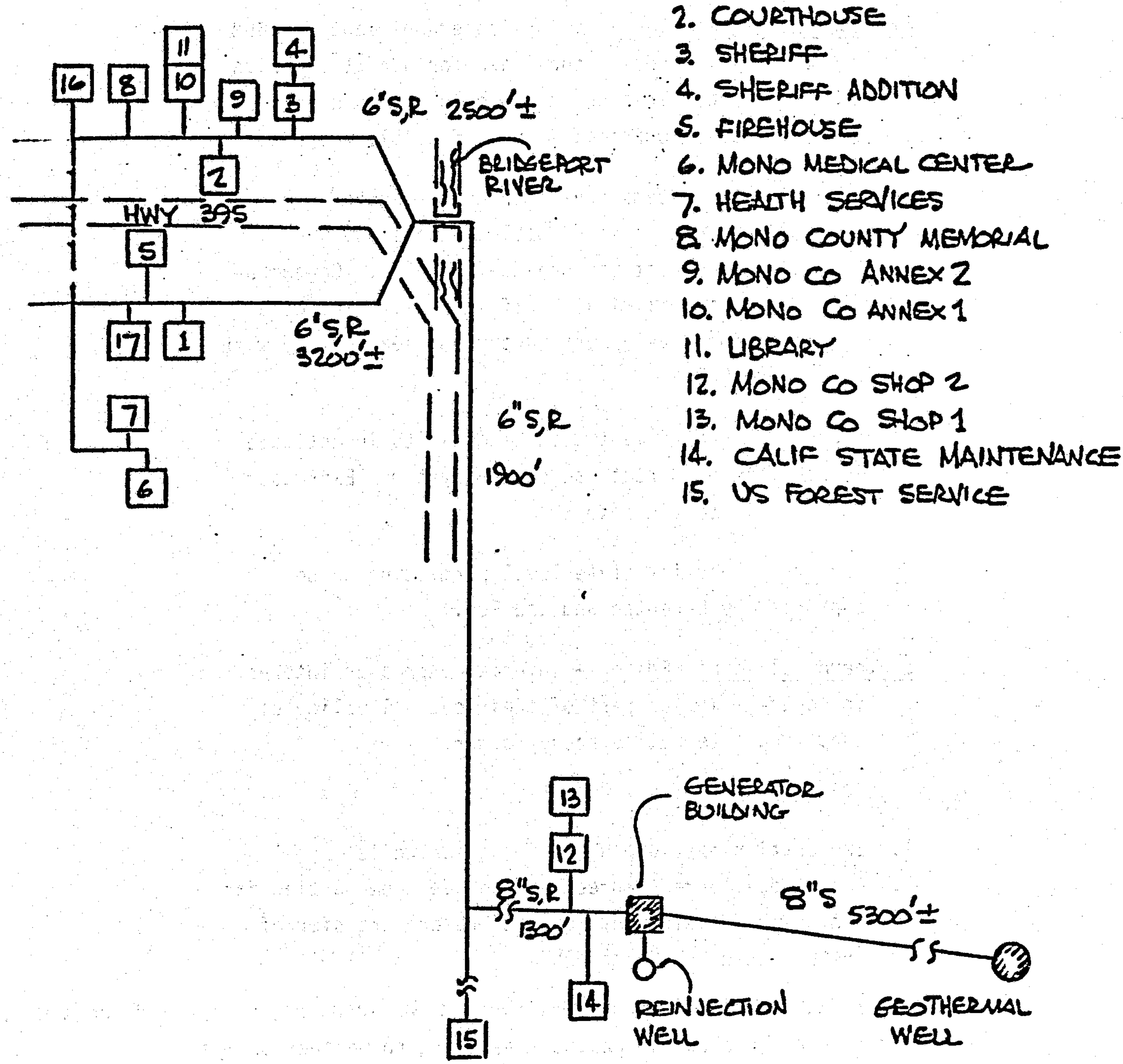
FIGURE 8 CONT.

SITE PLAN SCHEMATIC GEOTHERMAL SYSTEM



LEGEND

1. ELEMENTARY SCHOOL
2. COURTHOUSE
3. SHERIFF
4. SHERIFF ADDITION
5. FIREHOUSE
6. MONO MEDICAL CENTER
7. HEALTH SERVICES
8. MONO COUNTY MEMORIAL
9. MONO CO ANNEX 2
10. MONO CO ANNEX 1
11. LIBRARY
12. MONO CO SHOP 2
13. MONO CO SHOP 1
14. CALIF STATE MAINTENANCE
15. US FOREST SERVICE

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III. Principal Participants, Next Steps, Impacts & Mitigations

Presuming the formal feasibility study (Contract 500-81-003) will be positive under one or more configurations, the principal participants and key conditions are as follows:

Francana Resources, Inc. - major lease applicant for BLM non-competitive lease, sub-lease for direct use with Lahontan, Inc. This depends upon BLM completion of primary leases to Francana and a feasible project.

Lahontan, Inc. - systems developer committed to develop system, provided it is feasible. Sub-lease with Francana for direct use heat below 250°F. Cogeneration requires amplification of lease with Francana. Agreement for development up through feasibility with Bridgeport PUD.

Bridgeport PUD - agreement with Lahontan to investigate feasibility of direct use energy system. Expressed interest in cogeneration.

Mono County - lead for state level permitting to be supported by Lahontan and the PUD.

Southern California Edison - informal expressed interest in cogeneration as part of their overall policy of supplying alternative energy power.

Major steps required are:

1. Exploration for supply and injection wells
2. Formal development agreements between the parties for financing, development, operations and transfer of system ownership to the PUD.

Once a permitting schedule can be firmed, then financing, design and construction can be completed in about 18 months - assuming no weather delays.

V. CONCLUSIONS AND RECOMMENDATIONS

1. Now that the geothermal information center and OIT TA programs are being set up, the Commission must maintain continuity and momentum if they expect to meet their objectives of encouraging development and use of this resource.

2. In this light, certain near-term projects will require funds from Federal government grant programs and CEC-TA for early feasibility effort to accelerate implementation.

3. All of the contact work with trade associations and economic development state agencies must be continued or credibility will be lost.

4. One factor must be clearly remembered - geothermal direct heat development requires an economic development approach.

5. Agriculture, the largest cash industry in the state, has the best fit with geothermal direct heat. Emphasis must be given to this area. The CEC should leverage its limited funds and make use of the massive agricultural infrastructure in California.

6. Moderate to high temperature sites (200 - 300°F) are the most cost effective and lowest risk areas to give focus for the CEC effort for full, commercial scale operations. The small scale "ma & pa" operations can then hookup at minimum risk.

7. District Heating Systems - with a good initiator - are necessary elements for a full complex of large and small industry and for community/commercial participation.

8. Small scale electric (~0.5 - 3 MWe) can be a key to the economic viability for a number of sites studied. These units also can stimulate development of moderate to high temperature resources development in California. Full scale demonstration is required to accelerate use of this existing technology.

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VII. GLOSSARY

Cascading - Flowing or stepping down to decreasing levels of geothermal fluid 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 artificially controlled environment to increase yield, such as a greenhouse, confined poultry or swine raising complex

Geothermal Resource - An identified hydrothermal production site as indicated 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, an area designated by the Secretary of Interior as most likely having geothermal resources that can be used to produce electric power.

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 developing or utilizing geothermal direct heat

Cogeneration - Conversion of geothermal heat into electrical energy and direct 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 a significant increase in energy costs. Energy sensitive businesses usually have either a product that has energy as a significant 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 or food process 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.

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