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CALIFORNIA ENERGY COMMISSION
U.S. DEPARTMENT OF ENERGY
GEOTHERMAL RESOURCES COUNCIL

MASTER

GEOTHERMAL ENERGY

OPPORTUNITIES FOR CALIFORNIA BUSINESS

A TWO-DAY CONFERENCE ON DIRECT UTILIZATION OF GEOTHERMAL ENERGY

Conference Proceedings for

September 28-29,1981
Hanalei Hotel
San Diego, California

P500-82-009

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CALIFORNIA ENERGY COMMISSION

U.S. DEPARTMENT OF ENERGY

GEOTHERMAL RESOURCES COUNCIL

GEOTHERMAL ENERGY: OPPORTUNITIES FOR CALIFORNIA BUSINESS

Conference Proceedings for
A Two-Day Conference on
Direct Utilization of
Geothermal Energy

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February 1982

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State of California

GOVERNOR'S OFFICE

SACRAMENTO 95814

EDMUND G. BROWN JR.

GOVERNOR

The people, businesses, and industries of California are meeting today's energy challenges by developing economic and reliable energy alternatives. Geothermal energy is one of these alternatives.

California leads the nation in geothermal energy development. Geothermal resources are available in forty-six of the State's fifty-eight counties. Today, over 900 megawatts of electricity are generated from the State's rich geothermal steam fields, but abundant hot water resources for direct use applications are still underdeveloped. Investment in geothermal direct use provides business and industry with the opportunity to achieve greater energy self-reliance while conserving our limited petroleum resources.

California has established a State goal of 5,000 megawatts of electricity generated from geothermal resources by the year 2000, and is equally committed to the formation of a strong market for geothermal direct use applications.

The information contained in this booklet will assist you in evaluating the potential opportunities for using geothermal energy. Please feel free to contact the California Energy Commission for any additional assistance.

Sincerely,

EDMUND G. BROWN JR.
Governor

ABSTRACT

On September 28-29, 1981, the California Energy Commission, the U.S. Department of Energy, and the Geothermal Resources Council held a two-day conference on direct utilization of geothermal energy. The purpose of the conference was to inform members of the state's business and financial community and state and local governments about the tremendous opportunities for directly using California's abundant, low temperature geothermal energy resources.

The conference which was entitled "Geothermal Energy: Opportunities for California Business" was attended by over 200 persons representing business and government. This document contains the proceedings of that conference. It includes copies of the oral presentations and written materials of the individual speakers and workshop panelists who participated in the conference sessions.

For further information on direct use of geothermal energy in California, we invite you to contact:

California Energy Commission
Geothermal Program Manager
1111 Howe Avenue, MS-66
Sacramento, CA 95825
(916) 924-2496 or 2499

Many people contributed their ideas, skills, and time to make "Geothermal Energy: Opportunities for California Business" a successful conference. First, we are grateful to the speakers and workshop leaders for their participation. We would also like to thank David N. Anderson and Beverly Hall of the Geothermal Resources Council for helping us put the conference together.

ACKNOWLEDGEMENT

Funding for these conference proceedings has been made possible through Cooperative Agreement No. DE-FC03-79ET27135 with the U.S. Department of Energy and the California Energy Commission.

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WELCOME

OPENING REMARKS

by

C. SUZANNE REED*
COMMISSIONER
CALIFORNIA ENERGY COMMISSION

Welcome/Introductory Remarks

I would like to welcome you to our conference "Geothermal Energy: Opportunities for California Business." The purpose of this two-day conference is to bring together members of the business, financial, and local communities to discuss the potential opportunities in California for the direct use of geothermal energy.

We are fortunate in having with us today some of the leading technical and financial experts on direct use projects. Before we begin with our first speaker, I would like to provide you with a brief overview of the state's involvement in geothermal energy development and a few of our current programs to offer assistance in developing these resources.

We have all become painfully aware of oil price increases and periodic disruptions of oil supplies reflected in gasoline lines and rapid energy price increases in California. For at least the next two decades, California is expected to experience continuing oil and natural gas price increases and almost certainly one or more abrupt oil supply disruptions. Energy costs in California are expected to more than double before the end of this decade due to increasing foreign oil prices.

Recognizing the adverse impacts of rising energy costs, current shortages in investment capital, and the continuing threat of serious oil supply disruptions, the state has adopted an energy policy of channeling scarce capital investment funds into energy conservation and renewable energy sources.

The California Energy Commission is the principal agency in the state charged with responsibility for promoting the development of geothermal resources in California. It has streamlined the regulatory process for licensing geothermal power plants and has approved 5 geothermal electric generating plants with a combined capacity of 430 MW. In addition, the Commission has funded 11 feasibility studies for geothermal direct heat in California, some of which you will hear about today, and is providing funding for a number of development projects.

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*Ms. C. Suzanne Reed was a Commissioner at the California Energy Commission for the past four years. Also, Ms. Reed served as the presiding member of the Geothermal Policy Committee for the Commission.

Other state agencies, including the Office of Planning and Research and Department of Conservation, have played active roles in expediting permitting of geothermal wells and assessing the potential and distribution of geothermal resources in California.

One of the major state efforts to encourage development of California's geothermal resources was passage of Assembly Bill 1905 in May 1980, authored by Assemblyman Douglas Bosco. This bill provides funding to mitigate impacts from such development by establishing a geothermal development grant program, administered by the California Energy Commission, for local governments having geothermal resources. California became the first state to pass such legislation which allows revenues from federal geothermal leases to be disbursed as grants to local governments for geothermal planning, mitigation, and development activities. Businesses with geothermal resource potential can become eligible for these funds by joining with local governments to apply for grants. Beginning October 1, 1981, applications for projects will be solicited by the Energy Commission for awards totalling $340,000 this year with available sums expected to increase in future years. Local jurisdictions eligible for these grants include cities, counties, and special districts that have geothermal resources. This includes a fairly large number of local jurisdictions since 46 of California's 58 counties have indications of geothermal resources.

In summary, I would like to conclude by saying that we are here to help you explore the opportunities for direct use of geothermal in California and to provide you with information and assistance in pursuing these projects. I personally am very enthusiastic about the response and interest you have shown in geothermal direct use. I am also pleased that we can provide a forum for you to explore the possibilities of this resource for your particular firm or community and share your expertise and experiences with us and each other.

WELCOMING ADDRESS

by

Roger Hedgecock*
San Diego County Supervisor

I. WELCOME

On behalf of the San Diego County Board of Supervisors and the residents of this region, it is my pleasure to welcome you to this conference. In addition, I want to express my appreciation to the California Energy Commission, the U.S. Department of Energy, and the Geothermal Resources Council for organizing this conference and for their wisdom in choosing such an appropriate location to stage it.

II. SAN DIEGO IS AN APPROPRIATE LOCATION FOR THE CONFERENCE

Residents of this region have demonstrated their awareness of the potential role of alternative energy resources.

Awareness has been stimulated by the active role of county government in encouraging alternatives:

- o 3,000 solar systems, over 3,000 lots created with solar access since January 1979.
- o Partly as a result of the county's first-in-the-nation solar mandate ordinance, solar access ordinance, pool heating ordinance, priority processing for solar developments, and the Oceanside municipal solar utility.
- o Also, San Diego Gas and Electric Company (SDG&E) purchase of Cerro Prieto geothermal generated electricity and county development of the San Diego Energy Recovery (SANDER) project.

III. WHY IS SAN DIEGO A LEADER?

The region possesses few traditional energy resources:

- o No hydroelectric, indigenous fossil fuels. The distances imported electricity must be transmitted further compound the problem.
- o Financial problems of the primary utility--SDG&E--have resulted in the second highest utility rates in the nation and a utility cannot finance major new centralized generating capacity.

*Supervisor Hedgecock has been serving as San Diego County Supervisor, Third District, since January 3, 1977. Since his election to the Board of Supervisors, Mr. Hedgecock has been successful in reducing the cost of government, removing unnecessary governmental regulation, and reforming the welfare system in San Diego County.

- City of San Diego Industrial Development bonds so that SDG&E can meet commitments for completion of San Onofre Nuclear Generating Station (SONGS) 2 and 3.

- The Eastern Interconnect illustrates the inability of the region to provide for its own need from traditional, indigenous resources.

IV. GEOTHERMAL: PART OF A STRATEGY FOR SAN DIEGO'S ENERGY INDEPENDENCE

Geothermal energy is available in relatively abundant supplies in the San Diego-Imperial Valley area:

- o Warner Springs,
- o Jacumba, and
- o Heber.

Rapidly increasing utility rates are causing the private sector to explore utilization of these resources:

- o Rohr industrial process heat, and
- o Warner Springs project.

V. NEED FOR A PARTNERSHIP BETWEEN GOVERNMENT AND PRIVATE SECTOR TO ENSURE DEVELOPMENT

Insensitive or unreasonable government regulation must be identified and eliminated.

Cite deregulation of wind-powered generating systems as an example of the need for commitment by government to development alternatives.

Incentives are also necessary if long-term benefits of energy independence are to successfully compete with short-term considerations.

DEVELOPING THE RESOURCE

EXPLORING FOR AND DEVELOPING GEOTHERMAL ENERGY RESOURCES IN CALIFORNIA

by

Gerry W. Huttrer*
Republic Geothermal, Inc.

I. INTRODUCTION

There are significant opportunities for geothermal development in California. The Geysers resource, originally exploited in an area covering about 6 square miles, now appears to include more than 200 square miles. The developed part contains a dry steam resource, while the majority of the area appears to contain very hot water and/or two-phase resources. Current produced steam temperatures are about 475°F, but temperatures in excess of 600°F have been recorded in the central part of the thermal anomaly. Reserves are estimated to exceed 2,000 megawatts in the dry steam area alone. To put it another way, these known reserves are equivalent to about a billion barrels of oil used to fuel boilers of electric power plants.

Known resources in the Imperial Valley could support more than 7,500 megawatts of electric power generation. This estimate does not include extensions of the resources contained in the ultradeep hypersaline reservoirs currently being developed that may underlie virtually the entire valley! The deep resource could be many times greater than that currently recognized and, in my view, is very likely to make the Imperial Valley geothermal reserves equivalent to more than 10 billion barrels of oil.

Starting with these known geothermal deposits and adding areas such as Surprise Valley, Medicine Lake, Long Valley, and parts of the Mohave Desert, all of which may have very significant potential, one can see that geothermal resource hunters are in "Elephant Country" when working in California.

II. EXPLORATION PARAMETERS

There are two distinct groups of geothermal developers. One group seeks high-temperature resources suitable for production of electricity, and the other group seeks lower temperature waters that can be used for industrial, agricultural, aquacultural, space heating, or balneological purposes. Some parameters for high-and low-temperature geothermal resource exploration vary significantly; however, one common objective exists for both groups--profitability. All of the various conditions must result in economically viable projects whose returns equal or exceed those of alternative investments before the geothermal project under consideration will be initiated.

*Mr. Huttrer is currently Manager of Exploration for Republic Geothermal, Inc. He has worked in engineering geology and mineral exploration in the United States and overseas for eight years. Since 1971, Mr. Huttrer has specialized in exploration management for electric and nonelectric resources.

A. High-temperature Resource Parameters

1. Need resource temperature of 300°F or higher, with flows and pressures adequate to sustain about 2 megawatts per well.

2. Salinity can be a significant cost or benefit factor depending on its type and concentration.

3. Depths of up to 14,000' are being exploited; however, costs escalate rapidly with increasing depth.

4. Location of the resource is fairly critical; i.e., it should be in a high demand area near an existing transmission grid.

5. A progressive, adventurous utility should be available to provide a market.

B. Low-temperature Resource Parameters

1. Need water temperature of only 90°F for some applications, although 150 - 250°F is far more desirable.

2. Need adequate production for proposed use.

3. Location of the resource is critical with respect to land availability, resource ownership, transportation, market, labor supply, climate, topography, and raw material supply.

4. Depth to resource must be shallow, less than 2,000' preferably, in order to minimize drilling costs.

5. The salinity may be a critical cost factor if extensive steps must be taken to prevent corrosion.

Obviously the high-temperature resource development requires much greater cost and risk, but it also can have a return on investment as good or better than the oil and gas it displaces because of the large quantity of resource used in electric power generation. In view of the general thrust of this meeting, I will concentrate hereafter on topics pertaining primarily to the search for nonelectric resources.

III. EXPLORATION

In order to identify, acquire, and characterize low- and medium-temperature geothermal resources, the following tasks must be accomplished:

A. Survey the market and determine the potential value of the resource to the available market.

B. Determine end-user requirements.

1. If project is already operative:

   a. Temperature.

   b. Quantity.

   c. Cost of displaced or competing energy.

   d. Cost of retrofitting existing systems.

   e. Distance to resource site.

2. If the project is not already operative, then the following, in addition:

   a. Climate.

   b. Transportation.

   c. Raw material proximity.

   d. Labor.

   e. Budget constraints.

C. Study geologic environment for sites and resources likely to meet required parameters, including probable availability of resource and site for surface utilization.

D. Research existing groundwater data and geologic structural and stratigraphic publications seeking possible reservoir rocks (aquifers and fracture conduits) with high natural recharge potential.

E. Conduct absolute minimum, but adequate, predrilling geologic, geochemical, and/or geophysical work.

F. Obtain rights to resource (i.e., lease or buy).

G. Obtain permits.

H. Drill to confirm resource.

I. Test resource so as to thoroughly characterize its quality, quantity, and potential productive life.

IV. <u>DEVELOPMENT</u>

A. Confirm resource market by:

1. Identifying and contacting potential users.

2. Obtaining contract(s) for sale of resource at a price that is profitable for resource developer, yet competitive or cheaper than fuels presently being used.

B. Establish financing--prerequisites are that:

1. Data from drilling and field testing can convince investors/lenders that the resource is capable of supplying the project adequately to provide sufficient return.

2. The stability of the end-user project with respect to internal cash flow, market prospects, competition, and sales growth is adequate to convince investors/lenders to finance the facilities.

C. Complete resource facility:

1. Design well or wells, fluid handling equipment, heat exchangers, etc. and integrate with end-user facility.

2. Install and test facilities.

V. OPPORTUNITIES FOR LOW-TEMPERATURE GEOTHERMAL DEVELOPMENT IN CALIFORNIA

A. Imperial Valley

The Imperial Valley presents an unusual opportunity for low-temperature development in California. This is true because high-temperature resources are currently being exploited for electrical power generation. These resources are water dominated, and they yield significant quantities of hot brine that can be made available downstream from the electricity generating turbines for utilization for a multitude of purposes prior to its reinjection.

Investigations of specific opportunities for use of this heat source are in progress, and they may soon mature. Nevertheless, as electrical development of the Valley increases, so will the amounts of brine available for direct use; and it would, therefore, seem prudent for all potential end users of such a heat source to promptly contact the developers of electric projects and initiate planning for integrated high- and low-temperature projects.

B. Surprise Valley

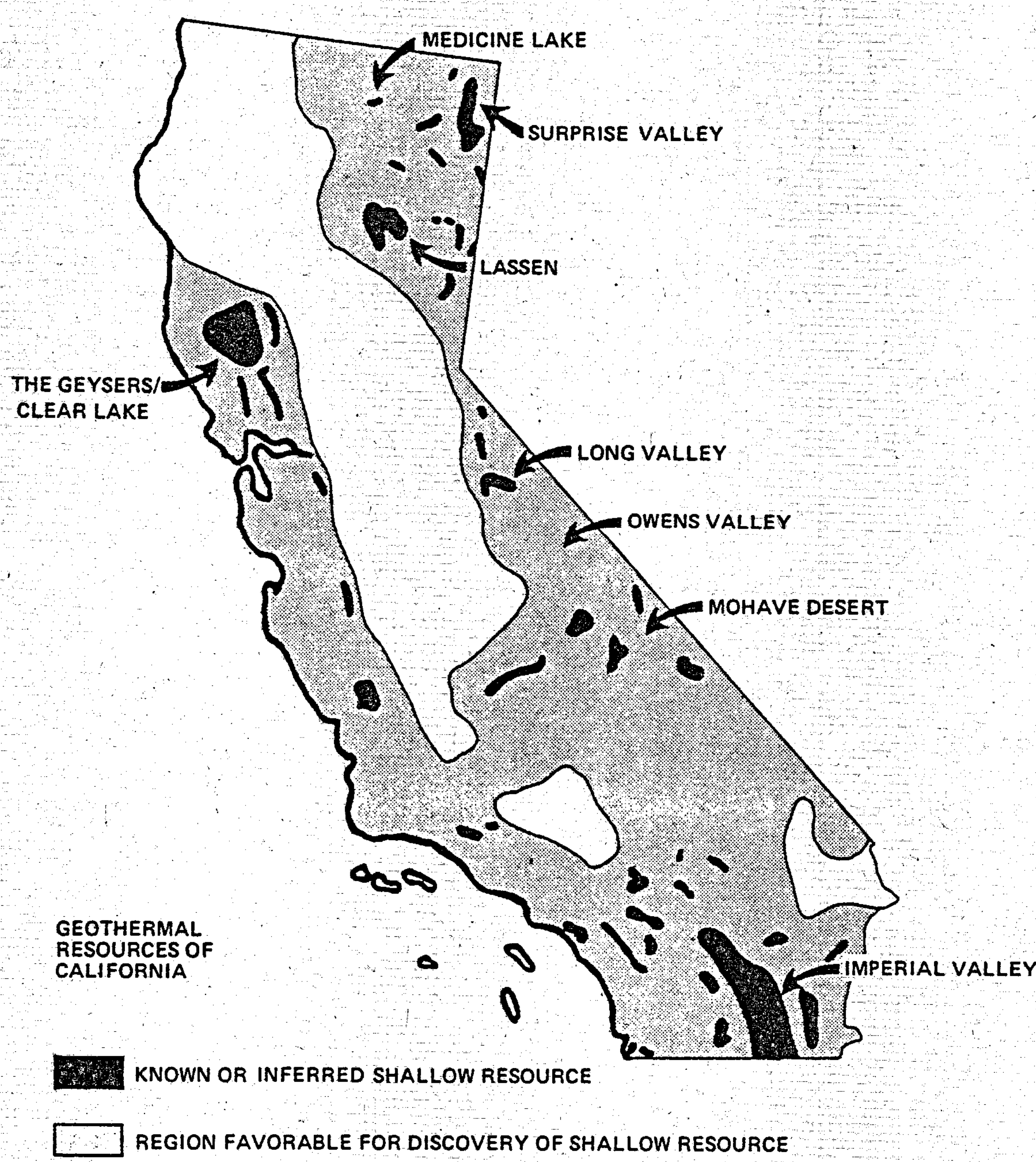
The existence of resource with marginal potential for power generation has been indicated by the results of drilling to date. Cascaded effluents from a power plant or direct utilization of the native hot waters may present significant opportunities for the Alturas-Modoc County region.

C. Owens Valley

The existence of thermal waters has long been known in this area. There may be economic viability in projects that utilize the hot water for space heating, district heating (Bishop, Bridgeport, Lone Pine), agriculture, or mining-related purposes.

D. Other Areas

The map accompanying this paper is derived from the California Department of Conservation, Division of Mines and Geology, Map No. 4 of their California Geologic Map Series on which are depicted known or implied geothermal resource areas of California as well as the very extensive areas of potential resource. Anyone who has a business or is considering entering into a project that can be located in this broad area should examine this map and consider the utilization of geothermal resources in their business plan as an alternative to hydrocarbon fuel or to electricity purchases.


MEDICINE LAKE
SURPRISE VALLEY
LASSEN
THE GEYSERS/
CLEAR LAKE
LONG VALLEY
OWENS VALLEY
MOHAVE DESERT
IMPERIAL VALLEY
GEOTHERMAL
RESOURCES OF
CALIFORNIA
KNOWN OR INFERRED SHALLOW RESOURCE
REGION FAVORABLE FOR DISCOVERY OF SHALLOW RESOURCE

SUMMARY

of

AN ASSESSMENT OF CALIFORNIA'S LOWER TEMPERATURE GEOTHERMAL RESOURCES

PRESENTATION

by

Brian H. Sway, Deputy Director*

California Department of Conservation

Geothermal resources can be found throughout the State of California. Low and moderate temperature geothermal resources can be found along the entire length and breadth of this state. Although low and moderate geothermal energy has been neglected in California in recent times, it is a plentiful resource. Underutilization has not always been the case.

Even before the coming of the European settlers and any written accounts of uses of geothermal springs, the American Indians used thermal areas as campsites and sites for religious ceremonies. Evidence for this is found in the large numbers of artifacts that have been discovered in and around thermal springs and pools throughout California and in folklore among the members of various Indian tribes. A recent study of the Calistoga area in Napa County by the Division of Mines and Geology uncovered evidence of such uses. According to all historical sources and local lore, the Wappo Indians residing in the Upper Napa Valley were the first to utilize the hot springs and steaming mud at the present site at Calistoga for sweat houses and other ceremonial purposes.

From the earliest history of the American settlers in what is now the State of California, many of the hot spring areas have been known and visited, not only for campsites with natural heat for cooking, but also for the curative properties of their hot waters, steam, and hot muds. Beginning in the 1840s and 1850s, it became popular to build resort hotels or spas in many of the better hot spring areas. Some of these areas, such as The Geysers, were in locations so remote that they required construction of extensive wagon roads over extremely rough terrain to bring in the guests. Even though roads deteriorated in a few years to horse trails because of difficulty of maintenance, still the guests came--even on horseback.

In the 1870s, some of the outlying areas began to lose favor, as resorts closer to population centers became more popular. However, interest did not die, and new facilities, such as the large bathhouse built at Elsinore Hot Springs in 1888, continued to flourish. Through the turn of the century, the

*Mr. Sway is the Deputy Director for the California Department of Conservation, which includes in its organization the Divisions of Oil and Gas and Mines and Geology. Mr. Sway has been involved in the development, enactment, and administration of many of this state's existing geothermal policies and programs.

spas and the hot springs remained popular. However, by the 1920s, a gradual decline in interest began, and many resorts were forced to close their doors by the beginning of World War II. The well-built hotel at Byron Hot Springs near Tracy was used as a prisoner of war holding facility for higher echelon German officers during World War II.

Many of the early resort hotels and associated buildings made use of "natural steam heat" to keep their room temperatures comfortable for occupants in winter. Although some of these early heating systems still survive, the chemistry of the waters and a lack of maintenance have combined in many instances to take their toll and have resulted in system failure due to scaling and corrosion of pipes and related equipment.

Of course, the high cost of energy that our country now faces has brought about a change of thinking with regard to potential uses of lower temperature geothermal resources. Today, in California, we are seeing a revival of interest in geothermal space heating that runs the gamut from private home heating to major industrial facility and district heating in small to medium size towns and cities. The Department of Conservation routinely receives requests for assistance to help determine whether a resource is available for this purpose. City and county governments and owners of large industrial plants are among those making such requests.

Not too surprisingly, agriculture, one of our more energy sensitive industries, is also eyeing lower temperature geothermal resources. Many of you here today are aware of the use of the resource in greenhouse-hydroponics operations, such as in the large facilities that were developed near Susanville in Northeastern California. Thirty greenhouses at nearby Wendel Hot Springs make use of geothermal heat to grow premium quality tomatoes and cucumbers in a year-round operation.

Below-boiling waters may be used in warming of soil, in fish farming, in refrigeration, and in simple process heating. The City of San Bernardino is making plans for possible use of geothermal heat in its waste water treatment facilities. Use of geothermal heat for sludge digestion could save the city nearly 110,000 therms of natural gas at a cost of $42,000 per year.

Also worthy of mention is the use of lower temperature geothermal resources in cogeneration. A geothermal fluid with a temperature that would make it noneconomic for electricity generation can be used in a geothermal power cycle if the cycle's peak temperature is boosted by burning of a supplemental fuel such as wood chips. Such a system has been proposed for the Honey Lake area and is being sponsored by the California Department of Water Resources together with Geo Products Corporation.

To place all of this in better perspective, I would like at this point to call your attention to the Geothermal Resources Map of California, produced by my department's Division of Mines and Geology. The work was done as part of the U.S. Department of Energy's geothermal resource assessment program for the western United States. The purpose of the map is to display the basic evidence for characteristics of the geothermal resources in California. The map is intended for use by the scientist and layman alike and is the first in a two-map set. The second map, which is in preparation, is intended mainly for the scientist and will present details of chemistry and other parameters.

The present map shows that 43 of California's 58 counties contain geothermal resources. The contents of the map include thermal springs and wells of record as of the date of publication, an outline of proven and inferred areas that may contain thermal waters, known geothermal resources areas (KGRAs), and cultural and topographic data. A table is included on the map that shows temperature, flow rate, total dissolved solids, and well depths for data points on the map.

Of particular importance are the areas of thermal waters shown in darker gray on the map. Such areas are known or inferred to be underlain at shallow depths (less than 1,000 meters) by water of sufficient temperature for direct heat applications. In some of these areas, there is currently some modest effort at development; in others the resource is still little used. These represent the best major areas in our state for the development of direct uses of the resource.

In addition to these very favorable areas, the Division of Mines and Geology, as part of its DOE sponsored work, has just completed reconnaissance investigations of 40 favorable geothermal sites, scattered throughout the state, that offer good opportunities for direct heat use. A complete set of reports, with descriptions and data gathered for each site, is soon to be released. In addition, work is now beginning on a second set of 40-site studies, and it is believed that the 80 sites that will have been investigated upon completion of the program will provide good opportunities for development.

Another very favorable opportunity for geothermal direct heat use is present in some of our state's oilfields. A just completed Division of Mines and Geology study of the Los Angeles County oilfields has shown that large volumes of brines produced with the petroleum often have high temperatures. The heat can be extracted and used in applications such as space heating and food and industrial processing. During our investigation we became aware of a petroleum production facility that was having difficulty getting rid of excess heat before disposing of brines down the drain, while next door was a potato processing plant that had to purchase expensive fuel for its operations! A cooperative agreement here could result in a great savings!

Detailed resource assessment studies in California for lower temperature geothermal resource areas are conducted regularly by the Department of Conservation, Division of Mines and Geology. In general, such studies involve detailed geological, geophysical, geochemical, and drilling efforts. Two such areas that have been recently studied by our department's team are the Calistoga (Napa County) area and the San Bernardino area. The Calistoga study revealed for the first time that there are two major heat centers--one near the center of town and one to the west--and that there are as many as seven individual and separate geothermal aquifers in the subsurface. Temperatures range up to 140°C.

In San Bernardino, there are three main geothermal areas, each controlled by faulting, with meteoric waters being heated and rising along the faults. The highest temperature of 84°C was recorded in the northernmost area called Arrowhead Springs, while temperatures of 56°C and 50°C were recorded in the southern and eastern areas of San Bernardino, respectively. Completion of each of these projects has resulted in ongoing efforts at development by private enterprise and by local government.

One of the things that we in the Department of Conservation are currently attempting to do is to improve efficiency in the development of our lower temperature geothermal resources. The Division of Oil and Gas, with regulatory authority over all geothermal drilling in the state, has needed some mechanism to remove some low-temperature wells from regulations written for higher temperature wells and thus to stimulate the use of this vast resource in the state.

To do this, AB 828 (Bosco) was introduced to eliminate certain cumbersome regulatory requirements designed for high temperature and pressure wells that should not be applied to low-temperature wells. AB 828 is awaiting the Governor's signature.

I have tried to give you an idea of the extent and availability of California's somewhat neglected but nevertheless plentiful resource, low and moderate temperature geothermal energy. Certainly lower temperaure uses of our geothermal resurces are deserving of more attention than they have so far received. The examples I have cited should give an idea of the resource availability and uses.

SELECTING THE HARDWARE

ENERGY CONVERSION SYSTEMS
THROUGHOUT THE WORLD

by

John W. Lund*
Geo-Heat Center
Oregon Institute of Technology

INTRODUCTION

Equipment for the direct utilization of geothermal energy, for the most part, utilizes known technology. Basically, hot water is hot water whether from a boiler or from the earth. The utilization of geothermal energy requires only straightforward engineering design and the use of currently available "off-the-shelf" equipment. The technology, reliability, economics, and environmental acceptability of geothermal energy have been demonstrated throughout the world.

However, it must be remembered that each resource is different, and the systems must be designed accordingly. Problems with corrosion and scaling are generally confined to the higher-temperature resources, as most of the low-temperature resources are relatively benign with low dissolved solids. Chemistry-related problems can be solved by proper material selection and engineering design. For some resources, standard engineering materials can be used if particular attention is given to the exclusion and/or removal of atmospheric and geothermally generated gases. For others, economical designs are possible which limit geothermal water to a small portion of the overall system by utilizing highly efficient heat exchangers and corrosion-resistant materials in the primary side of the system.

Today, over 5,000 megawatts thermal are utilized in the world for space conditioning (heating and cooling), agribusiness (agriculture and aquaculture), and industrial processes (GRC/Lund, 1979). The agribusiness-related uses utilize temperatures from 80° - 180°F, the majority of which is for greenhouse space heating. Space conditioning (mainly heating) utilizes temperatures from 150° - 200°F, with heat pumps extending the useable range down to 50°F. Industrial processing uses both steam and hot water, thus temperatures up to 300°F are often necessary; however, many drying processes require temperatures of only 150° - 200°F. A visual representation of the required temperature for various direct-thermal uses is shown in Figure 1 (Lienau/Lindal, 1974) on the following page.

EXAMPLES OF CURRENT UTILIZATION

Traditionally, direct use of geothermal energy has been on a small scale by individuals. Surface hot springs were utilized, and shallow wells could be

*Mr. Lund is currently a professor of Civil Engineering Technology, Associate Dean and Head of Engineering Technologies, and Associate Director of the Geo Heat Center at the Oregon Institute of Technology, Klamath Falls, Oregon. Mr. Lund has a Ph.D. in Civil Engineering from the University of Colorado and is a registered professional engineer in California and Oregon.

justified with on-the-spot use or short transmission distances in uninsulated pipes or channels. However, at today's prices for development and hardware, the cost savings of these individual uses are often marginal. Large-scale use demands require more production and can thus justify deeper wells, longer transmission distances, more sophisticated utilization, and lower temperatures.

Most of present-day developments involve large-scale projects, such as district heating (Iceland), greenhouse complexes (Hungary), or major industrial use (New Zealand). Heat exchangers are also becoming more efficient and better adapted to geothermal use, allowing the use of lower-temperature waters and highly saline fluids. Heat pumps are extending geothermal development into traditionally nongeothermal countries, such as France, Austria, and Denmark, as well as the eastern United States.

Space Conditioning

The most famous space-heating project in the world is the Reykjavik municipal heating project, serving about 97 percent of the 113,000 people in the capital city of Iceland. At present, a total of 1.0×10^{10} gallons of geothermal fluid are used annually to supply 16,000 homes with space heating. One field supplies water through two 14-inch and one 28-inch diameter pipelines over a 12-mile distance. Insulated storage tanks (6.9×10^6 gallons) are used to meet peak flows and provide an emergency supply in the event of breakdown in the system. A fossil fuel-fired peaking station is used to boost the 176°F water to 230°F during 15 to 20 of the coldest days of the year. The city is served by 9 pumping stations, distributing fluid through 200 miles of pipelines. The entire system provides 1,840 GWh per year or 420 MWt (including the peaking station, Lienau/Zoega, 1974).

An example of individual home space heating is in Klamath Falls, Oregon, where over 400 wells are used for space heating, using waters from 100° - 230°F. The principal heat-extraction system is the closed-loop downhole heat exchanger utilizing city water in the loop (Lund et al., 1974). Larger examples of space heating in Klamath Falls include the Oregon Institute of Technology campus, where three wells up to 1,800 feet deep each produce up to 450 gpm of 192°F water and heat approximately 600,000 ft^2 of floor space. The geothermal water is pumped from the well using deep-well turbine pumps and, in most cases, is used directly in the heating system for each building. The annual operating cost of the campus system is approximately $30,000, a savings of almost $400,000 per year when compared with the cost of heating with conventional fuel. A district heating project is currently under construction in the city, designed to provide heat to 14 government buildings. This initial phase (approximately 4 MWt) will provide 220°F geothermal water through an 8-inch diameter insulated steel line placed in a concrete tunnel to a central heat exchange facility. Plate-type heat exchangers will transfer heat to a secondary closed-loop FRP (fiberglass reinforced plastic) pipeline at 180°F. Proposed expansion of the system will heat 11 commercial city blocks (10 MWt) and eventually 57 downtown blocks of the central business district (40 MWt).

The cities of Boise, Idaho, and Susanville, California, are also constructing similar district heating projects.

A geothermal district heating system will generally have the same basic components as a conventional system. The production field, which includes wells, pumps and collection mains, replaces the boiler in a conventional system. All other components, such as piping, valves, controls and metering, etc., would be similar to a conventional system.

District heating metering systems for the purpose of billing consumers can be based on quantity of water used (volume metering), quantity of heat used (energy metering), or specified apportionment factors (nonmeter billing).

Geothermal energy can be used as a preheater in the case of a low-temperature resource. The geothermal fluid can be boosted to a higher temperature by fossil fuel, such as in the Reykjavik system, or to preheat a secondary fluid which is in turn peaked by fossil fuel. Capital costs are generally reduced by introducing an auxiliary boiler into large district heating systems. Designed to meet the peak heat load a few days out of the year by increasing fluid temperature, this results in smaller pipes, pumps, heat exchangers, and fewer wells.

Another possibility in the case of a low-temperature (140° - 160°F) geothermal resource is to include heat pumps in addition to the auxiliary boilers. A system of this type installed in the Paris basin supplies heat to 10,000 apartments and is claimed to be economical (GRC/Ryback, 1979). Low-temperature cooling can be provided by geothermal lithium bromide absorption chillers. Temperatures as low as 180°F can be used; however, higher temperatures are more efficient. Examples are chillers in Rotorua, New Zealand, and on the Oregon Institute of Technology campus.

Agribusiness

Agricultural applications are particularly attractive because they require heating at the lower end of the temperature spectrum where there is an abundance of geothermal resources.

All commonly marketed vegetables, flowers, house plants, and many tree seedlings are suitable for greenhousing. Greenhouse temperatures are a function of the crop; typical highest maintained temperatures range approximately from 65° - 80°F. Greenhouse heating can be accomplished by (1) circulation of air over finned-coil heat exchangers carrying hot water, (2) hot water circulating pipes or ducts located in (or on) the floor, (3) finned units located along the walls and under benches, or (4) a combination of these methods. The heating fluid in these units can be as low as about 90°F. The air circulation method is more common and utilizes forced-air fincoil units. The heated air is often passed through perforated plastic tubes running the length of the greenhouse in order to maintain uniform heat distribution.

Excellent examples of greenhouse operations exist in the United States, the largest being the Honey Lake Hydroponic farms complex near Susanville, California. Cucumbers and tomatoes are grown in a hydroponic system. Heat is provided to the greenhouses by geothermal fluid using forced-air heaters. At present, 60 greenhouses have been constructed, with expansion planned to over 200 units. South of Klamath Falls, at the Liskey Ranch, greenhouses are used for raising tree seedlings and, more recently, cacti. Heat is provided by under-bench finned-tube piping.

In Hungary, geothermally heated greenhouses amount to over 13 million ft^2. Many of these greenhouses are built on rollers, so they can be pulled from their location by tractors, the ground cultivated with large equipment, and then the greenhouse returned to its location. In addition, to minimize cost, much of the building-structure pipe-supporting system also acts as the supply and radiation system for the geothermal fluid. Some experimental work is being performed with grain, hay, tobacco, and paprika drying. In these cases, hot water supplies heat to forced-air heat exchangers and 120° - 140°F air is blown over the product to be dried (Lienau/Boldizar, 1974).

Environmentally controlled livestock raising provides significant advantages as compared to the typical practice of outdoor exposure to the elements. The level of thermal environmental control currently practiced ranges from floor heating for mostly open cattle finish-feed lots to totally enclosed raising of hogs and chickens. The totally enclosed systems utilize both space heating and floor-slab heating (at about 90°F) to maintain about 70°F.

Fish farming is that portion of aquaculture which involves the rearing and harvesting of aquatic animals. Among farmable species are common carp, Chinese carp, Indian carp, buffalo fish, paddle fish, catfish, pikes, perches, black bass, sunfish, tilapia, frogs, mullet, milkfish, eels, salmons, salmonids, smelt, sturgeon, shad, stripped bass, shrimp, lobster, crayfish, crabs, oysters, clams, scallops, mussels, and abalone.

Heating can be accomplished using hot water (90° - 110°F) bearing pipes in the growth ponds or by direct addition of suitable quality hot water (70° - 90°F) in order to maintain pond temperatures near 80°F. The main caution is testing the compatibility of the aquatic animal and the chemistry of the water when it is used directly in ponds and raceways.

One of the best agribusiness examples is in Japan. Here, greenhouses cover about 157,000 ft^2, where a variety of vegetables and flowers are grown. Many large greenhouses are operated as tropical gardens for sightseeing purposes. Raising poultry through the use of geothermal energy has been a very successful enterprise. Here, under-the-floor heating is utilized in sheds where 40,000 chickens are raised annually. Another successful business is breeding and raising carp and eels. Eels are the most profitable and are raised in 10-inch diameter by 20-foot long earthenware pipes. Water in the pipes is held at 73°F by mixing hot spring water with river water. The adult eels weigh from 3-1/2 to 5-1/4 ounces, with a total annual production of 8,400 lbs. Alligators and crocodiles are also raised in geothermal water. These reptiles are being bred purely for sightseeing purposes. In combination with greenhouses offering tropical flora, alligator farms are offering increasingly large inducements to the local growth of the tourist industry (Japan Geothermal Energy Assoc., 1974).

Industrial Processes

Though there are relatively few examples of industrial processing use of geothermal energy, they represent a wide range of applications, from drying of agricultural products, wool, fish, earth, and lumber to pulp and paper processing and chemical extraction. The two largest industrial uses are the diatomaceous earth drying plant in Iceland and the paper and wood processing plant in New Zealand. Thermal energy up to 300°F can be used for a range of basic processes such as preheating, washing, cooking, evaporating, sterilizing, distilling, drying, and refrigeration.

An example of industrial processing is the use of geothermal steam for the Tasman Pulp and Paper Company in New Zealand. Here, 100 - 125 MW (180 tons/hr steam) of thermal energy are used for the lumber drying, black liquor evaporation, and pulp and paper drying. The total investment cost for geothermal is $6.8 million, the majority of which is for well development. This amounts to approximately $70 per kWt and will reduce the price of energy to 70 percent of conventional fuels for an annual savings of $1.3 million. The annual maintenance costs are 2 percent of the capital cost (Lienau/Wilson, 1974).

In Northern Iceland, a diatomaceous slurry is dredged from Lake Myvatn. This slurry is transported through a pipeline and held in storage ponds. The 80 percent moisture is then removed in large rotary-drum driers using high temperature geothermal steam. The plant produces 27,000 tons of diatomite filteraids per year, most of which are used in beer processing in Germany (Lienau/Lindal, 1974).

Two industrial processing uses of geothermal energy are of note in the United States: Medo-Bel Creamery in Klamath Falls, where low-temperature fluid is used for pasteurizing milk, and Geothermal Food Processors at Brady Hot Springs, Nevada, where high-temperature fluid is used for dehydration of onions and other vegetables.

CONCLUSION

At present-day prices, the geothermal application will cost about the same or less than the corresponding annual fossil-fuel cost. Due to the expected escalation of fossil-fuel prices, the costs of the geothermal system will decline. Most geothermal direct-use systems will pay for themselves in 5 to 10 years from savings in conventional fuel.

The economics are greatly enhanced where cascading (multi-stage use) is considered. The Japanese optimize cascading where geothermal fluids are first used for electrical power production, then space heating, cooking, and bathing (Otake). Here, an attempt is made to "squeeze" the "last drop of energy" from the fluid. Lower-temperature cascading could consider space heating, agriculture, bathing (swimming pools), and snow melting. Low- and intermediate-temperature geothermal resources can also be used to meet the base load of an energy demand. Heat pumps and fossil fuel can then be used to meet the peak demands, thus conserving the resource and minimizing capital investments.

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DIRECT UTILIZATION TECHNOLOGY: STATE OF THE ART

by

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INTRODUCTION

This paper is intended to convey some ideas as to how a geothermal project develops and to point out considerations that lead to the selection of the actual hardware. Today's "state of the art" provides a wide variety of materials and equipment that can be used in various combinations and configurations to perform a specific geothermal function. Most of the hardware is "off-the-shelf," and there is seldom need for custom designed specialty items.

To illustrate project development and equipment selection an actual on-the-line geothermal application has been selected for discussion. This application involves space heating, potable hot water, and swimming pool heat for a small condominium. The four level condominium contains all units, a laundry, storage area, and a recreation room. The first thing discussed will be the geothermal well.

PRODUCTION WELL

The condominium is located on the southwest slope of Mt. Hood at Government Camp at an elevation of about 3,800 feet. In early 1980, geological work was completed that indicated a good possibility for hot water at a reasonable depth on property adjacent to the condominium, and exploratory drilling was begun.

The well was completed at a depth of about 2,000 feet in the late summer. Unfortunately, the well did not produce hot enough water for direct heating application. The well was filled in to a depth of 1,150 feet and reworked to produce from the bottom aquifer and a 900 foot aquifer. The well was tested at a flow of over 400 gpm of 70°F water. Water was of good quality, with the exception that it contained about five parts per million of hydrogen sulfide (H_2S). With knowledge of water temperature and quality a flow diagram for the condominium heat pump system was developed.

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FLOW DIAGRAM AND HEAT PUMP

Renovation of the existing lodge was under way in mid-1980 to convert the building to a condominium. Building plans were available, but the type of heating system had not been determined. Heat loss calculations were made to determine the peak heating required. Space heating for the building required 150,000 Btu/hr; heating the outdoor swimming pool required 250,000 Btu/hr; potable hot water required an additional 100,000 Btu/hr. Total peak heat required was 500,000 Btu/hr. As previously mentioned, the well water was not hot enough for direct heating, so the flow diagram (Figure 1) was developed based on a heat pump. Without getting into the details of heat pump technology, a heat pump uses the refrigeration principle to boost temperature to a useable level (Figure 2). In this application it was decided that a 135°F output temperature was desirable. Commercially available machines will produce temperatures up to 150°F. Higher temperatures, up to 220°F, can be reached by putting 2 machines in series. Commercially available machines will produce up to five million Btu/hr, and larger capacities can be obtained using selected components. The selected heat pump, under the operating conditions shown, extracts 351,000 Btu/hr from the water and uses 149,000 Btu/hr of equivalent electricity to develop the 50,000 Btu/hr of total output. In heat pump language this is a "coefficient of performance" (COP) of 3.36, which is obtained by dividing 500,000 by 149,000. It is a measure of the heat produced compared to the electricity used. The heat pump system could also be designed to produce space cooling. For this, heat would be injected into, rather than extracted from, the well water. However, the condominium is located where summer air conditioning is not necessary.

Heat pump evaporators typically use copper or copper-nickel tubing. This heat pump is no exception. Though the well water is otherwise acceptable for direct use in the evaporator, the small amount of H_2S is extremely destructive to copper alloys. Therefore, a heat exchanger was placed between the well water and the heat pump evaporator circulating water, which is high quality water. This heat exchanger is constructed of corrosion resistant type 316 stainless steel which is expected to give satisfactory life in this service. Since heat is extracted from a lower temperature water in the evaporator, there is a slight decrease in COP, about 5 percent, as compared to using the 70°F directly if that was acceptable. For any water source heat pump, the COP decreases as the heat pump output temperature rises and increases as the heat pump input temperature rises (Figure 3). For this application the net effect will be that the average COP will be higher than 500,000 Btu/hr, the output temperature can be decreased below 135°F, and the input temperature to the evaporator will rise slightly as the heat exchanger heat load decreases.

INJECTION WELL

Before the well pump can be selected the method of disposing of the geothermal water must be decided upon. At Government Camp it was permissible to inject the water using a relatively shallow well. The well was pump tested to determine the injection pressure needed to achieve the design flow rate. This pressure, plus system pressure drop, is added to the production well lift pressure to determine the total pressure that must be developed by the pump. In some cases it is desirable to use a separate injection pump. The amount of injection pressure needed is dependent on the standing water level (static level) of the injection well. A high water level indicates the need for pressure, and frequently no pressure is necessary with low water levels. In an ideal situation with the production and injection well identical in design and accessing the same aquifer, pressure for injection would be needed if the draw down of the production well exceeded the static level of the injection well. Draw down is the difference in feet between the pumping level and the static level. For example, if the static level in both wells was 60 feet, and the pumping level was 115 feet, then the draw down is 55 feet. This is less than the 60 foot static level, so no pressure would be necessary. Water level in the injection well would rise 55 feet, which is 5 feet below the surface level. Of course, this ideal system assumes identical wells, which is seldom the case. An injection well must be carefully designed and tested. This well was completed to 400 feet, fully cased, and perforated for the bottom aquifer. It accepted 200 gpm of injection water at 18 psi pressure and 100 gpm at about 4 psi.

WELL PUMP

Selection of the well pump is normally limited to the submersible type or to vertical turbine pumps. Temperature and corrosive properties of the geothermal water are important considerations. If the water temperature is above 86°F, the normal submersible pump used for potable well water cannot be used. However, properly designed and applied submersibles have operated at temperatures as high as 300°F. The maximum permissible temperature is limited by the temperature that the electrical insulating material will withstand. Submersible pump components in contact with the well water are constructed of corrosion resistant alloys. For very deep wells with very high lifts, the submersible pump is frequently the only choice.

If the lift is 300 feet or less, a vertical turbine pump should be considered (Figure 4). At water temperatures above 250°F the practical lift limit would be lower. The critical temperature problem is the selection and method of lubrication of the line shaft bearings. If water high in solids is in contact with the bearings, problems are induced by salt deposits. Corrosion problems can be satisfactorily controlled by proper metallurgy selection. A turbine pump permits the use of a variable speed driver (Figure 5). There are several advantages to using the driver installed between the electric motor and the impeller shaft. These include no-load starting, shock and vibration protection, and minimum horsepower requirements. The variable speed driver works somewhat like an automobile's automatic transmission. Hydraulic fluid maintains a coupling between the motor shaft rotor and the impeller shaft rotor. The desired speed is obtained by the quantity of fluid in the coupling space between the rotors. These drivers are available in power ratings from 1 hp to 5,000 hp. The power-saving aspects of variable speed drivers are particularly important in geothermal space heating applications, where average pumping rates are low, frequently 20 to 30 percent of design rates (Figure 6). For flows ranging from 20 to 60 percent the electrical power savings is about 40 percent in a typical installation.

The well pump installed at the condominium is a submersible pump. For this application the pumping horsepower is quite low, and the additional cost for a vertical turbine pump with or without variable speed driver could not be justified. In this low temperature service the submersible pump is expected to perform satisfactorily, and the supplier has provided a guarantee. The pump was set at 150 feet with an expected pumping level at design flow of 115 feet. The static level is approximately 55 feet. Well piping is 2-1/2 inch black pipe. Standard weight pipe (Schedule 40) is used for the first 40 feet and the last 10 feet of depth. Heavier pipe (Schedule 80) with a coal tar epoxy coating is used in between where the H_2S corrosion environment is greatest.

HEAT EXCHANGERS

As previously mentioned, a plate heat exchanger was selected to isolate the heat pump evaporator from the geothermal water for corrosion reasons (Figure 7). Other geothermal waters frequently are prone to deposit salts. Salt deposits decrease the effectiveness of heat transfer equipment and can ultimately restrict liquid flow through piping and equipment. Both problems can be minimized by using a two loop system, which isolates the geothermal water from much of the piping and equipment. If the transfer piping is to be protected the exchanger should be located close to the well. The secondary loop is usually a closed loop circulating a treated water whose quantity is monitored. The plate heat exchanger is well suited for this service. The exchanger consists of a sandwich of corrugated plates clamped together by rods. Points of contact between plates are sealed from leakage by gaskets. The plates can be quickly disassembled for cleaning.

Primary and secondary fluids are passed through alternate passages between the plates. Counter-flow conditions and high turbulence produce a very effective heat exchanger which is small in size. In addition, more than one service can be attached to a single frame. Temperature approaches of 5°F are easily obtained, as compared to about 20°F for the conventional shell and tube exchanger.

Seldom is mild steel acceptable for heat exchanger construction in geothermal applications. In corrosive resistant materials the plate heat exchanger is less expensive than the shell and tube exchangers (Figure 8). When comparing 18/8 stainless steel exchangers of the 2 types, the plate heat exchanger cost about 60 percent of the cost of a shell and tube exchanger.

The plate heat exchanger for the swimming pool and the potable hot water were also less expensive than shell and tube exchangers and were purchased on that basis.

PIPING AND PIPING INSULATION

As previously mentioned, steel pipe, a portion protected externally with a coal tar epoxy, was used down hole in the well. Carbon steel is the most widely used metallic pipe in geothermal duty and usually has an acceptable service life. Use of alloy pipe is restricted due to cost, and copper and aluminum piping are not acceptable because of their susceptability to corrosion. There is a wide choice of nonmetallic pipes that are inert to normal chemical compounds found in geothermal water. Temperature is a limiting criterion for selecting these pipes. An attached (Figure 9) illustrates the approximate maximum temperature for the various materials. Polyethylene is at the low end of the scale with a maximum temperature tolerance of only 100°F.

Carbon steel is at the high end of the scale, being useable in some applications above 700°F. Piping of each of these materials has its place in geothermal systems. Each has specific handling, assembly, thermal expansion, and cost considerations. Generally speaking, the various piping materials are more expensive the higher the temperature tolerance. However, the installation cost for the plastic is less expensive. They are light to handle, can be assembled with pressure joints, can be thermally welded, and most can be welded with solvents. Of course, local code requirements must be considered when selecting pipe.

Fiberglass reinforced epoxy pipe (FRP) is widely used in geothermal applications, since it can tolerate temperatures up to 300°F. Buried FRP pipe can be installed without expansion loops or joints, utilizing concrete constraining blocks at valves, turns, and branches. The FRP pipe cost the same as steel pipe, when comparing insulated steel pipe. FRP pipe and the other nonmetallic pipes are not subject to external corrosion that frequently destroys buried steel pipe.

Various piping insulating materials are used, sometimes field installed or frequently factory installed, on the pipe. For long runs of pipe, factory installed insulation is usually preferred. One method is to foam approximately 2 inches of polyurethane between a polyvinyl chloride outer jacket and the inner pipe, in sections of about 20 feet in length (Figure 10). This is a very effective insulation. Other satisfactory insulating materials are calcium silicate, 85 percent magnesia, mineral fiber, and cellular glass. These are usually purchased preformed to fit the particular pipe size.

Sometimes it is unnecessary to insulate the pipe. If a lower water temperature can be tolerated, the decision may be made on the basis of economics. Simply burying bare steel pipe can reduce heat loss by about one third. With a selected light, dry soil placed around the pipe and enclosed in a wraparound plastic film, an additional savings in heat loss can be achieved. The actual pipe material, whether plastic or steel, has no significant effect on the heat loss from buried pipe.

For the low temperature piping at the Government Camp condominium 2-1/2 inch PVC pipe was used. This pipe is inexpensive and easy to assemble using solvent welding. The pipe exterior to the building was insulated with preformed urethane and buried to a depth of three feet. The PVC inside the building was not insulated. The hot piping inside the building is copper, which is satisfactory, since it does not come in contact with geothermal water. Copper meets the local code, and though expensive to purchase, it can be quickly installed. Piping was insulated with a wraparound urethane type insulation.

SPACE HEATING EQUIPMENT

Various methods of space heating are available. Five methods are shown on an attached graph (Figure 11), titled Temperature Range of Space Heating Methods. Bare tubes in masonry floors or ceilings can be used to space heat at entering water temperatures as low as 85°F. Finned tubes in forced air ducting can be used at temperatures as low as 105°F, forced air room convectors as low as 120°F, and natural air flow convectors down to 140°F. Radiators are not much good below 160°F. These are approximate design limits and are absolute. As entering water temperature increases, so does the number of options available. At 160°F all five methods can be considered. The amount of water circulation varies considerably for each of the methods. The following is a comparison made for direct geothermal space heating at a load of 28,000 Btu/hr, based on maintaining a 65°F room temperature.

Method	Water In (°F)	Water Out (°F)	Flow Rate (gpm)
Bare Tubes in Masonry Slab	85	81	14.0
Finned Tubes in Forced Air Duct	105	75	1.87
Forced Air Flow Room Convectors	120	85	1.60
Natural Air Flow Room Convectors	140	110	1.87
Room Radiators	160	140	2.80

The largest flow requirement listed is for the bare tubes in masonry (14.0 gpm), because the low temperature of the inlet water permits only a small temperature drop of 4°F. It may be seen that finned tubes in ducting is a very effective method of transferring heat. In this example, the discharged water is cooled to 75°F, an approach of 10°F to the room temperature of 65°F. Low discharge water temperature is important in direct heating geothermal applications to maximize the utilization of the resource. However, it is not important in heat pump applications, since discharge water is returned for reheating. The heat pump normally works with a 10° to 20°F rise in temperature on the circulating water stream. The condominium heat pump works with a 10°F rise; that is, the water returns to the condenser at 125°F and leaves at 135°F. The hallways are heated with forced air flow room convectors, and natural air flow base board type room convectors are used for room heating. The average water temperature in the condominium convectors is 130°F (which is a good lower limit for the average temperature in natural air flow convectors). At a lower average temperature the length of the convectors becomes excessive. Baseboard convectors are an inexpensive and attractive method of heating.

CONCLUSION

If a geothermal resource exists, materials, equipment, and technology are available to match the resource to the job. Technical assistance and information on geothermal applications are available from the Geo-Heat Center at Oregon Institute of Technology.

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Government Camp, Oregon

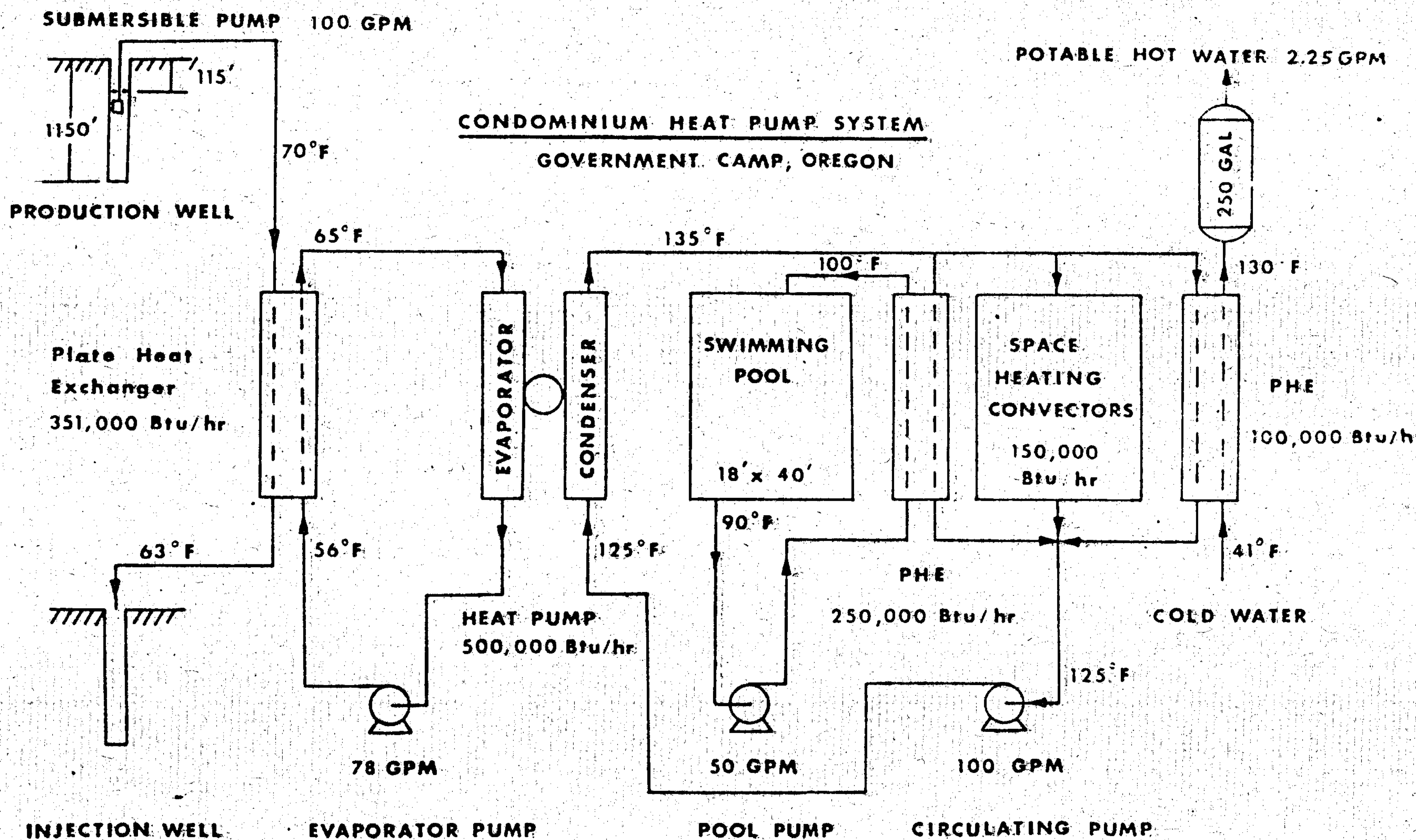
CONDOMINIUM HEAT PUMP SYSTEM
GOVERNMENT CAMP, OREGON
SUBMERSIBLE PUMP
100 GPM
115'
1150'
70°F
PRODUCTION WELL
65°F
135°F
100°F
POTABLE HOT WATER 2.25 GPM
250 GAL
130°F
Plate Heat Exchanger
351,000 Btu/hr
EVAPORATOR
CONDENSER
SWIMMING POOL
18' x 40'
SPACE HEATING CONVECTORS
150,000 Btu/hr
PHE
100,000 Btu/hr
63°F
56°F
125°F
90°F
PHE
250,000 Btu/hr
41°F
COLD WATER
HEAT PUMP
500,000 Btu/hr
125°F
78 GPM
50 GPM
100 GPM
INJECTION WELL
EVAPORATOR PUMP
POOL PUMP
CIRCULATING PUMP

FIGURE 1

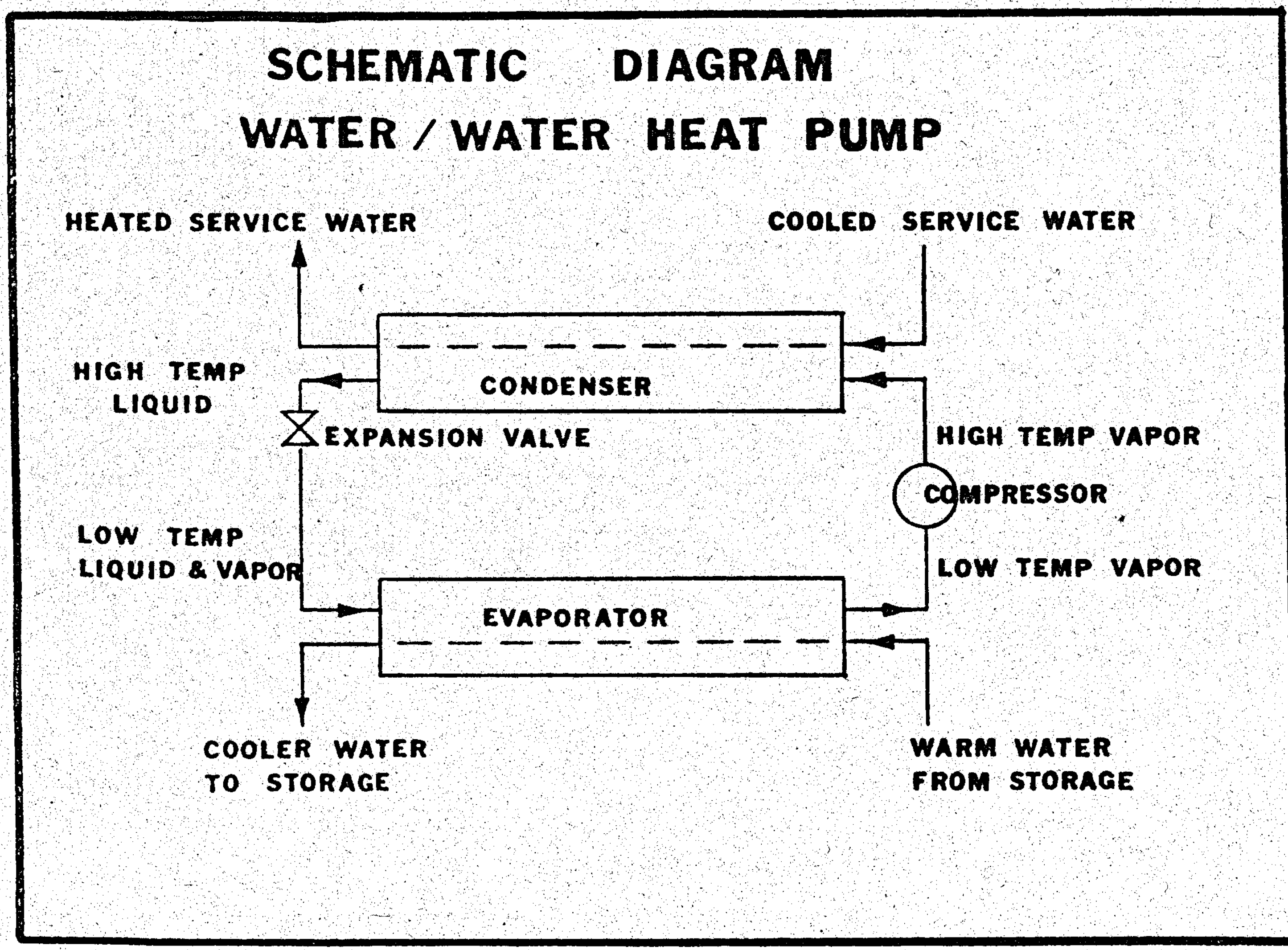
SCHEMATIC DIAGRAM
WATER / WATER HEAT PUMP
HEATED SERVICE WATER
COOLED SERVICE WATER
HIGH TEMP LIQUID
CONDENSER
EXPANSION VALVE
HIGH TEMP VAPOR
COMPRESSOR
LOW TEMP LIQUID & VAPOR
LOW TEMP VAPOR
EVAPORATOR
COOLER WATER TO STORAGE
WARM WATER FROM STORAGE

FIGURE 2

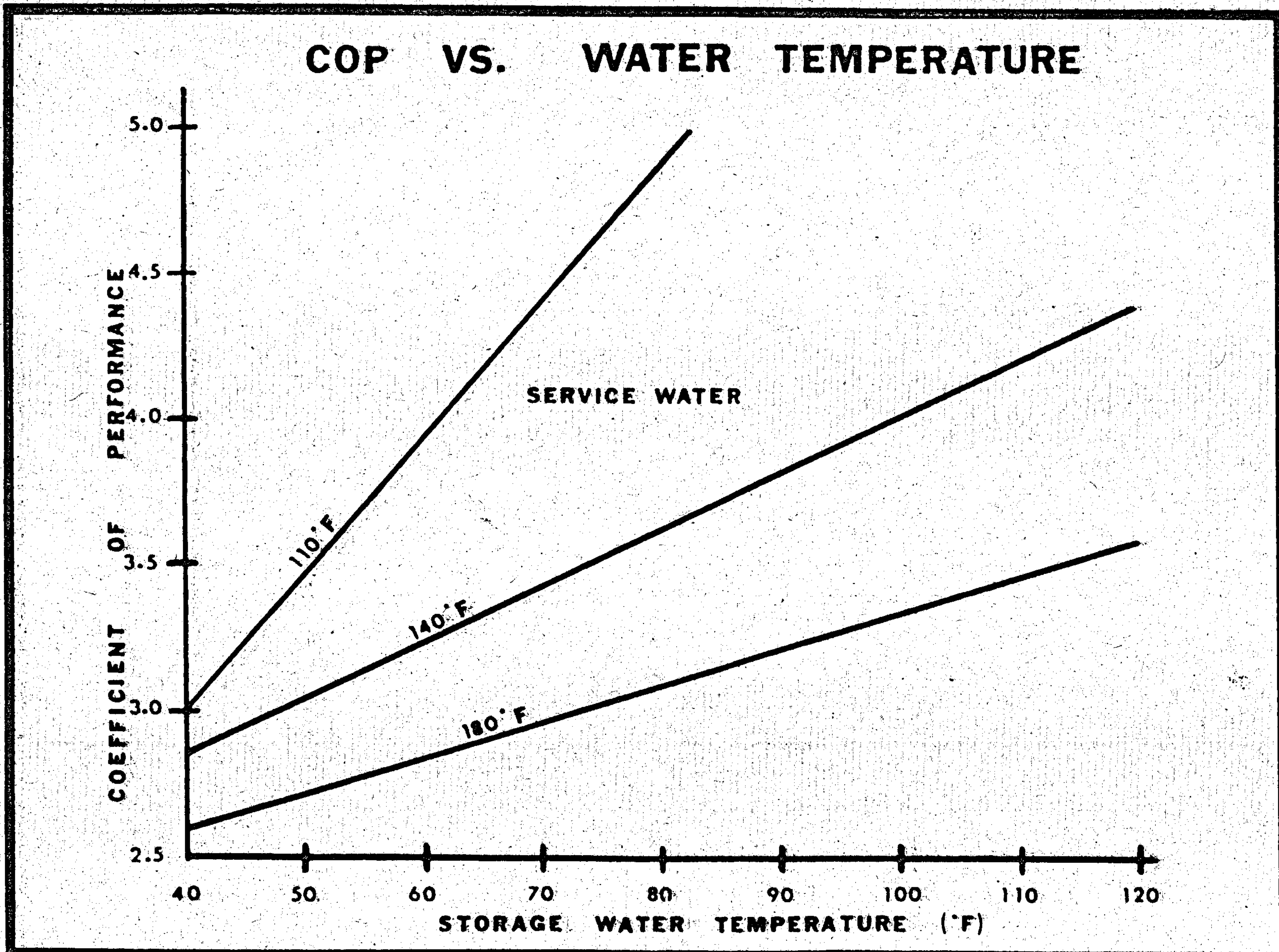
COP VS. WATER TEMPERATURE
COEFFICIENT OF PERFORMANCE
5.0
4.5
4.0
3.5
3.0
2.5
SERVICE WATER
110°F
140°F
180°F
40
50
60
70
80
90
100
110
120
STORAGE WATER TEMPERATURE (°F)

FIGURE 3

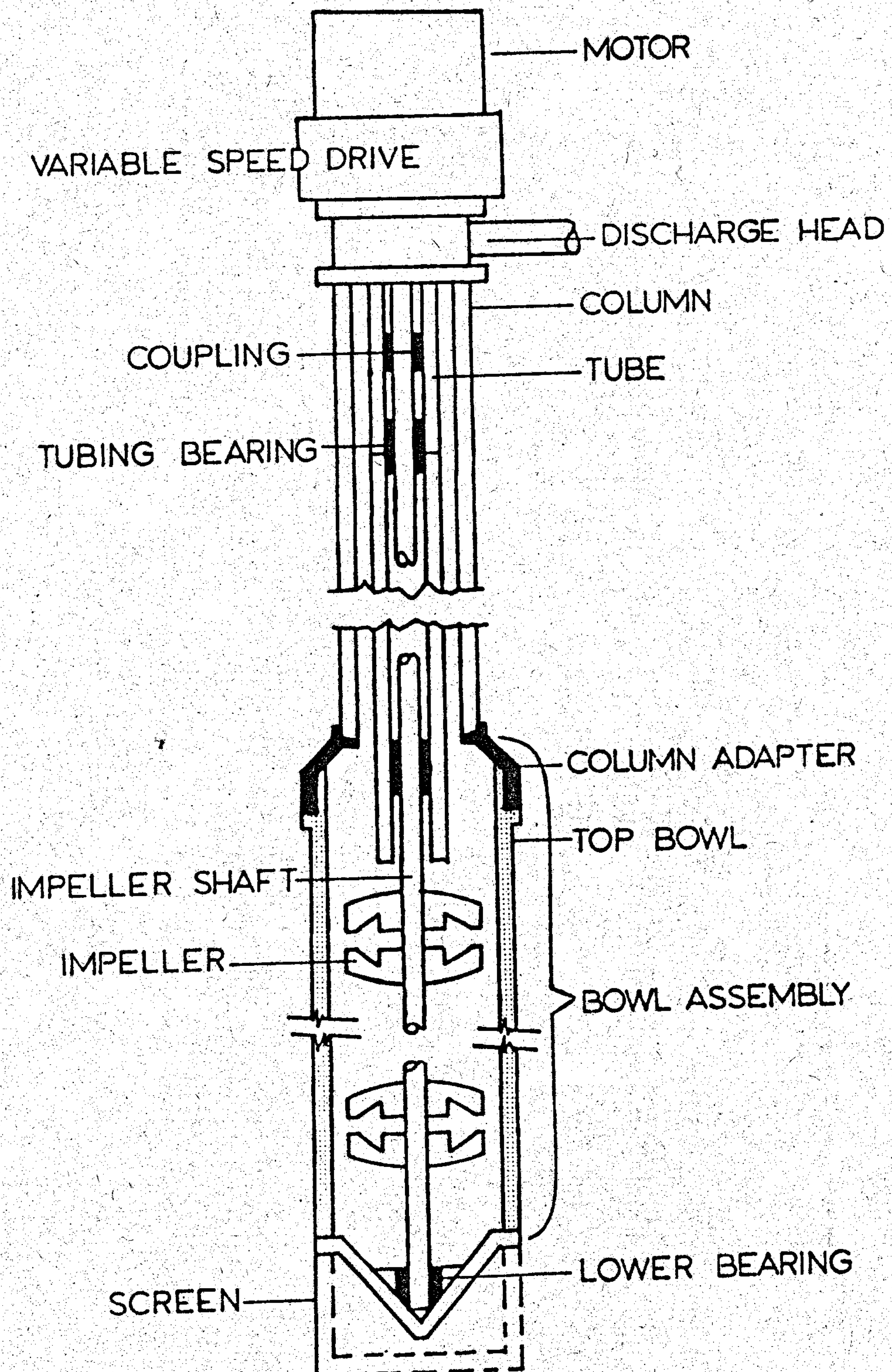

FIGURE 4. VERTICAL TURBINE PUMP WITH VARIABLE SPEED DRIVE

VARIABLE SPEED DRIVE

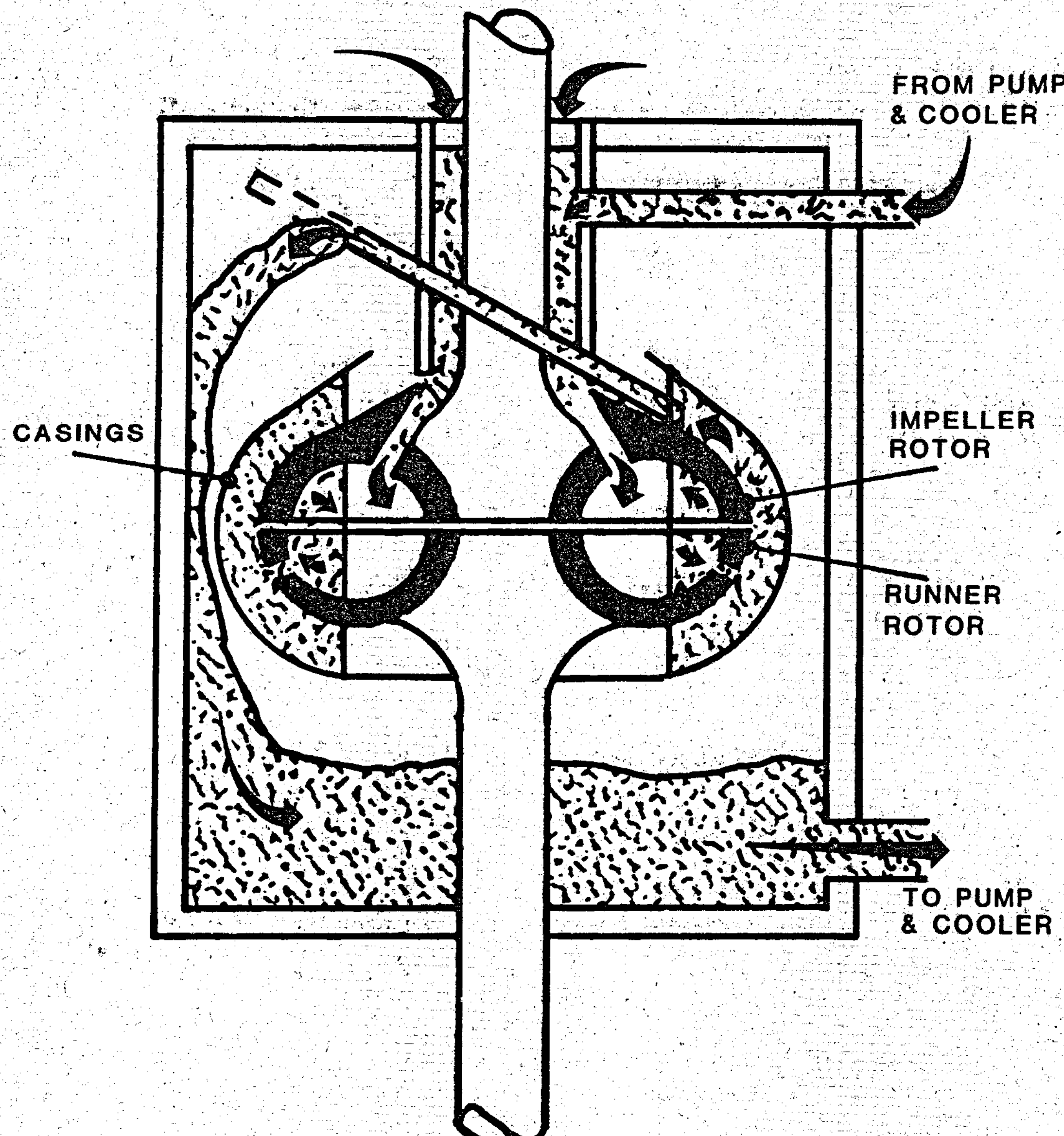

FIGURE 5

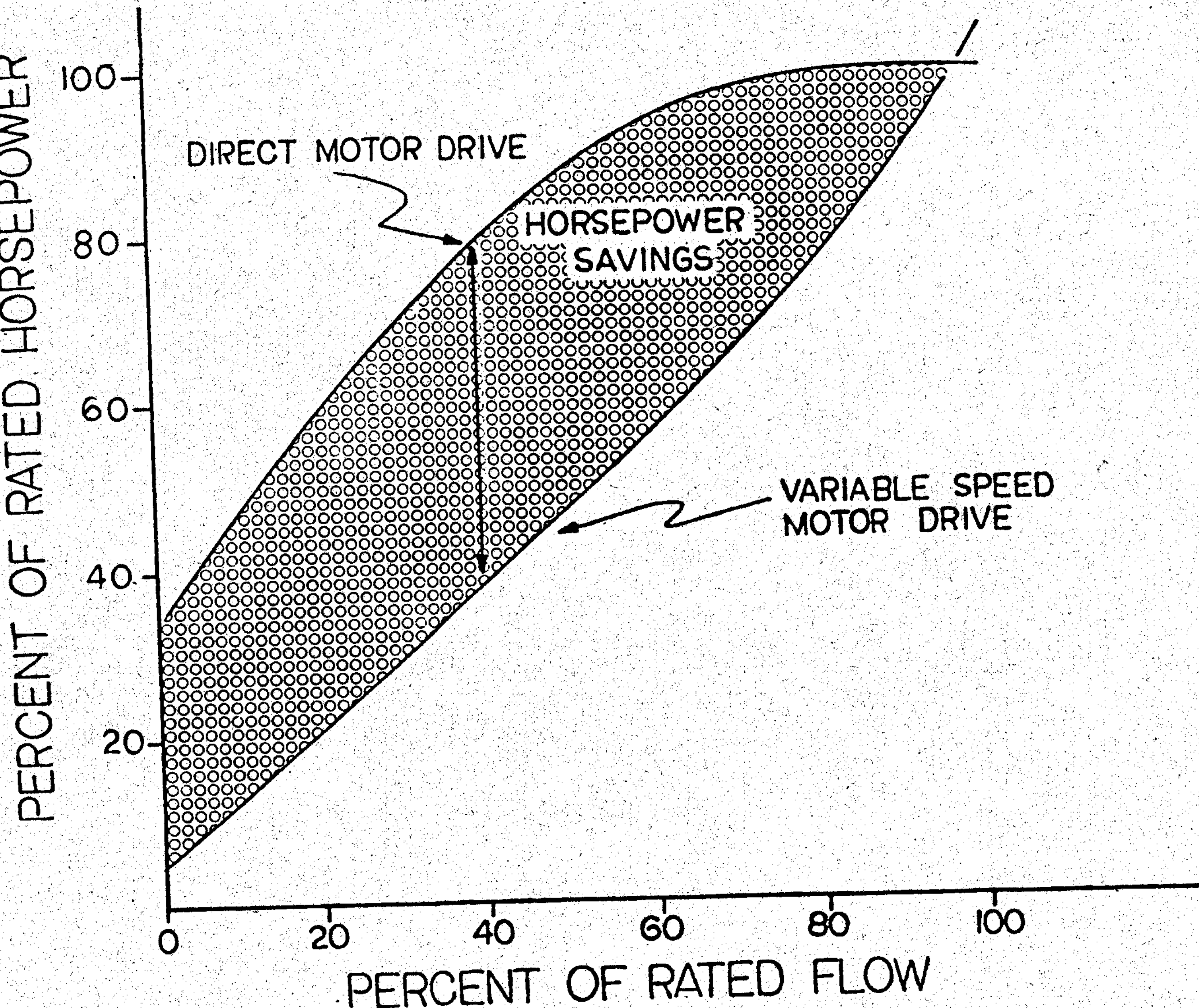

FIGURE 6. PUMP HORSEPOWER SAVINGS WITH VARIABLE SPEED MOTOR DRIVER

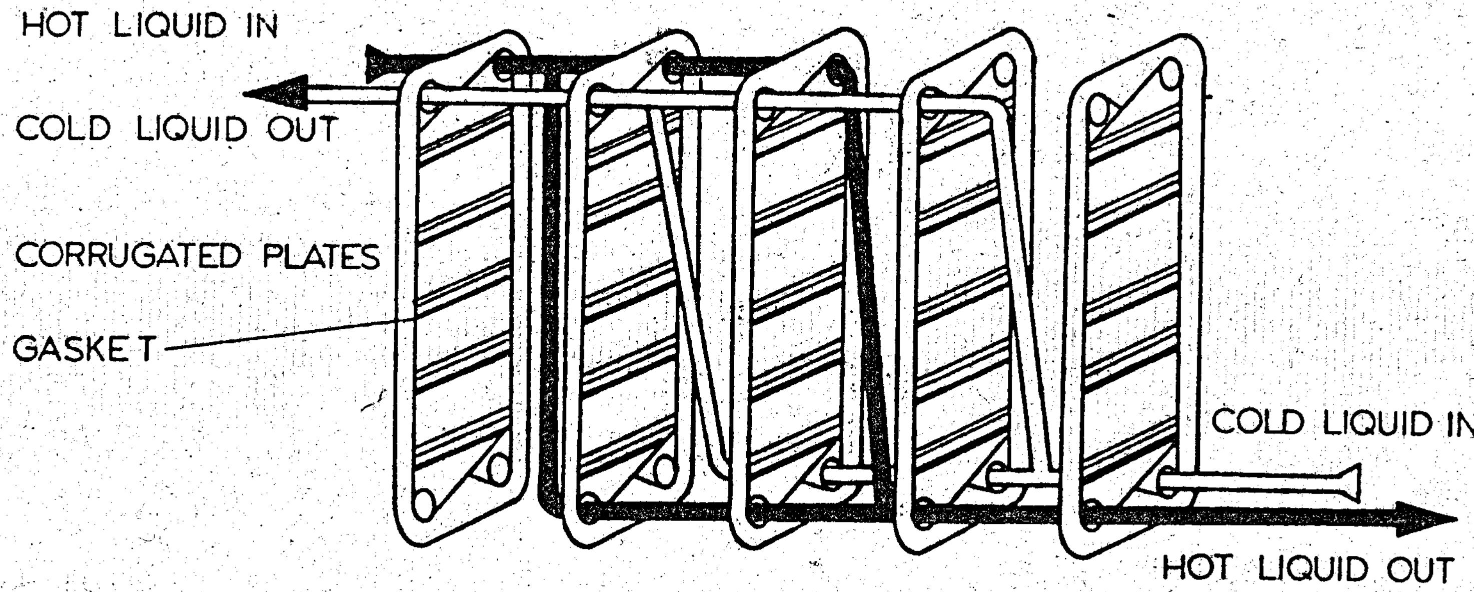

FIGURE 7. PLATE HEAT EXCHANGER

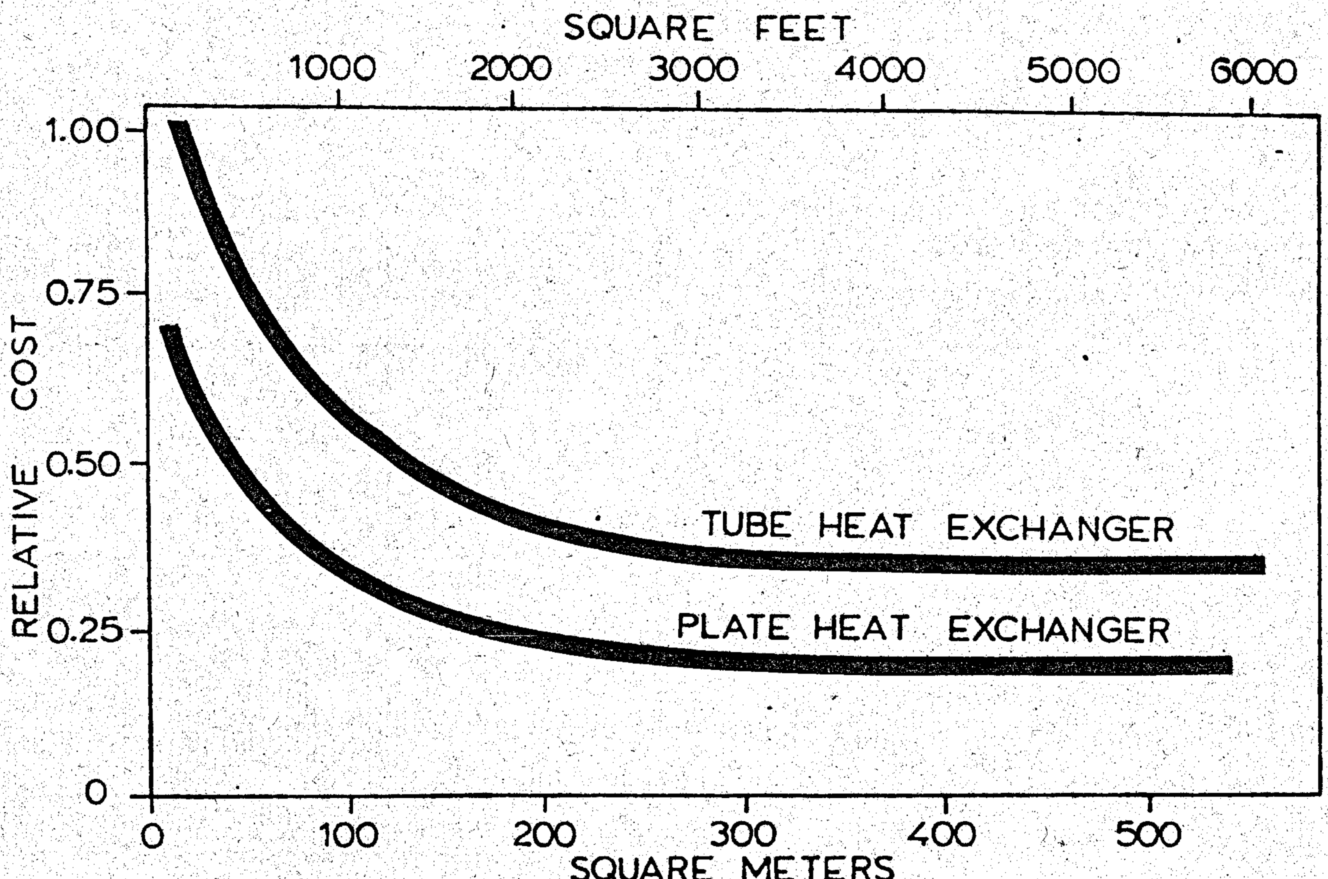

FIGURE 8. RELATIVE COST OF STAINLESS STEEL PLATE AND TUBE HEAT EXCHANGERS

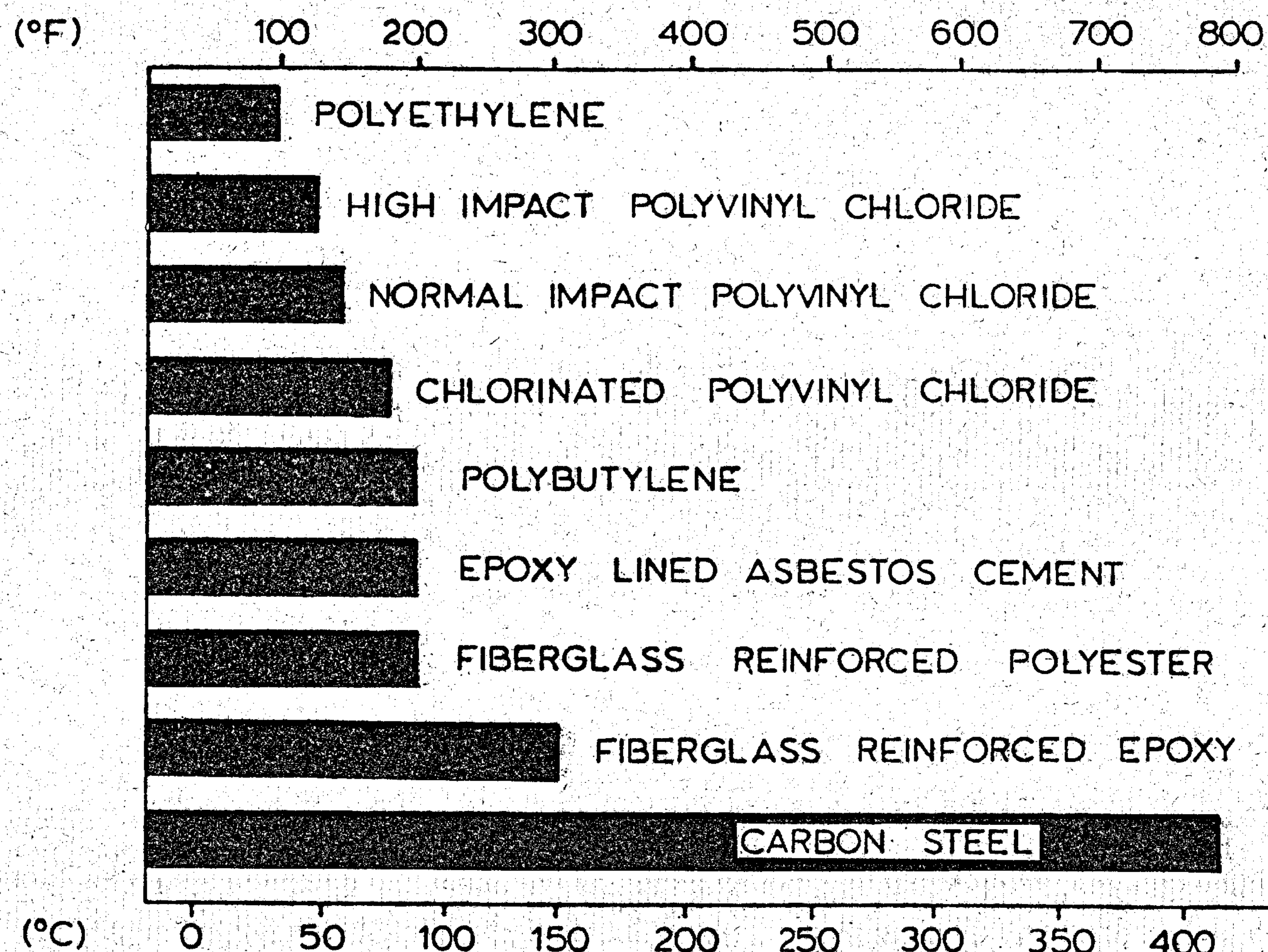

FIGURE 9. MAXIMUM TEMPERATURES ~ PIPING MATERIALS

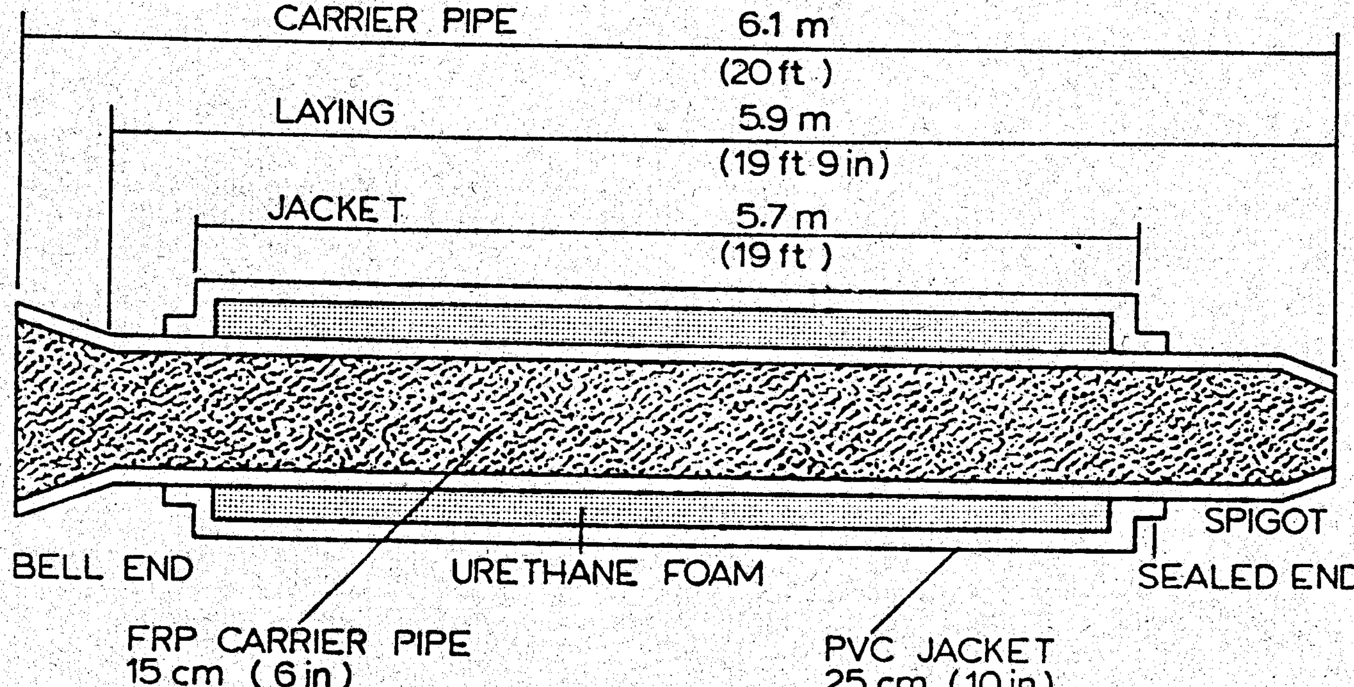

FIGURE 10. FRP PIPE

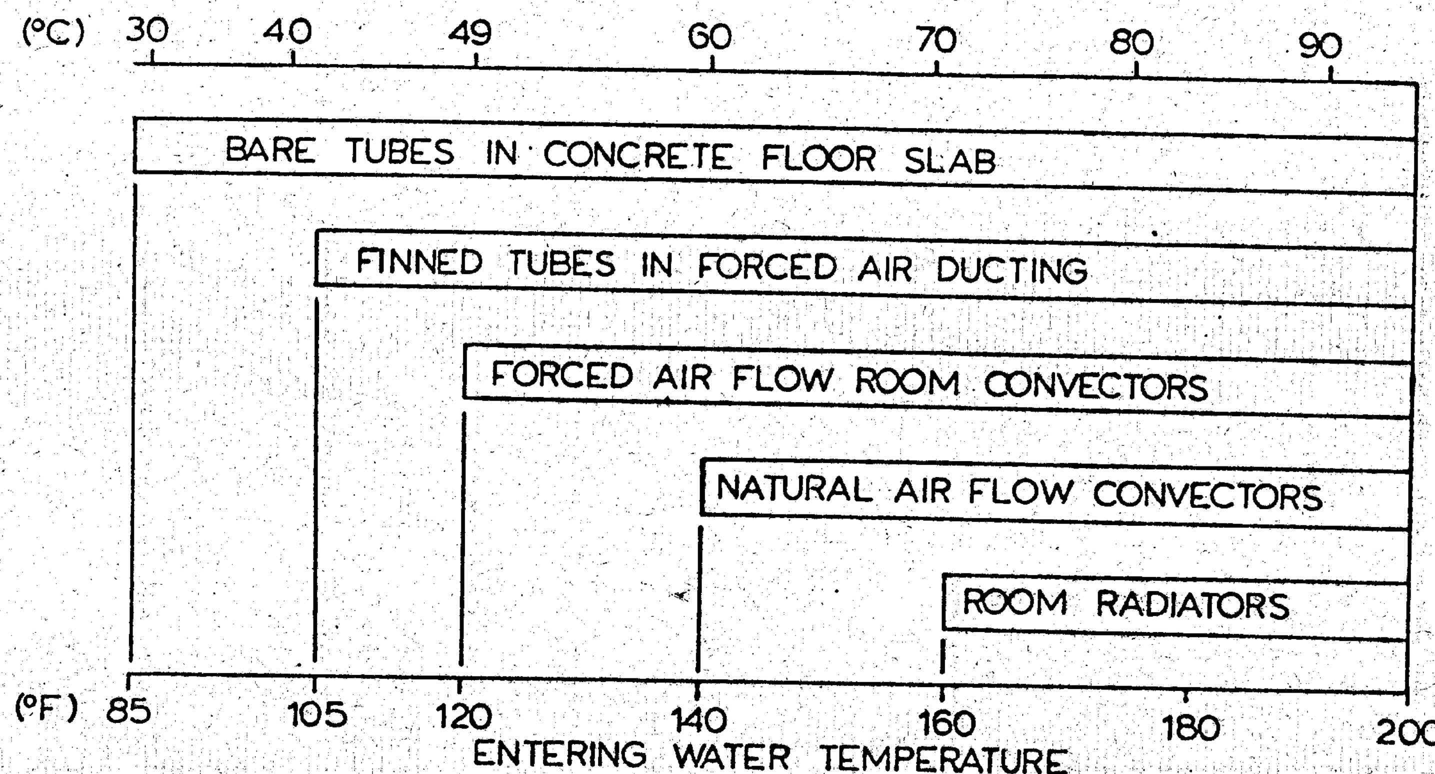

FIGURE 11. TEMPERATURE RANGE OF SPACE HEATING METHODS

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MAKING DOLLARS AND SENSE OUT OF GEOTHERMAL ENERGY

ECONOMICS OF DIRECT USE PROJECT DEVELOPMENT

by

Charles V. Higbee*
Geo-Heat Center
Oregon Institute of Technology

INTRODUCTION

Direct use geothermal projects are capital intensive. That is, they require large amounts of capital to develop the resource and the delivery system (pipelines). Once completed, the annual savings resulting from low cost geothermal energy must be large enough to repay the capital investment over the project life. Direct use projects can be highly successful, saving hundreds of thousands of dollars annually, or they can be a disaster. One thing they all have in common is that they are site specific. Given that the resource temperature is compatible with the end use, they are technically feasible. The technology for direct use geothermal projects has been proven since the turn of the century. The question then is, are they economically feasible.

ECONOMIC FACTORS AFFECTING THE FEASIBILITY OF DIRECT USE GEOTHERMAL PROJECTS

Efficiency

In a conventional system, using water heated by fossil fuel, the water is heated to some temperature in a boiler delivered to the system where heat is extracted and then returned to the boiler to be reheated. The efficiency of the system is the efficiency of the fuel firing the boiler. The amount of heat extracted by the system is not of major importance. Many conventional systems supply heat at 200°F, extracting 20°F in the system, and return the fluid at 160°F. However, more energy would be required at the boiler to raise the fluid up to 200°F.

With geothermal systems, Mother Nature supplies the energy to the boiler. Therefore, if we can increase the amount of heat extracted from 20°F to 40°F, the cost of energy is cut in half. Of course, this is oversimplified because it would require a more expensive system to extract more heat, but at the same time fewer production wells would be required, and production well pumping costs would decrease.

There is always the problem that the end user has a lower limit on temperature that prohibits the extraction of more heat. In such a case, it is worthwhile to consider other uses of the geothermal energy which has been pumped to the surface. For example, suppose a food processor has a lower limit of 220°F to accomplish a dehydration process. This processor pumps 240°F fluid from a resource and injects it at 220°F. Now, suppose an alfalfa pelletizing plant has a lower limit of 160°F. This plant could accept the 220°F effluent and

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discharge it at 160°F. Next, a greenhouse operation takes the 160°F fluid and extracts 60°F, discharging fluid at 80°F. One can see how a total of 160°F has been extracted from the resource. Such efficiency would lower the cost of energy tremendously. Naturally, it is easier said than done. We have not considered load balancing and the compatibility of the users. Obviously, the greenhouse operator does not need 160°F heat in July when the food processor and alfalfa pelletiser would be in operation. This paper does not address itself to the compatibility of end users, but it certainly must be considered.

Within the past year, irrigation water too warm for crops was proposed to supply heat to a water to air heat pump for a greenhouse operation. A considerable amount of study had been done to find if the heat pump would lower the temperature sufficiently for irrigation. The only point overlooked was that when the greenhouses need heat, crops are not being grown, and when crops are being grown, the greenhouses do not need heat.

Annual Load Factor

The annual load factor is determined by evaluating the percent of time the geothermal system will be used based on its peak capacity. It is not economically feasible to spend $40,000 for a summer home if it will only be occupied one week out of the year. Similarly, it is not economically feasible to develop a geothermal system which would only be in operation 5 percent of the time. As the annual load factor increases, the economic feasibility improves. The ideal situation would be to operate the system at a 100 percent load factor. About the only way to achieve load factors approaching 100 percent would be to generate electricity. Most district heating in the United States have load factors in the neighborhood of 20 percent. Food processors who operate 3 shifts per day and are able to store the input product can have load factors in the neighborhood of 70 percent. As an example, if $500,000 is invested in a project that saves $20 per hour of operation and the system is only utilized 20 percent of the time, it would take over 14 years to pay back the capital investment using a zero rate of interest. If capital were evaluated at 12 percent, the project would operate at an annual deficit of $25,000 and would never be paid back. If the system were utilized 100 percent of the time, simple payback would occur in less than 3 years with zero interest. With 12 percent capital, the project would pay back in less than 4 years.

Pipelines

Transmission lines are extremely expensive, and therefore, it requires a high annual load factor combined with very efficient use to warrant the transmission of hot water, even over a distance of five miles. Of course, it is cheaper to lay pipe in the desert than in downtown Los Angeles, but the best rule of thumb is to build the end use at the site of the resource so that lengthy pipelines are not necessary.

Cost of Financing or Required Return on Invested Capital

As the rate of return or the interest charged increased, the economic viability of the project decreases. This is not to say that geothermal is not feasible with the high prime rate with which we are faced today. It simply means that the factors mentioned above need to be optimized in order to overcome high rates of financing or to obtain an acceptable rate of return on investment. There are many feasibility studies which have been performed that indicate very high rates of return. Dehydration plants, aquaculture, and greenhouse complexes are but a few. The rate of return on an energy system when compared to those using fossil fuels ranges from 20 to 60 percent per year. The tax laws encourage development of geothermal projects with up to 25 percent investment tax credits, deductions of intangible drilling costs in the year incurred, and depletion allowances. A word of caution: many direct use projects are so capital intensive with relatively little savings in the early years of the projects that the incentives cannot be taken without other sources of income to apply the write-offs against. With other sources of income, the project becomes involved in the preference income and minimum tax laws.

A final word of caution: in completing life-cycle costs for direct-use projects, it is necessary to establish an economic life for the project. Next, we forecast conventional energy inflation rates over the economic life in order to determine whether or not the geothermal project is economically feasible. It is of utmost importance that the economic life be kept relatively short, 20 years or less, although most geothermal projects last much longer, and extreme caution must be used in assigning inflation rates to conventional energies. Feasibility studies have been performed using inflation rates as high as 20 percent for conventional energies. Such a feasibility study makes geothermal energy look extremely attractive, when in fact the project may very well operate in the red for its entire life. The Geo-Heat Center has been criticized from time to time for using extremely low inflation rates, such as 0.9 percent for electricity and 1.2 percent for natural gas. These annual rates are in addition to the economic inflation rate. The criticisms came in recent years when natural gas was inflating at 14 percent beyond the economic inflation rate. However, in 1980 the price of natural gas failed to keep up with the economic inflation rate, and in 1981, Pacific Power and Light announced a rate decrease. By holding conventional energy inflation rates to a minimum, projects that have good economic feasibility will remain feasible in the face of low inflation rates and will be much more feasible if the inflation rates of conventional energies prove to be higher.

STATE AND FEDERAL FINANCIAL INCENTIVES FOR THE DIRECT UTILIZATION OF GEOTHERMAL ENERGY

by

Jack McNamara*, President
J.M. Energy Consultants

After more than a decade of study, analysis, and debate, investors in direct use geothermal energy utilization projects have finally been accorded significant financial incentives by both the state and federal governments. These financial incentives are in the form of both tax advantages and nontax, risk-reducing programs, such as loan guarantees.

The tax side incentives create increased returns for equity investors, while the nontax programs seek to reduce the risk for the debt portion of the costs of a geothermal project. Although the Reagan Administration has somewhat curtailed federal funding for some of these latter programs, the tax side advantages remain impressive and unimpaired. There also exists the possibility of new risk-reducing initiatives at the state level.

A. TAX INCENTIVES

1. Intangibles

The investor who puts up equity in order to finance the various phases of a direct use geothermal project can expect to receive extremely favorable tax treatment for those expenditures. This is particularly true during the higher risk exploration and development phase of the project.

After passage of the Energy Tax Act of 1978, a current write-off of the so-called "intangible" portion of all geothermal well drilling costs is allowed under IRS Code Section 263(c). These "intangible" well costs (IDCs) include expenses incurred for fuel, wages, hauling, and the like, i.e., expenses for nonsalvageable (and therefore nondepreciable) items. Moreover, "intangibles" usually account for 70 to 75 percent of total well costs. Ordinarily, of course, the costs of drilling a successful well, like the capital costs of any productive asset, would have to be capitalized and recovered over time. For oil, gas, or geothermal wells, this would be through depreciation (for the tangible portion) and "cost depletion" (for the intangible portion). However, IRS Code 263(c) allows the taxpayer the "option" of deducting all of the "intangible" costs only in the year they are incurred. This greatly increases the investor's rate of return on equity, even in the absence of leveraging. All costs of an unsuccessful well are, of course, immediately deductible as a "dry hole" loss.

*Mr. McNamara is the President of J.M. Energy Consultants Inc. and is a self-employed attorney engaged in private practice focusing on energy and natural resource matters.

2. Investment Tax Credits

Whereas the "intangibles" write-off boosts investor returns in the exploratory and development stages of a direct use project, the additional 15 percent business energy investment tax credit, passed into law by the Energy Tax Act of 1978 and clarified by the Windfall Profits Tax Act of 1980, gives a one-time credit against taxes due. Unfortunately, the IRS regulations carrying out this statute have placed a minimum 50°C (128°F) "threshold" on the "geothermal deposits" whose use would qualify for the business tax credit. The IRS has also chosen to exclude by regulation any equipment which has a "dual" role (i.e., could function with or without geothermal energy) as well as all the tangible portion of exploratory and development wells. These creative IRS bits of administrative law-making are now the subject of pending corrective legislation to "clarify" congressional intent.

Residential users of geothermal energy are eligible for a different tax credit, one equal to 40 percent of the costs (up to $4,000) of direct use projects which provide space heating and cooling in a "dwelling unit." All of the costs of wells drilled for such projects (tangible and intangible) are specifically eligible for this credit as the result of "clarifying" language in the Windfall Profits Tax Act of 1980. But in that case, the taxpayer must choose between the investment credit or the current write-off on the intangible items.

3. Percentage Depletion

This deduction, of a flat percentage of the gross income from production of a "geothermal deposit", was granted by the Energy Tax Act of [IRS Code Section 613(c)]. By 1984, this deduction, currently 20 percent, will decline to 15 percent of such income and remain at that level, providing a partial "shelter" for the geothermal revenues of direct use projects and a further boost in rate of return to its investors.

B. NONTAX INCENTIVES

Whereas tax incentives encourage equity investments in direct use geothermal projects, nontax incentives seek to reduce the risk for lenders who could put up the bulk of project costs. Although this leveraging also increases returns to equity, these nontax incentives are aimed primarily at enticing the financial community into funding geothermal projects and secondarily at encouraging large energy users who are extremely adverse to risk taking but who would otherwise utilize geothermal resources. The most famous of these nontax programs is the Geothermal Loan Guarantee Program (GCGP), while others [passed as part of the Energy Security Act of 1980 (ESA)] include reservoir insurance and both feasibility study loans and reservoir confirmation loans.

1. GLGP

The GLGP was enacted into law as Title II of the Geothermal Energy RD&D Act of 1974. The GLGP guarantees 100 percent of a loan covering up to 75 percent of project costs. It has passed through a difficult infancy and is just now receiving widespread lender and end-user acknowledgement and acceptance. The aforementioned Energy Security Act(ESA) of 1980, therefore, extended the GLGP's life from 1982 to 1989. Reagan Administration fiscal 1982 funding of the program is, unfortunately, sharply reduced. This is a valuable program and should be supported. However, many, if not most, direct use geothermal projects are "bankable" without a federal loan guarantee by the more prominent geothermal lenders. This is one major advantage of direct use geothermal investment over its electric "cousin."

2. Reservoir Insurance

The ESA also authorized DOE to study the need for federal reservoir insurance as a major risk reducer for utility and direct users as well as their financial backers. Unfortunately, the recent funding cutbacks and overall OMB posture have thus far precluded this much-needed program, although a private sector mode is theoretically available. For the direct user, the need for this insurance would be as a security blanket for the lender. As we noted, this is much less of a requirement in direct use projects. Nonetheless, it would give added incentive for sources of long-term debt on both types of geothermal projects, and its institution should be an industry priority.

3. Other Federal Programs

Feasibility study and reservoir confirmation loan programs both aimed primarily at large potential direct users who are not prone to taking risks (tax write-offs notwithstanding) are also on the books as a result of the ESA but have not been adequately funded. In their absence, tax-driven investor dollars must be substituted during these risky exploratory steps in order to confirm both overall project and geothermal resource viability for end users and/or potential lenders.

4. State Programs

After several years of urging by both the California Energy Commission and Department of Conservation, the State Legislature created the California Alternative Energy Finance Authority. At this point, they are considering funding several specific projects for private entities by selling their bonds, either through private placement with a large financial institution or publicly. The proceeds would then be loaned to the private applicant with an additional small charge by the authority. If this type of funding can be utilized, it will mean the opening of a major source of capital for direct use geothermal projects. The bonds that are marketed to provide the loan funds are not backed by the "full-faith and credit of the state, but by the credit worthiness of the private entity and its project.

GEOTHERMAL ENERGY: IT'S ROLE IN OUR ENERGY FUTURE

SUMMARY

of

title: [GEOTHERMAL ENERGY: ITS ROLE IN OUR ENERGY FUTURE]

PRESENTATION

by

The Honorable Lawrence Kapiloff*,
Member, California State Assembly

I am here to give you an overview of what we have done and what we hope to do to encourage what I consider to be the single major source of alternative energy in California. I have been primarily interested in developing geothermal energy for electrical use. But I find this gathering rather intriguing in that there are over 300 people here to talk about direct use of geothermal energy. In 1975 I created, by legislation, a geothermal task force which wrote the most definitive report on geothermal energy ever written. The California Energy Commission (CEC) utilized some of these facts, but most of this information has remained unused.

One of the things we learned during our hearings, which took over a year, is that so much of the resource is tied up by so few economic interests. What is refreshing about today's meeting is that apparently the "low-grade" types of anomalies are not as totally controlled. Over 68 percent of the high grade resources in California are controlled by oil companies. The government is going to have to get involved if the resource is to be fully utilized. If the government does not, people will sit on their resources until it best suits their interest to develop it. An oil company executive looking at his resources would know that he could use geothermal energy after utilizing his other two resources, oil and uranium.

Today, we can locate the resources, educate the public on potential uses of geothermal energy, and then begin to develop a totally new industry which will employ a lot of people for many applications. It is going to be up to you and some people who are far-sighted enough to make investments to pioneer all types of applications. With increasing energy prices, this relatively plentiful resource will become increasingly utilized in California.

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*78th District Assemblyman, Mr. Kapiloff is currently the Chairman of the Select Committee on Acid Rain, a member of the Assembly Standing Committee on Ways and Means, Revenue and Taxation, Natural resources and Energy and Rules. Prior to his election, Mr. Kapiloff worked for 11 years as a government attorney for San Diego County specializing in tax law.

OPPORTUNITIES FOR CALIFORNIA BUSINESS

GEOTHERMAL ENERGY: OPPORTUNITIES FOR CALIFORNIA BUSINESS

by

Lynn A. Schenk,* Secretary
Business, Transportation and Housing Agency
State of California

Good afternoon. As a San Diegan, I am pleased to have the opportunity to welcome you to San Diego. If you have not been here before, I hope you can take time to discover why we are so proud of San Diego. One of the most attractive aspects of our area is the vigorous economic growth we enjoy at the same time we maintain a rewarding life-style. Because we value this winning combination, geothermal energy is a particularly attractive energy source.

But, of course, we want to convince you that direct use of geothermal energy is an opportunity for business throughout California. My part in this conference is to present a simple message: business is good in California, and geothermal energy is good for California business.

THE CALIFORNIA ECONOMY

California in 1981 stands on the threshold of a new and even stronger era of economic prosperity.

- o Although we are on the western edge of the continent, California is the financial and intellectual center of the rapidly growing American west;
- o Our ports and cities are the points of contact with the growing markets of the Pacific rim countries;
- o The productivity of our labor remains 10 percent above the national average;
- o We are the center of innovation in key industries of the next decade: semiconductors, aerospace, biotechnology, and alternative energy.

These strengths have resulted in real gains for California:

- o 212,000 new jobs in California in 1980;
- o 27 percent of the job growth in the nation occurred in California;
- o Personal income increased 12.6 percent in 1980 or 2.2 percent in real increases;

*Ms. Schenk was appointed as Secretary of the Business, Transportation and Housing Agency on October 6, 1980. Prior to her appointment, Ms. Schenk was an attorney for San Diego Gas & Electric Company, an adjunct professor at the University of San Diego Law School, and a White House fellow on the staff of both Vice Presidents Nelson Rockefeller and Walter Mondale.

- New business incorporations have increased steadily since 1975; by 1980 the annual total was more than double the 1975 level.

Yet, we cannot assume that this healthy growth will inevitably continue. There are critical obstacles which could delegate California to the slower economic growth found in many other states. I believe that the three major obstacles today are, first, the unabating record high interest rates, second, the increasing competition for our manufacturing assembly plants from other states with lower costs, third, and finally, the increasingly fierce international challenge being mounted by the Japanese and Europeans for our technological leadership.

We can meet these challenges and allow the California economy to fulfill its promise. If successful, we can maintain our quality of life, extend our technological leadership, and create quality employment for all Californians. To do this, we must develop a strategic vision for the California economy, to be developed and carried out by a coalition of business, labor, and government, each playing critical roles.

The Brown Administration has laid the groundwork with initiatives that have addressed regulatory reform, tax relief, housing, transportation, industrial innovation, capital formation, and other issues of importance to business. In the tax arena, for example, we worked with small businesses to successfully pass a capital gains elimination bill, which the Governor signed last week, and shortly, he will announce the formation of the California Commission on Industrial Innovation.

But today's topic is energy, and here the Brown Administration has directed a great deal of its attention because it is so vital to the survival of our economy and, in fact, our way of life.

You will notice that I did not mention energy as a major threat to our future economic prosperity. Despite our preoccupation with energy in the decade of the 70s, I think the business of California--present and future--will be wise enough to turn this challenge into secure supplies and business opportunity.

I do not mean to tell anyone here that energy today is not an issue:

- Energy costs are rising;

- Periodic oil price hikes and threats to supplies are disruptive;

- Energy competes for capital which could be used for other new investment and expansion;

- The need to conserve energy has required dramatic changes in existing facilities.

For these and other reasons, the strong policy of this administration has been to channel as much scarce public and private capital investment funds as possible into energy conservation and renewable energy resources, such as geothermal energy.

Alternative energy development provides a number of significant advantages to business:

- o It can provide secure, uninterruptible energy supplies;
- o It promotes greater price stability than conventional energy supplies;
- o It is a significant economic stimulant by creating new industries and new jobs and strengthening the economic base;
- o In addition, the environmental degradation of conventional sources can be avoided.

It has been said that the emphasis of the Brown Adminstration on so-called "alternative" energy and conservation is somehow anti-business, that we have hampered our electric utilities. But I do not believe moves away from foreign oil and away from constructing enormous capital-intensive central power plants toward our own indigenous energy and a more efficient use of energy are anti-business. In fact, every year bears out more clearly the wisdom of this path for the economic health of California. It is this path which can help to meet and overcome the obstacle I spoke of earlier.

DIRECT USE OF GEOTHERMAL ENERGY

Your materials and other speakers will present some stunning examples of how direct geothermal energy is providing, and will provide, savings to California business. To highlight a couple of examples:

1. It was estimated in an Energy Commission market study that between 25 percent and 50 percent of the energy costs of businesses in the lumber and wood, paper, and chemicals industries could be satisfied by using geothermal energy; it also was estimated that between 15 percent and 30 percent of the energy costs of companies with proximity to known geothermal resources could be displaced by using geothermal energy. These are impressive savings figures for a variety of processes ranging from space heating and cooling to drying dehydration and boiler operation.

2. Rohr Industries here in Chula Vista believes it will be able to use a geothermal system with an estimated cost of $2.4 million that could reduce the plants natural gas consumption by 41 percent for an annual savings of $184,000 at current prices.

3. Nakashima Nursery in Imperial County has recently completed a 100,000 square foot complex that is heated by geothermal energy. They have reduced the consumption of natural gas by 90 percent.

These savings direct capital away from costly, often foreign-owned fuel and back into more productive activity. Funds spent on new energy technologies, be they geothermal or others, can be investments in California business. As leaders in technological change, we are often the greatest beneficiaries of this move to greater energy efficiency and independence. These are opportunities for our component and system manufacturers, engineering and construction firms, servicers, and installers.

GOVERNMENT ASSISTANCE

The indications there are on savings and on jobs. We know there is a potential market. We know that some companies have made good use of geothermal energy. We all know that business people can be the most rational people in the world if given the right information. So what is missing to get more industries to use geothermal?

This is where we in government can play a constructive role. The Energy Commission has surveyed business about what they need to get them to make the decision to use geothermal. According to this information, the most important stimuli for business would be:

- o Tax incentives;
- o Technical information; and
- o Proven reliability.

This conference addresses each of these areas. The point here is that we do not believe in government handouts or false cost effectiveness. We do believe in information and incentives to grab the attention of business to a technology we know will be good for all of us.

Safe-Bidco

A state-supported loan program to help small business in alternative energy fields, such as geothermal energy, is up and running in Sacramento.

State Assistance Fund for Energy, California Business and Industrial Development Corporation (SAFE-BIDCO, for short) will operate on a statewide basis.

It has a $2.5 million line of credit from the state, but SAFE-BIDCO has projected a level of $18 million in loans by the end of 1984. The basic $2.5 million of capital will be recycled in secondary money markets through the sale of those portions of the loans that are guaranteed by the federal government. The Small Business Administration (SBA), for example, will currently guarantee up to 90 percent of a small business loan.

SAFE-BIDCO, created under legislation authored by Senator David Roberti last year, is an experiment. Its mandate is to be self-supporting in the marketplace. And its mandate is also to make credit available to small business people who have been turned down by commercial lenders because they are dealing in alternative energy technologies and markets that are unfamiliar.

It is expected that SAFE-BIDCO will concentrate on suppliers of alternative energy systems, but it can also loan money to small businesses who want to invest in conservation or alternative energy sources to reduce energy costs in their own facilities.

Small businesses who want to be on the list to receive SAFE-BIDCO loan application packages when they are available next month may write to 1029 H Street, Suite 500, Sacramento, CA 95814.

CONCLUSION

I am excited by the potential for growth in the California economy. We remain stronger than the rest of the country. Our growth in the past decade has led us to a position of extraordinary income and quality of life. Yet our pre-eminent position is by no means guaranteed. Economic turmoil at the national and international levels, technological and economic competition from other states and abroad, and a shortsighted commitment to outmoded energy sources, could slow our progress. Fortunately, our future is, to a great extent, in our own hands. Let us join together in a new coalition to seize the opportunities that present themselves to us and secure our economic future.

SUMMARY

of

title: OPPORTUNITIES FOR CALIFORNIA BUISNESS

PRESENTATION

by

Jeffrey Wiegand*, President
Alternative Energy, Inc.

I am going to be addressing the opportunities for geothermal direct use in Southern California. We are indebted to the geological faults for geothermal energy. I will be talking about the four areas that are faulted in the Southern California area: San Diego, Imperial Valley, San Bernardino, and Los Angeles.

In San Diego there are several faults near the border which give us our very modest resource. In the town of Imperial Beach we have about 16 warm wells in which we have encountered geothermal energy at very shallow depths. This resource has been untapped, unexplored, and virtually ignored. We hope this will change in the near future because there is an agricultural area down there that could use this type of resource for soil warming and other end use applications. There is also a geothermal resource well at the Rohr Plant in San Diego Bay.

Ninety miles east of San Diego is the Imperial County with at least four Known Geothermal Resources Areas (KGRA): Salton Sea, Brawley, Heber, and East Mesa. There are approximately a half dozen direct use applications in some stage of maturity right now. These include a space heating and cooling plant in El Centro for the El Centro recreational center and an alfalfa drying feasibility study that was just completed by Westec Services. In the alfalfa feasibility study the low cost of alfalfa as a commodity made the feasibility somewhat questionable.

The resource in the Imperial Valley ranges from 250°F to 550°F within 9,000 feet. The whole area is ripe for direct use application. In East Mesa there are a couple of direct use applications in progress. One is a food drying operation under the leadership of Buck McCabe of Magma Power Company. Also, Ultra Systems received a state grant to analyze the feasibility of an ethanol project powered by geothermal energy. Nakashima Nursery in Imperial Valley is now using geothermal energy to raise flowers. The towns of Brawley and Calipatria, which are in the central part of the Valley, have both applied for HUD assistance to use geothermal energy for municipal space heating and cooling. They were denied but are still very anxious to pursue district heating. The opportunities in the Imperial Valley are virtually limitless

*Since August 1979, Dr. Wiegand has been President of Alternative Energy Incorporated which provides financial and technical services for alternative energy development.

because of the agriculture that is processed there. The potential for ethanol plants is very exciting, and industrial as well as municipal uses are also waiting to be tapped.

The City of San Bernardino is dissected by a couple of main faults of the San Andreas Fault system. Associated with these faults is a geothermal resource of at least 145°F to 200°F. Six entities in the city have joined together to space heat and cool their facilities with geothermal. These include San Bernardino Valley College, the Orange Showground, Aerospace Center, the County Jail, and Norton Air Force Base.

In addition to the space heating and cooling operation, the City of San Bernardino analyzed using geothermal energy for its waste water treatment plant. They analyzed the various heat uses of the treatment plant and found sludge digester heating to be the most optimal use of geothermal energy. The state has granted them money to move forward and develop this use.

The California Energy Commission is funding a project through the County of Los Angeles to evaluate the geothermal energy potential in Los Angeles County. Most of the geothermal energy in Los Angeles lies in the oil fields in the LA basin many of which are on faults. The Willmington, Tarns, and Long Beach oil fields all underlie the Newport-Inglewood Fault zone. They produce approximately 95 percent water for every 5 percent oil. That is equivalent to 19 barrels of water coming up for every barrel of crude. A lot of that water comes up at temperatures between 110°F - 240°F. The water is delivered to the surface cost free because they are already pumping to get the oil. The economics of this project look good because of the flow rates and the free delivery of water. Hot oil and gas by-product wells exist even in downtown Los Angeles, Venice Beach, Alondra, Londale, and Sante Fe Springs. The exciting thing is, with approximately 8 million people in these areas, the chance of finding a direct use application that will make economic sense is vastly improved.

In summary, the Imperial Valley has a resource of unprecedented temperature and volume. Also, the applications are numerous. San Diego has a very modest resource not yet analyzed. Applications include soil warming, space conditioning, agriculture, and aquaculture. The City of San Bernardino has a resource of up to 200°F. The giant Los Angeles resource has low temperatures but huge volumes. It is just now being analyzed and has an unknown but hopefully significant future awaiting it.

FINANCING THE PROJECT

FINANCING GEOTHERMAL PROJECTS
LIFE WITHOUT FEDERAL ASSISTANCE

by

John H. Woods*
Bank of Montreal

ABSTRACT

At the time of this presentation there is question as to the continuance of the Department of Energy's Geothermal Loan Guarantee Program (GLGP). There is support for the program by several of our elected officials and industry members; however, the Administration is striving to curtail and/or eliminate government guarantee programs, as it believes the private sector can and will finance themselves. While we do not know the outcome of the GLGP, industry should recognize that they should prepare themselves to finance their geothermal projects on a conventional basis.

In order to discuss the financing of the geothermal industry, it is important to briefly review the history of the industry in the United States.

The geothermal industry in the United States is a relatively young industry, although the resource has been used for various direct applications on a modest scale for many years. In the United States, the first commercial well for electricity was drilled at The Geysers in 1954, and the first power generation was in 1960. While we can chart geothermal activity for electrical purposes, we are not as fortunate in direct use, yet because of the lesser temperature requirements, direct use applications offer substantial potential.

The financing of the geothermal industry on a project basis prior to the Department of Energy (DOE) Geothermal Loan Guarantee Program (GLGP) became effective had for the most part been nonexistent. There are a number of reasons why there has been a lack of direct project financing made available to this industry. They are:

- o Financing of a geothermal project carried a higher risk factor than a bank could prudently accept without some form of outside support.
- o Until the 1973/74 oil embargo, geothermal development outside The Geysers was not competitive with fossil fuels. Therefore, any possible project financing was confined to The Geysers field.
- o The investment needed to develop a geothermal field to support a major geothermal project is substantial. Most of the medium-sized development

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companies did not have the financial resources to furnish this investment need, and those that did were reluctant to tie up a substantial amount of their financial resources in just one project.

- Project financing has to be evaluated by a lender as to the estimated geothermal reserves, the expected reservoir life, and on having the field developer pledge a firm steam sales contract with an acceptable end user. The techniques to evaluate the known reserves and expected life have not been satisfactorily determined. Also, the end user companies have been reluctant to make a financial commitment as it relates to an industrial complex because of their concern about the geothermal resource life.

Congress recognized the need to attract proper financial assistance in order to escalate the development of geothermal resources and enacted the GLGP under Title II of the Geothermal Energy Research, Development and Demonstration Act of 1974. This guarantee program is administered by the United States Department of Energy (DOE). With the enactment of the GLGP, a financial institution could become involved in financing the geothermal industry. Our bank looked at the GLGP as the window we needed to see how the industry operated so that we could participate in the future without a guarantee, much as we do in other energy industries. We not feel that conventional project financing can be provided to the industry.

Over the last several years a number of people have asked me to describe a project loan as it relates to a geothermal project. There are a number of ways a project loan can be set up, but the ingredients are basically the same. Generally the lender is looking to the project for the repayment of the loan and limiting the outside financial support of the borrower to perhaps guaranteeing completion and covering cost overruns. Each project loan is tailor made, but to give you some idea of what is involved, let me walk you through a typical loan transaction.

The developer holds the geothermal rights in a leasehold section. Their geothermal consultants have completed their geological studies that indicate a potential resource to support an industrial use. The developer drills sufficient wells to allow a reservoir engineer to establish the reservoir capacity and expected life to support a plant for a term that is sufficient for a company to amortize the plant over a reasonable term. The developer at this point negotiates a contract to sell the resource to an industrial company that will construct a plant. The company starts its permitting process after it has satisfied itself with the reservoir capacity and life. The price of the resource is to be competitive with other fuels available. Price increases are tied into other fuel costs or on a known cost of living index. The price has to be sufficient to repay the project loan and allow a reasonable return on the developer's investment. At this point the developer requests a project loan from a lender. The lender evaluates the project costs, management abilities, the reservoir report, and the features of the steam sales contract. This latter item is the most critical, as the repayment of the project loan is calculated to come from the industrial company payments. Once the lender has satisfied itself on these points, a loan is approved equal to, say, 66 to 75 percent. The lender will carve out of the steam sales agreement sufficient revenues to repay the loan over a term of 5 to 10 years after operating revenues start or a total loan term of 7 to 12 years.

It sounds simple enough, but a true project loan takes a considerable amount of time to negotiate between the developer, lender, industrial company, and the various attorneys, accountants and geothermal consultants.

Another vehicle used to finance a geothermal project is geothermal reservoir insurance. A major insurance company has indicated that they will provide this form of coverage. Basically, the program calls for the developer to drill sufficient geothermal production wells so that his reservoir engineer can provide a reservoir report that is confirmed by an independent reservoir engineer retained by the insurance company. Then a determination is made as to the insurance coverage needed, as it can cover their equity and/or loan amount for the seller or buyer of the resource. The insurance covers two phases of the project: the development stage (guarantees that the resource will be equal to that stated in the reservoir engineer's report) and then up to a term of seven years. It will cover complete or partial failure of the resource.

To develop a successful geothermal project there is the need for a combination of equity and, most times, debt. The forms these can take can vary, such as:

- o Equity.
  - Borrower's own resources.
  - Drilling Funds--Raise equity to drill a certain number of wells.
  - Limited Partnership--Raise equity for the entire project.
  - Joint Venture--Raise equity from another entity.
  - Leasing--Ownership held by another party that leases it to the borrower.
  - Sellers Resources--Raise equity from a supplier of service or materials.
  - Purchaser's Resources--Raise equity from the end user of the geothermal resource.
  - Cost Sharing--Grants and other forms of contributions from outside parties (demonstration facilities).
- o Debt.
  - Project Loan--Stands alone on the assets of the project.
  - Developer's Credit--Full guarantee of the developer.
  - Limited Guarantee--Such as completion, cost overruns, performance.
  - Production Payment--A carve-out from the project's revenues.
  - Take-or-Pay Contract--A hell or high water repayment requirement.

- Take-and-Pay Contract--Agreement to pay for all of the product that is delivered.

- Short-/Long-Term Debt--Development and takeout loans.

The geothermal industry is maturing, and as it grows there will be opportunities to finance viable projects under various methods as detailed previously. More and more the lenders are gaining confidence in the reliability of the resource. As in the oil and gas industry, where billions of dollars have been loaned secured by nothing but the oil and gas in the ground, you will see more geothermal projects financed on their own resources. As the industry matures so is its reservoir engineering, and once we have complete confidence on their reservoir reports we will make project financing loans.

SOURCES OF PRIVATE INVESTMENT CAPITAL
A CASE STUDY

by

William R. Brink*
Coopers & Lybrand

WHAT IS PRIVATE INVESTMENT CAPITAL?

If you ask a variety of people to define private investment capital, you will undoubtedly receive a variety of answers. So let us agree on a simple definition for this brief talk.

For this discussion, private investment capital is any form of capital financing that is not public, that is, capital financing that is not gained through a filing through the Securities and Exchange Commission. Naturally this definition opens a lot of financial country for this discussion! Section 1244 stock, general and limited partners, friends and relatives, banks, savings and loans, venture capitalists, leasing operations, loan sharks, and underworld money launderers are all potential sources for private investment capital.

A CASE STUDY OF WHAT?

I reviewed experiences of clients and associates who have sought private investment capital packages. At first I was looking for the case which would be most helpful to the most attendees at this conference. Each case seemed very specific to the project involved and would be of little use to others. In many cases, the actual arrangements and agreements are confidential to protect bargaining positions on future projects. I also noted that the bulk of conversations and effort revolved around how to go about finding private investment capital. I decided that the most interesting and useful case for the conference was the universal case of what to do to locate private investment capital.

WHAT IS CRITICAL TO ACQUIRING PRIVATE INVESTMENT CAPITAL?

Hunting for private investment capital is a lot like hunting for a new career or a new job. It is a tough and demanding task that starts with a thorough understanding of yourself and what you really need or want. Searching for a new career or private investment capital are also alike in that you need plenty of contacts and referrals to find what you are really after; placement agencies and newspaper advertisements usually do not lead to satisfactory results.

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But, what is really critical to acquiring private investment capital? I believe the secret lies in a formalized approach. A few people are lucky; they simply look around for awhile and stumble across what they are after. If you turn out to be one of those lucky people, good for you! But souls that are that lucky are few and far between (and a formal approach would not do their luck any harm anyway). There are people around who seem to get the careers and private investment capital they want when they need them. These people appear to have some common characteristics that boil down to a formal approach, even though some find the process so natural that they do not seem to be aware of how formal and organized their approach really is. What I will discuss now is my impression of how these successful people operate when they successfully search for private investment capital or, more to the point, how you might operate to be equally successful.

HOW SHOULD YOU GO ABOUT PURSUING PRIVATE INVESTMENT CAPITAL?

Step 1-A

Like the career search process, you must start from a thorough understanding of yourself, who you are, what you are worth, what you need, and what you want. For the private investment capital search, this is more than a good resume. You should probably start by writing a term paper about yourself--an autobiography with references and footnotes, a resume, and a financial worth statement. Even if you never give such a document to anyone, you will find the exercise valuable as a refresher course on yourself so that you will be better prepared to answer questions about your past, your credibility, and your value to the project.

A valuable next step is to write a term paper on your project (yes, it is like being back in school again). You will need to write about not only how the project idea was born, but also how the project will operate, who the key players will be, who the important purchasers of outputs will be, who the crucial suppliers to the project will be, what the project cash flows are expected to be over the next few years (including tax benefits), and the make-up of assets and resources to be capitalized. As with any good term paper, you will need to provide a variety of exhibits, like pictures of comparable projects, letters of intent from suppliers, records of discussions with key purchasers of your products, and tables of cash forecasts for one or more likely scenarios.

If your project is very large or complex, you should also prepare a separate paper on the industry or industries that are most vital to your project: How does the industry operate? What is critical to profits? What is its history? What is its outlook? Who is likely to be your chief competitor(s)? Your industry paper may be rather short and to the point if you can attach recent market studies or articles from associations or media releases.

Too much paper writing? You are going to be asking people to trust you with a lot of their money, and they want to know if you are a professional and if you are prepared to professionally handle their investment with due care and attention. Demonstrating your preparation and professionalism through basic documentation is hardly asking too much, and yet few people take the time to do proper research and documentation. Too many try and "wing it" and wonder why finding and acquiring private investment capital has so many dead ends and delays. If you want to use other people's money, you need to earn it and deserve it.

Step 1-B

You are no doubt concerned that you will never get your "homework" finished, and even if you do, it will not be "A" grade work, right? The professionals do it, presidents do it, consultants do it; but, you say, they have a huge advantage. They have staffs to help them, right? That is true, but you probably have a larger staff than you think, and, except for expenses, your staff is free! Your most valuable free staff member is probably the research librarian at your nearby central library. These professionals are almost always overqualified, underutilized, and hungry to prove their value to anyone who will give them a chance. Introduce yourself and spend a few minutes explaining that you are getting a project off the ground and need to find capital to support your effort. Also, explain that you need to prepare documentation about the industry, your markets and your suppliers, and the sources of investment capital that may be able to help you out. The research librarian will usually be able to provide amazing amounts of on-hand material and will be able to work through university and national sources to locate more material, leads, and lists than you probably dreamed existed. They can also provide you with the most recent publications on financing sources and structures which can serve as your personal primer on private investment capital alternatives.

Industry associations and the United States Small Business Administration can also provide valuable sources of counseling and material concerning your project and project start-ups and financing. They can also put you in touch with industry and financial individuals that can provide you with further assistance and counsel, so always ask for referrals to others who may be able to give you a hand or more information. While most people will turn to the associations, few seem to give the Small Business Administration a call, but the Small Business Administration has a variety of free and low cost publications that can be helpful, and their loan application packages (even if you do not submit them) can be used as an outline for preparing the papers we mentioned above.

You may find that your "staff" is providing you with so much help you can not get your arms around it all to boil it down into usable papers or documents. If so, you may want to add a relative, friend, or student who can write well to be your "editor." Or, lacking such a friendly source, you may find your local college to be a gold mine of business writers. Business schools are usually looking for real world special projects and assignments for their students. Consider contacting a local college and offering your situation as an opportunity for a student or students to do research and prepare materials about your project. Let them prepare the various papers and studies and you modify them as necessary for your own use. The students will usually do an impressive job, and the only cost to you will be their expenses. If you really get lucky, you may locate a graduate student who will be able to provide a full range of quasi-consulting services through his campus and professional resources.

Step 1-C

While you are doing all of the work in Steps 1-A and 1-B, you will need to set up and maintain a contact file. The basic file will be a vest pocket telephone and address diary (the business office of your telephone company will usually provide these free). As you collect materials about or from various contacts, you will need a simple filing system to hold the information for ready retrieval. Keep track of anyone who may be able to help you with your private investment capital search: bankers, lawyers, accountants, auditors, tax counselors, investment brokers, professors, other project developers, potential major suppliers, potential major customers, potential equipment suppliers, leasing companies, marketeers, Geothermal Resource Council members, etc. Few people can tackle a private investment capital search relying on just their own direct contacts. Successful searches are almost always accomplished through a long chain of referrals and introductions. Occasionally private investment capital is located through advertisements in leading business and financial publications, so you should monitor these too, but I do not believe you should count on many worthwhile leads from these advertisements. While you will start your search in your local area, do not forget major national sources. At the end of this article I have listed a few places to get you started with "out of town" sources. You may wish to contact them to see if they have a program appropriate for you, and do not forget to ask for suggestions or referrals!

Step 2

With your homework done, or at least well under way, your next step is to hit the private investment capital trail. Where to head first will depend on your homework and where your most promising leads are pointing. This part of the process is very much like the job-hunting process. You do not wander around asking for a job or money. For each contract and interview, you do your homework and have clear objectives concerning what you want to get across and what you want to ask and receive, including additional ideas and contacts. For this part of your search process, you would do well to review your interviewing skills and develop them with each contact you make. As far as basic personal skills go, interviewing is probably the most valuable skill you will need to successfully track down and capture the elusive private investment capital package.

Step 3

Let us call this the final step: negotiating and closing on private investment capital agreements. Unless you are a very seasoned and wise private investment capital user, your chances of having a satisfying experience without professional assistance are pretty slim, especially if you decide to set up partnerships or use foreign entities in your structure. You must keep in mind that any provider of private investment capital is in a position to get the best deal they can for their investment. No matter how honest and friendly they may be, their loyalties necessarily lie on their side, not yours. On your own, you may end up with an acceptable deal for yourself, but professional assistance will probably improve your long-range well being and will head off later unsettling experiences. To protect themselves from charges that they may have taken advantage of you, most reputable private investment capital sources will ask that you complete the final negotiations under professional guidance.

Where possible, get a "plain English" version or at least a summary memorandum of important legal documents, and ask as many questions as you want. There is no shame in asking questions to make sure you understand what is going on. But there is shame in not asking questions and letting yourself and your project be unnecessarily molded and manipulated by others when you should be in control.

AND A FEW LAST COMMENTS

Keep a strong heart. Acquiring private investment capital is usually a long, frustrating process that will probably test your endurance and disciple more than running your business will. And do not forget those who helped you along the way. Follow up each contact with a short letter thanking them. If a contact's referral looks promising, drop them another line to let them know how things are going and how much you appreciate the lead. Once your project gets underway, prepare a summary of the final deal and let those who helped you most in on how the project is going and how grateful you are for the help they gave you. (And do not forget the research librarian; you will have a friend and free research staff member for life if you let them in on what happened with the final deal!)

And one last point, as your "deal" gets really warm and you are headed down to the wire, consider running through a basic "monopoly" game about the various players you are dealing with. What is each giving? What is each getting in return? What are the key tax and liability issues for each player? Does each player seem to be playing a proper business hand, or do some appear suspiciously generous or unreasonably tough? I do not mean that you should develop an actual game, but on paper you should run through the pros, cons, and plays and see if it all looks reasonable. If it does not, get out your contact book and (before you sign off and it is too late) go talk with someone who can help you sort out the "strange" parts and what you might want to do about them.

Good luck with any private investment capital search you undertake, and may all your breaks be something other than your patience or perseverance.

AND A FEW MORE PLACES TO CONTACT

The offices below often have small-scale simple programs that may be appropriate to your project. I have not verified these addresses lately, but most should be okay. (Again, be sure to ask for suggestions and referrals!)

Aetna Business Credit, Inc.
P.O. Box 118
Hartford, CT 06103

Commercial Credit Business
Loans, Inc.
300 St. Paul Place
11th Floor
Baltimore, MD 21202

Community Services Administration
1200 - 19th St., N.W.
Washington, DC 20506

Department of Defense
Pentagon
Washington, DC 20301

Department of Housing and Urban
Development
7th & D St., S.W.
Washington, DC 20410

Department of the Interior
1951 Constitution Ave., N.W.
Washington, DC 20242

Department of Labor
200 Constititution Ave., N.W.
Washington, DC 20210

Export-Import Bank of the
United States
811 Vermont Ave., N.W.
Washington, DC 20571

Farmers Home Administration
South Building, Wing 4
14th and Independence, S.W.
Washington, DC 20250

Ford Motor Credit Company
P.O. Box 1729
The American Road
Dearborn, MI 48121

General Electric Corporation
260 Long Ridge Road
Stamford, CT 06902

Minority Enterprise Small Business
Investment Companies
Office of 301(d) Operations
U.S. Small Business Administration
1441 L St., N.W.
Washington, DC 20416

National Association of Business
Development Corporations
P.O. Box 262
Manchester, ME 04351

Directory of State Small
Business Programs
Office of Chief Counsel for
Advocacy
U.S. Small Business Administration
1441 L Street, N.W.
Washington, DC 20416

Small Business Investment Companies
Office of 201(d) Operations
U.S. Small Business Administration
1441 L Street, N.W.
Washington, DC 20416

U.S. Department of Commerce
Economic Development Administration
Office of Business Development
Washington, DC 20230

U.S. Small Business Administration
1441 L St., N.W.
Washington, DC 20416

Westinghouse Credit Corporation
650 Smithfield Street
Pittsburgh, PA 15222

FINANCING OF AGRIBUSINESS PROJECTS

by

PAUL RODZIANKO*
PRESIDENT, GEOTHERMAL ENERGY CORPORATION

By now, we have all heard how difficult it is to buy a house under these financing conditions. You even have to hunt and hunt before you see a straight mortgage these days, what with all the wraparound and graduated varieties--even lotteries. Today, I would like to shun the traditional approach to financing geothermal projects and would like to dwell on some other considerations for arriving at flexible investment decisions from the resource producers point of view.

Two basic strategies could be utilized in the financing of an agribusiness project powered by geothermal. The first of these is the traditional objective of financing a resource, producing it, and selling it to an unrelated third party which uses it for its own purposes. The second approach--and the one I would like to focus on--involves organizing a joint venture between the resource owner and the end user, each of which would share proportionally in the enhanced, combined project (in some instances the resource owner and end user will be the same party).

What each of these strategies can do in a particular situation is totally dependent on the objectives of each of the parties involved in the project. I would like to refer you to the outline published in the proceedings of this workshop of the "Financing" section in the Food Processing Panel. Before an approach can be finally committed to, all aspects of a given project have to be quantified as much as possible, and the relative strength and weaknesses of the proposal as well as the reasons for considering it in the first place have to be clearly spelled out. This latter aspect will have a major impact in the level of "exposure" considered.

Let us suppose that Company A runs its operations based on natural gas, has a high fixed investment in relatively new facilities which are not operating at full capacity, and, to avail itself of the geothermal option, would have to relocate some of its operations to a remote geothermal resource. Clearly, no incentive exists to make any financial commitment to any incremental risks, such as "reservoir" risks, and is justifiably not considered by management. Company B, however, will soon run out of natural gas contracts priced at one-third of any new replacements and has a close to obsolete plant, which is costly to operate and running at near capacity. No alternative energy source other than geothermal energy is readily available, and the company could use

*Mr. Rodzianko is President of Geothermal Energy Corporation. He is currently a director and member of the Executive Committee of the Geothermal Resource Council and chairman of its Audit Committee as well as president of its New York section. Mr. Rodzianko serves concurrently as Chairman of the Board and President of Geothermal Food Processors, Inc., in Brady Hot Springs, Nevada.

the tax benefits. Company B, therefore, must convert or risk being noncompetitive. Assuming the availability of capital or credit, Company B has every incentive to make the move if it wants to stay in business, and any perceived incremental risks are assessed fully rather than rejected outright as with Company A.

Clearly these examples are extremes. Most companies considering geothermal facilities will fall between them. Looking from the perspective of the processor, several topics become important to assess probably in this sequence:

- o Applicability of geothermal energy to process (broad or narrow sustitution possibilities, economics, geographic constraints, etc.);
- o Need to consider geothermal energy source (essential or optional);
- o Approach to conversion (total or gradual; marketing involved);
- o Availability of corporate resources (capital and management available or not);
- o Desire or need to mitigate corporate exposure (finance, joint venture, or straight purchase of resource; outside participation in plant); and
- o Decision to proceed (intangible considerations; need for flexibility, etc.).

The sequence of decisions taken up above may well lead a resource user to opt for the most flexible approach, one in which the resource producer accepts the risks and expenses associated with managing geothermal production while the resource user manages the manufacturing and marketing aspects of the business. By means of a joint venture or partnership, profits would be distributed proportionately to both parties.

Our own experiences have involved fully integrated operations, and I will describe these in my verbal comments to you bearing in mind the point of view described above.

RESERVOIR INSURANCE
OFFSETTING THE RISKS OF GEOTHERMAL DEVELOPMENT

by

Norman K. Barrett,* Senior Vice President
Corroon & Black of Pennsylvania, Inc.

This opportunity to learn more about California's direct use geothermal potential is greatly appreciated. I sincerely thank our friends at the California Energy Commission and the Geothermal Resources Council for their invitation to participate. Our program is a unique insurance approach that invites our clients to participate in tailoring the manuscript policy provisions to meet their particular financial needs. It is, therefore, important that we understand each other's problems as much as possible.

You may be wondering how aviation insurance specialists have become involved in geothermal resource insurance programs. Well, it happened some what serendipitously when a Philadelphia client informed us that their Los Angeles subsidiary (Geothermal Resource International) was confronted with a somewhat complex insurance problem. GRI owned a number of DC-9 aircraft which were being leased for airline use. We outperformed the competition and won the account.

The ensuing close broker-client relationship soon revealed the stringent need for geothermal resource insurance. Several major brokerage firms had been approached previously with this problem, and their response was "it can't be done." Corroon & Black Corporation decided to "grab the brass ring" and immediately assigned high priority to the development of a geothermal resource insurance program. We approached Mr. John Cox, President of the Insurance Company of North America, with our concept and were granted top level cooperation, which culminated in late 1979 with INA's commitment and their designation of my firm as their sole managing agency for geothermal insurance.

Our geothermal resource insurance program is, first and foremost, a strategic financial tool designed to stimulate private sector investment in geothermal projects. It ensures the presence of a sufficient quantity and quality of resource over an agreed period of time, thereby removing the major risk which private sector lenders are unwilling to bear (i.e., geothermal resource inadequacy). If a geothermal facility cannot meet the geothermal project's resource specifications, the developers' investments in the project are greatly reduced in value, perhaps even to the point of total loss if the project must be terminated.

This geothermal resource insurance program is offered, initially, in two phases to any person or entity with a financial interest in the project:

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*Mr. Barrett is the Senior Vice President of the Pennsylvania subsidiary of Corroon and Black Corporation, which specializes in airline and alternative energy insurance programs. In his four years at Corroon and Black of Pennsylvania, Mr. Barrett and his colleagues have created alternative energy insurance programs such as the geothermal resource insurance program.

1. Preoperational: The project construction period from the date of reservoir confirmation (following completion of exploration) to the date of commencement of commercial operations.

(An independent, qualified geothermal engineer will have confirmed the reservoir specifications.)

2. Operational: The period from the commencement of commercial operations until the completion of an agreed number of operational years--not, initially, to exceed seven years.

NOTE:

- o If the insured construction period is one year and the insured operational period is seven years, that is an initial noncancellable commitment of eight years!

- o The reservoir insurance is, of course, subject to negotiated renewal.

INDEMNIFICATION

The insured is indemnified for his economic loss resulting from resource capability reduction or project termination because of resource inadequacy (subject to a negotiated percentage of self-insured retention by the insured--not to exceed 10 percent).

Each policy is tailored to the specific financial needs of each particular insured:

Examples of different "loss payable" approaches are as follows:

1. The cost of retrofit to an alternate source of heat, including:

   - o The actual installation cost of a steam boiler sufficient to produce the specified heat; plus

   - o The actual cost of the alternate fuel required. (Subject to a specified limit per year.)

   Such alternate fuel cost may range from total dependence on the alternate fuel (because of the complete resource failure) to partial dependence (because of resource capability reduction).

2. The loss of royalties and/or production payments.

3. The loss of income flowing from the project (thereby interrupting the insured's debt service and payment of fixed costs).

4. The unamortized portion of the insured's investment in the project, as of the time of the occurrence of resource capability reduction or project termination.

To sum up, the insuring of the production capability of a geothermal reservoir removes the major risk that stands in the way of private sector financing.

Because of the broad diversity of the many geothermal projects submitted, each must be underwritten on the basis of its own individual peculiarities.

Since the time is limited for this presentation, I am prepared not only to answer all of your questions here during the remainder of my 20 minute allocation but also invite you to question me elsewhere during the rest of today and all day tomorrow.

Thank you for your kind attention.

GEOTHERMAL RESOURCE INSURANCE

Co-Developed by INA and Their Managing Agency
Corroón & Black of Pennsylvania, Inc.

BACKGROUND

America needs to develop new sources of energy in order to expedite the achievement of independence from foreign oil supplies. There are substantial risks involved in the development of alternate sources of energy, and efforts to tap such sources often expose corporate assets to high technological risk and the threat of financial loss.

Of major concern when considering the development of a particular alternative source of energy is its economic feasibility. Many alternative sources of energy which are currently being studied cannot economically justify commercial production at this time. However, geothermal energy is one source of power that has proven to be economically feasible on a commercial basis.

Man's use of geothermal energy dates back many centuries to the ancient cultures of Greece, Rome, Babylonia, and Japan. In 1867 the Hungarians dug a geothermal well, and by early 1900, other geothermal wells were being drilled in Iceland, Germany, and Italy (today 380 megawatts of electricity are being generated at Lardarello, Italy). In 1943, Reykjavik, Iceland, commenced switching over from coal to geothermal hot water for heating homes and for industrial uses. Today almost the entire city is geothermally heated.

IN THE UNITED STATES

The largest geothermal electric power generation complex in the world is located at The Geysers in Sonoma County about 90 miles north of San Francisco, California. Pacific Gas and Electric Company's first geothermal plant (producing 12.5 megawatts) went on line in 1960. As of January 1980, production has grown to more than 660 megawatts plus an additional 245 megawatts which are under construction. Another 220 megawatts are expected to be completed by 1982. The *present total proved* capacity of The Geysers exceeds 2,000 megawatts.

GENERAL NATURE OF GEOTHERMAL RESOURCES

Vast amounts of geothermal energy are stored within the earth. If one considers the United States, for example, and includes only those geothermal resources with temperatures exceeding 300 degrees Fahrenheit, it has been estimated that about 450 million kilowatts of electricity could be generated.

The greatest economic potential for utilizing geothermal resources exists in those areas where geological anomalies have allowed the earth's magma to penetrate abnormally close to the earth's surface. By far, the greatest number of the most promising known geothermal resource areas (KGRAs) in the United States of America are located in the western United States, the Gulf Coast geopressured areas, and along the Atlantic coastal plain from New Jersey to Georgia.

GEOTHERMAL PROJECT CONSIDERATIONS

In view of the present energy shortage, why cannot more geothermal projects be completed? The answer seems to lie in the extent to which the risks inherent in such projects are understood and dealt with.

The following are of critical concern in the development and utilization of geothermal resources:

- The possibility that a producing reservoir will be unable to sustain its pressure and/or volume over an extended period of time;
- The risk of a reduction of the temperature of the geothermal resource;
- The need to provide for a workable reinjection plan which not only solves related environmental problems (such as pollution and subsidence) but also recycles the effluent back through the hydrothermal system from which it originated;
- The technology for each particular geothermal project must be advanced enough to produce the geothermal resource in sufficient quantity and quality to assure its economic feasibility; and
- The need to cope with whatever impurities are present in the geothermal resource of each particular project in order to assure uninterrupted operation of the gathering system and generation equipment.

GEOTHERMAL RESOURCE CATEGORIES

Hydrothermal Convection Systems

Vapor-Dominated Systems--Produce saturated and, often, superheated steam.

Hot-Water Systems--Are dominated by circulating water which transfers the heat and creates and controls the subsurface reservoir pressures.

Geopressured Water Systems

The heat of the earth is trapped in subsiding basins beneath insulating clay deposits, creating high water temperatures and pressures.

Hot Dry Rock Deposits

Impermeable rocks cover magma chambers resulting in temperatures which increase with depth and proximity to the magma. The Department of Energy is conducting experiments which are expected to result in the utilization of this high grade energy source by the early 1990s.

Magma Systems

Buried magma sources comprise very large concentrations of high grade energy. The commercial utilization of such systems awaits the solution of a number of very complex technological problems.

INSURANCE DESCRIPTION

The geothermal resource insurance program is designed to ensure the long-term availability of the resource at the needed quantity and quality level established for the project during the simulation modeling and sampling period. This unique insurance concept is a strategic financial tool that will expedite investment in both direct and indirect uses of geothermal energy. Insurance is afforded not only against loss arising out of project termination because of resource inadequacy, but also against loss resulting from capability reduction. Coverages are offered for a noncancellable policy period encompassing the project construction period plus an operational period of up to seven years.

I. INDIRECT USE OF GEOTHERMAL RESOURCE (Electricity Generating Plant)

A. The Expediting Phase (Construction Period)

Coverage for the expediting phase will go into effect after completion of the reservoir process and will remain in effect until the commencement of the normal commercial operation of the geothermal power plant. Inception of such insurance coverage occurs only after confirmation of the proven reserve capacity of the geothermal resource involved. An independent, qualified geological engineer will have determined through production well testing that sufficient geothermal resource is available to operate the proposed geothermal power plant at the nameplate level. Such expediting phase coverage will ensure the availability of the geothermal resource in sufficient quantity and quality required to operate the proposed geothermal power plant after completion of construction thereof. In the event that the proposed project must be scaled down or terminated due to inadequacy of the resource, the policy will indemnify the insured based upon his resulting financial loss.

1. Insured

   Any persons or entities with financial interests in the Electricity Generation Project.

2. Indemnification in the event of:

   a. Project Termination Prior to Project Completion: Payment of the sunk costs of the project as of the date of termination.

   b. Project Capability Reduction: Inability to achieve the project's target capability with subsequent commercial operations at the reduced capability. Payment of agreed amounts to assure continuation of the debt service and payment of the fixed costs.

B. The Operational Phase (Operational Period)

Coverage for the Operational Phase will go into effect at the time of the official commencement of commercial operation of the geothermal power plant, following the successful completion of the Expediting Phase. Project termination due to inadequacy of the resource will be covered as in the Expediting Phase. Coverage for loss of earnings due to inadequacy or scale-down of the geothermal resource will also be available. Insurance for the Operational Phase will be written for a maximum noncancellable period up to seven years. Such coverage can be cancelled only for nonpayment of premium, fraud, or misrepresentation on the part of the insured. Renewal of the policy may be effected beyond the seven-year Operational Phase Coverage Period.

1. Insured

   Any persons or entities with financial interests in the geothermal project.

2. Indemnification in the event of:

   a. Project Termination: The payment of the unamortized sunk costs of the insured as of the date of termination.

   b. Project Capability Reduction: Inability to continue production at the target capability level—with subsequent continuation of operations at a reduced level—payment of agreed amount to assure continuation of debt service and payment of the fixed costs.

      The loss payment will be subject to a "retroactive provision" involving a lock-box at a bank, with subsequent reimbursement of such payment upon resumption of normal operations. All of the project's fixed obligations and loan service shall first be paid by the trustee out of available revenue before any such reimbursement is paid to the insurer.

      The insurances afforded under subparagraphs I.a. and I.b. will be subject to an agreed self-insured retention. The percentage which normally will not exceed 10 percent is subject to negotiation.

II. DIRECT USE OF GEOTHERMAL RESOURCE (Space Heating, Agriculture, Aquaculture, Greenhouses, Alcohol Production, Food Processing, Health Spas, etc.)

A. Insureds

Any persons or entities with financial interests in the geothermal project.

B. Coverage Period

The construction period plus an agreed number of operational years up to a maximum of seven operational years.

C. Indemnification

The insured's loss resulting from geothermal resource inadequacy hazard.

D. Definitions

1. The term "insured's loss" is dependent upon the particular need of each project. This may include:

   a. The actual cost, including the cost of installation, of an alternatively fueled steam boiler sufficient to produce the degree level and quantity of heat required in the geothermal project specifications.

   b. The actual cost of the alternative fuel required to produce the heat necessary to meet the geothermal project specifications.

   c. The annual cost of redrilling or reworking the geothermal well.

E. Other Insurance Concepts

This geothermal resource insurance program can be tailored to meet the particular financial needs of each specific geothermal project.

Geothermal Market

There are two categories of geothermal facilities, each involving several potential purchasers of geothermal resource insurance programs.

Geothermal Facilities Categories:

1. Indirect users (electricity generation plants).

2. Direct users.

   o Space heating and cooling (space conditioning);

   o Agriculture and aquaculture (greenhousing, livestock raising and processing, food processing, alcohol production, health spas, fish farming, etc.); and

   o Industrial processing (lumber and paper pulp drying, vegetable dehydration, milk pasteurization, etc.).

The following are potential purchasers who may have insurable interests in the adequacy of the geothermal resources which supply the energy required for geothermal facilities:

1. The Developer

   The individual or entity responsible for exploratory drilling and, subsequently, the completion of all production and reinjection wells required for the long-term commercial operation of the geothermal facilities.

2. The Operating Company (of an Electricity Generation Plant)

   The operating company may be the utility purchasing the produced electricity, or a subsidiary of such utility (functioning in the capacity of plant owner or leasee).

3. An Entirely Independent Company

   A company which derives its compensation from royalties and/or production payments.

4. The Source of Financing

   Banks, investment companies, investor groups, etc.

   Insuring the risk of geothermal resource inadequacy provides the security needed to obtain private sector capital financing for geothermal facilities.

   The complex financing arrangements for an electricity generation plant may be expedited by insuring not only against project termination because of resource inadequacy ("total loss"), but also against resource capability reduction ("partial loss").

   Such a geothermal resource insurance program provides a very potent strategic financial tool for achieving commercial operation of the plant at the earliest possible date.

   The presence of this insurance allows the construction of the plant to proceed at the same time as the postexploration field development. No longer will the expensive completed field lay idle (incurring loss of interest and production income) while the plant permitting and construction is being completed.

   Furthermore, such expediting of the project maximizes the favorable financial impact of investment tax credits and accelerated depreciation allowance.

Geothermal resource insurance is not an equivalent substitute for a Department of Energy loan guarantee. The DOE loan guarantee enables a developer or owner to secure up to 75 percent of the project cost through a governmental guaranteed loan. In some instances the INA geothermal resource insurance may be an adequate replacement; however, the INA policy does not cover certain business risks that are insured under the government guarantee program. The requirements of the insured and his operation must be ascertained in order that the geothermal resource insurance can be tailored to meet his specific needs.

For those projects in which geothermal resource insurance is requested, INA has adequate reinsurance capacity and is committed to responding to clients' needs in an expeditious manner.

INA's very extensive insurance facilities are also available to underwrite the conventional insurances needed for each geothermal project (such as builders' risk, comprehensive general liability, worker's compensation, professional liability, etc.).

Premium financing arrangements may be made in order that the geothermal clients' cash flow parameters may be coordinated with the timing of the geothermal project's ultimate commercial production.

Underwriting Information

The following initial underwriting information is needed for a quotation:

- The projected costs for field development and facilities construction. Please show the estimated time span for each and furnish copies of all pertinent contracts among the parties involved.

- A description of the type of system to be used, including wells, power stations, steam and/or water treatment, reinjection plans and time tables for construction.

- Definition of the total areas allotted for the projects use and all accumulated technical information relative to the reservoir, the individual wells, and the proposed geothermal facilities.

- The proposed facility operating plan and projections for the project's commercial operations.

- A positive geothermal reservoir report by a qualified geothermal expert and his recommendation to proceed with full-scale development.

For further information on the geothermal resource insurance program you may contact:

INA Special Risk Facilities, Inc. 1221 Avenue of the Americas New York, New York 10020	or	Corroon & Black of Pennsylvania, Inc. 1530 Chestnut Street Philadelphia, Pennsylvania 19102

ENERGY SUCCESS STORIES

SUMMARY

of

NEW MEXICO STATE GEOTHERMAL DIRECT USE DEMONSTRATION PROGRAM

PRESENTATION

by

George Scudella*, Resources Bureau Chief
New Mexico Energy and Minerals Department

New Mexico has 8 KGRAs (Known Geothermal Resource Areas) and 12 KGRFs (Known Geothermal Resource Fields). A KGRA is defined by the United States Geological Survey as an area having sufficient geothermal potential to warrant spending money for development, and a KGRF is defined by the New Mexico Land Office as an area in which geothermal energy may be capable of being produced in commercial quantities.

The following tables list areas and sites of geothermal prospects in the state for both electrical and thermal uses. The prospective sites are listed in three categories: proven, potential, and inferred.

Proven sites are those which are in an advanced stage of development or commercialization by a private company or by government for specific applications or those on which favorable quantitative data on the measured subsurface temperatures or land volume of water flows is available.

Potential sites are those sites on which there is exploration/development activity, or on which some favorable quantitative subsurface data have been estimated or measured.

Inferred sites or areas are those identified by surface manifestations, such as wells or springs, chemical thermometry, or proximity to potential or proven sites.

There are nine geothermal developments in the state that are currently active demonstration and commercialization projects. Of those projects, six are demonstration projects that were initiated by the New Mexico Energy and Minerals Department and cost-shared with federal and private funding sources:

1. Carrie Tingley Hospital at the City of Truth or Consequences. This is a geothermally preheated hot water system designed, installed, and operated by the BDM Corporation. The project utilizes an old active well system that provides natural hot water for the hospital's two therapeutic pools. The capacity of the system is equipped to handle 170,350 liters of continuously pumped well water (43°C) which contains a useful heat content of 12,000 Btu/min.

*Mr. Scudella is the Chief of the Resource Bureau for the New Mexico Energy and Minerals Department and supervised the policy, planning, and evaluation of alternative energy resources and appropriate technologies. Mr. Scudella also serves as New Mexico's geothermal program manager and has primary responsibility for the United States Department of Energy Geothermal Commercialization Program and for New Mexico's geothermal research development and demonstration projects.

2. University President's House/University Center, NMSU, Las Cruces. This is a space-heating project for the residence for which a well has been drilled into the Los Alturas Geothermal Anomaly, which underlies the residence. The space-heating system uses 50°C water from a depth of 137 meters (450 ft) at a flow rate of 64.3 liters/min. The project started June 28, 1979; the construction was completed in September 1980; and the residence was occupied in December 1980.

3. Solar-assisted geothermal greenhouse, Faywood Hot Springs. The resource is the Faywood Hot Springs, 48.3 km (30 miles) southeast of Bayard, New Mexico, which flows at 132.51/m 57°C (125°F). The objective is to construct and operate the geothermal greenhouse using runoff water from the hot spring and produce native plants for waste tailings reclamation projects by Kennecott Copper Corporation. This development is being constructed and operated by handicapped labor from the Southwest Services for Handicapped Children and Adults, which owns the greenhouse.

4. City of Truth or Consequences Senior Citizens Center. This is a retrofit space-heating project which will tap the underlying artesian thermal water basin under the city. The well water temperature in the area averages 43°C. The geothermal water will be pumped from a 154 meter or less well which is being drilled on city property. This well will be connected to the city's Senior Citizens Center to supply up to 100,000 Btu/hr during peak demand period.

5. Solar-assisted geothermal greenhouse, Taos. The resource is the Ponce de Leon Hot Springs near Ranchos de Taos. The springs discharge 1,305,977 liters per day at 35°C at an elevation of about 2,256 m. The project will analyze and determine the use of a geothermal heat recovery system to provide thermal energy for greenhouse space heating for growing cash crops (for 5,574 m^2) and other commercial processes. This project uses technology transfer from power plant waste heat recovery and is conducted by Solar America, Inc., of Albuquerque.

6. L'Eggs Products, Inc., Mesilla Park. This project evaluated the potential resource and the engineering for bringing geothermal energy on line for industrial processes at the hosiery manufacturing plant. An 1,800 feet test well was drilled on the plant site on May 12, 1980. No appropriate resource was found, but a warm bottom hold temperature of 32°C was encountered. It was determined from a series of economic and engineering studies that the development of a deep resource would not be economically suitable for the company's requirements and needs.

With the exception of some aged hot spring resort spas, most private business enterprises utilizing geothermal energy in the state started in the 1960s. The most significant developments are listed here:

1. Baca location geothermal power plant demonstration program, Jemez Mountains. The resources of the project area inside the Valles Caldera include both a liquid and vapor-dominated reservoir. The major, liquid-dominated reservoir is over pressured and contains a calculated 1.8 x 10 kg of fluid in place. The average reservoir fluid temperature is in excess of 260°C. The main production and injection zone is the lower

Bandelier Tuff; the upper Bandelier forms the cap rock. Since the first geothermal well was acquired in 1963, Union Geothermal of New Mexico has drilled 23 wells, and probably 10 to 15 more wells may be needed for the proposed 50 MWe plant. Final approval of the environmental impact statement was made in May of 1980. Authorization for construction is still pending from the Public Service Commission, and additional water rights are needed from the State Engineer's Office before construction can begin.

2. The Aminas Valley geothermal greenhouses. Operators: Tom McCants and Dale Burgett. Two hothouse operations are described together because of the same underlying resource, identical characteristics, energy use applications, and geothermal energy requirements.

3. The resource is the "Animas hotspot," a very shallow anomalous aquifer, where abundant water of 102°C (215°F) is obtained at depths of less than 29 meters. The thermal anomaly has no surface manifestations, and it is very geophysically conspicious in a one square mile section. This apparently is a fault-controlled feature adjoining a sediment-filled basin.

4. The two greenhouse operations overlying the thermal anomaly use 3,600 Btu/min and 1,700 Btu/min with no thermal drawdown. The thermal capacity is used for the production of various high priced floral plants, particularly roses.

5. Geothermal heat pump system of Sandia Savings Building, Albuquerque. Two aquifers, 90' and 270' deep, supply cool and warm waters according to the seasonal demand. Two wells are involved in this operation. The shallow well supplies cool water with a temperature range from 17°C to 21°C (60° to 70°F). The deeper well supplies warm water at 26°C to 27°C. The water is withdrawn from either the cool or warm well, depending on the season and injected into the other well. A heat exchanger and three 100 horsepower compressors are used to boost or lower the water temperatures for winter heating or summer cooling. Heating requires 2,518,000 Btu/hr and cooling requires 3,467,182 Btu/hr.

THE BACA RANCH GEOTHERMAL DEMONSTRATION

The proposed Baca project consists of geothermal well-field development, power plant and transmission line construction, and operation of a turbine generator building, cooling tower, hydrogen sulfide abatement system, and an electrical switchyard. The well-field system consists of geothermal well, piping, steam separators, and a liquid injection system. Electricity will be transmitted from the plant by a newly constructed transmission line. During operation, fluid will be transported from wellheads through pipelines to localized or "satellite" flash separators, from which steam will be sent to an injection plant. Noncondensable gases will be removed from the geothermal fluid in the turbine condenser and processed through a hydrogen sulfide abatement system.

The goal of the federal geothermal program is to accelerate commercial development of geothermal energy in an environmentally sound manner. In pursuit of this goal, a program opportunity notice (PON) was issued to prospective offerers on September 30, 1977, inviting organizations to submit proposals to design, construct, and operate a geothermal electric power plant in the United

States using a liquid-dominated geothermal reservoir. The objectives of the PON were selected to provide the maximum stimulus to nonfederal development of the widest spectrum of hydrothermal resources usable for electrical production. The project described herein is that selected by DOE from responses to the PON.

The objectives of the demonstration plant are to provide information on the economic, technologic, and environmental aspects of electrical generation from a liquid-dominated resource. Current geothermal technology in the United States, with the exception of those at The Geysers and two national parks, are likely to be liquid dominated and, since the development risks of liquid-dominated resources are not well known, this demonstration is aimed at enhancing development of electrical production from the bulk of the United States geothermal resource.

The Baca demonstration will cost $140 - $148 million. The cost of the project will be shared by the United Stated Department of Energy, Public Service Company of New Mexico, and Union Oil Company.

In July 1981, activities at the Baca had to be modified, and construction plans were suspended for an indefinite period. Union Geothermal Company has been having problems bringing adequate steam on line. The most recent wells have been encountering high temperatures at depth, but the pressure has been too low to bring the steam to the surface. Union has begun a multimillion dollar well field stimulation program to see if sufficient steam can be generated to warrant the continuation of the project.

HOT DRY ROCK PROGRAM

In 1970, scientists at Los Alamos Scientific Laboratory (LASL) developed the concept of extracting heat from hot underground rock. This concept has been taken to actual demonstration with support of the United States Department of Energy and is known as the Hot Dry Rock Program.

The first deep exploratory hole was drilled in 1974 to a depth of 9,610 ft. The second deep hole was drilled in 1975. LASL fractured the rock at the bottom of one hole with pressurized water. After the fracturing was completed, water was injected down one hole and brought up the other hole as steam.

The two holes have been connected to a heat exchanger, similar to a large automobile radiator. Scientists are currently studying the mechanical, chemical, and thermal properties of the system.

LASL has announced plans to build a 5 - 10 megawatt electrical demonstration plant to demonstrate the production of electricity from hot dry rock. If the first demonstration is successful, the 10 megawatt plant may be expanded to 100 megawatts, which could supply electricity to 10,000 consumers.

The cost of generating power from hot dry rock systems may be as low as 3 - 4¢/kWh, which is competitive with the current cost of power from coal, oil, or nuclear plants. As the costs of fossil fuels rise, the relative cost of geothermal power should decrease and its future grow even brighter.

Currently, the Hot Dry Rock Program at LASL employs about 100 employees and has an annual budget of about $17 million.

SUMMARY

of

GEOTHERMAL ENERGY: A HEDGE AGAINST ESCALATING ENERGY COSTS

PRESENTATION

by

Robert R. Miller
Rohr Industries

A brief introduction of the company, its manufacturing function, and its geological setting is the first of six points in this presentation. A series of eighteen slides is used throughout the discussion to define and feature certain segments of the talk.

Sixty-five percent of the natural gas used at Rohr today is for manufacturing activities, 25 percent is for space heating, and 10 percent for sanitary water and cafeteria use. Gas-fired manufacturing equipment includes paint drying ovens, processing facilities, heat treating furnaces, and foundry heating equipment. This equipment represents a capital investment of several million dollars over a period of the past 25 years.

The energy management program of Rohr Industries has been actively pursued since 1975, and our natural gas usage is now 35 percent below that used in 1972. Numerous energy conservation measures have been implemented, including a plantwide energy monitoring system, translucent roof sections for natural light, and the upgrading of various building lighting systems and processing equipment.

A part of the energy management program is the use of alternative energy systems. A large restroom facility has had its hot water supply heated by the sun since 1977. A cogeneration plant was installed and made operational in February 1979 in cooperation with Applied Energy Incorporated.

In 1979, Rohr Industries was made aware of a potential geothermal energy source beneath its Chula Vista properties, however, because of the lack of geothermal resource information, was unsuccessful in a DOE request for a quote involving a geothermal direct heat demonstration. Some exciting possibilities did present themselves in the preparation of the quote and a more recent successful California Energy Commission Geothermal Resource Assessment program, which is discussed briefly in the presentation.

Six large buildings are candidates for conversion to a direct use geothermal system. Total heat source requirements of these buildings equate to 18,000,000 Btu/hr. These needs are space heating, processing, and paint drying functions. All of these facilities, at the present time, have their

*Mr. Miller is the Manager of Plant Engineering and Energy Management at Rohr Industries, Chula Vista, California. He is active in the San Diego Chapter of ASHRAE, and he represents Rohr Industries on the Energy Committee of the California Manufacturers Association.

heat source requirements supplied by either direct-fired or indirect-fired natural gas heating equipment which can be retrofitted to use hot water from a geothermal production well and distribution system.

The natural gas supply, which can be replaced by geothermal energy in the form of 140°F circulating water, represents 41 percent of the yearly natural gas demands of the plant. The geothermal energy would then replace 500,000 therms of purchased natural gas at a current cost of $230,000 per year, $287,500 in 1982, $359,375 in 1983, and so forth, assuming a 25 percent natural gas cost jump per year in this area of Southern California.

Rohr Industires, in conjunction with their subcontractors, Science Applications, Alternative Energy, Inc., Geothermal Services, and Geo Drill, began an investigation of the geothermal resource underlying the plant in July 1980. The program, which was funded by the California Energy Commission, involved six tasks.

Legal ownership of the geothermal resources underlying the property was investigated by the company's legal department, and in the areas in which a production well might be drilled, it was found to be owned by Rohr.

After a resource investigation was made in the form of a literature search and gathering of local geothermal information, a series of 5 shallow 100 foot holes were drilled in an attempt to determine the best location for an exploration well. Site No. 6 was determined to be the location for an exploration well drilled to a depth of 1,143 feet in January of this year. Temperature gradients were developed after repeated temperature checks were made over a period of nearly five weeks. The greatest temperature rise per 100 feet occurred between 300 feet and 800 feet below grade, with a bottom hole temperature as shown of 92°F at 1,143 feet.

A potential "most probable" geothermal resource of 150°F is now believed to underlie the Rohr property at a depth of 4,500 feet. It is also estimated that a most likely flow rate would be 600 gpm, based on water well information in nearby areas.

An economic analysis with sensitivity to economic variables was developed as part of the assessment. The analysis indicated that Rohr could expect a 39.75 percent return on investment, and the geothermal resource could replace any alternative energy source costing over $3.25 per million Btu (current cost of natural gas is $4.70 per million Btu) when the capital costs for the system were kept within $3,500,000. A slide provides variables to the base case and reveals how these base case costs can vary with the price of energy, interest rates, and a multitude of other variables.

The final point in the presentation indicates current company policy toward development of the resource.

The financing options that Rohr planned to use, most notably the Geothermal Loan Guarantee Program, the Geothermal Reservoir Confirmation Program, and the User Coupled Confirmation Drilling Program, either have had severe budget cuts or funds have not been appropriated. However, Rohr's current policy toward the development of geothermal resources is to pursue development with the understanding that there is still considerable inherent risk involved with the resource assessment. Because the development of geothermal resources in the Chula Vista and San Diego areas may provide both regional and national benefits, Rohr would prefer to share the monetary risk with other potential beneficiaries and will continue to pursue various financing alternatives.

SUMMARY
of
THE SUSANVILLE SUCCESS STORY

PRESENTATION

by

Philip Edwardes*
Geothermal Principal Investigator
City of Susanville

It is unique in many respects that a small city of 7,000 people should take upon itself to exploit and develop this geothermal resource with the intent to sell the energy to the community. Development has been done by the private sector and not by the city.

The story goes back to 1974 when what was then the California Department of Commerce initiated a study to investigate possible ways of mitigating the closure of a major employer in the area. The study showed that Susanville had a geothermal potential and should try to pursue that potential. In September 1974, the Bureau of Reclamation initiated an in-house study to look at Susanville's resource area. In 1975, the National Science Foundation, in conjunction with the Energy Research and Development Administration (ERDA), looked at geothermal development for Susanville and other communities, again mainly in the northern part of California. In 1976, at the request of the City of Susanville, Congress authorized the Bureau of Reclamation to initiate a resource evaluation. They expended, over time, $1.3 million. This special bill was carried by Congressman Biz Johnson and Congressman Cranston. In 1978, under contract with DOE, Aerojet did a site-specific study of the Susanville area. From that, it was defined that Susanville had a potential to create a heating district. In February 1979, DOE awarded Susanville a Phase I Engineering Contract. So, as you can see, between 1974 and 1980, there were enormous amounts of paper studies.

Now, we get down to the interesting areas. We have at least four feet of studies in my office. They were all pertinent and necessary because there was no other way to get into the geothermal business at that time. The city's objective was to create job opportunities. We were looking for commercial use of geothermal energy rather than a heating district. Because of the nature of the funding available, we had to use the heating district as a vehicle to reach that objective. In May 1980, the exciting stage started. We were given our hardware dollars by DOE, and as of the end of September 1981 we effectively completed the construction of the heating district which encompasses 14 public buildings.

Susanville is a very compact little community; while the population is 7,000 people, we have 15,000 within a five-mile radius of the city itself. The North Honey Lake Geothermal Resource area includes Susanville, Litchfield, and

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*Mr. Edwardes is the Geothermal Principal Investigator for the City of Susanville and the Program Coordinator for the DOE funded Susanville Geothermal Energy Project ($2 million allocated).

Wendel-Amedee. Under the DOE program, we put together a large team. This team, which includes DOE, has really put this project together. Without the strength of the team and the tenacity of the people involved, we would not have completed our existing DOE project.

Since we have gone into the construction phase of our DOE project, we were awarded a grant by HUD of $800,000 to demonstrate the use of geothermal energy in 126 low- to moderate income homes. This was supported by $100,000 from the Farmer's Home Administration to take the geothermal waters from the heating district to an economic development area. We have a 67 acre site adjacent to the HUD area, which will be developed by private enterprise.

All good geothermal projects need a well which produces steam. The Litchfield well is 935 feet deep and produces, under test flow conditions, 700 gallons a minute at 170°F. We hope it will give us more than that. But at the present, the drawdown is 130 feet.

I think one of the most dramatic things to come out of the Susanville project has been the spin-off benefits that have occurred as a result of the DOE participation. We hear a little criticism of DOE sometimes, but I think particularly in our community, without their participation, none of what has occurred in our valley would have happened. We are happy to say that we have been able to get our project together, within budget, and slightly ahead of time. But as a result of that commitment, we probably have now in excess of $10 million going in or actually gone into our geothermal development with a promise of a lot more development in the pipeline.

The Susanville Correctional facility currently uses 750,000 gallons of oil for space heating and domestic purposes. We have a geothermal lease area which is owned by the city under the original Bureau of Reclamation program. That resource is approximately 180°F at somewhere around 1,300 feet. The Litchfield development, as we call it, has an interesting composition in terms of participants. Once we defined we had the resource, the City of Susanville took the lead to try and get the California Correctional facility people interested in using geothermal energy. The California Energy Commission granted the City of Susanville $90,000 to initiate an engineering study. The California Department of General Services did the dirty work of taking through the legislature a request for $1.43 million to retrofit the facility to geothermal energy. The City of Susanville, along with its developers, Carson Development Ltd., is raising $900,000 to develop 2 production wells and supply 1 mile of pipeline to take the geothermal energy to the boundary of the correctional facility. We hope construction will commence in early 1982 an be completed for the winter of 1982-83. The first increment of displacement will be for some 500,000 gallons of oil. The success of this program will, in retrospect, probably be attributed to two things. One, the ability to be able to insure the resource and show the differential price between oil and geothermal cost, and two, by the enormous diversity of participation. The other important factors have been the ability of the correctional system to enter into a long-term contract with the City of Susanville to supply the energy and, getting private participation at the front end, taking all the risks.

The City of Susanville does not restrict itself to geothermal energy. We are also looking at cogeneration using city waste. This may sound distant from geothermal energy, but we felt that our resource within the city is relatively limited and we may need some back-up system. This project is being financed entirely by private money on behalf of our college system. We have an objective in our county to be energy self-sufficient within the decade. There is currently $80,000,000 worth committed to the valley, and by the end of 1985 we will not have done our work if that has not esclated to $100,000,000. For a community of 24,000 people, I think this is just reward for 8 hard years of work.

What is our future? I think our community owes the rest of our fellow citizens a debt of gratitude for the money that has been spent. I think we have a moral obligation to make sure that $5,000,000 of federal and state funds will be expended expediently and that we will produce a good project that will have a potential for replication. I believe that we have the commitment of our community and the commitment of our team members to be able to reach that goal.

GEOTHERMAL APPLICATIONS IN THE NURSERY INDUSTRY

by

Salvatore Pantano*
Geothermal Floral

The question most often asked of me is "Why did you build a greenhouse for cut flowers at Canby, California, in Modoc County?" The answer is very simple: my property is a natural resource; it has an artesian hot springs that flows at the rate of 350 gallons per minute at 210° Fahrenheit. It is producing between 290,000 Btu and 323,000 Btu per minute, which is the equivalent of 525 to 538 barrels of fuel oil per week.

At these rates it is a shame to have all of this energy flowing out of our artesian spring and only be using it to heat one-tenth of an acre now and two-tenths of an acre by the end of October, when we expect to have our next phase of greenhouses completed.

You must be thinking that I am not a very good businessman to only be using the equivalent of 35 to 40 barrels of fuel oil per week when we have 525 to 538 available to use. Let me explain the problems which we have encountered in attempting to build our project.

My first decision was to determine how to use the hot water. As a realtor, our firm has sold land in the Half Moon Bay area to flower growers, and I have seen the growth of greenhouses in that area as well as the Watsonville area.

In January of 1980 I took a trip to the Susanville area after hearing that there were greenhouses being heated with geothermal hot water. One was Hobo Hot Springs, which was no longer in operation. The Wendel greenhouses were producing cucumbers at the time and had just changed growers for the fourth time. I also went to Lakeview, Oregon, to look at a tomato operation which did not look very successful.

I decided to grow cut flowers, not vegetables, as it appeared to me that my chances of success would be greater in the cut flower business.

A flower grower contacted me, and we proceeded to put figures together relating to construction, set up, operating, carrying costs, and income projections in order to make a presentation to lenders for a loan.

I approached Production Credit in Half Moon Bay with a loan proposal only to be advised that my project was too far away for them to be able to service the loan. During our discussion questions came up about the distance of shipping. The cold climate with snow and high wind might be a problem to growing flowers in California's most northeasterly county. I talked to the Bank of America,

*Mr. Pantano is the owner of Geothermal Floral in Canby, California. He is presently operating one-tenth of an acre of greenhouses, which will be expanded to two-tenths in October. The long-range plan is to have three acres of greenhouses heated with geothermal hot water.

Wells Fargo Bank, both in Belmont and Alturas, Production Credit, and the Farmer's Home Loan Bank of Alturas, all to no avail in trying to obtain financing for three acres of greenhouses. When I cut back the size to an acre and a half they still said "No."

During this period of time I made a trip to the Oregon Institute of Technology and met with Paul Lienau, Gene Ryan, Gene Culver, Charles Higbee and Bob Johnson, all of whom were very helpful and encouraging. They recommended various ways in which my geothermal spring could be utilized. From the trip came the idea of cascading uses of the geothermal water, first for greenhouses, then for a mushroom farm, and ultimately for raising prawns.

During this time my grower got discouraged and we parted ways. I heard about the University of Nevada Research on raising prawns using geothermal water, and on a trip to Reno discussed their system. I made a call to Wholesale Florists to determine if and when our greenhouse was built, would they be interested in buying our flowers. Mr. Jay Regas said "yes," and if we had a particular grower, he would buy our flowers sight unseen because of the quality of flowers he grew as well as the fact that Canby is a lot closer to Reno than San Mateo County, so his freight cost would be less. How lucky can you be; one call got me the name of a grower who was going to be looking for a position because the firm he was employed with was phasing out their cut flower operation and changing to potted plants and then going to a market for the flowers.

Bill was intrigued with the idea of using geothermal water to heat the greenhouses due to the fact that flowers need heat in the winter months and also because the firm he was with had to cut back on heating to keep their costs down. He also mentioned that the light intensity at my elevation would be helpful to the growth of the plants in the winter when market prices are good.

So we started all over again, going to all of the sources previously mentioned. This time we were armed with a wholesaler in Reno and another in Portland that would buy our flowers because of the quality of flowers he grew. The results were somewhat better but changed too. Have you ever built a greenhouse before? Has your grower built one and set one up before? This was just a different way of saying "No."

We had chosen the strongest greenhouse to withstand the snow load and winds of the area and still left empty handed after again cutting back from three acres to an acre and one-half. By this time both Bill and I were getting down in the dumps. Jerry Shibata of Mt. Eden Nursery Co. mentioned a meeting in Santa Clara where Tom Byrne of the University of California, Davis, was giving a presentation about gerbera. He suggested that Bill and I go to it. Bill went to the meeting and was enthused with the idea of growing the gerberas, and I got excited when it was determined that we could build the greenhouse and set up our operation and make a profit without a million dollars having to be spent. Again, I tried to get financing for two-tenths of an acre only to be told by my friendly bank, Production Credit, "why not just build a tenth of an acre and use your own cash." <u>WHICH I DID</u>.

Now we finally were ready to get started. The greenhouse and the gerberas were ordered. Bill placed an order for soil mixed to his specifications. A spraying machine was ordered as well as all of the sundry items necessary to start up the operation.

One day toward the end of May I received a call from ICX saying that our greenhouse was on their dock in Hayward, that they do not go into Canby, and what should they do with it.

In the meantime I purchased a mobile home to be delivered on June 1st for Bill's new home in Canby. There was an old well on the property we knew would be a good site for the residential well to be drilled, as the old one did not meet the present county code. We decided to drill a well close to where our three acre complex would ultimately be built. We drilled to 680 feet and only got 3 gallons a minute.

When the greenhouse finally got there, this was missing, and that was missing. Bill found himself driving back and forth to Alturas 17 miles away to buy nuts, bolts, and nails, as nothing is available in Canby.

Our greenhouse came in parts, a part now and a part then, with the door finally arriving August 10th. The gerberas had arrived in Reno on July 9th and were planted, with poly covering the door.

We pump directly from our geothermal spring to the greenhouse. We had to change pumps twice until we found one that would take the 210° temperature without losing its prime due to the NTS curve. Then we had to put a ball check valve in so the pump would not lose its prime. In the latter part of August, due to cool evenings, the system failed due to the check valve seat warping. Although the check valve was designed to withstand 210° water, the washer was only designed for 185° water. We now have a system including the seat that will take 250° water. The system is designed to maintain the greenhouse at 60° when the outdoor temperature is 20° below zero.

We are heating the roots of the plants on the ground and have tubing suspended in the upper portion of the greenhouse to heat the air above the plants. There is a total of four miles of ethylene, propylene diene monomer tubing in our one-tenth of an acre greenhouse.

Since the door was installed our plants have been doing very well. On September 15th we cut our first three flowers and expect to be able to start shipping weekly to our wholesalers in Reno and Portland by mid-October.

In one way it is great not to have a loan to make payments on, but the sad part is seeing all that geothermal water being wasted.

WORKSHOP PANELS

DISTRICT HEATING

MODERATOR: Charles V. Higbee

PANELISTS: John T. Nimmons, Earl Warren Legal Institute
Institutional Options for District Heating

Charles V. Higbee, Oregon Institute of Technology
Economic Considerations for Geothermal District Heating

Philip A. Edwardes, City of Susanville
Project Implementation

Norman E. Donaldson, Westinghouse Electric Corporation
Heat Pump Technology and Geothermal Applications

Jeffery B. Weinress, Bank of America
Financing District Heating Projects

Philip A. Edwardes, City of Susanville
How to Succeed with a District Heating Project

WORKSHOP PANEL

OUTLINE

DISTRICT HEATING

I. INSTITUTIONAL OPTIONS FOR DISTRICT HEATING--John T. Nimmons, Earl Warren Legal Institute

A. Introduction: District Heating Defined

B. Basic Institutional Problems

C. Issues Affecting

D. Illustrative Cases

II. ECONOMIC CONSIDERATION FOR GEOTHERMAL DISTRICT HEATING--Charles V. Higbee, Oregon Institute of Technology

A. Basic Parameters

- o Resource Availability
- o Proximity to End Use
- o Injection
- o Water Quality
- o Temperature
- o Size of Project

B. Costs

- o Construction Costs
- o Distribution System
- o Operating Costs
- o Comparative Fuel Costs
- o Inflation
- o Forecasting Problems

C. Public Acceptance

DD-18 GDU

III. PROJECT IMPLEMENTATION

A. Project Implementation--Philip A. Edwardes, City of Susanville

B. Heat Pump Technology and Geothermal Application--Norman E. Donaldson, Westinghouse Electric Corporation

- Industrial Heat Pump Defined
- Heat Pump Applications to Geothermal
- Applying Heat Pumps to District Heating
- Heat Pump Availability
- Heat Pump Cost

IV. FINANCING DISTRICT HEATING PROJECTS--Jeffery B. Weinress, Bank of America

A. Introduction

B. Economic/Project Considerations

C. Financing Public District Heating Projects

D. Financing Private Development

E. Recommendations

V. HOW TO SUCCEED WITH A DISTRICT HEATING PROJECT--Philip A. Edwardes, City of Susanville

~~SUMMARY~~
~~of~~
INSTITUTIONAL OPTIONS FOR DISTRICT HEATING
~~PRESENTATION~~

by

John T. Nimmons
Earl Warren Legal Institute

The core idea of district heating is the transmission and retail distribution of geothermally heated fluids from a central extraction source to multiple end users within a circumscribed geographical area.

COMMUNITY SYSTEMS VS. LIMITED SYSTEMS

There are two polar cases in district heating; Communitywide System vs. Limited Systems. The Communitywide System is intended to serve the general public within whatever area the resource is capable of supporting. The objectives of the Communitywide System range from offering low-cost heat to community residents to increasing revenues for local governments to providing for economic development (such as Susanville, California where they are using geothermal energy to attract new industry). Most often, the end results are a combination of all three of these objectives. A limited system is intended to supply a predetermined set of identifiable users like an industrial park, the occupants of a shopping center or a residential subdivision. There it is a limited system. You know what it consists of before you start. It is not intended to serve the community in the same way as the communitywide system. The limited system is probably initiated by a resource developer interested in creating a market for geothermal heat, a property owner or developer interested in enhancing the value of his property for sale or lease purposes, or a group of individuals or business concerns with some common interest in lowering their energy costs. Between these polar cases, there are a lot of variations. Many people think of district heating as the communitywide system. But in district heating, that is not the only thing that we are talking about. A lot of the kinds of issues that arise do so in the context of the industrial park where you may only have ten users, a shopping center, or a residential subdivision.

SCOPE OF ACTIVITIES

The functions that a district heating project are intended to undertake can vary. First, you may already have a well, so the exploration end of the project is really a very minor part of it. The primary emphasis is the production wells and the construction and operation of the distribution systems. Secondly, your district heating project might just be for basic exploration. There is not a production well and there has not been a lot of exploration in the area. The attributes that your institutional entity is going to have will vary depending upon what functions your district heating project is going to undertake.

PUBLIC ENTITIES VS. PRIVATE ENTITIES

There are three basic institutional options in district heating: public entity, private entity, or some combination of public and private. Public entities are cities, counties, or special districts (which are local government units formed to serve one or a few limited purposes). It is a government unit. A private entity includes private commercial business enterprises or a cooperative. A cooperative is the appropriate entity to think about for a limited type system. You know who your users are in advance and they have common interests. Their primary interest is in providing low-cost heat to its members. The choices among these entities, the decisions about the roles each one might play, and the structure and relationship among them ultimately depend on the specific issues of each project. But there are generic issues that come up with most of these systems.

ISSUES AFFECTING INSTITUTIONAL CHOICES

There are several issues affecting institutional choices. The first one is the capacity to proceed at all. This is rarely a problem for private entities because they are free to engage in any lawful activity that serves the purposes for which it is formed. But this is not so for public entities. They are creatures of statute and they can only do what they are authorized to do by the laws that create them. The basic rule is a city, county, or local government unit like a special district has no inherent powers. It only can do what it is authorized to do. One must first consider CAN the city, county, or special district undertake this at all. Does it have the legal authority to undertake any kind of utility services (geothermal, in particular)? A developer must make sure in the beginning that it either does or can obtain the authority. If it requires legislation, you may have to delay your project years by choosing an entity that is not authorized to proceed.

FINANCING AND COST CONSIDERATIONS

The types of financing and the cost of capital are going to vary, depending upon the entity that you choose. In general, public entities find it difficult or impossible to finance the high risk phase of geothermal district heating systems. In the more conventional phases, the distribution end particularly, the cost of capital may be lower. On the other hand, private entities are much more flexible in financing the high risk phase, but the cost of capital is likely to be more. They cannot issue tax exempt bonds which lower the cost of capital for a public entity. The major point is that the entity you choose, public or private, will have a real impact on your financing cost.

PUBLIC UTILITY REGULATION OF GEOTHERMAL HEAT SUPPLIERS

Another major issue is the prospect of Public Utility Regulations. For public entities, city, county, or special districts, it is not likely to be a problem because they are almost always exempt from public utility status. The same is true of cooperatives if they serve only their own members. But a private entity producing and distributing geothermal fluids in California may then be treated as a public utility. That means it is under comprehensive supervision of the Public Utilities Commission (PUC), and the PUC controls its service area and regulates its rates based on its cost of service. This is a major consideration for someone who is considering a district heating system. It also applies to those entities that may only be serving a few users.

Other issues to consider are accommodation of competing interests (for example, Boise, Klamath Falls, and Susanville district heating projects) and resource management and protection. (See references for detailed reports.)

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Discussion of basic public utility issues affecting geothermal heat distribution; review of applicable law of 16 states known to have geothermal potential; and analysis and recommendations for state policy toward geothermal heat distribution.

SUMMARY
of
Title: "ECONOMIC CONSIDERATIONS FOR GEOTHERMAL DISTRICT HEATING"
PRESENTATION

by

Charles V. Higbee
Geo-Heat Center
Oregon Institute of Technology

Assume that you already have a well. First, you need to consider these BASIC ECONOMIC PARAMETERS:

AVAILABILITY OF THE RESOURCE--Who does it belong to? What are the penalties to leasing it? (For example, if it is on federal land or privately owned land, you are going to have to lease and pay royalties to the resource.)

THE PROXIMITY TO THE END USE--It is difficult to move the user to the resource in district heating. However, we are trying it in North Bonneville where we are going to build a town where the resource is. You cannot really transport geothermal energy over very long distances.

CONSIDER WHETHER YOU HAVE TO REINJECT--Many artesian wells do not need to pump to retrieve the water but you do need to reinject.

WATER QUALITY--You probably will have to heat exchange the fluid.

TEMPERATURE--This country is geared to heating systems that supply 200 plus degrees Farenheit water, taking about 20 degrees Farenheit out of it and returning it to the boiler at 180 degrees Farenheit. If you do not have a resource that can supply you with that, then you are going to have higher retrofit costs. That means that you cannot go down to lower temperatures, especially with a new design. It is easy to design a system that can work with 120 - 130 degrees Farenheit water, and when you get down to lower temperatures you can even go with heat pumps. You need to be careful with heat pumps that the electricity needed to run the heat pump is not so great as to make the cost of the geothermal system non-economical. Another thing to consider is that today the Internal Revenue Service (IRS) has sought to set a temperature limit on direct use geothermal energy. If you are in the heat pump range you are not going to get a tax credit for your efforts to save energy.

SIZING OF THE HEATING DISTRICTS--The best is to optimize the resource--use all of it by expanding the size of the district to maximize the use of the resource.

POPULATION DENSITY--Cost increases tremendously as population density decreases. With less energy users in a given area, the geothermal heat must be distributed over a large area.

The second economic consideration is COST of a district heating system.

CONSTRUCTION COST, PIPELINE DISTRIBUTION, AND WELL DRILLING--These are the largest costs of a district heating project. You need to consider how expensive ditching is as well as where you are going to lay the pipeline. These will affect whether you are going to direct bury it or put it in a concrete vault. Although more expensive, in congested areas, there are advantages to using concrete vaults. Such advantages are:

a. They are readily accessible in case you get a failure in the pipeline.

b. This also provides access or routing for public utilities for pipelines, phone lines, and domestic water.

OPERATING COSTS are also important. When comparing to a conventional system, make sure you compare in all areas: salaries, maintenance, and system management. Also, when making cost comparisons, make sure you consider operating and maintenance costs on both conventional and geothermal systems. We estimate that when you go into district heating, your maintenance cost may decrease. When you do your economic analysis, you have to compare what you project your cost to be over the economic life of the project to conventional fuels. Keep the life of the project short; the longer your project, the more inaccurate your forecasts are going to be. Also, keep your inflation rate conservative or low. If possible, estimate cost using no inflation rates because we have a terrible time forecasting fossil fuel inflation rates.

PUBLIC ACCEPTANCE is the 3rd economic factor to be considered. Several problems were encountered in the Klamath Falls experience. The problems were not the resource or the availability of the resource. They estimated the cost to drill to 1,000 feet to be $38 -$40 thousand per well. As it turned out, they hit the resource on every well they poked at 300 feet. The water produced was cleaner and hotter than was estimated. Klamath Falls is sitting on one of the finest resources in the nation. The problem lies in the lack of exchange of information between the city and the public. This led to public distrust. They thought they were going to be cheated by the district heating system. Well owners decided to get an injunction against the system. As it stands now, unless something changes, the project as originally proposed will fall apart.

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DISTRICT HEATING
PROJECT IMPLEMENTATION

by

Philip A. Edwardes
City of Susanville

With dramatic cost escalations due to the current inflationary era we live in, time and timing become extremely critical considerations in project development. Two important considerations need to be carefully examined: (1) availability and cost of off-the-shelf hardware and (2) critical items and decision points.

1. AVAILABILITY AND COSTS OF OFF-THE-SHELF HARDWARE

Typically, both factory and agency inventories are at a purely service level. Delivery delays for major standard components (fan coil units, heat exchangers, etc.) of a retrofit package vary between 6 and 10 weeks. If any special materials are utilized due to adverse geothermal fluid chemistry, a further 4 to 6 weeks can be added to normal delivery times.

Valves, metering devices, special fittings in sizes of 8 inches and above, require 8 to 12 weeks lead time; and if special materials are required, allow for a 50 percent increase in lead time.

Insulated pipeline in sizes 3 inches to 12 inches in all major brands presents no major problem. Three to six weeks delivery appears standard.

Turbine pumps and wellhead gear delivery varies considerably with different manufacturers. A specially designed and manufactured pump to suit specific water quality conditions is likely to take 12 to 16 weeks.

Cost of standard off-the-shelf heat exchangers and fan coils are dwarfed by the horrendous cost of valves, meters, and fabrication costs associated with an average retrofit package. Component costs seem to vary little between manufacturers.

Major pipeline manufacturers appear to be extremely interested in the geothermal industry; and thus, competition can considerably affect published prices. Generally, the price per inch of diameter varies slightly between manufacturers despite differences in materials used.

Turbine pumps and wellhead gear costs vary considerably between manufacturers. A 100 percent cost difference for similar duties are common. Pump life also varies; so basically, costs can be controlled by specifications.

Generally, in any special order placed (particularly where special metals are defined) the price appears to be controlled purely by the imagination of the vendor.

2. CRITICAL ITEMS AND DECISION POINTS

CRITICAL ITEMS:

a. Turbine Pumps

b. Heat Exchangers

c. Valves and Metering Devices

DECISION POINTS:

In order that a construction contract may proceed and be implemented in an expedient manner, and especially where more than one contractor is involved, careful consideration should be given to scheduling of procurement packages to ensure that delays in construction do not occur due to delays in delivery of long-lead items. CLOSE COMMUNICATION WITH INDUSTRY PRIOR TO THE PROCUREMENT PROCESS IS ESSENTIAL. Close evaluation of the cost effectiveness of special metal used in necessary periodic replacement of standard equipment may be cost effective and keep the project within budget.

DISTRICT HEATING
HEAT PUMP TECHNOLOGY AND GEOTHERMAL APPLICATION

by

Norman E. Donaldson
Westinghouse Electric Corporation

I. INDUSTRIAL HEAT PUMP DEFINED

A. Machine to Transfer Heat Energy from One Heat Carrying Element to Another While Also Amplifying the Temperature (Fig. 1)

B. Uses Refrigeration Cycle to Transfer Energy.

1. Similar to Common Reversible Type Air to Air Residential Heat Pump but

a. Operates in higher temperature range

b. Water to water type

c. Nonreversible

C. Typical Industrial Heat Pump Cycle (Fig. 2)

D. Possible Range of Temperature Amplification (Fig. 3)

II. HEAT PUMP APPLICATION TO GEOTHERMAL SYSTEMS

A. To Provide Higher Using Temperatures when the Geothermal Source Temperature Is Not Adequate

B. To Help Overcome Problem of Inadequate Geothermal Water Flow

C. As a Lower Cost Answer to Deep Well Expense for Obtaining Higher Temperature Water (Fig. 4)

1. Can use lower temperature source water at shallow well depths.

III. APPLYING HEAT PUMPS TO DISTRICT HEATING

A. Circulate Geothermal Source Water and Use Multiples of Heat Pumps at Point of Use

B. Use Heat Pumps at Central Plant and Circulate Higher Temperature Use Water, as in Our St. Joseph's Indian School Installation at Chamberlin, South Dakota

IV. HEAT PUMP AVAILABILITY

A. Now Becoming Available from Several Manufacturers.

B. One Manufacturer Has Capacity Ranges from 100,000 Btu/hr to 20 Million Btu/hr

C. One Manufacturer Can Operate to Provide up to 220°F

V. <u>HEAT PUMP COST</u>

A. Installed Cost Varies Greatly Depending upon System Complexity and both Source and Use Water Temperatures

B. Installed Costs Range from $15,000 to $60,000 per Million Btu/hr Output

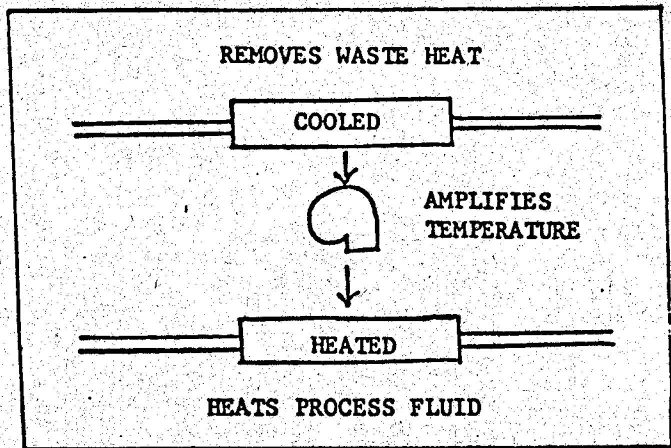

Fig. 1

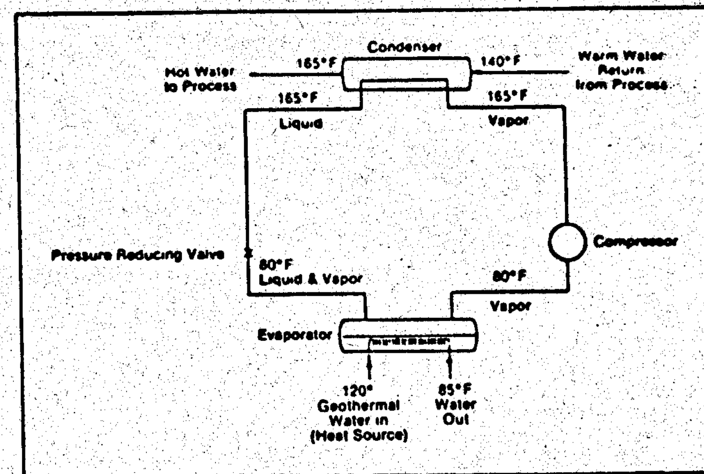

Fig. 2 Heat pump schematic diagram

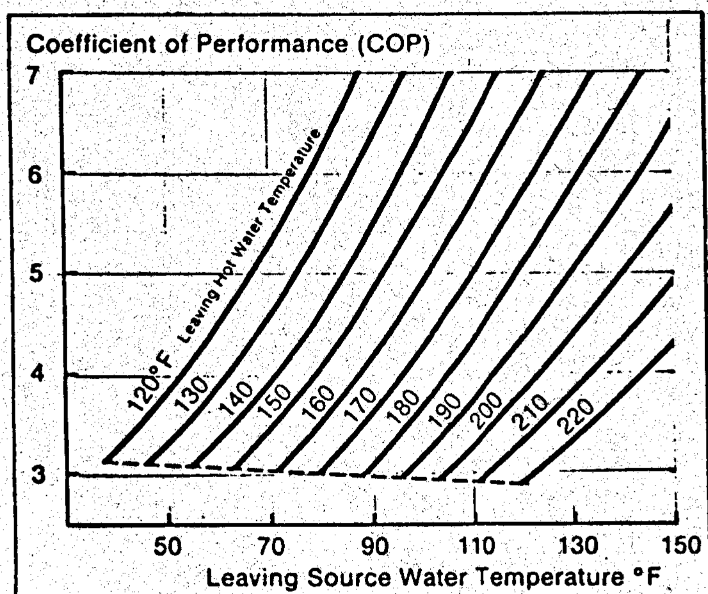

Fig. 3 Typical Performance Characteristics of heat pumps

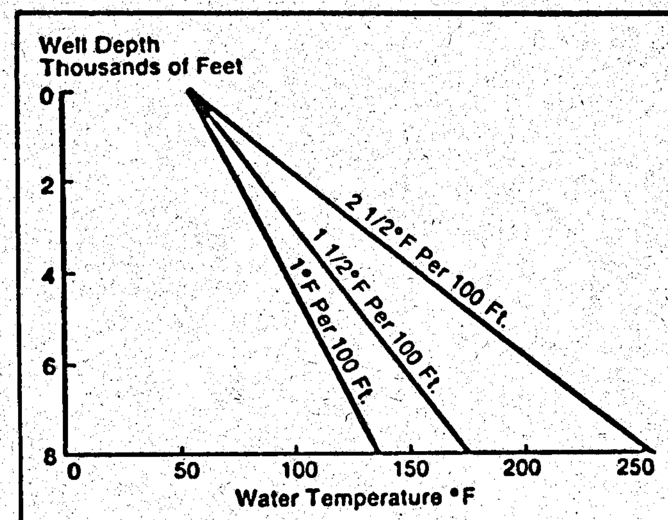

Fig. 4 Temperature of formation water vs well depth

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FINANCING DISTRICT HEATING PROJECTS

by

Jeffery B. Weinress
Bank of America

I. INTRODUCTION

A. Obtaining conventional financing for geothermal projects is no longer an impossible proposition, though "project financing" is difficult.

B. The best example of this are projects at The Geysers utilizing geothermal steam to generate electricity. This is now recognized as a conventional business and banking proposition. There are no major or unusual impediments to raising the necessary capital to finance such projects.

C. On the other hand, what is needed now is a record of similar successes using wet steam (hydrothermal) for electric generation, particularly in the Imperial Valley. Then utilities will want, and private capital will flow to, hot water geothermal projects. Meanwhile, most of these projects will continue to be done only with government support or as part of a large corporation's R&D budget.

D. Financing district heating systems falls somewhere between these two extremes. At present, we have a clear case of the "chicken and egg" problem: successful projects cannot happen without financing, and financing will not be generally available until there are more successful projects. Given a 20-year period and an ample supply of visionary and intrepid entrepreneurs, there is little doubt that district heating systems will achieve a record of success enabling such projects to compete successfully in capital markets. However, if one is prepared to put in a great deal of work and spend a considerable amount of money on professional fees and services, financing can be arranged. The success stories in Susanville and Boise attest to this.

II. ECONOMIC/PROJECT CONSIDERATIONS

A. Because district heating systems are generally used only part of the year, project economics tend to suffer. Economics would improve if the system were downstream of another use (i.e., a power plant) or the system involved one or more large-scale users (hospitals, for example), particularly if heat is required year-round.

B. Distinction needs to be drawn between:

1. Public district heating projects, and

2. Private developments.

III. FINANCING PUBLIC DISTRICT HEATING PROJECTS

A. History and cost effectiveness frequently lead such projects into revenue bond (tax-exempt) financing. Indeed, almost any project can attempt to obtain such financing, since the California State Legislature recently established the California Alternative Energy Source Financing Authority. This authority is authorized to issue up to $200,000,000 in revenue bonds and bond anticipation notes for projects utilizing alternative sources of energy. There are two problems, however, with this alternative:

1. Such revenue bonds offer the bondholder no source of payback other than the project being financed. At present, however, the financing community perceives geothermal energy as a technology and enterprise still in its infancy. Whether this perception is true or not is irrelevant; the fact that it exists is enough to significantly stifle revenue bond sales. With the market for private capital so competitive, proven investments are likely to win out every time over new energy technologies.

2. Professional fees associated with such financings are quite high ($50,000 on up to several hundred thousand dollars). IRS rules, in particular, need professional attention in such financing.

B. Success in raising such funds will depend upon:

1. Risk mitigation measures such as (a) bank standby letters of credit (effectively guaranteeing a project), (b) reservoir insurance, (c) municipal bond insurance, or (d) comingling the project with other of the community's revenue generating activities (i.e., having a local power agency sponsor the issue).

2. Proper structuring of such projects, legally and tax-wise.

3. Attempting to "privately place" rather than publicly sell the revenue bonds. A privately "negotiated" deal with one bond purchaser is much more likely to be successful (especially if that purchaser is a local individual or bank).

4. Asking the State Authority to "pool" your issue with other bonds (whose technologies and economics are at least equally favorable to yours) or to come up with some new form of "insurance" or "reserve fund" for such bond issues. In this regard, Oregon's action in authorizing $300 million in general obligation bonds should be noted (such bonds are backed by the state's taxing authority).

Therefore, you should obtain the services of a good investment banker early in the game to maximize your chances of success. It should be noted that commercial banks cannot underwrite revenue bonds at present.

IV. FINANCING PRIVATE DEVELOPMENT

A. This would be more easily accomplished as part of an overall development plan for a new area. This way the system can be paid for in the sale price of new homes.

In this manner, a developer could obtain financing.

B. Fund raising will be easier if a local utility has agreed to manage and maintain the system once it's up and running.

V. CLOSING RECOMMENDATIONS

A. Your chances of success will be increased if you:

1. Develop a complete, well-documented business plan (describing resource, utilization technology, management, legal structure, marketing, environmental matters, financing plan, and project economics).

2. Work with professionals obtaining not only their expertise, but their connections.

3. Seek additional support in Sacramento and Washington so that the "chicken and egg" problem can be surmounted as quickly as possible. If the government is willing to take on some of the perceived risk in such projects, everything will move faster.

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HOW TO SUCCEED WITH A DISTRICT HEATING PROJECT

by

Philip A. Edwardes
City of Susanville

Hindsight is a valueless gift. However, never neglect to capitalize on the hindsight of others!

Despite how careful a project manager may be, five stages of a project will occur.

Stage 1--Excitement--Euphoria

Stage 2--Disenchantment

Stage 3--Search for the guilty

Stage 4--Punishment of the innocent

Stage 5--Distinction for the uninvolved

Be forewarned!

The following litany of do's and don'ts may aid in avoiding major pitfalls:

1. Establish the ability of the lead agency/corporation, etc., to aggressively pursue the objectives of the project and provide necessary support, often unpopular, to project management.

2. All necessary "enabling" legislation, ordinances, by-laws, etc., should be in place prior to project commencement.

3. Establish relationship between project and existing third party and/or existing interest groups and resolve differences prior to developing project.

4. Develop a strong project "Team." Careful selection of geologist, designers, engineers, consultants, etc., will have an extremely beneficial impact on project well-being.

5. Always, even in the case of prototypic projects, be aware from the outset that the project must be cost-effective design/engineering to dollar availability and best bottom line. A sound project will always attract investors.

6. The procurement process is extremely important. Maximize project visibility. Make full use of construction industry publications, building changes, etc., which are far more effective than daily newspapers. Solicit interest from manufacturers. They have long lists of contractors on file.

7. Procurement process and review of contracts always take longer than expected.

8. Attempt to schedule the procurement process to minimize total in-field construction time. This helps to maximize effectiveness of project manager and in-field inspection process. It also allows for an orderly checkout procedure. This is extremely important where several subcontractors are involved.

9. Take care to avoid excessive overdesign. Special metals, equipment, etc., are extremely expensive. Check the cost effectiveness, and if necessary, use materials with a shorter life span, but ensure ready access to weak points and include in maintenance manuals. Technology is changing daily and a greater and better choice may be available in the future.

10. A well-defined and implemented resource evaluation is the cornerstone to a successful project. Adequate availability of energy through a well-planned long-term lease agreement is essential.

11. Free and close communication between all "Team" members is paramount.

12. Any contract is a two-way street. Make decisions as quickly as possible, provide all necessary support, and have a close working relationship with all subcontractors.

13. A well-planned active public awareness program keeps the public informed and helps to minimize friction.

14. Financing is always difficult. Do not be afraid to be creative, persistant, aggressive, and pigheaded.

15. A project manager must have a well-developed sense of humor and access to a permanent, hard-working "Guardian Angel."

INDUSTRIAL PARK DEVELOPMENT

MODERATOR: Fred Longyear

PANELISTS: Fred Longyear, Lahontan, Inc.
Geothermal Industrial Parks--"Parks of Commerce"

Roy A. Cunniff, New Mexico State University
Economic Considerations

Robert J. Schultz, EER, Inc.
Hardware (Engineering) Considerations

John H. Woods, Bank of Montreal
Financing a Geothermal Industrial Park Project

William R. Brink, Coopers and Lybrand
Financial Incentives--Tax Items

WORKSHOP PANEL OUTLINE

INDUSTRIAL PARK DEVELOPMENT

by

Fred Longyear
Panel Moderator

I. GEOTHERMAL INDUSTRIAL PARKS--"PARKS OF COMMERCE"--Fred Longyear, Lahontan, Inc.

A. The Formation of a "Park of Commerce"

B. Parks--Existing and Under Development

C. Parks--In Planning and Proposed

II. ECONOMIC CONSIDERATIONS--Roy A. Cunniff, New Mexico State University

A. Basic Considerations

1. Location

a. Access to Market

b. Access to Labor

c. Access to Raw Material

2. Other Factors

a. Land Cost

b. Energy Cost

c. Labor Cost

B. Trade-offs

1. Increased Loan Payments

2. Utility, Land, and Labor Cost Savings

C. Cascading

D. Advantages

III. HARDWARE (ENGINEERING) CONSIDERATIONS--Robert J. Schultz, EER, Inc.

A. Resource vs. Design

B. Engineering

C. Utilization Factor

D. Temperature Requirements

E. Piping

F. Water Quality

G. Water Disposal

H. Costs

IV. FINANCING A GEOTHERMAL INDUSTRIAL PARK PROJECT--John H. Woods, Bank of Montreal

A. Introduction

B. Financing

C. Data Requirements

V. FINANCIAL INCENTIVES-TAX ITEMS--William R. Brink, Coopers and Lybrand

A. Economic Recovery Tax Act of 1981

B. Accelerated Cost Recovery System--Depreciation

C. Investment Tax Credits

D. Energy Tax Credits

E. Percentage Depletion

GEOTHERMAL INDUSTRIAL PARKS--"PARKS OF COMMERCE"

by

Fred Longyear
Lahontan, Inc.

I. THE FORMATION OF A PARK OF COMMERCE

A. A Geothermal Park of Commerce Is an Economic Development Project

Three prime areas must be addressed in the planning and development of a park.

1. Institutional--Is the community's attitude and capacity suitable for development of a geothermal park of commerce?

   - Competitive Institutional Processes (permitting, etc.) in Place,
   - No Organized Intervenors,
   - Positive Public Attitude, and More Important, and
   - Economic Development Expertise.

2. Resource--Is the Geothermal Direct Use Resource Economically Adequate?

   - Adequate Temperature and Flow Rate
   - Economic Fluid, Quality, and
   - Low Cost Supply System (short transmission lines, shallow wells, low brine content, etc.).

3. Viable Users--Is the Energy Use Load Economic?

   - Load Large and Dense Enough to Generate the Revenue, at Incentive Prices, as Required to Support the Development and Operation of the System, and
   - Is the "Anchor" Load Based upon Viable Operational Entity?

B. Today, successful development of geothermal direct use is a "medium-sized" development: medium-sized applications + medium-sized industrial park developers + medium-sized investors.

C. The Major Pitfalls in Development Today Are:

- Institutional Impediments,

- o High Cost of Financing, and
- o Lack of Growth in Agribusiness and Food Industries.

However, there are solutions to these problems, as evidenced by the following developments.

II. PARKS--EXISTING AND UNDER DEVELOPMENT

A. Brady Hot Springs, Nevada

1. Onion Processing Plant producing 26 million pounds per year of dry onions and plans for ethanol and mushrooms

B. Klamath Falls, Oregon

C. Litchfield, California

III. PARKS--IN PLANNING AND PROPOSED

A. Susanville, California

B. Bridgeport, California

C. Imperial County, California

D. Pahoa, Hawaii

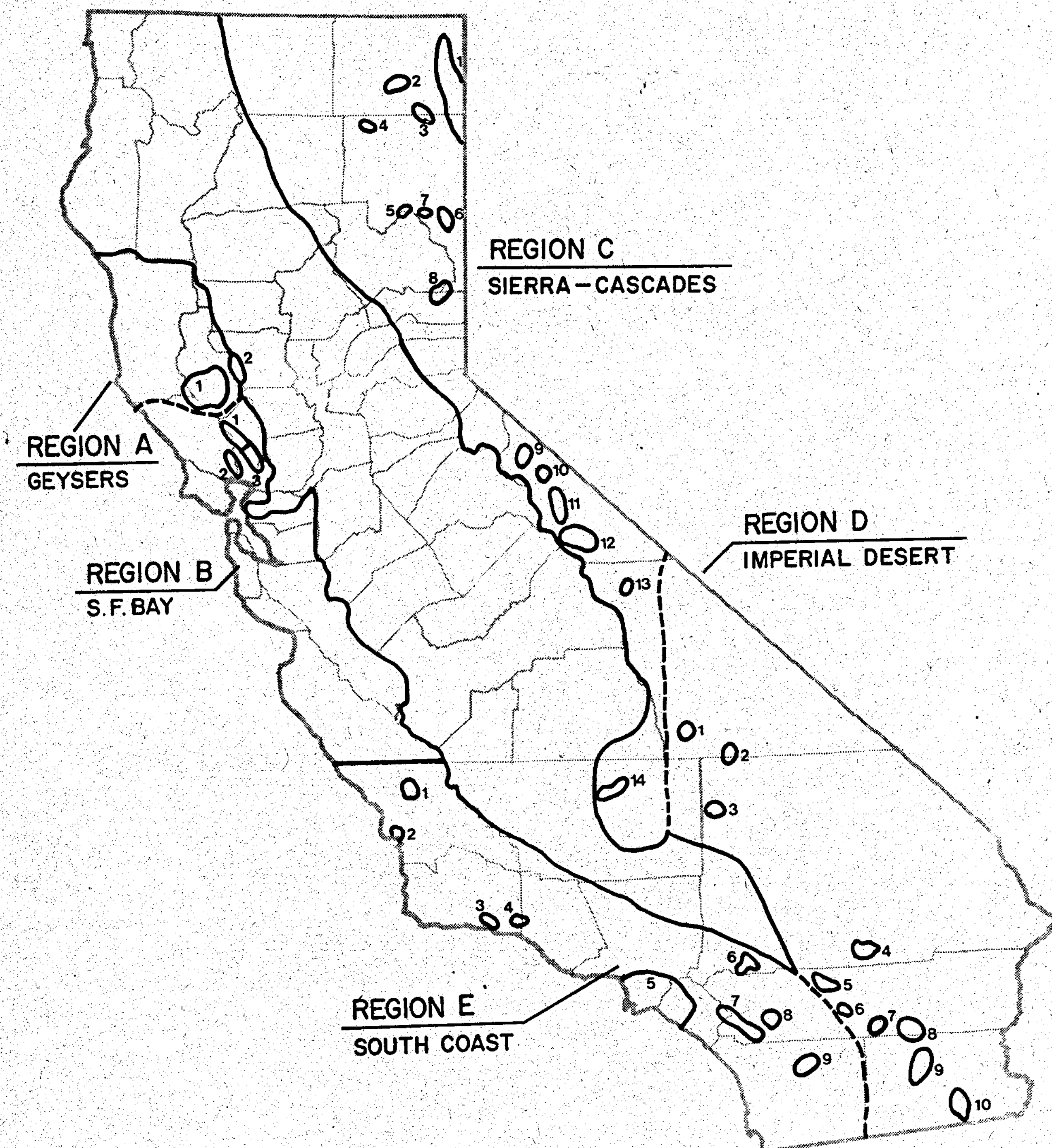
E. State of California Market Survey

F. Heating Districts, Western States

Currently, 26 million pounds per year of dried onions are being processed at an onion processing plant in Brady Hot Springs, Nevada. This plant has plans for expansion which include ethanol and mushroom production.

Adjacent to the Oregon Institute of Technology are three tenants and space for 22 more. The current plans are to cascade spend geothermal fluids from OIT and the Merle West Hospital for a commercial and electronic space heating project.

A third direct use project which is being promoted by the City of Susanville and Carson developers is under way in Litchfield, California. Their anchor land is the prison which burns over 3/4 million therms per year in fossil fuels. They can pay off their $1.4 million retrofit in seven years using geothermal direct heat. Also, the wells and pipelines of the system will be paid off in about nine years. There is an adjacent park of commerce planned that would be oriented toward agri-business. This sets a prototype approach for other areas. Four different state agencies have been involved in this project plus the Legislature and the Governor's Office. The city and private developers have come up with a unique means of financing.


REGION A
GEYSERS
REGION B
S.F. BAY
REGION C
SIERRA–CASCADES
REGION D
IMPERIAL DESERT
REGION E
SOUTH COAST
1
2
3
4
5
6
7
8
9
10
11
12
13
14

<u>GEOTHERMAL RESOURCE SELECTION CRITERIA</u>

Fluid temperature >50 C (122 F)

Well depths <760 M (2500 ft.)

Brine concentration <5000 PPM

Well sites <.6KM (1 mi.) from load

Local permitting <6 months

GEOTHERMAL RESOURCE SELECTION CRITERIA

RATING FACTORS

Proximity to a labor base

Adequacy of transportation

Proximity to community services

Local sources of raw materials

Adequate, concentrated load

Competitive conventional utility costs

Competitive land costs for business

Good community attitude & business climate

Attractive living conditions

Local financial institutions

Other plus, minus factors for each site

GENERIC APPLICATIONS SCREENING

APPLICATION SECTORS

District heating & cooling

Commercial

Intensive/confined growing

Waste processing & methane

Food & kindred products

Animal feed processing

Lumber & wood products

Selected paper products

Chemicals & allied products

Geothermal-electric effluent resource & small electric

GENERIC APPLICATIONS SCREENING

CRITERIA

Overall economic conditions

Energy Sensitivity

Replication/Transferability

Fit with geothermal

Economic development limiting factors

Historical Utilization

Propensity for branch plants

Overriding factors

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INDUSTRIAL PARK DEVELOPMENT
ECONOMIC CONSIDERATIONS

by

Roy A. Cunniff
New Mexico State University

1. Introduction

Any industry must consider several factors in arriving at a decision where to build. These are:

- o Location--Access to market.
- o Location--Access to labor.
- o Location--Access to raw materials.

Other factors are considered but are less significant:

- o Land cost (1 - 2% of total).
- o Energy cost (15 - 25% or total).
- o Labor cost (marginal cost 10 - 30%).

2. With this introduction, use will be made of Figure A to highlight the "Three Locations" problem in the context of geothermal energy. This will lead into Figure B, and a simple comparison is drawn between building "here" or building where geothermal resources exist.

3. With Figure C, I will attempt to explain some of the trade-offs that must be considered.

   - o Trade off the increased loan payment resulting from the geothermal front-end investment against reduced utility costs.
   - o Trade off the combined cost savings from lower utility costs, cheaper land, and cheaper labor, to provide a profit margin which could result in early payback on the relocation.

4. Figure D is used for a general discussion of the factors which must be considered in arriving at a decision for geothermal usage. This must be a general assessment, because each industry-geothermal match is a unique configuration which requires a tailored analysis. This then will lead me to Figure E, which portrays in simplified form the versatility of geothermal, and highlights the fact that cascaded uses can be very profitable.

5. I will close with Figure F, which is a capsule commentary. There are significant advantages to geothermal, but to gain those advantages, expert advice is needed.

BASIC CONSIDERATIONS

IF YOU HAVE		THEN
Access to markets		Geothermal offers benefits
Access to labor	⟹	Inexpensive energy
Access to raw materials		Reduced operating costs
		Out-year price stability
		Easy to expand

Figure A

LOCATION VS LAND COSTS

Current Locations

- Transportation Available
- Utilities Available
- Labor Available
- Land Cost High ($15,000/acre)

Geothermal Sites

- Remote
- Few people
- Scarce utilities
- Land Cost Low ($5,000/acre)

- Raw materials could favor either sector

Figure B

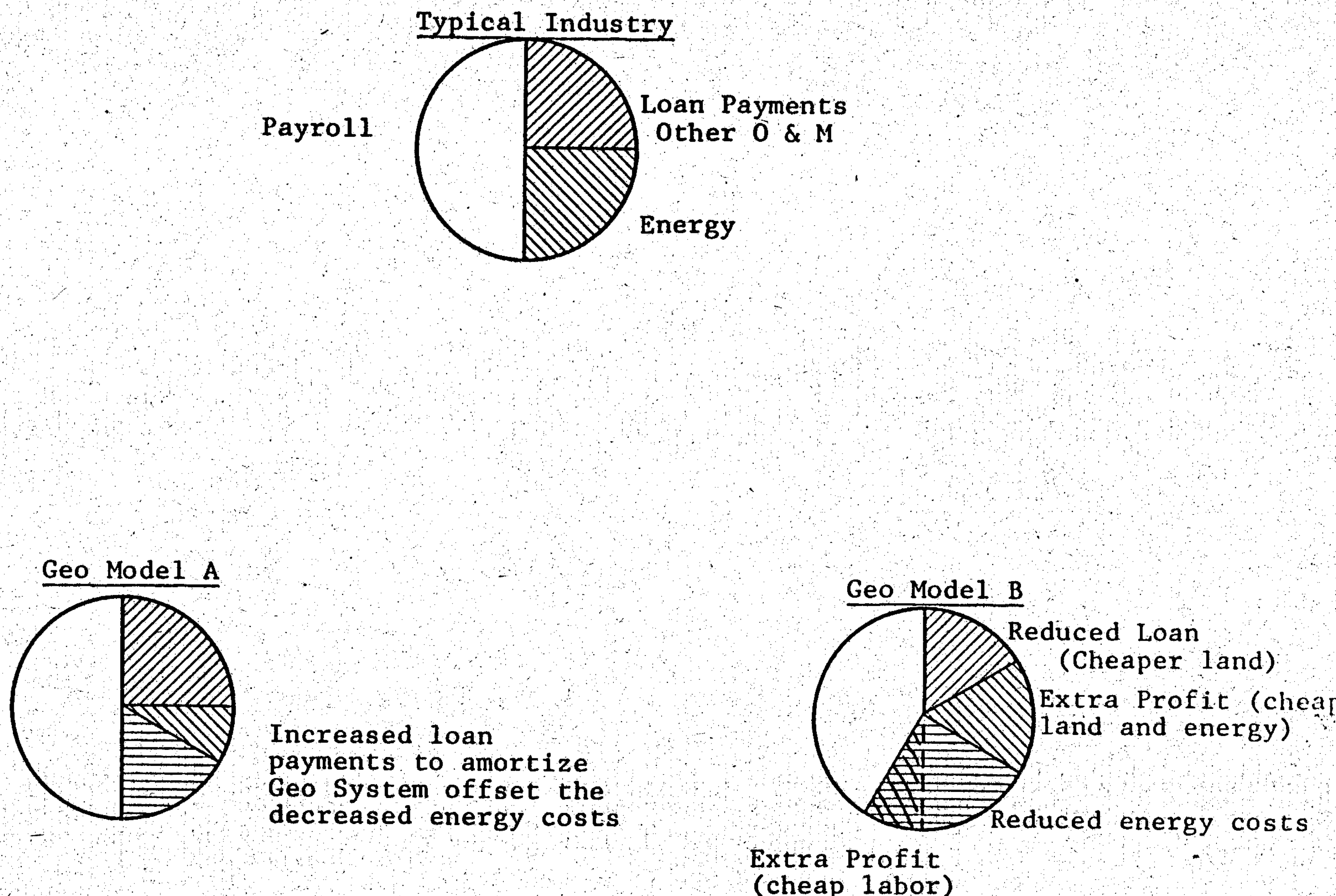

Typical Industry
Payroll
Loan Payments
Other O & M
Energy
Geo Model A
Increased loan payments to amortize Geo System offset the decreased energy costs
Geo Model B
Reduced Loan (Cheaper land)
Extra Profit (cheap land and energy)
Reduced energy costs
Extra Profit (cheap labor)

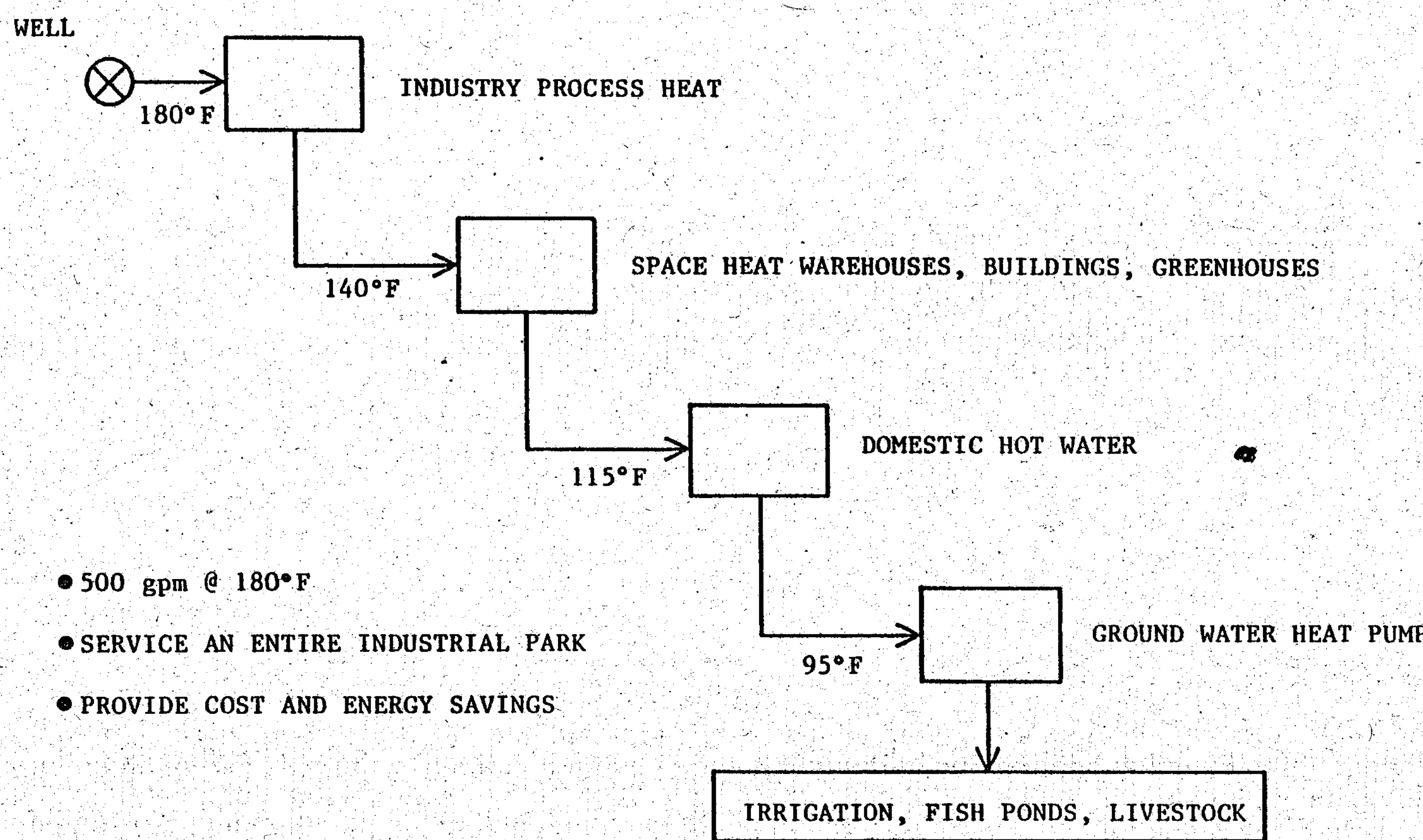
Figure C

GEOTHERMAL CONSIDERATIONS

- o Drilling
  - o Do it yourself
  - o Lead Firm in Park
  - o Buy the water
- o In-use
  - o Corrosion resistant materials
  - o Back-up energy source
  - o Revamped process heat use
- o Disposal
  - o Re-use the water
  - o Direct disposal
  - o Water treatment
  - o Disposal wells

Figure D

CASCADED USES



- 500 gpm @ 180°F
- SERVICE AN ENTIRE INDUSTRIAL PARK
- PROVIDE COST AND ENERGY SAVINGS

Figure E

BIG PROJECTS REQUIRE BIG FIRMS

GEOTHERMAL IS HIGH COST BUSINESS

A Major Residential Subdivision (1,500 homes)

- $150 million for Subdivision
- $5 million for geothermal system

A City of 5,000 People

- $20 million geothermal option

A Major Shopping Center

- $45 million for construction
- $2 million for geothermal option

New Ethanol Plant

- $80 million
- $3 million geothermal option

ARRAY OF SPECIALIZED FIRMS

Land Acquisition Experts

Geothermal Exploration and Drilling

Large A&E Firms

- HVAC expertise
- Design
- Cost analysis
- Product knowledge

Tax and Finance Experts

Grantsmanship

Politics and Policies

Figure F

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INDUSTRIAL PARK DEVELOPMENT
HARDWARE (ENGINEERING) CONSIDERATIONS

by

Robert J. Schultz
Engineering and Economics Research, Inc.

The decision to develop and use a geothermal resource for an industrial park must be evaluated thoroughly from both a technical and economic viewpoint. As one would suspect, the technical (geological and engineering) issues and the economic issues are interrelated to the extent that the developer must continue analyzing the integrated system during development. Eight major areas of consideration that impact the cost and design of the system hardware have been identified for further review:

1. RESOURCE--The issues that have to be included in the hardware/system development design and cost for resource delivery and energy expended fluid disposal are (a) number of production and injection wells, (b) spacing or distance between wells, (c) well head temperature, (d) pumping depth of resource, (e) annual operating hours, and (f) distance to site.

2. ENGINEERING--Normal design practices used with other energy systems often must be altered to be compatible with geothermal conditions. In addition to the normal design considerations of headloss, expansion, and heatloss, consideration must be given to pumping of high temperature fluids, fluid chemistry (corrosion and scaling), potential of temperature cascaded use, energy expended fluid return, handling of noncondensable gases and selection of fluid to be supplied to user (steam or hot water). Design and fabrication costs for a geothermal system can be greater than normal energy system costs.

3. UTILIZATION FACTOR--The utilization factor, the percentage of the time the system is being operated, is critical in amortization of energy production and delivery system expense. Utilization factor is calculated by dividing the amount of energy actually used by the yearly capacity of the system. Typical utilization factors are (a) industry, 75 percent to 95 percent and (b) space heating, 20 percent to 30 percent.

4. USE TEMPERATURE AND TEMPERATURE DIFFERENTIAL- ΔT--The temperature requirements of industrial park participants are critical to the park developer. A developer must determine the amount of process heat that can be obtained from his geothermal resource and decide what percentage of the parks process heat requirements can be fulfilled by his resource. Temperature boosting may be required for a portion of the fluid if the geothermal resource supply temperature is inadequate. Temperature boosting must be carefully analyzed, since this technique is usually not economical. The ΔT or amount of energy that can be removed (sold) from the supply fluid is extremely critical. The larger the ΔT, the less fluid out of the ground, and the greater the return on each pound of fluid handled.

ΔT is a function of supply temperature and use temperature. The closer these two temperatures approach each other, the smaller the ΔT available for utilization.

5. PIPING--Normally, two piping systems, complete with valves, expansion joints, controls, and pumps, are required. One is the transmission/distribution system, the other is the collection and energy expended fluid return system. Piping system can be fabricated from either metallic or nonmetallic materials:

   o Metallic.

      - Black pipe.

      - Copper.

      - Stainless steel.

      - Exotic metals.

   o Nonmetallic.

      - Cement asbestos.

      - Polymer concrete.

      - PVC (150°F max).

      - CPVC (212°F max).

      - Fiberglass.

      - Polypropylene.

      - FRP (Fiberglass reinforced plastic--300°F max).

   Nonmetallic piping materials generally cost less, but material selection criteria should include water quality fluid temperature, maintenance costs, and original capital cost.

6. WATER QUALITY--Water quality varies greatly from geothermal resource to resource. Geothermal fluid temperature and chemistry are closely related in that there is a general increase in total dissolved solids as temperature increases. The chemical components found in the fluids are a function of the local insitu geology. The chemical components present in geothermal fluids are the primary causes of corrosion and scaling when fluids are used as heat sources. Corrosion and scaling can be controlled through material selection and process control.

7. DISPOSAL--The energy expended fluids must be disposed of after heat extraction is completed. The disposal technique selected should be reviewed in light of accepted practices and cost. The four common options for geothermal fluid disposal are (a) discharge to surface waters if the fluids are environmentally benign; (b) discharge to

evaporation/infiltration ponds; ponding requirements will depend upon flow rates and evaporation/infiltration rates; (c) injection into shallow, intermediate, or deep aquifers depending upon local conditions and environmental regulations; or (d) used for secondary purposes: energy expended geothermal fluid could be beneficially used for agriculture or other purposes but may require fluid treatment before use.

8. COSTS--Two types of hardware costs are associated with the development and operation of an industrial park. They are capital costs and operation and maintenance costs. The major elements which comprise these costs are listed below:

Capital Costs:

- Engineering Design
- Piping
- Valves
- Pumps
  - Wellhead
  - Circulation
  - Injection
- Consumer Hookup
- Controls and Process Instrumentation
- Backup Components
- Disposal System
- System Installation
- Right of Ways
- Transmission
- Distribution
- Collection
- Return

Operations and Maintenance Costs:

- Pumping costs
  - Fluid withdrawal

- Transmission
- Injection

- o Maintenance
- o Scheduled Replacement
- o System Operators
- o Billing/collection

The costs listed above do not include either the resource development costs (geoscience activities, well drilling, well testing, etc.) or the normal site development costs (land, roads, services, etc.).

FINANCING A GEOTHERMAL INDUSTRIAL PARK PROJECT

by

John H. Woods
Bank of Montreal

I. INTRODUCTION

The idea of having an industrial park development centered around a reasonable and reliable energy resource holds great promise, as industry is concerned not only that its traditional sources of energy have placed a heavy burden on its operating costs but also this source may be cut off in periods of shortage. Utilizing a proven geothermal resource provides certain industrial users with several applications in their operations such as process hot water, refrigeration, space heating, and in certain high temperature resources, electricity. In turn, the industrial park developer can spread his capital costs for developing the geothermal resource over these several applications ("cascading") which makes the geothermal resource cost competitive with other energy sources. Other attractive features a developer can offer industry are:

- o Lower energy escalation--Once the initial capital cost is in place for a geothermal development project, there is little additional operating cost for a developer; therefore, he can offer further energy pricing benefits.

- o Industrial employee housing--The geothermal resource benefits can be used to provide space heating/cooling for residential housing. This can provide an industrial company with the necessary employee housing near its operating plant.

II. FINANCING

From a lender's point of view, the only difference between the financing of a geothermal industrial park development and a conventional park is the resource risk. In some cases, a lender may have some concern about the location of the development, since it has to be near the resource; however, this can be overcome by having firm long-term leases from financially able companies. The risk factor is a matter of education. There is the need to provide a reliable geothermal reservoir analysis by a proven reservoir engineer, which supports the resource capacity and life. The lender will also have to investigate the favorable history of geothermal performance throughout the world. As an incentive, the developer can provide a slightly higher interest rate and/or a resource guarantee or insurance coverage. Once the lender's barrier has been broken (the first financing), then other lenders will accept geothermal as an acceptable risk without any pricing or support incentive.

III. SOURCES OF FINANCING

An industrial park development may or may not include the development of the geothermal resource, but, in both cases, this factor has to be taken into consideration. Therefore, the development is no different than a conventional industrial park. The sources of financing normally will include a construction and completion phase. The construction phase will be by a commercial bank and in some instances an institution lender (for example a life insurance company) who will normally require a take out commitment from a long-term lender after construction is complete and certain occupancy has been achieved. This two-tiered financing can be arranged directly with the lenders or through mortgage or investment banking companies. An important factor in financing geothermal projects has been the United States Department of Energy under their Geothermal Loan Guarantee Program. The continuance of this program is not known at this time.

SUMMARY
of
Title: "INDUSTRIAL PARK DEVELOPMENT FINANCIAL INCENTIVES--TAX ITEMS"

PRESENTATION

by

William R. Brink
Coopers and Lybrand

I. ECONOMIC RECOVERY ACT OF 1981--HIGHLIGHTS

There have been a lot of tax changes. Among them are reductions in tax rates, faster depreciation, liberalized taxes to lease (which means if you are tied up in leases, you can get some additional tax benefits now), R&D tax credits (specific to certain conditions), state and gift tax, longer NOL (net operating loss) and tax credit carryforward (so you can now carry your losses further out), and new at-risk rules (if you do not have something at risk, you probably will not get a tax credit or benefit).

II. ACCELERATED COST RECOVERY SYSTEM--DEPRECIATION

Accelerated cost recovery system is equal to depreciation. This provides for shorter tax lives (five to seven years which enables you to get a faster tax write-off), depreciation in full value instead of partial value, and an extended carryforward period on your losses.

III. INVESTMENT TAX CREDITS

Investment tax credits are easier to get now. They have increased allowances in some cases. Tax credits are available for new equipment and under certain conditions on used equipment also. There also is an extended carryforward period on investment tax credits. If you happen to be carrying the tax credits yourself and cannot use them now, you can carry them out for a few more years. You are not as likely to lose them; this has happened in small projects before. There is also a liberalized recapture now. Investment tax credits are not cut and dry. You have to find out what is qualified and nonqualified. If you are careful and have the right tax man, you can move something from the nonqualified column to the qualified and thus get a tax credit. On the other hand, if you are not careful, something that is qualified right there on the check list will be disqualified.

IV. ENERGY TAX CREDITS

In energy tax credits, not much has changed other than the carryforward. On the handout page 157, geothermal qualifies for a 15 percent energy credit along with solar. Also, there are two personal primers for energy tax credits.

1. IRS Publications--The IRS has a shelf full of publications on tax credits, depreciation, and special booklets for farming, individual, and business. Publication 900 is the catalog from which you can select a variety of publications having to do with fuel taxes, interest expenses, deduction, etc. If you call or write the IRS they will send it to you free of charge.

2. U.S. Master Tax Guide--This gives you a check list and discusses in more detail the items that fit into the different categories. This publication will also help you do some depreciation projections.

V. PERCENTAGE DEPLETION

Percentage depletion is a certain percentage of gross income from the property during the tax year, but the deduction for depletion under this method cannot be more than 50 percent of taxable income from the property figured without the deduction for depletion. Rents and royalties paid or incurred for the property must be excluded from gross income from the property when figuring percentage depletion. A net operating loss deduction is not deducted from gross income from the property for figuring the 50 percent limit nor are charitable contributions allowed as a deduction from gross income in figuring the limit.

Geothermal deposits qualify for percentage depletion. A geothermal deposit is a geothermal reservoir of natural heat stored in rocks or in a watery liquid or vapor. It is not considered a gas well. Geothermal deposits located outside the United States or its possessions do not qualify.

The applicable percentages are:

1980	22%	
1981	20%	
1982	18%	
1983	16%	
1984	15%	(thereafter @ 15%)

Economic Recovery Tax Act of 1981

The principal thrust of the Economic Recovery Tax Act of 1981 and its corollary — the recent Federal budget reductions— is to bring about substantial improvement in the Nation's economy. The new law makes fundamental changes to the tax system which will have a significant impact upon the financial strategies of businesses and individuals.

The combination of the uniform reductions across all individual tax rate brackets, the reduction in the top rate of taxation applicable to dividends and interest, the reduction of the maximum capital gain rate, and major changes in the taxation of estates will free up major sources of additional funds for capital investment. This will result in a change in the relative attractiveness of various investment alternatives, and the decision processes of many individual investors.

For business, a new system of property depreciation, which is no longer tied to the useful-life concept of prior law, is expected to provide an important investment stimulus to improve the productivity and efficiency of American business. Another important capital incentive is the new 25% tax credit for incremental research and development expenditures.

In many cases, businesses with an urgent need to invest in new technology or in capital equipment to achieve greater productivity may not be able to realize the reduction in the cost of such investments intended by the Act. For example, tax benefits may not be of value to companies experiencing heavy losses in recent years or to companies involved in new types of business undertakings.

Accordingly, there is likely to be a proliferation of transactions structured to shift corporate tax benefits to investors who can more advantageously use them. Opportunities to shift tax benefits available through leasing have been specifically expanded by the Act.

State and local taxation should now be given greater attention as federal tax rates are reduced and funds available to state and local governments come under increasing pressure, because of the reduction of available Federal subsidies and property tax reform.

An important factor in current and future tax planning will be the large number of effective dates contained in the new law. A number of changes are retroactively effective to various dates in 1981, and to 1980 in one case. Many changes take effect at the beginning of 1982, and some several years later. In addition, some are subject to transitional rules spanning several years.

A number of administrative changes have been enacted including:

- Starting in 1982, interest rates on tax deficiencies and overpayments will be recomputed each year at 100% of the predominate prime interest rate (the old law required 90%);
- A "penalty" tax ranging from 10% to 30% of *tax* underpayments due to excess valuation; and a 50% "penalty" tax on the amount of *interest* on tax underpayments due to negligence;
- An increase in the civil and criminal penalties for filing false W-4's;
- Increased penalties for failing to file information returns;
- Congressional prohibition against fringe benefit regulations extended to December 31, 1983;
- Income exclusion for services received under qualified group legal service plans is extended three years until December 31, 1984;
- Technical and clarifying changes were made in the 1980 law which imposed tax and reporting requirements on foreign investors who own interests in U.S. real estate.

Economic Recovery Tax Act of 1981

A number of provisions of the new law can have an immediate and dramatic impact upon financial plans and the development of strategies for 1981. Some of the important areas are set forth in the following summary:

Capital Gains

The maximum tax rate on long-term capital gains is reduced from 28% to 20% effective for sales occurring after June 9, 1981. Although current transactions for persons above the 50% bracket will benefit from this change, deferral of income until 1982 should still be considered to accomplish cash flow and other objectives.

Dividends, Interest, and Short-term Capital Gains

Planning to defer investment income until 1982 for those in high brackets is particularly important because the reduction in rates on investment income to a maximum of 50% does not occur until January 1, 1982.

Depreciation and Investment Credit

The increase in the amount of investment credit, and the complete new system of accelerated depreciation methods and lives (ACRS), are applicable to all personal and real property placed in service since the beginning of 1981. Before the end of 1981, these provisions should be analyzed and various strategies considered, including the election of alternative methods and lives provided in the system.

Personal Property

Attention should be paid to the placing of personal property into service before the end of 1981. Under the new system, the full amount of cost recovery determined for the first year of an asset shown on the applicable table is deductible regardless of the month in which the property is placed in service. The half-year convention has been built into these tables.

Also, to facilitate the shifting of tax benefits, the liberalized corporate leasing rules can be used for property placed in service earlier in 1981 if appropriate action is taken within three months of the date of enactment.

Rehabilitation Credit

Larger credit amounts for property 30 years and older, and historic structures, apply to rehabilitation expenditures incurred after December 31, 1981. However, the current 10% credit for 20- to 30-year structures will lapse, and the tax benefits will be lost, unless rehabilitation begins before the end of the year.

New Incentive Stock Options

The new rules which contain significant advantages to many participants in stock option plans may apply to options granted since January 1, 1976 and exercised during 1981, if both the employee and employer agree, and the option otherwise qualifies under the new rules.

New Research and Development Credit

The new 25% credit can apply to expenditures made after June 30, 1981. However, the incremental test requires developing optimal strategies for undertaking discretionery activities between late 1981 or early 1982.

Estate and Gift Tax

These changes are fundamental to the entire estate tax structure and will require attention over the next several years. As an important example, gifts made after December 31, 1981 will be eligible for the new annual gift tax exclusion of $10,000 per donee or $20,000 in the case of a joint gift. The exclusion for gifts made during 1981 will be subject to the current $3,000/$6,000 limitation.

Sale of Personal Residence

Sales of residences made within the 18-month period preceding July 20, 1981 will be eligible to complete the rollover transaction in the 24-month period which is allowed in the Act. Also the increase in the exclusion for gains realized by individuals 55 years or older from $100,000 to $125,000 applies to sales occurring after July 20, 1981.

Overview of Accelerated Cost Recovery System (ACRS)

To stimulate investment and economic expansion, a new mandatory accelerated cost recovery system (ACRS) has been established to provide for more rapid depreciation of capital assets and liberalization of the investment tax credit.

ACRS will apply to assets placed in service after December 31, 1980. The cost of tangible depreciable property is recovered over 3-, 5-, 10- or 15-year periods, which is significantly shorter under ACRS than under prior law.

- Most personal property is in the 5-year class (defined as property not in 3-, 10-, or 15-year classes).
- Cars, light-duty trucks, research and experimentation equipment and certain other short-lived property are in the 3-year class.
- Theme park structures, mobile homes and railroad tank cars are in the 10-year class.
- Depreciable real property is in a 15-year class.
- Special rules have placed certain single purpose agricultural structures and certain petroleum and storage facilities in the 5-year class.
- Assets amortized or depreciated under a special method, such as the unit-of-production method, are not subject to ACRS.
- For purposes of computing a corporation's earnings and profits, cost recovery is computed at a straight-line rate over an extended recovery period.

A half-year of depreciation is allowed for the year property is placed in service. For example, if the straight-line method and a 5-year recovery period are used, a half-year of cost recovery is allowed in the first year, and the remaining cost is recovered in the next four years.

Observation: The half-year convention is reflected in the recovery tables. This is because all ACRS property, regardless of when placed in service during the year, is allowed one-half of a year's depreciation (unless subject to short taxable year rules). Businesses receive a premium by placing assets in service by the end of their taxable year rather than in the following year. In addition to accelerating depreciation, the investment credit will be available one year earlier.

For personal property placed in service from 1981 to 1984, cost recovery is allowed based upon a 150% declining balance method with optimal switchover to straight-line.

ACCELERATED COST RECOVERY SYSTEM OVERVIEW
(Excluding Foreign Assets)

Class	3-Year	5-Year	10-Year	15-Year	15-Year Real Property
CONTENTS OF CLASS	• Cars • Light trucks • R&D equipment • ADR midpoint of 4 years or less	• Most machinery and equipment (not in 3- or 10-year class) • Single purpose agricultural structures • Petroleum storage facilities • Public utility property with ADR midpoint of 18 years or less	• Railroad tank cars • Public utility property ADR midpoint of 18.5 to 25 years • Recreational facilities and theme park structures • Qualified coal conversion property of public utilities • Depreciable real property with ADR midpoint of 12.5 years or less • Manufactured homes	• Public utility property with ADR midpoint of over 25 years	• Real property (other than items redesignated personal property in 5-year class or real property in 10-year class)
LIMITED EXPENSING OF PROPERTY IN YEAR PLACED IN SERVICE[1]	Yes	Yes	Yes	Yes	No
INVESTMENT CREDIT	6%	10%	10% (except real property)	10%	0
OPTIONAL EXTENDED RECOVERY PERIODS	5 or 12 years	12 or 25 years	25 or 35 years	35 or 45 years	35 or 45 years
HALF-YEAR CONVENTION[2]	Yes	Yes	Yes	Yes	No (Prorated by months)
METHODS USED FOR RATES[3]	1981-1984 150% DB/SL 1985 175% DB/SYD 1986 200% DB/SYD	Same as 3-year	Same as 3-year	Same as 3-year	• Low income housing 200% DB/SL • All other real property 175% DB/SL
DEPRECIATION IN YEAR OF DISPOSITION	None	None	None	None	Prorated by months
RECAPTURE[4]	In full	In full	In full	In full	• No recapture Property using S.L. • Excess of accelerated over SL Residential using accelerated • Full recapture Commercial using accelerated
ITC RECAPTURE	2 percentage points for each year below 3	2 percentage points for each year below 5	2 percentage points for each year below 5	2 percentage points for each year below 5	N.A.

[1]Annual Limits.

1982 and 1983	$ 5,000
1984 and 1985	$ 7,500
After 1985	$10,000

[2]The half-year convention has been built into the recovery tables. The full amount provided in the tables for the first year is deductible regardless of the month placed in service.

[3]Straight-line is optional for all classes but must be used if extended recovery is elected.

[4]Recapture of expensed items is immediate and overrides installment sale provisions.

Personal Property

The new law phases in an accelerated method which maximizes the benefit of the cost recovery deduction in the early years of an asset's use, and automatically switches over to a straight-line or sum-of-the-years digits method at the point necessary to continue maximization of depreciation deductions.

PERSONAL PROPERTY COST RECOVERY

This illustration compares the deductible amounts over 6 years for a new machine which costs $100,000, and has a 10-year useful life and salvage value of $10,000 under prior law. The machine falls into the 5-year class and is placed in service on July 1, 1982.

	NEW LAW		PRIOR LAW	
Year	Accelerated*	Straight-line	Accelerated (DDB)	Straight-line
1982	$15,000	$11,112	$10,000	$4,500
1983	22,000	22,222	18,000	9,000
1984	21,000	22,222	14,400	9,000
1985	21,000	22,222	11,520	9,000
1986	21,000	22,222	9,216	9,000
1987	-0-	-0-	7,373	9,000
Total	**$100,000**	**$100,000**	**$70,509**	**$49,500**

*Taken from the prescribed tables using 150% declining balance method in 1982 with optimal switchover to straight-line in 1983.

Extension of Net Operating Loss (NOL) and Investment Credit Carryforwards

The new law extends the carryforward period to 15 years for net operating losses for taxable years ending after 1975. A 15-year period is also available for unused investment credits arising from years ending after 1973. There has been no change in the provision that net operating losses and investment credits can be carried back three years.

RECOVERY PERCENTAGES PERSONAL PROPERTY PLACED IN SERVICE 1981-84

	Class of Investment			
Year of Ownership	3-year	5-year	10-year	15-year Public Utility Property
1	25	15	8	5
2	38	22	14	10
3	37	21	12	9
4		21	10	8
5		21	10	7
6			10	7
7			9	6
8			9	6
9			9	6
10			9	6
11				6
12				6
13				6
14				6
15				6
Total	**100**	**100**	**100**	**100**

For 1985, the cost recovery schedules approximate the 175% declining balance method with a change to sum-of-the-years digits. After 1985, the cost recovery schedule will be based upon a 200% declining balance method with a change to sum-of-the-years digits.

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RECOVERY PERCENTAGES
PERSONAL PROPERTY PLACED IN SERVICE IN 1985*

Year of Ownership	Class of Investment 3-year	5-year	10-year	15-year Public Utility
1	29	18	9	6
2	47	33	19	12
3	24	25	16	12
4		16	14	11
5		8	12	10
6			10	9
7			8	8
8			6	7
9			4	6
10			2	5
11				4
12				4
13				3
14				2
15				1
Total	100	100	100	100

*The recovery in 1985 schedule approximates the 175% declining balance method with an optimal change to sum-of-the-years digits.

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RECOVERY PERCENTAGES
PERSONAL PROPERTY PLACED IN SERVICE AFTER DECEMBER 31, 1985*

Year of Ownership	Class of Investment 3-year	5-year	10-year	15-year Public Utility
1	33	20	10	7
2	45	32	18	12
3	22	24	16	12
4		16	14	11
5		8	12	10
6			10	9
7			8	8
8			6	7
9			4	6
10			2	5
11				4
12				3
13				3
14				2
15				1
Total	100	100	100	100

*The recovery after 1985 schedule approximates the 200% declining balance method with an optimal change to sum-of-the-years digits

Recapture

The recapture rules of both personal and real property cost recovery allowances are as follows:

Rule	Property
No recapture	All real estate using straight-line method
Excess of accelerated over straight-line	Residential property using accelerated method
Full recapture	Commercial and industrial property using accelerated method
	Substantial improvements using accelerated method
	All personal property

Anti-Churning Rules

Rules are provided to prevent persons (or related parties) from converting pre-1981 owned personal and real property into property qualifying for the new accelerated cost recovery benefits.

Investment Tax Credit

Liberalized Incentives

The new law encourages investment in both new and used property by establishing new investment credit rules. The new rules apply to property placed in service in taxable years beginning after 1980.

A 6% credit applies to qualified property in the 3-year depreciation class; and 10% for all other qualified property. (Under the old law, the credit was 3-1/3% for property with lives of 3-5 years, 6-2/3% for 5-7, and 10% for over 7 years). The investment credit carryover period is extended to 15 years for credits arising in taxable years ending after 1973.

The used property limitation is raised from $100,000 to $125,000 in tax years beginning in 1981 and $150,000 in tax years beginning after 1984.

For progress payments beginning in 1982, the requirement that property have a 7-year life before the progress payment election will apply has been changed. Now the election is available provided that property qualifies for the investment credit (e.g., that it be at least 3-year class property) and has a normal construction period of at least two years. If an election is already in effect for other property, then property subject to the new rules would be covered automatically.

New "At Risk" Rule

New investment credit at risk rules are effective for property placed in service after February 18, 1981 (except for property acquired under a binding contract entered into on or before that date). This provision may postpone or eliminate allowance of the portion of credit attributable to nonrecourse financing. However, borrowings from (or guaranteed by) Federal, state or local governments and amounts borrowed from banks, insurance companies, credit unions, pension trusts and most other persons in the business of lending money avoid application of the new at risk rules. This "safe harbor" is only applicable where there is an at risk amount equal to at least 20% of the asset basis. Special at risk rules apply to certain energy property.

Neither widely-held corporations nor real estate activities are subject to the at risk rules.

Observation: While the new at risk rules were aimed at tax shelters, all sole proprietorships, operating partnerships, and Subchapter S corporations can be directly affected. The February 18, 1981 effective date may cause a *loss* of credits on 1981 returns for equipment purchased since the beginning of the year.

Recapture

The investment tax credit recapture rules are modified to reflect the liberalized credit percentages. The following table shows the percentage of qualified basis on which recapture is computed:

Years Held	3-Year Property	5-, 10-, 15-Year Property
less than 1	100%	100%
between 1 and 2	66%	80%
between 2 and 3	33%	60%
between 3 and 4	—	40%
between 4 and 5	—	20%

Energy Credits

The energy credits operate independent of the ITC. Thus, a particular component of an alcohol fuel plant might qualify for one credit or the other, or both. Experience to date has shown that typically the total dollar savings from combined ITC and energy credits will be 20% of an average 80% of total costs. For example, on a $10,000,000 plant combined credits would be approximately $1,600,000 (20% x $8,000,000).

The energy credits vary by amount and expiration date. The different percentages and expiration dates are outlined below:

	Energy %	Expiration Date
Alcohol Plants		
alternative energy property	10	12/31/82
biomass property	10	12/31/85
Solid Waste Recovery (direct burning)		
recycling	10	12/31/82
Solid Waste Recovery (solid fuel) from waste		
recycling	10	12/31/82
biomass	10	12/31/85
Small Dams		
qualified hydroelectric generating equipment	11 maximum	12/31/85
Space Heating		
solar	15	12/31/85

Keep in mind that in the case of certain long-term projects (e.g., those with a two or more year construction period) it is possible to extend the expiration date of the credits through a special election. Otherwise, energy credits could be lost in total, or in part, for projects placed in service after the appropriate effective date.

[¶ 67] Check List XIII—Investment Tax Credit—Sec. 38 Property

- Elevators (¶ 539C)
- Escalators (¶ 539C)
- Fences for livestock (¶ 539Z.25)
- Horticultural structures, single purpose (¶ 539Z.011)
- Leased equipment (¶ 539Z.017)
- Livestock (other than horses) (¶ 539Z.012)
- Livestock structures, single purpose (¶ 539Z.011)
- Property used for lodging (¶ 539)
  - Coin-operated vending machines, washers and dryers (¶ 539Z.012)
  - Mobile homes (more than 50% transient use) (¶ 539C)
- Property used outside United States
  - Aircraft (¶ 539C and 539Z.65)
  - Communication satellites (¶ 539Z.012)
  - Motor vehicles (¶ 539C)
  - Offshore drilling equipment (¶ 539C)
  - Property used in U. S. possessions (¶ 539C)
  - Shipping containers (¶ 539C)
  - Ships (marine vessels) (¶ 539C and 539Z.4556)
  - Submarine telephone cables (¶ 539Z.012)
- Public utility property
  - Parts and components (¶ 539Z.30)
  - Steam-generating electric power plant (¶ 539Z.30)
- Research and storage facilities
  - Air-conditioning and humidity control systems required for proper operation of other machinery (¶ 539Z.23)
  - Corn cribs (¶ 539Z.25)
  - Dry-kiln and control room structures (¶ 539Z.45)
  - Gas storage tanks (¶ 539C)
  - Grain storage bins (¶ 539C and 539Z.27)
  - Liquefied petroleum gas equipment (¶ 539Z.225)
  - Milk storage refrigerator and freezer structures (¶ 539Z.425)
  - Oil storage tanks (¶ 539C)
  - Oil storage terminal facility's fuel oil blending property (¶ 539Z.2843)
  - Potato storage facility (¶ 539Z.295)
  - Propane gas storage tanks, water heaters and water softeners (leased) (¶ 539Z.278)
  - Refrigerated portion of building (¶ 539Z.195 and 539Z.25)
  - Reservoir for use with electric generating plant (¶ 539Z.30)
  - Silos (¶ 539Z.25)
  - Storage facility for grain or other commodities (¶ 539Z.27)
- Tangible personal property
  - Automatic vending machines (¶ 539C)
  - Automotive test tracks and facilities (¶ 539Z.13)
  - Bank vault doors (¶ 539Z.15)
  - Boiler facility (¶ 539Z.195)

Tangible personal property—continued
  - Commuter highway vehicle for transporting employees (¶ 537H.0255)
  - Control room structures (¶ 539Z.45)
  - Display racks (¶ 539C)
  - Display shelves (¶ 539C)
  - Drive-up tellers' windows in banks (¶ 539Z.15)
  - Dry-kiln structures (¶ 539Z.45)
  - Electroplates (¶ 539Z.296)
  - Fire extinguishers (¶ 539Z.103)
  - Floating docks (¶ 539Z.229 and 539Z.26)
  - Gasoline pumps (¶ 539C)
  - Golf course watering system, including pump and portable sprinklers (¶ 539Z.267 and 539Z.68)
  - Grocery counters (¶ 539C)
  - Hydraulic car lifts (¶ 539C)
  - Laboratory facilities (¶ 539Z.195)
  - Mechanized conveyors (¶ 539Z.55)
  - Mushroom beds, conveyors, machinery and pipes (¶ 539Z.28)
  - Neon and other signs (¶ 539C)
  - Night depository facilities in banks (¶ 539Z.15)
  - Office equipment (¶ 539C)
  - Offset-lithography films (¶ 539Z.296)
  - Piping machinery (¶ 539Z.55)
  - Power machinery (¶ 539Z.55)
  - Printing presses (¶ 539C)
  - Production machinery (¶ 539C)
  - Propane gas storage tanks, water heaters and water softeners (¶ 539Z.278)
  - Record vault doors (¶ 539Z.15)
  - Refrigeration equipment (¶ 539Z.425)
  - Refrigerators (¶ 539C)
  - Reusable containers (¶ 539Z.44)
  - Testing equipment (¶ 539C)
  - Transportation equipment (¶ 539C)
  - Vending machines (¶ 539Z.278)
  - Voice communication systems (¶ 539Z.55)
  - Walk-up tellers' windows in banks (¶ 539Z.15)
  - Wall-to-wall carpeting (¶ 539Z.2798)
  - Water pumps (¶ 539Z.55)
- Other tangible property
  - Blast furnaces (¶ 539C)
  - Broadcasting towers (¶ 539C)
  - Burner and preheater structures—cement kiln (¶ 539Z.195)
  - Citrus trees (¶ 539Z.20)
  - Compressor station structures (¶ 539Z.22)
  - Drain tiles for field irrigation (¶ 539Z.25)
  - Drain tiles for pasture (¶ 539Z.25)
  - Electrical connections (¶ 539Z.24)
  - Fences used to confine livestock (¶ 539C and 539Z.25)
  - Gas pipelines (¶ 539C)
  - Grain storage bins (¶ 539Z.27)
  - Henhouses (¶ 539Z.25)

Check List XIII—Investment Tax Credit—Sec. 38 Property—Continued

Other tangible property—continued
  - Hydroelectric power plant structure housing generator and propulsion turbine (¶ 539Z.24)
  - Integrated hog-raising facility—automatic equipment (¶ 539Z.25)
  - Logging truck roads (¶ 539Z.45)
  - Marine terminal facility (¶ 539Z.2795)
  - Mooring cell (¶ 539Z.16)
  - Oil derricks (¶ 539C)
  - Oil pipelines (¶ 539C)
  - Orchards and groves (¶ 539Z.285)
  - Paved barnyards (¶ 539Z.25)
  - Plumbing connections (¶ 539Z.24)

Other tangible property—continued
  - Refinery equipment—concrete fire-dike walls, with valves, piping, and prefabricated walkways (¶ 539Z.42)
  - Roadways within manufacturing complex (¶ 539Z.2925)
  - Soft drink vending machine (¶ 539Z.278)
  - Storage facilities (used in farming) (¶ 539Z.25)
  - Trucking terminal improvements (¶ 539Z.60)
  - Waterwells (¶ 539Z.25)
  - Wells providing water for farm livestock (¶ 539Z.25)

[¶ 68] Check List XIV—Property Not Qualified for Investment Tax Credit

- Baseball player contracts (¶ 539Z.17)
- Bottles, reusable (¶ 539Z.44)
- Buildings
  - Airport hangars (¶ 539Z.195)
  - Apartment houses (¶ 539C)
  - Barns (¶ 539C)
  - Bus stations (¶ 539C)
  - Craneway structure (¶ 539Z.195)
  - Drive-up bank teller's booth (¶ 539Z.15)
  - Factory buildings (¶ 539C)
  - Garages (¶ 539C)
  - Laboratory "clean" rooms (¶ 539Z.195)
  - Office buildings (¶ 539C)
  - Quonset-type structures (¶ 539Z.195)
  - Ski-lift control houses (¶ 539Z.195 and 539Z.453)
  - Sports stadium (¶ 539Z.195)
  - Stables (¶ 539Z.25)
  - Stores (¶ 539C)
  - Trailer park launderette (¶ 539Z.48)
  - Warehouses (¶ 539C and 539Z.25)
- Inherently permanent structures
  - Floating dock (¶ 539Z.26)
  - Giant amusement slides (¶ 539Z.11)
  - Lobster pound (¶ 539Z.279)
  - Outdoor lighting facility (¶ 539Z.29)
- Intangible property
  - Copyrights (¶ 539C)
  - Patents (¶ 539C)
  - River bottom dredging (¶ 539Z.2795)
  - Subscription lists (¶ 539C)
- Livestock
  - Horses (¶ 539Z.012)
- Paved parking areas (¶ 539Z.2925)
- Property used by tax-exempt organizations, other than in an unrelated trade or business (¶ 539C)
- Property used for nontransient lodging (¶ 539C)
  - Mobile homes (¶ 539Z.48)
- Property used outside the United States, except as indicated at ¶ 67 herein (¶ 539C)
- Structural components of buildings
  - Air-conditioning system (¶ 539C and 539Z.103)
  - Ceilings (¶ 539C)
  - Chimneys (¶ 539C)
  - Concrete trenches in laboratory (¶ 539Z.195)
  - Doors (¶ 539C)
  - Electric wiring (¶ 539C)
  - Fire escapes (¶ 539C)
  - Floors (¶ 539C)
  - Heating system (¶ 539C and 539Z.103)
  - Hot water system (¶ 539Z.103)
  - Lighting fixtures (¶ 539C)
  - Paneling (¶ 539C)
  - Partitions (¶ 539C, 539Z.195)
  - Plumbing and plumbing fixtures—sinks and bathtubs (¶ 539C)
  - Polystyrene insulation (¶ 539Z.425)
  - Recessed lighting (¶ 539Z.195)
  - Ski-lift equipment (¶ 539Z.195 and 539Z.453)*
  - Sprinkler systems (¶ 539C and 539Z.195)
  - Stairs (¶ 539C)
  - Tiling (¶ 539C)
  - Walls (¶ 539C)
  - Water coolers (¶ 539Z.103)
  - Windows (¶ 539C)

* Tax Court has held that terminal and cable support towers of a ski-lift facility qualified for investment credit (¶ 539Z.453). The IRS National Office in LTR 7945004 agreed with the Tax Court.

[¶ 69] Check List XV—Property Eligible for Energy Tax Credit

[1] Principal Residence (¶ 527M.01)[2]

Energy-saving components

- Caulking for building joints, exterior doors and windows
- Flue opening modifications
- Furnace ignition systems replacing gas pilot lights
- Furnace replacement burners
- Insulation for ceilings, exterior walls, floors, forced air ducts, hot, bare pipes, hot water heaters (exterior installation), roofs
- Meters displaying energy usage costs
- Storm and thermal doors and windows
- Thermostats (automatic energy-saving setback and clock thermostats)
- Weatherstripping for exterior doors and windows

Renewable energy source equipment

- Geothermal energy equipment
- Geothermal wells
- Heat exchangers
- Rock beds
- Solar collectors

Renewable energy source equipment—continued

- Solar energy equipment
- Thermostats
- Wind energy equipment
- Windmills

Business Property (¶ 539Z.025)[3]

Alternative energy equipment

Equipment for producing natural gas from geopressured brine

Recycling equipment

Shale oil equipment

Solar or wind energy property

Specially defined energy property

- Automatic energy control system
- Heat exchanger
- Heat pipe
- Heat wheel
- Preheater
- Recuperator
- Regenerator
- Turbulator
- Waste heat boiler

[¶ 70] Check List XVI—Property Not Eligible for Energy Tax Credit

Carpets
Drapes
Exterior siding
Fluorescent lights
Heat pump
Hydrogen-fueled equipment
Replacement boilers and furnaces
Wood- or peat-burning stoves
Wood paneling

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[1] Credit for energy-saving components is available only for residences the construction of which was substantially completed before April 20, 1977. Credit for renewable energy source equipment is available for existing and newly constructed or reconstructed dwellings.

[2] Eligible payors include condominium unit owners (allocable share), cooperative housing association stockholders (allocable share), lessees if they actually pay for the item, and lessors if they actually pay for the item.

[3] Although property used primarily for lodging does not qualify for the regular investment tax credit, it may qualify for the business energy credit.

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PANELISTS: John Lund, Oregon Institute of Technology
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IV. FINANCING AN INDUSTRIAL GEOTHERMAL PROJECT--John Woods, Bank of Montreal

A. Financing

B. Sources of Funding

V. A DEVELOPMENT STRATEGY FOR COVER FORT-SULPHURDALE, UTAH--Wayne Portanova, Mother Earth Industries

SUMMARY
of
Titles "INDUSTRIAL USES
GENERAL OVERVIEW"

PRESENTATION

by

John Lund
Geo-Heat Center
Oregon Institute of Technology

I. RESOURCE CHARACTERISTICS VS. INDUSTRY DEMAND

Typical Temperature Ranges

The majority of resources are low temperature below 90°C (194°F). The main source of information in the United States is the USGS Circular 790 which is available from Menlo Park or Reston, Virginia. A series of maps accompany this circular which show each of the resources, mainly KGRAs. They give the temperatures, wells, flow rates, chemistry, and so forth as of 1977 - 1978. The California Energy Commission and the Division of Oil and Gas has specific state information available on specific resources and ongoing programs.

The main geothermal areas of California are (a) The Geysers and surrounding area, (b) Northeastern California (Modoc and Lassen counties), (c) Los Angeles Basin, (d) Imperial Valley, and (e) Eastern California (Inyo and Mono counties). The only area of the state that seems to be lacking in geothermal energy is the Central Valley Area.

Resource Utilization

There are a number of things that need to be considered. The first is direct use versus using a heat exchanger. You need to know whether your resource can be used directly or whether you need a heat exchanger. If you have a low temperature resource and you feel you can use it, many times these resources can be boosted with heat pumps. For instance, a 70 - 80°F resource can be boosted with a heat pump to 135 - 140°F. Geothermal resources can also be used for cooling purposes. Chillers or cooling systems that can go down use a resource as low as 180 - 190°F. This system may not be very efficient at that temperature, but it can be used. The other thing that needs to be considered is if the geothermal system is a new installation or a retrofit. If you are retrofitting a particular industry, your costs are going to be a lot higher than installing a new system. Another consideration is whether there is waste heat that can be used for another process. You can take the waste heat from a geothermal power plant or other high temperature industry and cascade it down so you squeeze as much energy as you can out of it. Often, cascading can make the geothermal project profitable when it would not have been otherwise. Peaking versus base load and load factor is another important item to consider. One thing most industries have going for them is a high load factor which can levelize their cost, enable them to have year-round operation, and reduce the number of wells required. Finally, the last resource utilization consideration is transmission distance. You can transmit a considerable distance (up to 5,070 miles in Iceland) and still be economical. But in some cases, it is not economical. It is not the temperature loss that is the problem but the cost of the transmission lines.

Drilling Techniques

The advantage of a low to moderate temperature resource is that you can use conventional well water drilling methods. Another drilling method used is cable vs. rotary drilling (see attached diagrams).

Sources of Information

There are several sources that provide information about geothermal energy. There are a number of technical assistance programs available which provide, in most cases, up to 100 hours of free technical assistance for preliminary engineering and economic studies and in some cases, for reservoir evaluations as well. Some institutions that provide these services are OIT, UURI, NMEI, INEL. Other agencies that provide information are the California Energy Commission, Department of Energy, and private firms (consultants, equipment suppliers). Also attached is a list of reference literature.

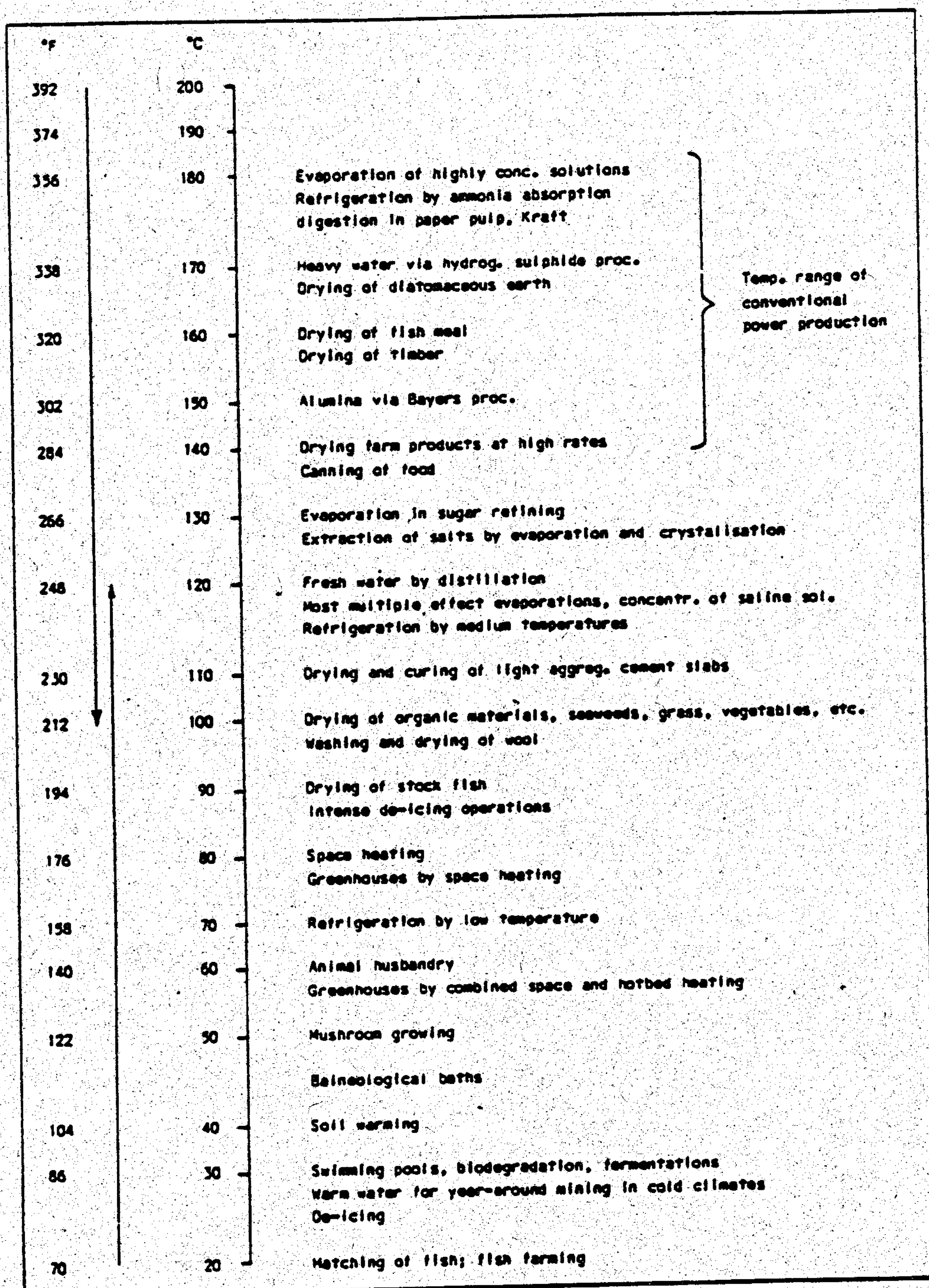


FIGURE 1. The approximate temperature required for various geothermal uses.

from GRC Special Report No. 7

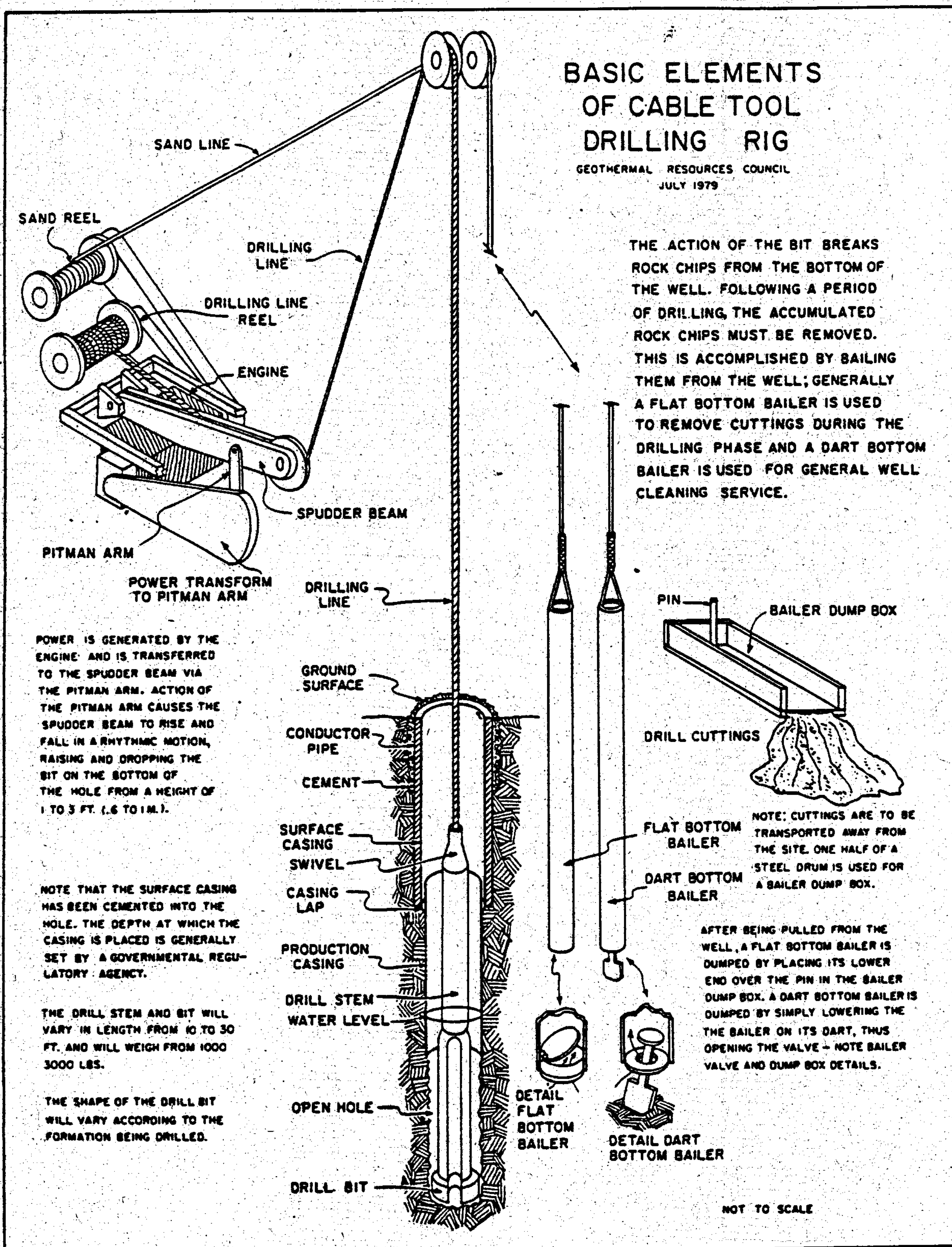


FIGURE 2

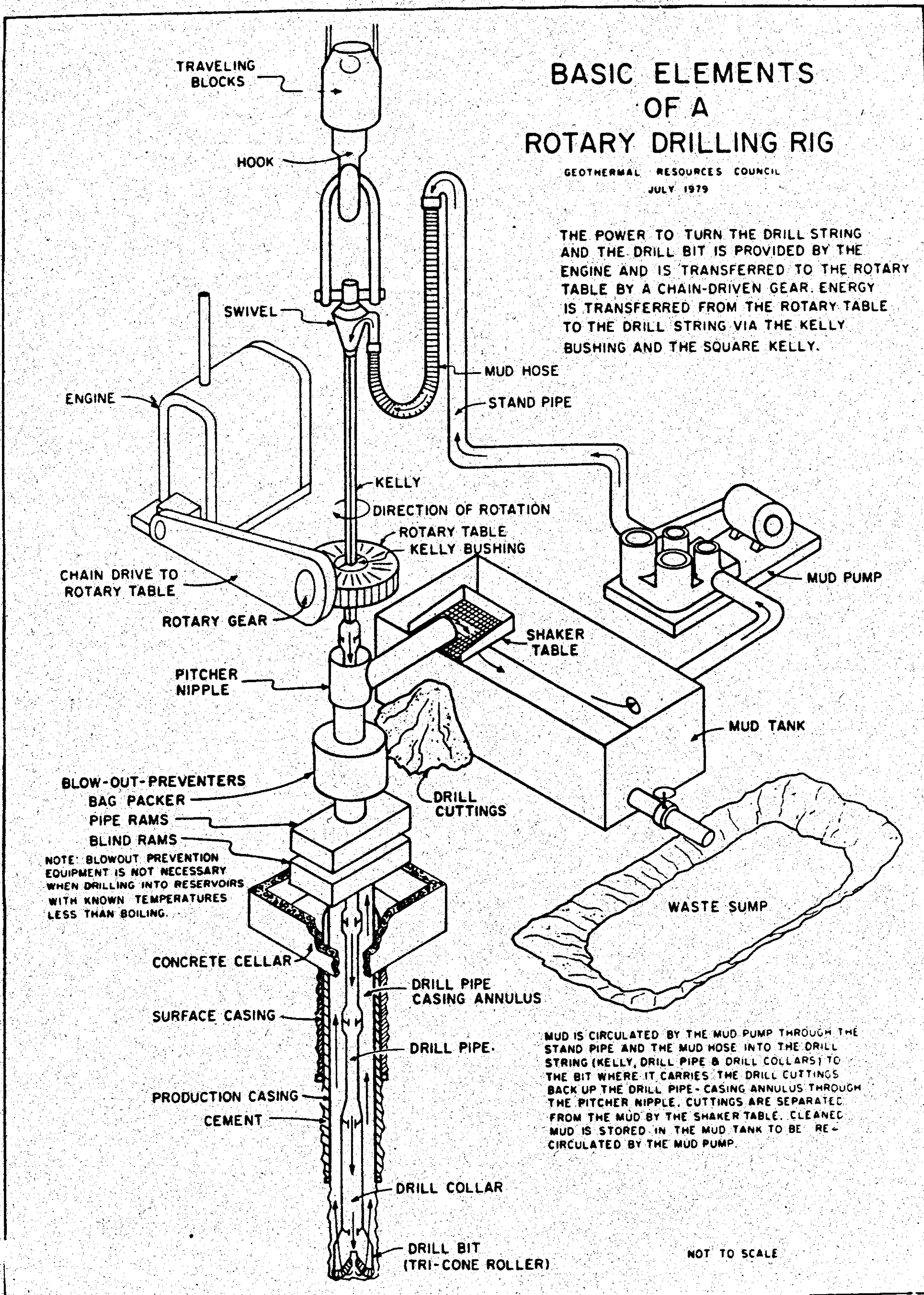
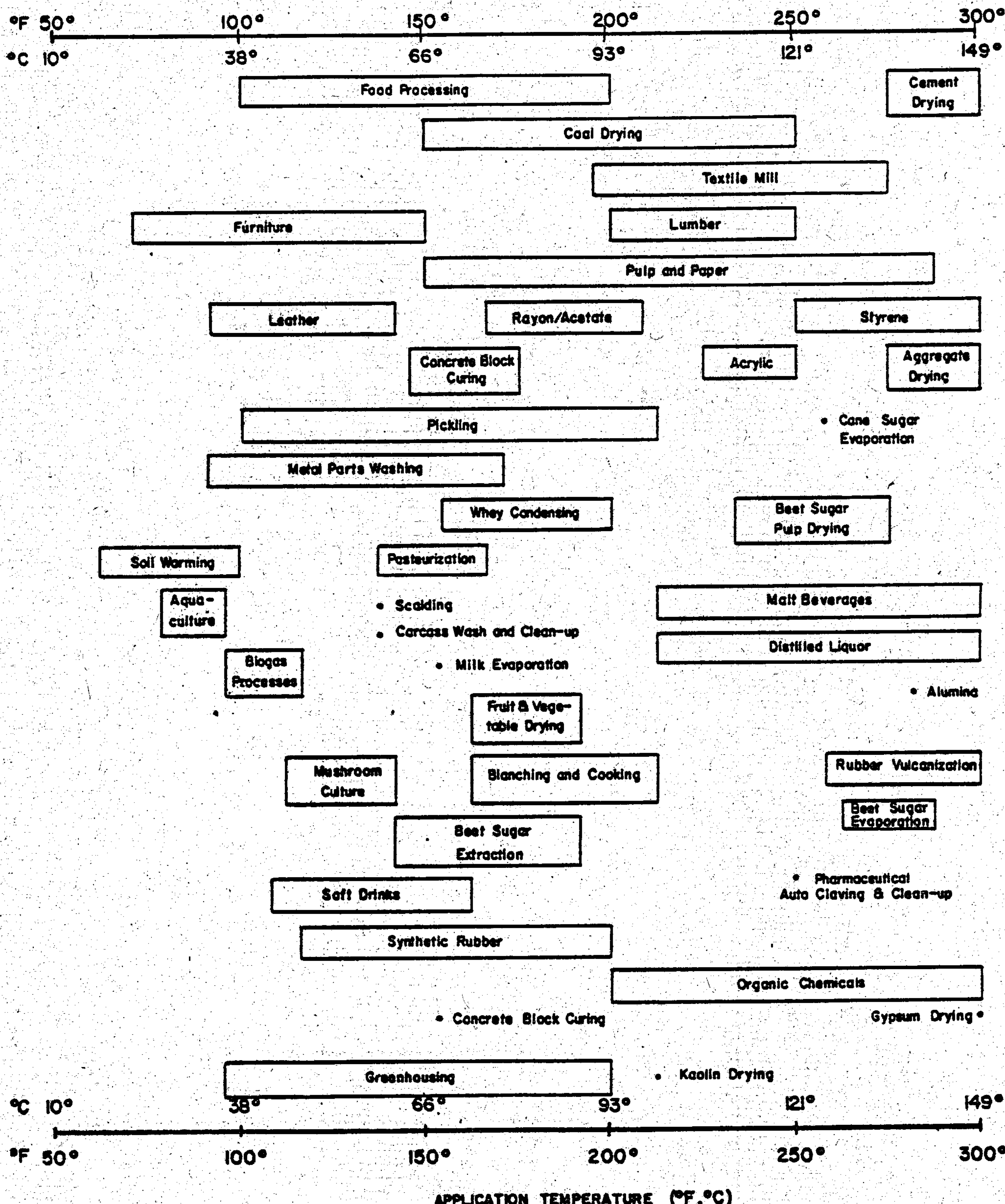

BASIC ELEMENTS
OF A
ROTARY DRILLING RIG
GEOTHERMAL RESOURCES COUNCIL
JULY 1979
THE POWER TO TURN THE DRILL STRING AND THE DRILL BIT IS PROVIDED BY THE ENGINE AND IS TRANSFERRED TO THE ROTARY TABLE BY A CHAIN-DRIVEN GEAR. ENERGY IS TRANSFERRED FROM THE ROTARY TABLE TO THE DRILL STRING VIA THE KELLY BUSHING AND THE SQUARE KELLY.
TRAVELING BLOCKS
HOOK
SWIVEL
MUD HOSE
STAND PIPE
ENGINE
KELLY
DIRECTION OF ROTATION
ROTARY TABLE
KELLY BUSHING
CHAIN DRIVE TO ROTARY TABLE
MUD PUMP
ROTARY GEAR
SHAKER TABLE
PITCHER NIPPLE
MUD TANK
BLOW-OUT-PREVENTERS
BAG PACKER
PIPE RAMS
BLIND RAMS
DRILL CUTTINGS
NOTE: BLOWOUT PREVENTION EQUIPMENT IS NOT NECESSARY WHEN DRILLING INTO RESERVOIRS WITH KNOWN TEMPERATURES LESS THAN BOILING.
WASTE SUMP
CONCRETE CELLAR
DRILL PIPE CASING ANNULUS
SURFACE CASING
DRILL PIPE
MUD IS CIRCULATED BY THE MUD PUMP THROUGH THE STAND PIPE AND THE MUD HOSE INTO THE DRILL STRING (KELLY, DRILL PIPE & DRILL COLLARS) TO THE BIT WHERE IT CARRIES THE DRILL CUTTINGS BACK UP THE DRILL PIPE - CASING ANNULUS THROUGH THE PITCHER NIPPLE. CUTTINGS ARE SEPARATED FROM THE MUD BY THE SHAKER TABLE. CLEANED MUD IS STORED IN THE MUD TANK TO BE RE-CIRCULATED BY THE MUD PUMP.
PRODUCTION CASING
CEMENT
DRILL COLLAR
DRILL BIT
(TRI-CONE ROLLER)
NOT TO SCALE

FIGURE 3



Application temperature range for some industrial processes and agricultural applications.

FIGURE 4

INDUSTRY	40°C-60°C	60°C-80°C	80°C-100°C	100°C-120°C	120°C-140°C	140°C-160°C	160°C-180°C	180°C-200°C	200°C	250°C
Meat packing	NA	99%	100%							
Prepared meats	NA	46.2%	61.5%	100%						
Natural cheese	23%	100%								
Fluid milk	NA	NA	100%							
Canned fruits and vegetables	NA	NA	22.7%	67.6%	100%					
Dehydrated fruits and vegetables	NA	100%								
Potato dehydration										
granules	NA	19.9%	40%	53%					100%	
flakes	NA	19.9%	40%	53%				100%		
Frozen fruits and vegetables	NA	NA	30%	100%						
Wet corn milling	21.5%			36.4%	46.6%		84.1%		100%	
Prepared feeds										
pellet conditioning	NA	NA	100%							
alfalfa drying	NA	NA	NA	NA	NA	NA	NA	NA	100%	
Beet sugar	NA	7.4%	22.4%		95.4%					100%
Soft drinks	60.9%	100%								
Sawmills and planing mills	NA	NA	NA	NA	NA	100%				
Alumina	NA	NA	NA	NA	76.2%					100%
Soaps	NA	NA	0.6%						100%	
Detergents	NA	NA	52.2%				99.9%		100%	
Concrete block										
low pressure	NA	100%								
autoclaving	NA	NA	NA	NA	NA	NA	NA	100%		
Ready mix	100%									

FIGURE 5 Industrial process heat requirements.

Industrial Process Heat Requirements at Temperatures 300°F (149°C) and Below

Industry - SIC Group	Application Temperature Requirement °F	(°C)	Process Heat Used for Application 10^{12}BTU/Yr	(10^{12} KJ/Yr)
Group 10				
1. Copper Concentrate - 1021				
Drying	250*	(121)	1.7	(1.8)
Group 12				
2. Bituminous Coal - 1211				
Drying (including lignite)	150-250*	(66-104)	18.0	(19.0)
Group 14				
3. Potash - 1474				
Drying Filter Cake	250*	(121)	1.03	(1.09)
Group 20 - Food & Kindred Products				
4. Meat Packing - 2011				
Sausages and Prepared Meats - 2013				
Scalding, Carcass Wash and Cleanup	140	(60)	43.7	(46.1)
Edible Rendering	200	(93)	0.52	(0.55)
Smoking/Cooking	155	(68)	1.16	(1.22)
5. Poultry Dressing - 2016				
Scalding	140	(60)	3.16	(3.33)
6. Natural Cheese - 2022				
Pasteurization	170	(77)	1.28	(1.35)
Starter Vat	135	(57)	0.02	(0.02)
Make Vat	105	(41)	0.47	(0.50)
Finish Vat	100	(38)	0.02	(0.02)
Whey Condensing	160-200	(71-93)	10.2	(10.8)
Process Cheese Blending	165	(74)	0.07	(0.07)
7. Condensed and Evaporated Milk - 2023				
Stabilization	200-212	(93-100)	2.93	(3.09)
Evaporation	160	(71)	5.20	(5.48)
Sterilization	250	(121)	0.54	(0.57)
8. Fluid Milk - 2026				
Pasteurization	162-170	(72-77)	1.44	(1.52)

FIGURE 6

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INDUSTRIAL USES
ECONOMICS AND ECONOMIC ANALYSIS

by

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New Mexico State University

I. INTRODUCTION

This presentation will cover in broad fashion the relative economics of geothermal energy. In perspective, the cost of geothermal energy is compared with current and projected costs of conventional energy.

II. SECTION 1

Figures 1 through 5 provide a background for comparison of geothermal energy costs. Figures 1 and 2 are broad in nature, and provide generalized data. Figure 3 is typical energy costs. I will use this to put Southern California energy costs in perspective and provide a brief discussion of the long-term price hikes to be expected. California, in particular, is expected to see price hikes higher than the national average. Figures 4 and 5 provide an overview of the relative cost effectiveness of geothermal energy, as a function of economies of scale.

III. SECTION 2

Figures 6, 7, and 8 are representative costs for two of the major elements of the geothermal systems. I will use these four figures to expand on the theme that a user must perform a complete analysis of his problem to determine whether or not to drill on his own property or to buy hot water from some more distant resource. The user must consider the relative importance of having depeletion allowances and tax credits for his own development, as contrasted with allowing the off-site developers to use these incentives to hopefully provide lower energy costs to the user. Also of significance is the relative importance of energy price protection to the user. Figures 9 and 10 are representative examples, showing benefits of geothermal groundwater heat pumps for larger-scale application and an example of a shared use resource which would be economical for two small to medium energy users.

GEOTHERMAL DIRECT USE OVERVIEW

- Low to moderate resources plentiful

Heating:	65 - 170°F	(Ground water heat pump 65 - 120°F)
Cooling:	170 - 190°F	
Process:	140 - 250°F	

- Small scale projects (under $10 million)
- Shallow, inexpensive wells (750 - 1500 feet; $35,000 - $100,000)
- Requires retrofit for most existing facilities
- Can be used for heating, process heat, some cooling
- Special category, ground-water heat pumps

Figure 1

GEOTHERMAL GROUND-WATER HEAT PUMPS

- Useful Water temperature range 65 - 120°F
- Ideal for users with water wells
  - More economical than other energy forms
  - Easily retrofitted
- Suitable for most new construction
- Typical Annual Heating Costs (Las Cruces)

ENERGY	$ COSTS
Natural Gas	206
Oil/Propane	315
All Electric	563
Conventional H. P.	363
Geo Heat Pump	194

FIGURE 2

TYPICAL WESTERN STATES ENERGY COSTS

FUEL	UNIT PRICE	$/MMBTU
Natural Gas	$4.54/mcf	$4.54
Propane	$0.75/gal	$6.00
Diesel	$0.85/gal	$6.80
Electricity	$0.055/khw	$15.27

Figure 3

GEOTHERMAL COST for TYPICAL INDUSTRIAL USERS

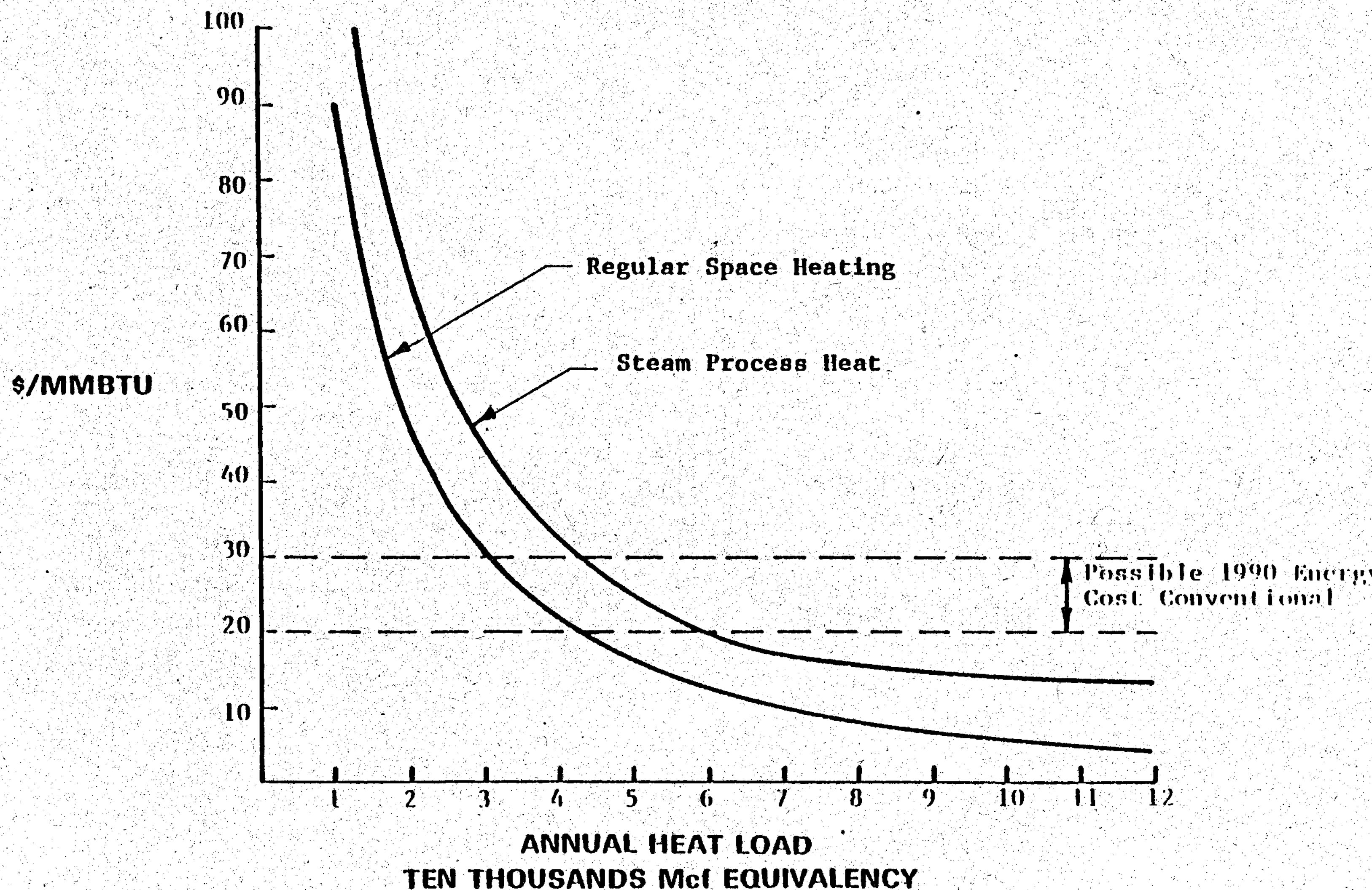
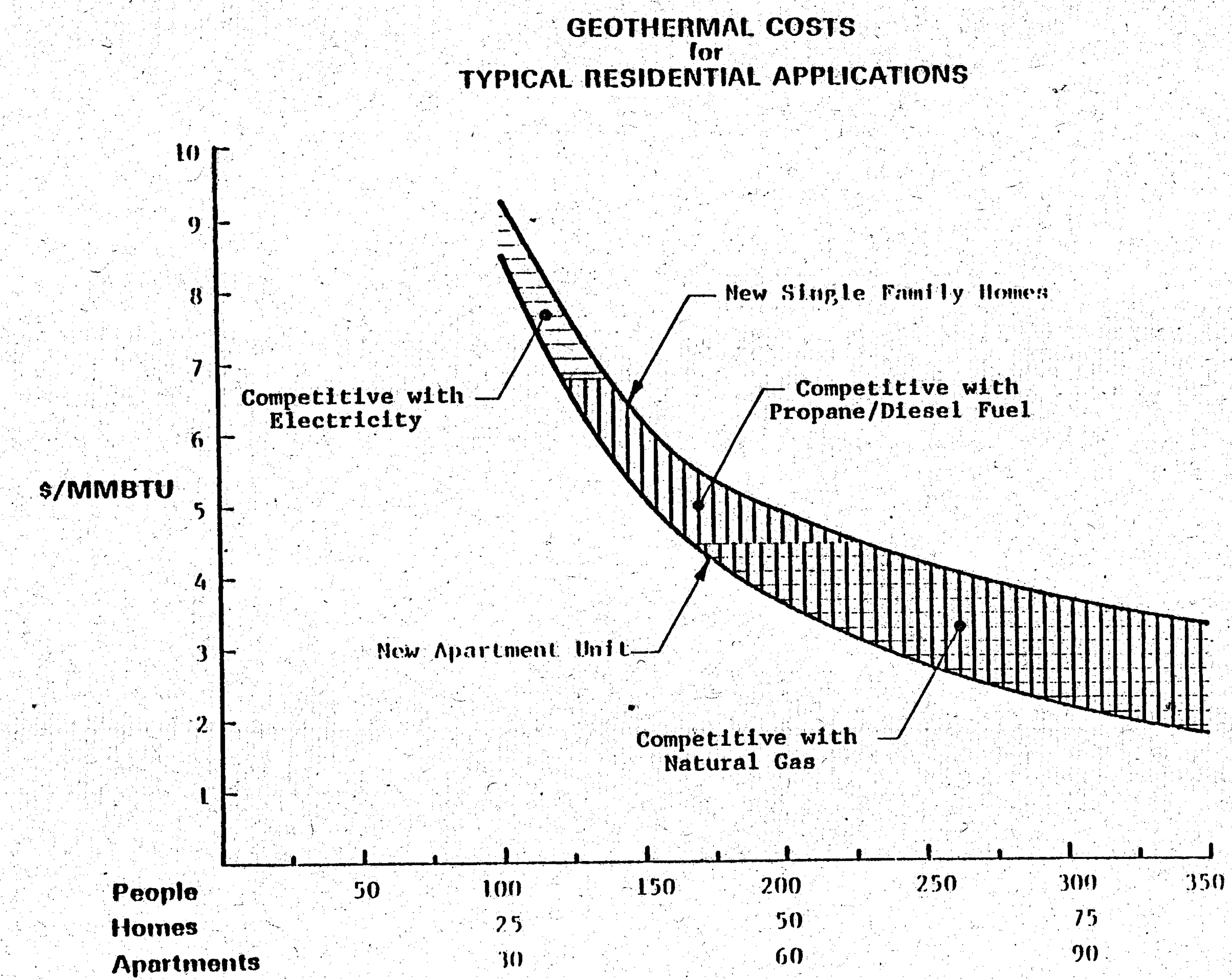


FIGURE 4



GEOTHERMAL COSTS
for
TYPICAL RESIDENTIAL APPLICATIONS
$/MMBTU
10
9
8
7
6
5
4
3
2
1
New Single Family Homes
Competitive with Electricity
Competitive with Propane/Diesel Fuel
New Apartment Unit
Competitive with Natural Gas
People 50 100 150 200 250 300 350
Homes 25 50 75
Apartments 30 60 90

Figure 5

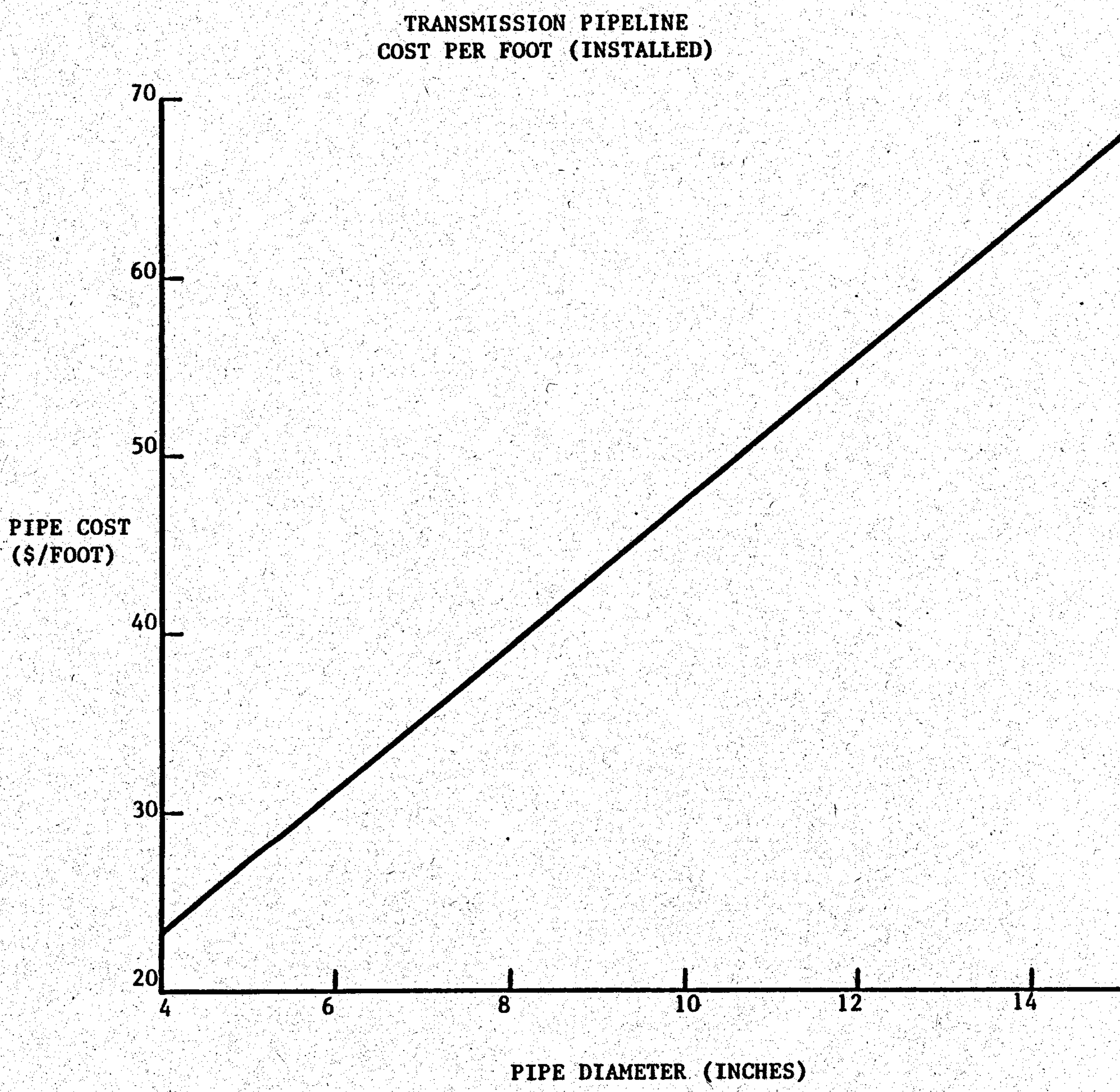

TRANSMISSION PIPELINE
COST PER FOOT (INSTALLED)
70
60
50
PIPE COST
($/FOOT)
40
30
20
4
6
8
10
12
14
PIPE DIAMETER (INCHES)

Figure 6

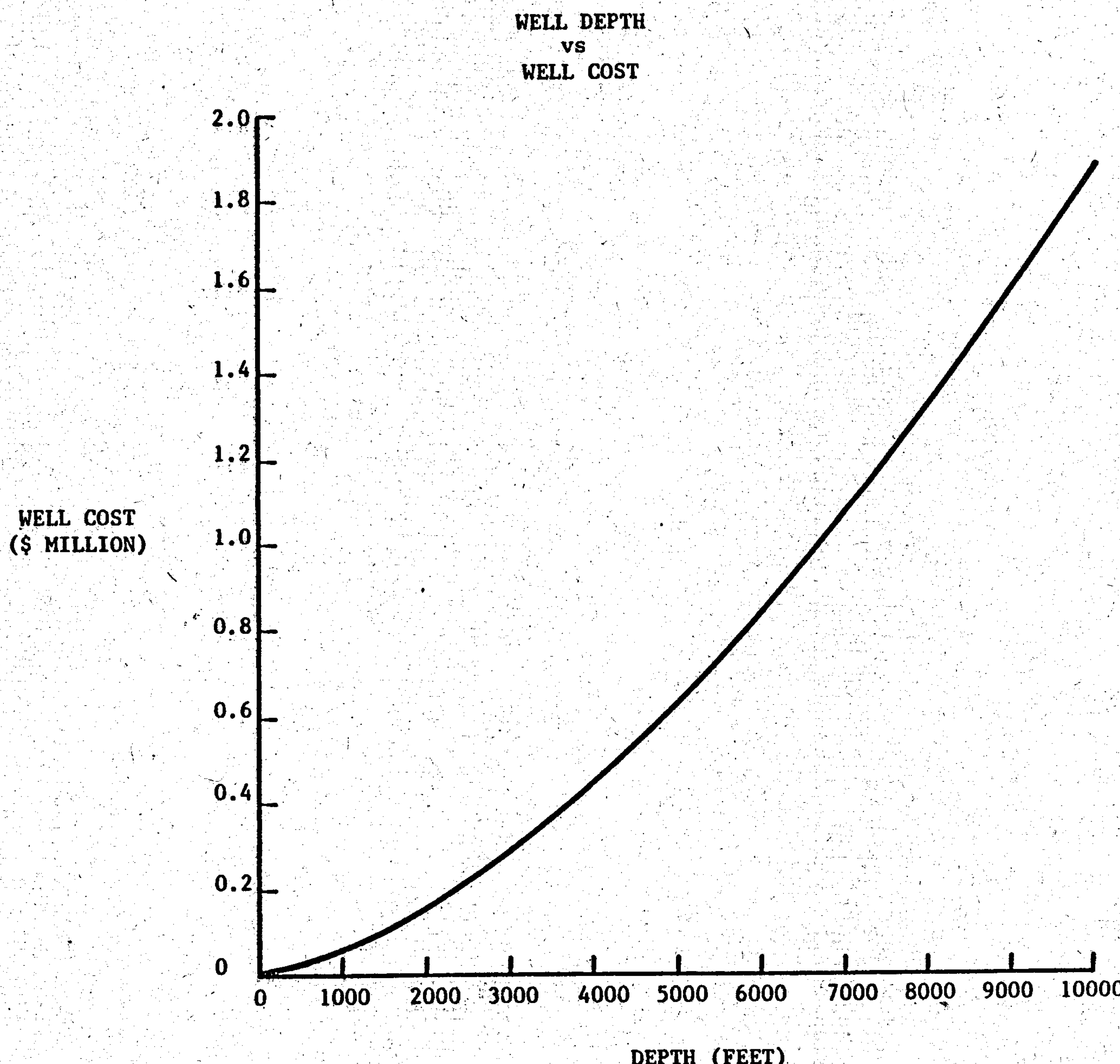
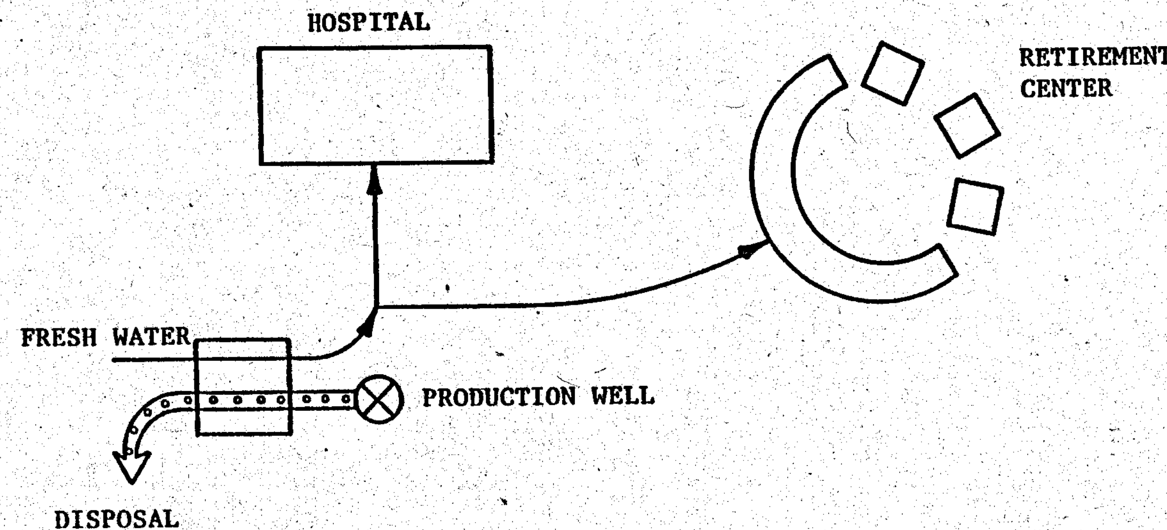

WELL DEPTH
vs
WELL COST
WELL COST
($ MILLION)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
DEPTH (FEET)

Figure 7

GOOD "SMALL" APPLICATION



- EACH USER: 6,000 MMBTU/YEAR (TOTAL 12,000)
- WELL PARAMETERS:
  - DEPTH: 600 Feet
  - TEMP: 130°F
  - FLOW: 70-100 gpm
- PAYBACK PERIOD: 2-3 YEARS

Figure 10

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INDUSTRIAL USES
AVAILABILITY AND COST OF HARDWARE

by

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I. HARDWARE INVOLVED IN GEOTHERMAL SYSTEMS

A. TYPES OF HARDWARE

1. Well Pumps and Drivers (available with proper metallurgy)

    a. Submersible--Moderate volumes and high lifts. Lifts to 15,000' 750 HP.

    b. Vertical Turbine--High volume, shallower lifts. Lifts to 800' less at temperatures above 250°F, 1,000 HP.

    c. Variable Speed Drivers--1 to more than 1,000 HP. Power savings of about 40 percent.

2. Heat Exchangers

    a. Shell and Tube--For flashing or condensing.

    b. Tube in Tube--Simple design, poor performance.

    c. Plate--Small size, large heat transfer, low pressure drop. Flows to 3,500 gpm, pressure to 300 psi, temperature to 500°F

3. Heat Pumps (where temperature boost required)

    a. Water/Water Type--To 5 x 10^6 Btu/hr single stage 150°F, 2 stage 220°F.

    b. Water/Air--Less than 10,000 Btu/hr to over 50,000 Btu/hr.

4. Piping and Piping Insulation

    a. Piping, Metallic, and Nonmetallic

        (1) Metallic--Normally carbon steel. Stainless too expensive, aluminum and copper unsatisfactory for corrosion reasons

        (2) Nonmetallic--Inert to normal chemical compounds. Limited by temperature

(a) Polyethylene 100°F Maximum

(b) PUC--2 Grades, About 140° Maximum

(3) Chlorinated Polyvinyl Chloride (CPVC) 180°F Maximum

(4) Polybutylene 200°F Maximum

(5) Epoxy Lined Asbestos Cement 200°F Maximum

(6) Fiberglass Reinforced Pipe (FRP) Polyester 200°F, Epoxy 300°F

(7) Carbon Steel +700°F, External Corrosion, a Problem with Buried Pipe

b. Insulation, Various Types, Prefoamed Polyurethane Widely Used

5. Space Heating Equipment

a.	Bare Tubes in Floor Slab	85°F minimum
b.	Finned Tubes in Forced Air Duct	105°F minimum
c.	Forced Air Flow Convectors	120°F minimum
d.	Natural Air Convectors	140°F minimum
e.	Radiators	160°F minimum

6. Valves and Controls, Simple, Same as Hydronic System

B. INSTALLATION

1. Done by normal craftsmen.

2. With the plastic pipe, the manufacturers instruction must be carefully followed.

3. Mostly predesigned or "off the shelf" items. Most less than three-month delivery.

C. COST--HIGH CAPITAL, LOW OPERATING

1. Retrofit versus new installation.

2. Well and well pump can be a major capital cost.

3. Pipe insulation a major cost. May not have to insulate.

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FINANCING AN INDUSTRIAL GEOTHERMAL PROJECT

by

John H. Woods
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I. INTRODUCTION

Industry, since the oil embargo of 1973-74, has been conducting extensive in-house reviews of their energy requirements as this cost component of their operations has increased substantially. Besides the major increase in energy cost, industry is also concerned with the availability of its fuel source. Therefore, geothermal energy offers a viable alternative. It is now up to the geothermal industry to promote its benefits to potential users.

II. FINANCING

The structuring of a geothermal project loan is basically the same as any alternate energy project. There are some differences, primarily the need to locate the overall project near the energy source. In many cases, this disadvantage of location offsets the benefits of the cost savings/availability of a reliable energy resource. For example, the need to be near a major transportation center can be more critical to certain industries than a reliable energy source (automobile manufacturer). Another feature that makes geothermal different than other energy resources is the benefit of "cascading," where temperature ranges can be utilized for various industrial applications. Iceland is a good example where geothermal resources are used for electricity, space heating, and for greenhouse heating.

In order for a lender to completely evaluate a given industrial geothermal project, they require information in the following areas:

- o Borrower,
- o Management,
- o Financial/Economics,
- o Project,
- o Geothermal Resource,
- o Resource Utilization,
- o Marketing, and
- o Legal/Regulatory.

Once the lender has evaluated this information, it is in a position to evaluate the risks associated with the project and if it is satisfied, can determine its loan requirements and pricing. Not every lender will evaluate its requirements or pricing in the same way, as business and loan policy varies from institution to institution.

INDUSTRIAL USES

A DEVELOPMENT STRATEGY FOR COVER FORT-SULPHURDALE, UTAH

by

Wayne A. Portanova
Mother Earth Industries

Introducing geothermal energy to the industrial marketplace is basically a new product introduction. Our new product is an unknown to most industrial users. Once acquainted, potential users may concede the relative advantages of geothermal usage in theory, but in practice they perceive large risks with any new energy form. As geothermal developers, we view our first task as one of risk reduction through entrepreneurial project development. If successful, we believe special adaptation of our geothermal resource to the needs of specially targeted industrial users will motivate them to relocate to our industrial complex on a profit sharing basis.

Stage One of the development strategy for the Cover Fort-Sulphurdale KGRA is to put the energy to use in a display case industrial process. Once we can show the advantages of geothermal, i.e., lower cost and reliability, we believe selected industrial users can be convinced that we offer a unique competitive advantage via lower energy costs.

The cornerstone of this strategy centers around our efforts over the past 12 months to develop a proprietary process to extract high-purity elemental sulfur from moderate grade ores, relying primarily on geothermal fluids for process energy.

The following reasons highlight our selection of this project:

1. Energy is a major component of the extraction process, yielding a significant competitive advantage.

2. World sulfur markets are extremely tight, permitting easy product marketing and healthy margins.

3. Moderate grade ore deposits are in close proximity to the geothermal field.

4. No one, to our knowledge, has successfully implemented a large-scale geothermally based industrial operation in the United States of America, allowing us the opportunity of becoming a market leader.

The prime difficulty experienced over the past year has not really been geothermally related at all. The two geothermal production wells have temperatures of 330 and 290 degrees F, which appear perfectly suited to sulfur extraction because of sulfur's 235 degree F melting point. However, experimentation with extraction processes to melt sulfur from the ore has lead us through three pilot process plants before achieving what we think may be the right technological approach. In short, we found it necessary to create a new process technology to match the industrial needs of the project with the available geothermal resource. We think other geothermal developers may experience this same challenge as they try to market their particular geothermal energy.

We recognize that there are probably less risky methods of putting the geothermal resource to work, such as promoting space heating or industrial drying. However, the types of industrial users we are interested in attracting to our industrial complex (e.g., pharmaceutical and electronic manufacturers) have industrial energy needs requiring custom tailoring. Special adaptation yields value-added for the industrial user and, as a result, a profit sharing developer.

While this may not be the best strategy for other developers, we believe we have assembled the right combination of elements, including geothermal resource, location, and management talent to make this a feasible approach for the industrial development of Cover Fort-Sulphurdale, Utah.

FOOD PROCESSING

MODERATOR: Paul Rodzianko

PANELISTS: Jack Cherne/Jay Seidman/George Gelb, TRW Energy Systems
Uses of Geothermal Energy in Food Processing

Gerald W. Huttrer, Republic Geothermal, Inc.
Economic Considerations

Joe V. Mullin, Proctor-Schwartz, Inc.
Food Processing Hardware--System Design Considerations

Paul Rodzianko, Geothermal Energy Corporation
Financing: Direct Use Projects

Jay F. Kunze, Forsgren/Perkins and Associates P.A.
Drilling and Reservoir Evaluation

WORKSHOP PANEL OUTLINE
FOOD PROCESSING

by

Paul Rodzianko
Panel Moderator

I. USE OF GEOTHERMAL ENERGY IN FOOD PROCESSING--Jack Cherne/Jay Seidman/George Gelb, TRW Energy Systems

A. Uses

- o Dehydration
- o Cooking
- o Drying
- o Freezing
- o Etc.

B. Plant Design Considerations

- o Available Data (existing processes)
- o Available Data (new processes)
- o Movement of Industry into the Field (timing)

II. ECONOMIC CONSIDERATIONS--Gerald W. Huttrer, Republic Geothermal, Inc.

A. Basic Parameters

- o The Resource
- o Geography
- o Market Considerations
- o Environmental Aspects
- o Timing

III. FOOD PROCESSING HARDWARE-SYSTEM DESIGN CONSIDERATIONS--Joe V. Mullin, Proctor-Schwartz, Inc.

A. Basic System Concepts

B. Design Considerations

C. Food Processing Applications

D. Conclusions

IV. FINANCING: DIRECT USE PROJECTS--Paul Rodzianko, Grace Geothermal/Geothermal Energy Corporation

A. Project Risk Assessment

- o Economics
- o Management
- o Marketing
- o Technology/Resource
- o Graphic Viability
- o Financial Climate

B. Sources of Financing

- o Commercial
- o Savings and Loans
- o Investment Bankers
- o Public Sectors

C. Financing Structures

- o Equities
- o Debt
- o Corporation vs. Project Financing

D. Conclusions

V. DRILLING AND RESERVOIR EVALUATION--Jay F. Kunze, Energy Services, Inc.

A. Drilling the Well

- o Well Planning
- o Rig Selection
- o Permits
- o Site Preparation
- o Auxiliary Services
- o Discovery
- o Costs

B. Well and Reservoir Evaluation

- o Well Stimulation
- o Artesian Flow
- o Reservoir Evaluation
- o Injection

USE OF GEOTHERMAL ENERGY IN FOOD PROCESSING

by

Jay Seidman
TRW Energy Systems

Where it can be used, the value and applicability of geothermal energy for the food processing industry can be measured in strictly economic terms. Within the realm of the food industry, geothermal resources that range from 20°F to 350°F offer direct applications of an energy resource that would otherwise have little value. Falling below the temperature ranges where it may be worthwhile to produce electricity on one hand (about 300°F - 150°C) and above the space heating range (below 175°F - 80°C), geothermal applications range from drying organic materials to evaporation and curing of food products.

Using geothermally produced heat in lieu of heat from gas, oil, or electricity usually implies some modification to process cycle time and/or equipment. Each of these can have a serious economic or process impact on the actual product. Food processing may be time dependent, in that prolonged exposure to low heat is not equal to short exposure to high heat with a degradation to the food product. Under these conditions of changes in process cycle time, other means of using the available geothermal heat must be established or extensive investigations into the actual cycle times for processing the food product developed.

Similarly, the availability of the heat at reduced temperatures may imply major modifications to existing equipment. Whereas current equipment may use high heat for short periods of time, with short exposure, low heats mean that the exposure time may be very large. For example, dryers may change from rotating drum types to long conveyer belt types with multiple drying stages (assuming that the product can be dried over these longer time periods).

In addition to the equipment and process time considerations, the physical availability of the geothermal energy at a site where it can be used in an overall economically competitive fashion must be evaluated. Practically, this has a serious impact on the use of geothermal energy, since this energy is generally available in areas that are not marketing centers. The economics associated with developing a food processing plant in those areas becomes the major consideration.

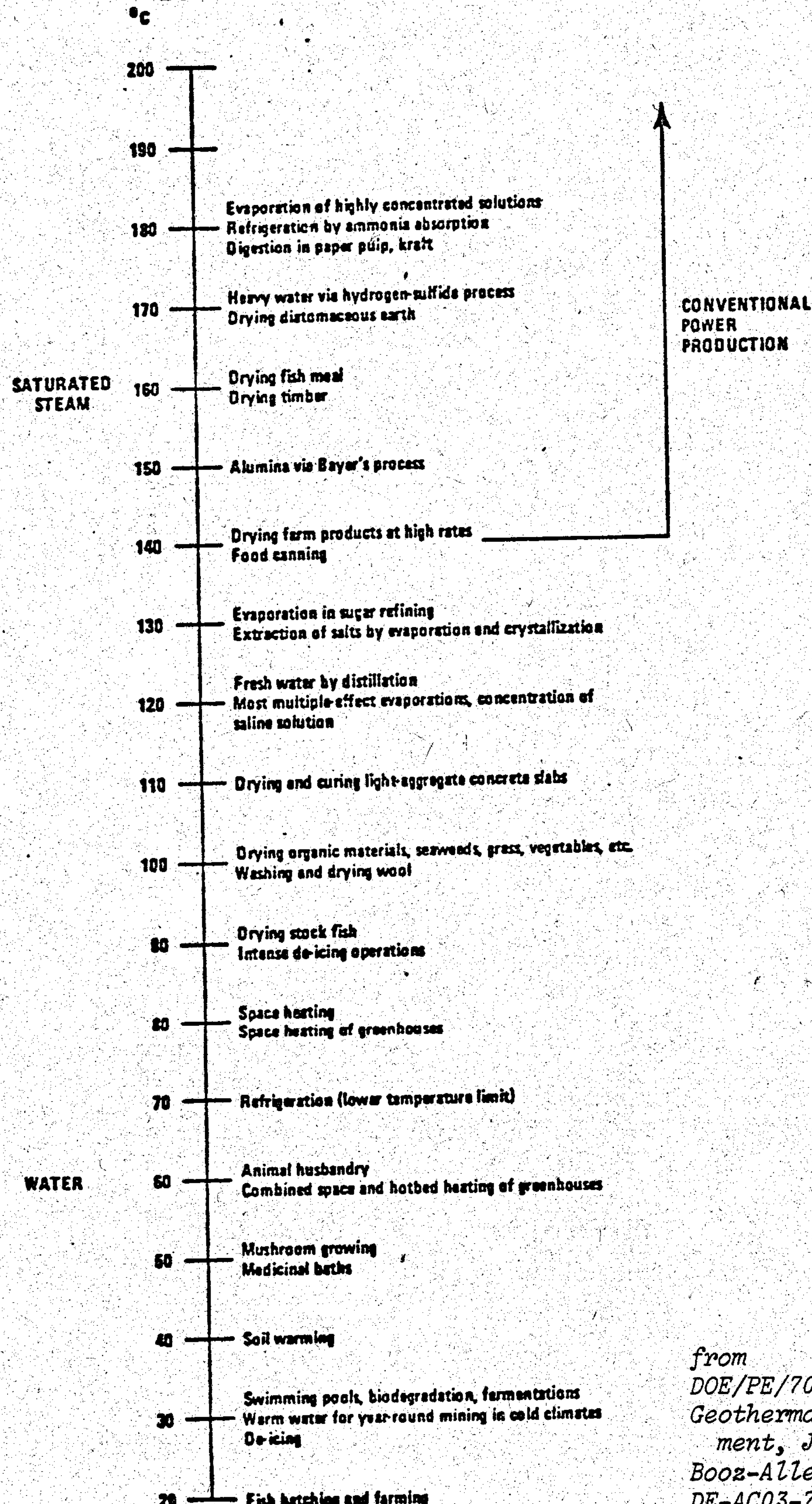
On the positive side, there is little question that if these three parameters are successfully solved, the use of geothermal energy as the energy source for many of the processing functions can prove valuable to the food processing industry. This has been amply demonstrated in dehydration, cooking, drying, freezing, and as an auxiliary source of plant maintenance.

The spectrum of applicable food processing industries that can capitalize on geothermal energy has had to be evaluated in terms of competing energy sources and has only been successful where the cost of the geothermal energy was demonstrably less than that of the available competing energy.

Plants have been built encompassing geothermal fluids for dehydration, cooking drying, and freezing, as well as auxiliary plant requirements for electricity and steam. In many cases, it has been necessary to cascade the energy in order to attain the competitive economic status.

Figure -1-

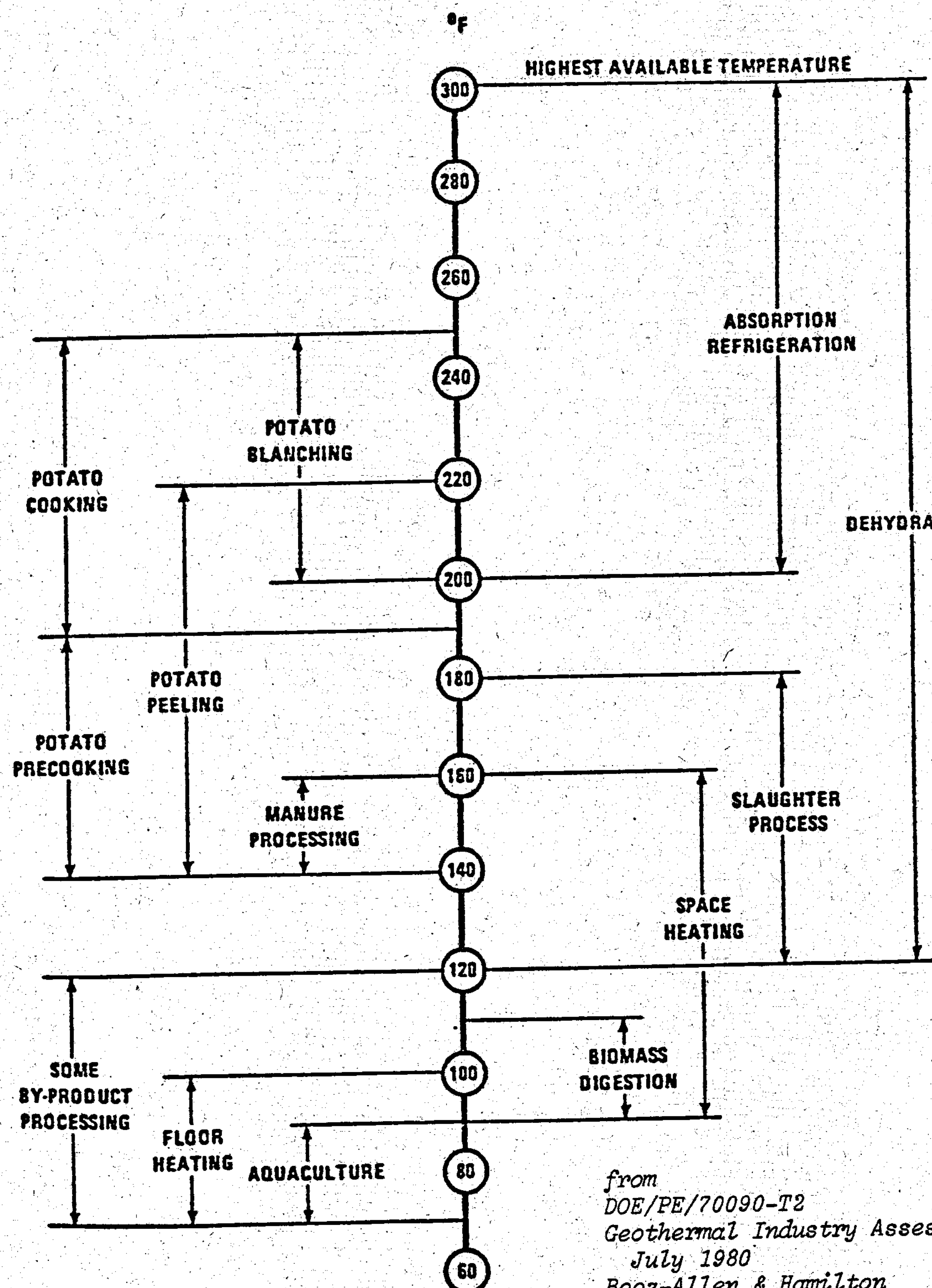
Approximate Geothermal Fluid Temperatures for Nonelectric Applications



from
DOE/PE/70090-T2
Geothermal Industry Assessment, July 1980
Booz-Allen & Hamilton
DE-AC03-79DE-70090

Figure
-2-

Approximate Range of Subsystem Temperatures



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FOOD PROCESSING
ECONOMIC CONSIDERATIONS

by

Gerald W. Huttrer
Republic Geothermal, Inc.

I. BASIC PARAMETERS TO CONSIDER

A. The Resource

1. Adequate Temperature--For planned use after cooling due to transportation

2. Adequate Quantities--For provision of needed Btu per hour.

3. Chemical Quality--Must be benign enough to minimize or avoid scaling, corrosion, or contamination of agricultural products

4. Recharge--Must be adequate to replenish the resource for at least 30 years and to minimize subsidence tendencies

5. Reservoir Size--Must be great enough to sustain production for 30 or more years

B. Geography

1. Land--Must be available for purchase or lease, including the rights to geothermal resources, at a reasonable cost

2. Transportation--Facilities should be nearby; airports within 100 miles if possible; railheads within 25 miles; and all-weather highways adjacent

3. Labor--Should be available within reasonable commuting distance; otherwise expensive infrastructure may have to be built

4. Climate--May determine the viability of outdoor product and/or raw material storage; will also determine the magnitude of space heating requirements (geothermal or conventional)

5. Topography--Should be amenable to relatively inexpensive facility construction

6. Fresh Water--Must be available for a multitude of reasons

C. Market Considerations

1. Raw Materials--Should be available readily or easily shipped in

2. Market--Must be accessible and predefined; contracts desirable to obtain financing

3. Commodity Stability--Must be assured for at least 30 years; i.e., no fads or cyclical products

4. Market Trends--Should be positive and on the upswing

5. Alternative Crops--Should be available so as to ensure maximum utilization of the resource on a year-round basis

D. Environmental Aspects

1. Site--Must not be constrained by ecological, archeological, historical, and/or social conditions

E. Timing

A food processor considering a change to or initiation of a geothermal plant must study its cash-flow prognoses and confirm that the project is going to begin at the right stage in the firm's growth.

SUMMARY

of

Title: FOOD PROCESSING HARDWARE
SYSTEM DESIGN CONSIDERATIONS

PRESENTATION

by

Dr. Joe V. Mullin
Proctor-Schwartz, Inc.

INTRODUCTION

Proctor-Schwartz manufacturers and installs process equipment to all the process industries: foods, chemicals, minerals, and textiles. Two-thirds of the company's work is domestic, including Canada. One-third is offshore, outside the continental United States. The work involves drying, roasting, toasting, baking, curing, heat treating, calcining--just about anything you can do with heat to process a particular product. We handle everything from vegetables to titanium dioxide pigment to polyester fibers. Characteristically, all these processes require considerable quantities of heat.

In 1973 there began a concern about energy supplies. Proctor-Schwartz began looking at many alternative energy resources to augment energy. Finally, we began to look at alternatives, specifically to natural gas and very much in the vegetable dehydration business. In California we are a major builder of equipment for the processing of vegetables and, in particular, onions.

DIRECT CONTACT VS. INDIRECT CONTACT SYSTEMS

In a direct contact system the geothermal fluid is put in direct contact with the end product. In an indirect contact system, the geothermal fluid is brought into a heat exchanger, which is part of the equipment, rather than using a separate heat exchanger. The hot air is passed through a coil, a fan, then through the bed of the product to extract moisture from it or to heat it, toast it, roast it, or whatever you are attempting to accomplish. Then as the air cools through the product, it is then reheated as it returns to the coil. This is important to remember because that is the type of system that is currently operating at Paul Rodzianko's plant, and yet it is not the kind of system that I, as a conservation engineer, originally proposed at that plant.

CORROSIVE SPECIES

The species that are most common in geothermal fluid are oxygen, hydrogen ion, chloride, sulfide ion, hydrogen sulfide (toxic material), and other materials that may not be toxic; but they do cause some difficulty, such as:

1. Pitting of metal surfaces,

2. Crevice corrosion which occurs in sharp reentering corners at the edges of wells or wherever there might be a deep slot, and

3. Stress corrosion and galvanic coupling.

These are not unsolvable problems but problems we must address in design. The easy way to solve these problems is to use an isolation system. With the isolation system in the primary heat exchanger, you only have to worry about the working fluid which is nicely controlled. The working fluid must be treated so it does not cause corrosion and scaling which are serious considerations to boiler users. Water treatment expenses for tap water are common. Corrosion is always a design consideration. Material selection is important as well as the type of system involved.

BASIC DATA ON PERFORMANCE OF THE HEATING COIL

A heating coil is a fluid to air heat exchanger. Heated geothermal fluid enters the heat exchanger where cool air is blown through; heat is transferred from the fluid to the air. By measuring the temperature drop between the front and end of the coil, we can estimate how efficiently the coils transfer heat to the air. Copper has 100 percent heat transferability. Mild steel is 90 percent of the efficiency of heat transfer of copper. Stainless steel is 70 percent of the efficiency of heat transfer of copper. Therefore, you pay a price of going to more exotic metals like stainless steel, not just the price of the metal itself, but the price of inefficiency. Additional coil will be needed in order to obtain the same heat transfer characteristics. As an engineer, that means I have to design a machine that fits more steel and more coil surface. I have to increase perhaps the configuration of the machine or just maybe stack more coil.

If you look at Raft River data, which measured the exposure of different materials to geothermal fluids, you will find copper and copper divided by nickel, a combination, do not do the job; they are susceptible to corrosion. Mild steel is acceptable in thick wall vessels but not in thin wall tubes, as you tend to get a lot of pitting, corrosion, and loss of metal surface. Therefore, what is left to use is stainless steel. 316 stainless steel can do the job. But you are paying the price of using stainless steel, in efficiency, for the price of stainless steel itself. Nonetheless, it is a solvable problem. It is a trade-off between price, efficiency, and long-term use. These are the kinds of problems engineers have to take into account when making this process equipment applicable to the problem.

FOOD PROCESSING
FINANCING: DIRECT USE PROJECTS

by

Paul Rodzianko
Grace Geothermal
Geothermal Energy Corporation

I. PROJECT RISK ASSESSMENT

A. Process Economics--Are the basic economics of the project able to earn a rate of return consistent with industry expectations? (Exclude special tax considerations in this analysis.)

B. Management--Do the personnel assigned to or originating the project have a track record of successfully coping with the industry's challenges? In a start-up situation, this aspect becomes particularly crucial.

C. Marketing--Is there a demonstrated market for the product or does one have to be created? Will the project depend on an existing sales force, a contract for output, or other approach?

D. Technology/Resource--Are there significant risks associated with these areas? Is the technology proven or the first of its kind? Is there an operating history associated with the geothermal resource or not?

E. Geographical Viability--Is a work force readily available? Does infrastructure exist to support the planned project? Are there other intangibles that could affect the project?

F. Financial Climate--Is the financial marketplace in a mode that encourages new plant investment or not? Interest rates, taxation, alternative opportunities, trendiness, etc.

II. SOURCES OF FINANCING

A. Commercial banks--Generally, conventional five to seven year lending at a rate floating over prime.

B. Savings and loans--Generally, mortgage lenders over middle to long-term at fixed rates, but variations exist.

C. Investment Bankers--Generally, structure transactions, including both debt and equity aspects, as well as other kinds of financing such as limited partnerships and R&D partnerships.

D. Public Sector Financing--Has been available in the form of grants, loans, and loan guarantees. States have varying energy programs with California and Oregon being among most active. Federally, the Geothermal Loan Guarantee Program appears in limbo and grants seem to have been cut back.

III. FINANCING STRUCTURES

A. Equities--Common and preferred.

B. Debt--Varying terms, recourse or nonrecourse, convertible features.

C. Corporate vs. Project Financing--Financing availability will depend on credit strength of entity itself or its sales contracts.

IV. CONCLUSIONS

Obtaining financing for a project is the acid test of its being economically viable. The closer to its being a start-up, the harder it is for a project to obtain nonrecourse debt financing. For direct use geothermal, the resource itself is only one of six main areas on which a project is evaluated and, as the result of a deficiency in any one of which, financing could be denied.

FOOD PROCESSING
DRILLING AND RESERVOIR EVALUATION

by

Jay F. Kunze*
Energy Services, Inc.

I. DRILLING THE WELL

A. Knowing (or not knowing) the target depth, formations to be encountered, at what depth the reservoir is to be found, etc. It is obviously of considerable advantage to have some information (or intuition!) concerning the above. Without such information, the well should be considered a "wildcat" well and surprises and high drilling costs are to be expected.

B. Rig selection is usually made on the basis of some of the above information. Rotary rigs are the overwhelming choice for geothermal wells, but cable tool rigs have their place for the shallower wells and for setting the surface casing in areas where loose sediments and much cool near-surface groundwater is present. (See Figure 1 for typical well design.)

C. Permits and other institutional factors should be resolved before committing to a drilling contract. Most western states have geothermal drilling regulatory agencies (usually the water resources department) which require permits. The permit is usually not issued without a detailed well design plan and use plan. On federal land, the U.S. Geological Survey is the cognitive agency to assist the agency that controls the land. Plans must be detailed, and permits typically require many months to obtain. Appropriate leases at the drilling site and surrounding it should be obtained to protect the developer.

D. Site preparation requires road access by heavy equipment, maneuvering room, a large pit to collect drilling fluids, etc.

E. Auxiliary services such as "mud" suppliers, stab equipment, cementing services, casing crews, logging, etc., must be arranged. A single drilling engineer usually is responsible for all such arrangements.

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*Jay F. Kunze is Vice President and General Manager of Energy Services, Two Airport Plaza, Idaho Falls, Idaho 83402. He received his Ph.D. in physics in 1959 and is a licensed mechanical engineer in several states. He was the developer and manager of the geothermal programs at the Idaho National Engineering Laboratory, such as the Raft River and Boise developments, from 1973 to 1978. In 1978 he formed Energy Services, Inc., a company that specializes in developing geothermal resources for clients who intend to use the heat for space heating or industrial processing.

F. Discovering the geothermal resource during drilling is difficult because the drilling fluid medium is the same as the formation fluid being sought, quite a different case from gas and oil.

G. Cost of geothermal hole to a given depth can vary by factors of two and more, depending not only on the types of formation but on the drilling techniques used. (Figure 2 is a summary of recent costs.)

II. WELL AND RESERVOIR EVALUATION

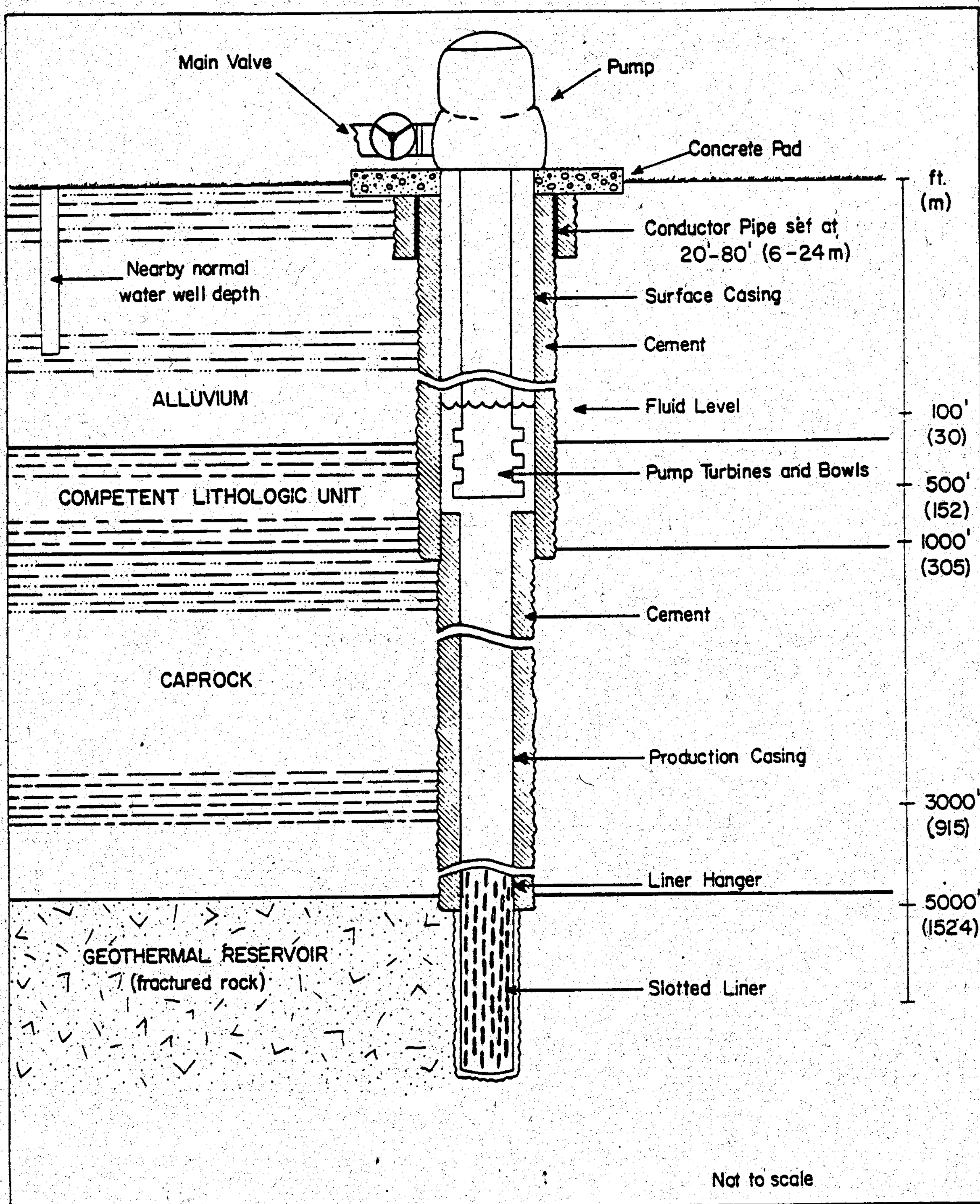
A. Stimulating and adequately protecting the production zone of the well is a prime consideration before and during well testing.

B. Artesian flow testing and/or pump testing can determine the expected long-term performance of the well, based on assumptions concerning the reservoir or supplying conduits. However, physical changes such as chemical blockage cannot be predicted by these tests.

C. Reservoir evaluation is important if more than one well is to be drilled for production and/or reinjection. Generally, additional observation points other than the producing well are needed.

D. Reinjection of the geothermal water after it has been used will become a more common requirement as geothermal energy development progresses throughout the country. Much geothermal energy occurs in areas of water shortage, and consumptive discharging of the used water is seldom permitted. An exception would be in cases where the geothermal water is substituted for other water rights for existing uses. If such is possible, then the chemical quality of the geothermal water and its environmental impact are important.

From GRC Special Report No. 7 (1979)



Typical design for a low- to moderate-temperature geothermal well.

FIGURE 1

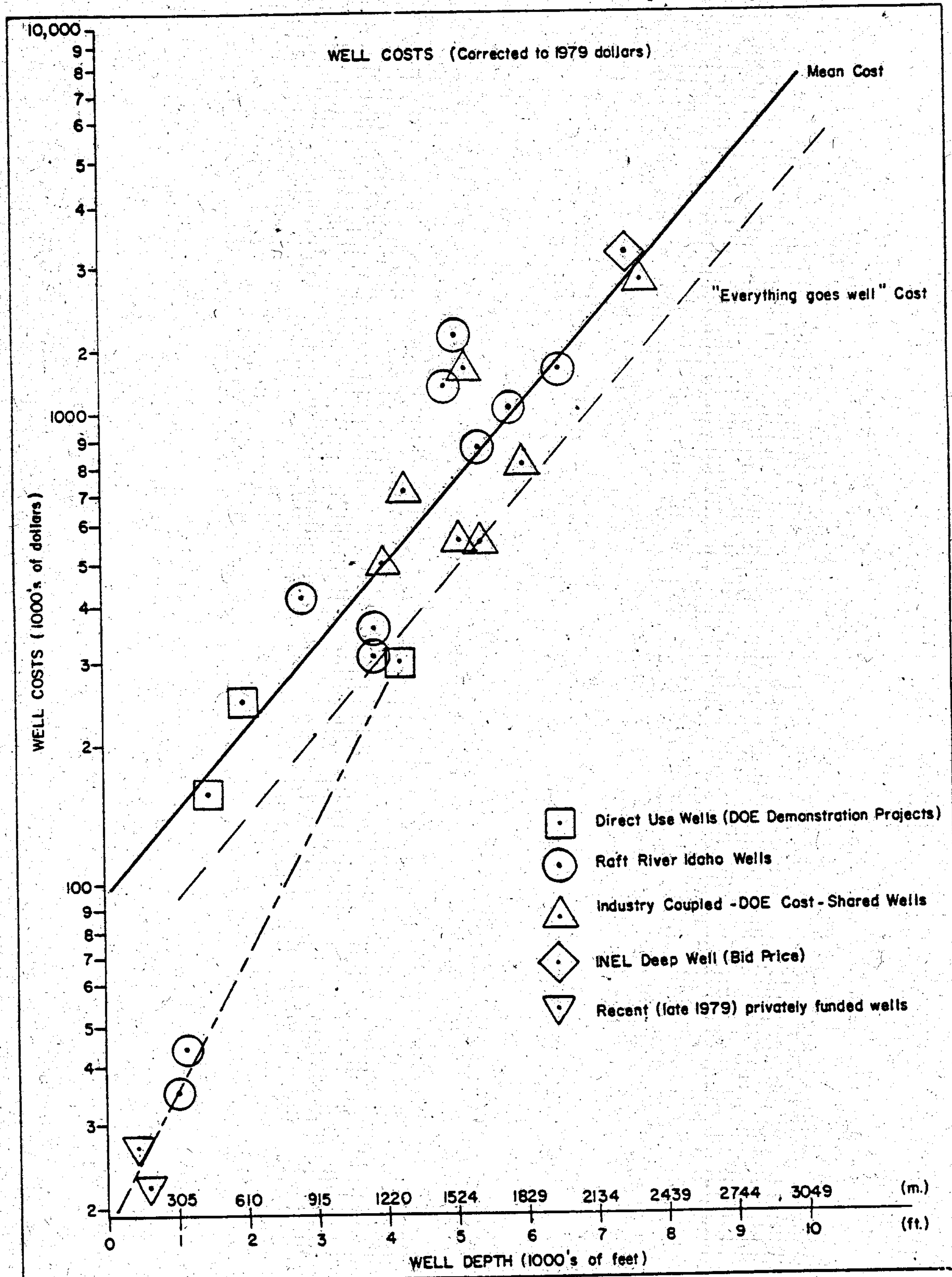


FIGURE 2 Typical drilling costs for geothermal wells (corrected to 1979 dollars).

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A useful and understandable textbook on well and reservoir evaluation.

AGRICULTURAL PRODUCTS

MODERATOR: Leonard A. Fisher

PANELISTS: Sal Pantano, Geothermal Floral, Inc.
Greenhouse Operations, Alturas, California

Kenan Smith, Oregon Institute of Technology
Aqua Farming with Geothermal Energy

Charles V. Higbee, Oregon Institute of Technology
Economic Considerations

Leonard A. Fisher, Leonard Fisher Co.
Hardware Availability and Considerations

Paul Rodzianko, Geothermal Energy Corporation
Financing

Eugene Luhdorff, Luhdorff, Scalmanini Consulting Engineers
Well Construction and Reservoir Assessment

WORKSHOP PANEL OUTLINE
AGRICULTURAL PRODUCTS

by

Leonard A. Fisher
Panel Moderator

I. GREENHOUSE OPERATION--ALTURAS, CA--Sal Pantano, Geothermal Floral, Inc.

A. Structure and Equipment

- o Structure of Facility
- o Heating
- o Cooling
- o Fresh water

B. Specific Crop

- o Gerberas
- o Market
- o Shipping

C. Expansion

D. Decision History

II. AQUA FARMING WITH GEOTHERMAL ENERGY--Kenan Smith, Geo-Heat Utilization Center

A. Definition

- o Background
- o Potential Crops

B. Why Use Geothermal Energy?

- o Increase Growth
- o Provide an Artificial Environment

C. OIT Research Programs

- o Background
- o Results

D. Conclusions

- o The Resource
- o Site Location
- o Pond Design
- o Temperature Control
- o Labor

III. ECONOMIC CONSIDERATION--Charles V. Higbee, Geo-Heat Utilization Center

A. Basic Parameters

- o Location Compatible with End Use
- o Heat Pumps
- o Resource Temperatures
- o Sizing Heat Load
- o Cascading
- o Design
- o Flow Rates
- o Transportation System
- o Labor Availability
- o Climatic Conditions
- o Comparison with Other Energy
- o Forecasting Problems

B. Market Considerations

- o Market Availability
- o Transportation
- o Labor

IV. HARDWARE AVAILABILITY AND CONSIDERATION--Leonard A. Fisher, Leonard A. Fisher Company

A. Availability of Hardware

- o Pumps

- o Piping
- o Heat Exchangers
- o Heating Systems

B. Equipment Installation

- o Site Considerations
- o Costing
- o Scheduling

C. Future Developments

V. FINANCING--Paul Rodzianko, Grace Geothermal/Geothermal Energy Corporation

A. Project Risk Assessment

B. Sources of Financing

C. Financing Structures

D. Conclusions

VI. WELL CONSTRUCTION AND RESERVOIR ASSESSMENT--Eugene Luhdorff, Luhdorff & Scalmanini, Consulting Engineers

A. Well Design and Construction

- o Importance
- o Preliminary Design
- o Well Construction
- o Final Design
- o Well Completion

B. Reservoir and Well Assessment

- o Importance
- o Test Procedures and Data Requirements
- o Reservoir and Well Analysis
- o Costs

AGRICULTURAL PRODUCTS
GREENHOUSE OPERATION--ALTURAS, CALIFORNIA

by

Sal Pantano
Geothermal Floral

Our greenhouse is a double poly house with a swamp pad cooling system. Our source of heating is from an artesian hot spring that flows at 350 gallons per minute at 210° Fahrenheit. We are pumping direct from the spring to our greenhouse. In the greenhouse, there are four miles of EPDM (ethylene-propylene-diene-monomer) tubing. The underroot heating system should cut overall heating costs while making growing much more productive. The overhead tubing will heat the air above the plants, thus allowing more of the root heating to remain closer to the plants where it is needed most.

Our heating control system is set right in the plant soil; it is set for 65° to maintain the temperature at the root leave so it does not go below or above the 65°.

Our swamp coolers are also set to maintain the greenhouse temperature in the daytime at 68°. When the greenhouse is closed up in the evenings, the air is circulated using a fan that blows air through a clear poly tube with air holes in it running the entire length of the greenhouse.

Our fresh water for irrigation is pumped from the same well that services the grower's mobile home. We attempted to drill a fresh water well closer to our greenhouse and went to 680 feet only getting 3 gallons a minute. When we go to a large complex we will have to put in a storage tank to make sure we have sufficient water for our needs at that time.

Our gerberas arrived July 9th, and on September 15th three flowers were cut and we expect to have a supply for our wholesalers in Reno and Portland by mid-October. Our production between now and then will be used by the local florist in Alturas.

Shipping will be by truck. The flowers will be picked up at our headhouse by a local freight firm in Likely, taking the flowers direct to Reno or Redding where they will be transferred to go on to Portland. The freight firm offers both refrigerated and heated trucks, so we do not expect to have any problems getting our flowers to our present markets.

When we expand to a full 3 acre operation requiring additional markets, the Alturas airport (17 miles from our location), which is in the process of expanding the air strip to about 4,500 feet (large enough for a D.C. 3) should be sufficient for our needs to ship to major markets in other parts of the country.

We feel that our geothermal hot spring will be giving us a competitive edge in the growing of cut flowers as our cost will be lower than growers using conventional means of heating their greenhouses. Also, the light intensity of our area gives us better growing conditions than most growers have in California.

DECISION HISTORY

The question most often asked of me is "Why did you build a greenhouse for cut flowers at Canby, California, in Modoc County?" The answer is very simple: my property's natural resource; it has an artesian hot spring that flows at the rate of 350 gallons per minute at 210° Fahrenheit. It is producing between 290,000 Btu and 323,000 Btu per minute which is the equivalent of 525 to 538 barrels of fuel oil per week.

At these rates, it is a shame to have all of this energy flowing out of our artesian spring and only be using it to heat one-tenth of an acre now and two tenths of an acre by the end of October when we expect to have our next phase of greenhouses completed.

You must be thinking that I am not a very good businessman to only be using the equivalent of 35 to 40 barrels of fuel oil per week when we have 525 to 538 available to use. Let me explain the problems which we have encountered in attempting to build our project.

My first decision was to determine how to use the hot water. As a realtor, our firm has sold land in the Half Moon Bay area to flower growers, and I have seen the growth of greenhouses in that area as well as the Watsonville area.

In January of 1980, I took a trip to the Susanville area after hearing that there were greenhouses being heated with geothermal hot water. One was Hobo Hot Springs which was no longer in operation. The Wendel greenhouses were producing cucumbers at the time and had just changed growers for the fourth time. Also, I went to Lakeview, Oregon, to look at tomato operation which did not look very successful.

I decided to grow cut flowers, not vegetables, it appeared to me that my chances of success would be greater in the cut flower business.

A flower grower contacted me and we proceeded to put figures together relating to construction, set up, operating, carrying costs, and income projections in order to make a presentation to lenders for a loan.

I approached Production Credit in Half Moon Bay with a loan proposal only to be advised that my project was too far away for them to be able to service the loan. During our discussion, questions came up about the distance of shipping. The cold climate with snow and high winds might present problems to growing flowers in California's most northeasterly county. I talked to the Bank of America, Wells Fargo Bank, both in Belmont and Alturas, Production Credit, and the Farmer's Home Loan Bank of Alturas, all to no avail in trying to obtain financing for three acres of greenhouses. When I cut back the size to an acre and a half they still said "No."

During this period of time I made a trip to the Oregon Institute of Technology and met with Paul Lienau, Gene Ryan, Gene Culver, Charles Higbee, and Bob Johnson, all of whom were very helpful and encouraging. They recommended various ways in which my geothermal spring could be utilized.

From the trip came the idea of cascading uses of the geothermal water, first for greenhouses, then for a mushroom farm, and ultimately for raising prawns.

During this time, my grower got discouraged, and we parted ways. I heard about the University of Nevada Research on raising prawns using geothermal water, and on a trip to Reno discussed their system. I made a call to Wholesale Florists to determine if and when our greenhouse was built would they be interested in buying our flowers. Mr. Jay Regas said "yes," and if we had a particular grower, he would buy our flowers sight unseen because of the quality of flowers he grew as well as the fact that Canby is a lot closer to Reno than San Mateo County, so his freight costs would be less. How lucky can you be; one call got me the name of a grower who was going to be looking for a position because the firm he was employed with was phasing out their cut flower operation and changing to potted plants and then going to a market for the flowers.

Bill was intrigued with the idea of using geothermal water to heat the green houses due to flowers' need for heat in the winter months when the firm he was with had to cut back on heating to keep their costs down. He also mentioned that the light intensity at my elevation would be helpful to the growth of the plants in the winter when market prices are good.

So we started all over again going to all of the sources previously mentioned. This time we were armed with a wholesaler in Reno and another in Portland that would buy our flowers because of the quality of flowers he grew. The results were somewhat better but changed too. Have you ever built a greenhouse before? Has your grower built one and set one up before. This was just a different way of saying "No."

We had chosen the strongest greenhouse to withstand the snow load and winds of the area and still left empty handed after again cutting back from three acres to an acre and one-half. By this time, both Bill and I were getting down in the dumps. Jerry Shibata of Mt. Eden Nursery Co. mentioned a meeting in Santa Clara where Tom Byrne of University of California, Davis, was giving a presentation about gerbera. He suggested that Bill and I go to it. Bill went to the meeting and was enthused with the idea of growing the gerberas, and I got excited when it was determined that we could build the greenhouse and set up our operation and make a profit without a million dollars having to be spent. Again I tried to get financing for two-tenths of an acre only to be told by my friendly bank, Production Credit, "why not just build a tenth of an acre and use your own cash." WHICH I DID.

Now we finally were ready to get started. The greenhouse and gerberas were ordered. Bill placed an order for soil mixed to his specifications. A spraying machine was ordered as well as all of the sundry items necessary to start up the operation.

One day toward the end of May, I received a call from ICX saying our greenhouse was on their dock in Hayward. They did not go into Canby, so what should they do with it.

In the meantime, I purchased a mobile home to be delivered on June first for Bill's new home in Canby. There was an old well on the property we knew would be a good site for the residential well to be drilled as the old one did not meet the present county code. We decided to drill a well close to where our three acre complex would ultimately be built. We drilled to 680 feet and only got 3 gallons a minute.

When the greenhouse finally got there, this was missing, and that was missing. Bill found himself driving back and forth to Alturas 17 miles away to buy nuts, bolts, nails, as nothing is available in Canby.

Our greenhouse came in parts, a part now and a part then, with the door finally arriving August 10th. The gerberas had arrived in Reno on July 9th and were planted with poly covering the door.

We pumped directly from our geothermal spring to the greenhouse. We had to change pumps twice until we found one that would take the 210° temperature without loosing its prime due to the NTS curve. Then we had to put a ball check valve in so the pump would not lose its prime. The latter part of August, due to cool evenings, the system failed because the check valve seat warped. Although the check valve was designed to withstand 210° water, the washer only was designed for 185° water. We now have a system including the seat that will take 250° water. The system is designed to maintain the greenhouse at 60° when the outdoor temperature is 20° below zero.

We are heating the roots of the plants on the ground and have tubing suspended in the upper portion of the greenhouse to heat the air above the plants. There is a total of four miles of ethylene, propylene diene monomer tubing in our one-tenth of an acre greenhouse.

Since the door was installed, our plants have been doing very well. On September 15th, we cut our first three flowers and expect to be able to start shipping weekly to our wholesalers in Reno and Portland by mid-October.

In one way, it is great not to have a loan to make payments on, but the sad part is seeing all that geothermal water being wasted.

Nakashima taps earth's energy to grow roses in the desert

by Takako Endo

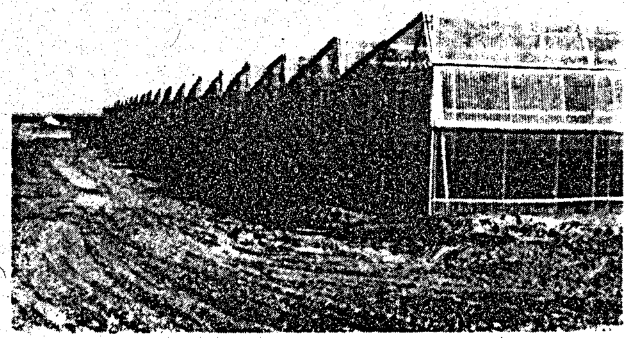
MITS NAKASHIMA knows there is more to the process of growing flowers than the sum of its parts. Love and skill, courage and strength, elation and disappointment are all part of his equation for success in the nursery business.

Although he "retired" several years ago, Nakashima continues to seize opportunities that help make the business's future bright. Growing roses with geothermal energy is an example of one of his projects.

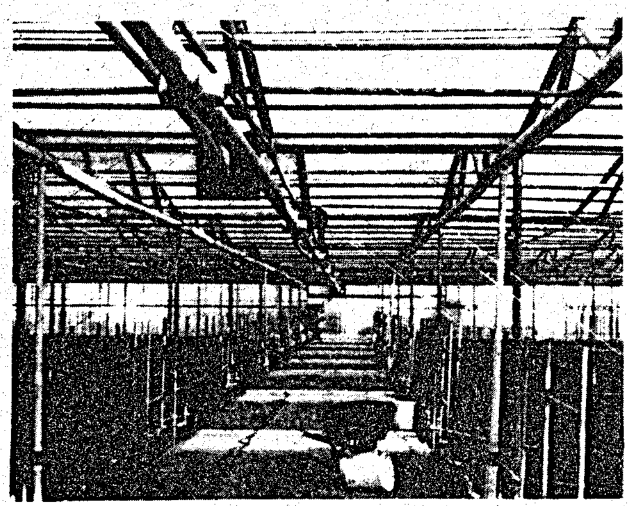
In 1977, Nakashima handed over the reins of Nakashima Nursery Co., Watsonville CA, to his son, Doug. But, instead of retiring, he launched an intensive program of study and research to find an alternative source of energy for his greenhouses.

"Our heating bill went up 833 percent in six years," Nakashima says. "And when natural gas is deregulated, the cost will probably jump even more. It was a matter of necessity."

Nakashima crossed and re-crossed the vast deserts of the southwest in his search for a solution. Solar? Wind? Wave? In 1979 alone, Nakashima put in 57,000 miles of driving and finally came to the conclusion that, for him, the solution might be geothermal energy.

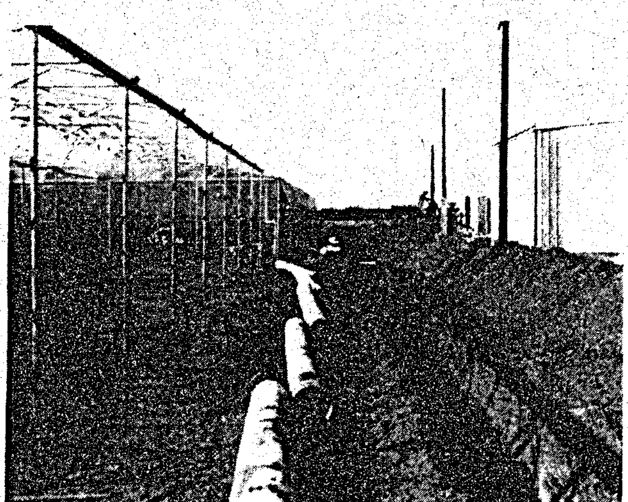


Above: Side view of one of Nakishima's desert ranges



Left: Each greenhouse has a 12-foot walkway through its center.

Below, left: 12-inch drainage lines were visible during construction.



Armed with scores of surface and sub-surface maps and charts, Nakashima narrowed his search for hot water to an area near Oasis, a town with a handful of buildings. In his mind, he drew a circle in and around lush, growing citrus trees. Nakashima purchased a 50-cent thermometer at a drug store and then went door to door visiting the farmers within the perimeter of that circle. He asked each one if he could measure the temperature of the hot water coming from underground. In this way, he pinpointed the area which he thought had the hottest water.

He negotiated for and purchased 40 acres of fairly level, virgin land on May 25, 1980. "I knew the ground was fertile," Nakashima says. "The grass was six feet tall. But whether or not we could get enough hot water was a gamble."

The site is 30 miles from the Mexican border. The Salton Sea is just a half-mile away. "It's beautiful," Nakashima sighs. "We're near Palm Springs. In fact, I call it 'poor man's Palm Springs.' But the extra point here is that we don't have smog. We're only 130 miles from the center of Los Angeles, so the trucking distance is really a third the distance from Watsonville to L.A. We have 350 days of sunshine.

"The first thing we did was to dig for hot water because, after all, that was the name of the game. Without hot water, the project couldn't take off.

"We hired a big drilling rig—not unlike those you see in the oil fields—and we began. Everything went along fairly well for

(Continued on page 112)

the first 600 feet. Then we hit a bed of solid rock. It took two weeks to drill through 20 feet of hard rock. It was touch-and-go, but after that, it was a lot easier.

"We hit hot water at 1,000 feet. That made my day."

He was told later by a government geologist that he was sitting "right on top of an aquafortis." Nakashima says, "I knew then that what I had sought for four years was here." This was the first of many exciting moments.

"The hot water has enough pressure to flow up without pumping," Nakashima explains. "It's an artesian well. We keep it capped when we don't need it. By turning a valve we can get hot water flowing into the greenhouses. No boilers. No burning of gas or oil. It's a dream."

The 115° Fahrenheit water comes up through a 14-inch well at the rate of 400 gallons per minute. This can be increased to 1,000 gallons per minute with the help of a small pump.

Next came the search for fresh irrigation water. Farmers in the area get their supply from canals fed from the Colorado River. "But the bad part about that was that the feeder outlet was 1½ miles away and the cost of the pipeline alone for us was approximately $60,000," Nakashima says. "Then, too, we'd have had to put in a requisition each time we wanted water. If others were ahead of us, we'd have had to wait our turn. Imagine having a hot spell and having to wait our turn for water! So we began a search for our own supply.

"I had a Bakersfield firm come out to find sweet water. Salinity is measured by an instrument much like an electrocardiogram. After an area was marked off as possibly having the greatest amount of sweet water, we began digging. At 200 to 300 feet we hit a river of sweet water with a third the salinity of the 'fresh Colorado River.'" This was another of Nakashima's exciting moments.

The sweet water is also from an artesian well. The water flows through a 12-inch steel casing into a 250,000-gallon reservoir. A float switch shuts off the flow when the reservoir is full. A 15-horsepower pump moves water from the reservoir to the greenhouse.

"What's so good about having our own source is that not only do we not have to wait our turn, but the canal water collects seeds as it flows in from the river. Even after filtering, those seeds can plug valves—those that get through sprout into weeds.

"With both hot and sweet water, I knew we were there to stay," Nakashima recalls.

"We laser-levelled the ground, put up a warehouse and built 21 greenhouses covering 100,000 square feet. The houses are made with aluminum framing with covers of double polyethelene with 6 to 12 inches of air between the two layers for insulation. The roof is saw-tooth style to maximize air flow and minimize maintenance of the plastic covers. A 12-foot walkway runs through the greenhouses, making it wide enough for a small car to maneuver easily.

"Hot water travels from the artesian well to the greenhouse in an 8-inch PVC pipe—underground—and runs the length of the houses with 4-inch manifold. We used six miles of 1-inch copper coils hung under the trusses to run the hot water through the houses. Spent hot water flows into a canal which, in turn, drains into the Salton Sea.

"Sweet water from the reservoir is fairly clean. Sand and debris settle to the bottom of the reservoir, but we filter the water anyway. Water gets to the greenhouse from the reservoir in PVC pipes for misting and for perimeter watering. One person can take care of the feeding and watering of the whole place (200,000 square feet) in 40 minutes." Fertilizing and irrigation is a single step using a completely soluble fertilizer.

"We had planned to put up 100,000 square feet each year for 10 years, but everything went along so well that we added another 100,000 square feet."

The first plantings were made during the last week of December and concluded in the first week of January. The first cuttings were taken the week of March 23 and produced 80 bunches. Eddie Fujita, Nakashima's marketing manager in Los Angeles, tagged them "Desert Geothermal Roses" and the 80 bunches were sold within 10 minutes. Eiju Sasajima, Nakashima's long-time marketing advisor, was joyously surprised. During the weeks that followed, the cuts increased to 1,000, then to 1,700 and then to 2,000 bunches.

"I figured if we could get 1,000 bunches a week, we could run that place in the black," Nakashima says, "but to get double that number was more than I had hoped.

"We grow about 20 or 21 different kinds, mostly new varieties. We have 'Excitement,' 'Sassy' and 'Lavonne'." Heck, if I had known how well 'Lavonne' would move, I'd have planted the whole place in that. It's a purple and you know how popular that color is today.

"Lots of growers warned me that the buds would be small because of the heat, but I think the flowers are of good size. The stems are sturdy and the leaves are clean. Frankly, they're better than I expected. Of course, new plants always produce good flowers. The real test is later."

But Nakashima doesn't appear worried. He seems to be floating on a carpet of joy. His exciting moments were becoming marvelous memories.

But even success has its share of problems, minor as they may seem. Because of the hot, dry climate, fungicidal diseases have not posed problems—but not so with infestations of mites and thrips. Controlling them is a time-consuming chore, but Nakashima seems to brush that off as a nuisance, not a problem. He just looks ahead to cutting 4,000 to 5,000 bunches of roses during Mother's Day week. A small amount of gardenias is also being grown on a trial basis.

"I'll be getting new neighbors soon," Nakashima reveals. "Kenzo Yonemitsu of Central Coast Greenhouses in Salinas is buying a place. Poor guy, price of land has gone up 4-fold since I bought. But I'm sure other growers will be coming too—which is good. The more of us the better. We can share the cost of transportation and buy in bigger lots."

Nakashima's voice trails off as if he's envisioning a future scene. This isn't the first time for Nakashima. When he moved from San Leandro to Watsonville as a second-generation grower, in February of 1962, he was nearly alone in the Monterey Bay area. But one by one, scores of other growers flocked to the area. It was an exodus from the San Francisco Bay area and the peninsula. Almost twenty years later, once again Nakashima finds himself nearly alone—this time in the desert. He has hot water for heating, sweet water for irrigating, 350 days of sunshine, no smog, virgin soil, close proximity to the marketplace and enough labor. After it's all well and done, one will wonder if there ever was a reason to question desert growing.

Nakashima has spent only about 40 hours at his new plant. The operation is left to a supervisor, Henry Arao, who keeps Nakashima posted via telephone (which was installed after a 4-month wait) and weekly sets of pictures. Nakashima's command post is at his home in Aromas, a 7 or 8 hour drive from Oasis.

Wondrous things seem still in store for Nakashima. In a quip perhaps more revealing than glib, he says, "I'm thinking about my next project." And off he goes to create more exciting moments. Maybe flower growing in outer space?

SUMMARY
of
AQUA FARMING WITH GEOTHERMAL ENERGY

PRESENTATION

by

Kenan Smith
Geo-Heat Center
Oregon Institute of Technology

Geothermal aquaculture is a relatively new field in an industry which has been in existence for nearly 4,000 years. Trout, salmon, crayfish, catfish, tropical aquarium fish, prawns, and others show great promise for geothermal cultivation. By controlling the environment through the direct use of geothermal energy, the stress level is reduced and an increased growth rate is usually observed. In addition, direct use geothermal allows for the propagation of crops that are not indigenous to the region.

A research program began in 1975 to study the potential uses of geothermal heat in aquaculture. The Oregon Institute of Technology has developed two one-half acre ponds with 27°C (or 80°F) water in addition to a small hatchery. The production of prawns raised in geothermal waters was about 1.4 times the productivity on Hawaiian prawn farms. A project involving 20,000 fingerling trout raised in geothermally heated ponds (60°F) resulted in a production rate three times greater than the local state hatcheries (45°F).

Limitations for a successful venture are dependent on several variables: the resource, site location, the market for the product, and the interrelationship between these variables. The quality and quantity of the resource is important and must suit the heating capacity and temperature requirements of the project. The site location is important because electrical costs vary from site to site as well as the proximity of the market. It was found that the best sized system was a one-quarter acre raceway with 50 feet by 200 feet by 4 feet deep measurements. Of all the temperature-controlled systems, the diffusion system was the best. In this system, each line is controlled by a thermostat. When the temperature decreases below the required temperature, a mechanism allows geothermal fluid through the valves until the temperature is again stabilized (see diagrams). It is helpful to have a trained aquaculturist on hand to manage the pond and spot problems before they become serious. In one of the latest experiments, they placed manzanita brush in the unlined pond to provide shelter for the prawns.

In conclusion, each resource and its potential will vary, but the overall feasibility for using geothermal for aquaculture has a very promising future.

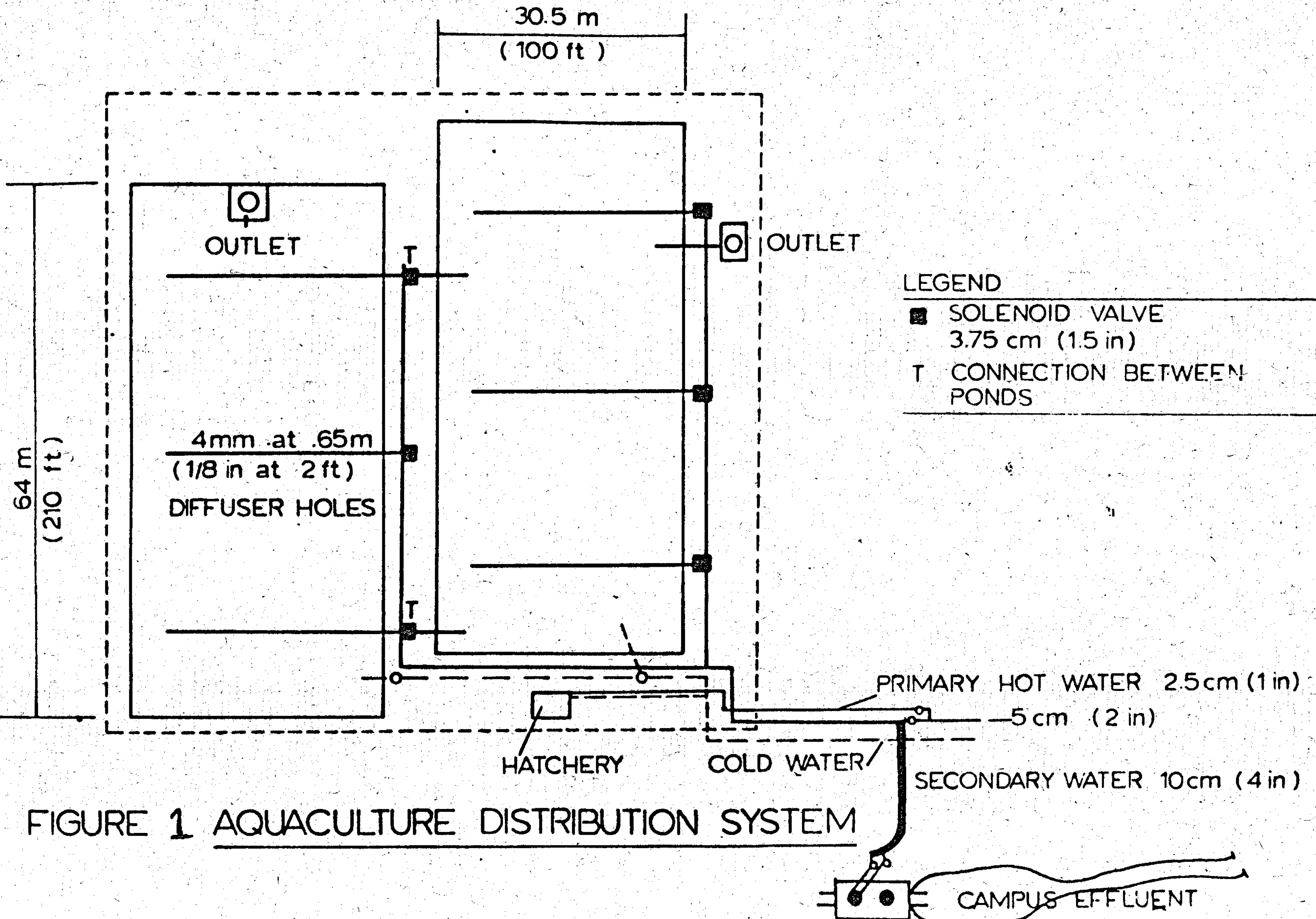


FIGURE 1 AQUACULTURE DISTRIBUTION SYSTEM

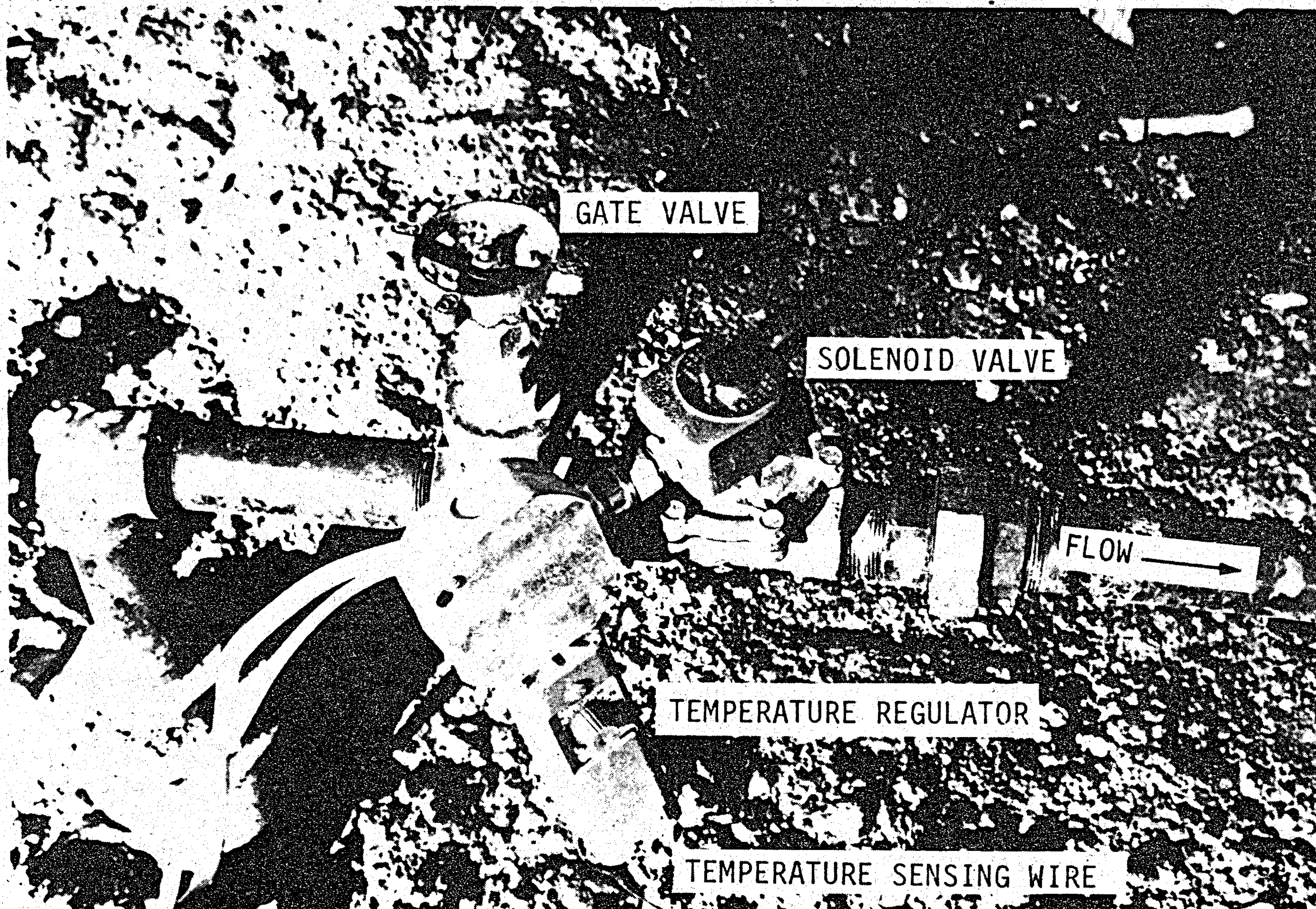

GATE VALVE
SOLENOID VALVE
FLOW
TEMPERATURE REGULATOR
TEMPERATURE SENSING WIRE

FIGURE 2

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SUMMARY
of
Title: AGRICULTURAL PRODUCTS
ECONOMIC CONSIDERATIONS

PRESENTATION

by

Charles V. Higbee
Geo-Heat Center
Oregon Institute of Technology

Many times people do not use common sense in evaluating the economics of a project. It is, therefore, important to identify the basic parameters necessary in evaluating the economics of a geothermal project. The outline lists these economic considerations.

It is especially important to use a relatively short economic life (20 years or less) when evaluating project economics and a conservative inflation rate or none at all. One cannot forecast accurately enough when looking 40 to 50 years ahead.

I. ECONOMIC CONSIDERATIONS:

A. BASIC PARAMETERS

1. Location and Land Cost
2. Location and Compatibility with End Uses
3. Heat Pumps
   a. Effluent
4. Resource Temperature
   a. Proper Range for Application
5. Sizing Heat Load
6. Cascading and Multiple Use to Maximize T
7. Design System to Resource Specifications
8. Flow Rates
   a. Peak Versus Average
      o Fossil Fuel Peaking

DD-18 GDU

- o Storage Peaking
- o Levelizing Load

9. Transportation System

   a. Methods of Minimizing Costs

10. Labor Availability

    a. Specialists Versus Unskilled

    b. Remote, Unattractive Sites

11. Climatic Conditions

    a. Affects Application

    b. Affects Product Selection

12. Comparison with Other Energies

    a. Conventional Energy Inflation Rates

13. Forecasting Problems

B. MARKET CONSIDERATIONS

1. Market Availability
2. Transportation
3. Labor

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SUMMARY
of
Title: HARDWARE AVAILABILITY AND CONSIDERATIONS

PRESENTATION

by

Leonard A. Fisher, P.E.
Leonard A. Fisher Company

EQUIPMENT AVAILABILITY

The hardware is what it takes to get the resource from the well to its end use. Most of the equipment utilized is off the shelf, that is, of a standard manufacturer, except for some of the pumping equipment. The first consideration is the pumps. The sizing of the pumps is a function of the lift of the well and the friction in the pump line which depends on the length of pipeline. Vertical turbine pumps, which have a lift of about 800 feet, are most commonly used. Submersible pumps are used for fluids at greater depths. They have a high lift. In an artesian flow, a common centrifugal pump can push the fluid from the surface reservoir to the end use.

Selection of piping is a matter involving several considerations. Heat losses, friction losses, expansion of pipes, and corrosion of pipes should all be considered. Metallic piping is very commonly used. Copper pipe has been used but is very susceptible to corrosion. There are a number of nonmetallic pipes used depending on the temperature of the resources. The question of insulation depends on the economic trade-off of insulation vs. the heat loss in the transportation of the fluid. The installation of pipes requires a skilled labor force. Many geothermal fluids contain dangerous or harmful chemicals such as boron. If this is the case, a heat exchanger is often used. The hot geothermal fluid is used to exchange heat to a cleaner circulation fluid. There are several common heat exchangers such as Shell and Tube, Plate, Downhole, Direct Contact, and Fluidized Bed. Once the hot fluid is to its end use, there are several options for heating systems. The most common is the forced air system (Figure 2). Convective heating systems consist of piping which is hung in the air. By natural convection in the structure, the heat is dissipated. Radiant systems are like a traditional steam radiator. They are commonly used in animal husbandry. A heat pump is good for an exceedingly low geothermal temperature. This requires electricity to get the heat out. A tempered fluid is used, for example, in aquaculture where a high temperature fluid must be cooled down. All these systems have varying costs.

EQUIPMENT INSTALLATION

There are several factors in equipment installation that are important in evaluating the cost of a system. They are site considerations, project demands, fluid properties, topography, and soils. Future developments may bring down cost. They include plastic tube heat exchangers, scale cleaners, and, perhaps, geothermal packaging for various sites.

In conclusion, every application is site specific, the cost at each site will be different, and capital cost result in a higher operation and maintenance cost.

The factors under equipment installation are all important considerations relating to the cost of a system. Costing estimates may be obtained from handbooks, vendor quotations, and people with similar experiences.

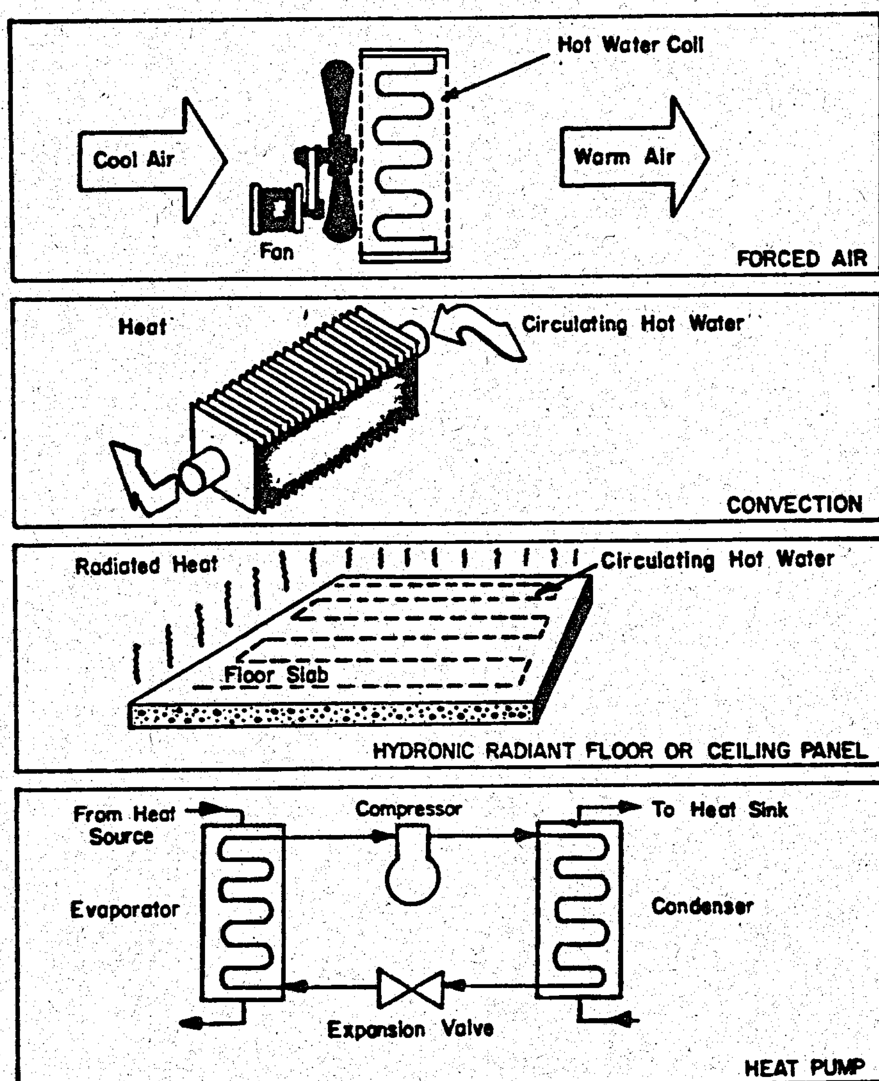

FIGURE 2. Space-heating systems suitable for geothermal applications (source: EG&G Idaho, Inc.).

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Sources of Information

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AGRICULTURAL PRODUCTS
FINANCING

by

Paul Rodzianko
Grace Geothermal
Geothermal Energy Corporation

I. PROJECT RISK ASSESSMENT

A. Process Economics--Are the basic economics of the project able to earn a rate of return consistent with industry expectations? (Exclude special tax considerations in this analysis.)

B. Management--Do the personnel assigned to or originating the project have a track record of successfully coping with the industry's challenges? In a start-up situation, this aspect becomes particularly crucial.

C. Marketing--Is there a demonstrated market for the product or does one have to be created? Will the project depend on an existing sales force, a contract for output, or other approach?

D. Technology/Resource--Are there significant risks associated with these areas? Is the technology proven or the first of its kind? Is there an operating history associated with the geothermal resource or not?

E. Geographical Viability--Is a work force readily available? Does infrastructure exist to support the planned project? Are there other intangibles that could affect the project?

F. Financial Climate--Is the financial marketplace in a mode that encourages new plant investment or not? Interest rates, taxation, alternative opportunities, trendiness, etc.

II. SOURCES OF FINANCING

A. Commercial banks--Generally, conventional five to seven year lending at a rate floating over prime.

B. Savings and loans--Generally, mortgage lenders over middle to long-term at fixed rates, but variations exist.

C. Investment Bankers--Generally, structure transactions, including both debt and equity aspects, as well as other kinds of financing such as limited partnerships and R&D partnerships.

D. Public Sector Financing--Has been available in the form of grants, loans, and loan guarantees. States have varying energy programs with California and Oregon being among most active. Federally, the Geothermal Loan Guarantee Program appears in limbo and grants seem to have been cut back.

III. FINANCING STRUCTURES

A. Equities--Common and preferred.

B. Debt--Varying terms, recourse or nonrecourse, convertible features.

C. Corporate vs. Project Financing--Financing availability will depend on credit strength of entity itself or its sales contracts.

IV. CONCLUSIONS

Obtaining financing for a project is the acid test of its being economically viable. The closer to its being a start-up, the harder it is for a project to obtain nonrecourse debt financing. For direct use geothermal, the resource itself is only one of six main areas on which a project is evaluated and, as the result of a deficiency in any one of which, financing could be denied.

AGRICULTURAL PRODUCTS
WELL CONSTRUCTION AND RESERVOIR ASSESSMENT

by

Luhdorff & Scalmanini, Consulting Engineers

I. WELL DESIGN AND CONSTRUCTION

A. Importance of Design

1. Optimal Yield

2. Hydraulic Efficiency

3. Sand Control

B. Preliminary Design

1. Exploration and Site Selection

2. Test Hole Construction and Evaluation

o Lithology

o Geophysical Logging Suite

C. Well Construction

1. Drilling Methods

2. Drilling Fluid

3. Formation Damage

D. Final Design

1. Components of the Well

2. Intake Section, Including Gravel Envelope

3. Materials of Construction

E. Well Completion and Development

1. Material and Artificial Well Completions

2. Well Development

F. Costs

II. RESERVOIR AND WELL ASSESSMENT

A. Importance of Reservoir and Well Assessment

1. Pumping Equipment Design

2. Projected Well and Well Field Performance

3. Operation and Maintenance Planning

B. <u>Test Procedures and Data Requirements</u>

1. Test Procedures

   o Variation of Reservoir Response with Flow Rate and Time

   o Constant Rate, Variable Rate, and Recovery Tests

2. Data Requirements

   o Flow Rate, Water Level, Time

C. <u>Reservoir and Well Analysis</u>

1. Reservoir Characteristics

2. Well Performance

   o Hydraulic Efficiency

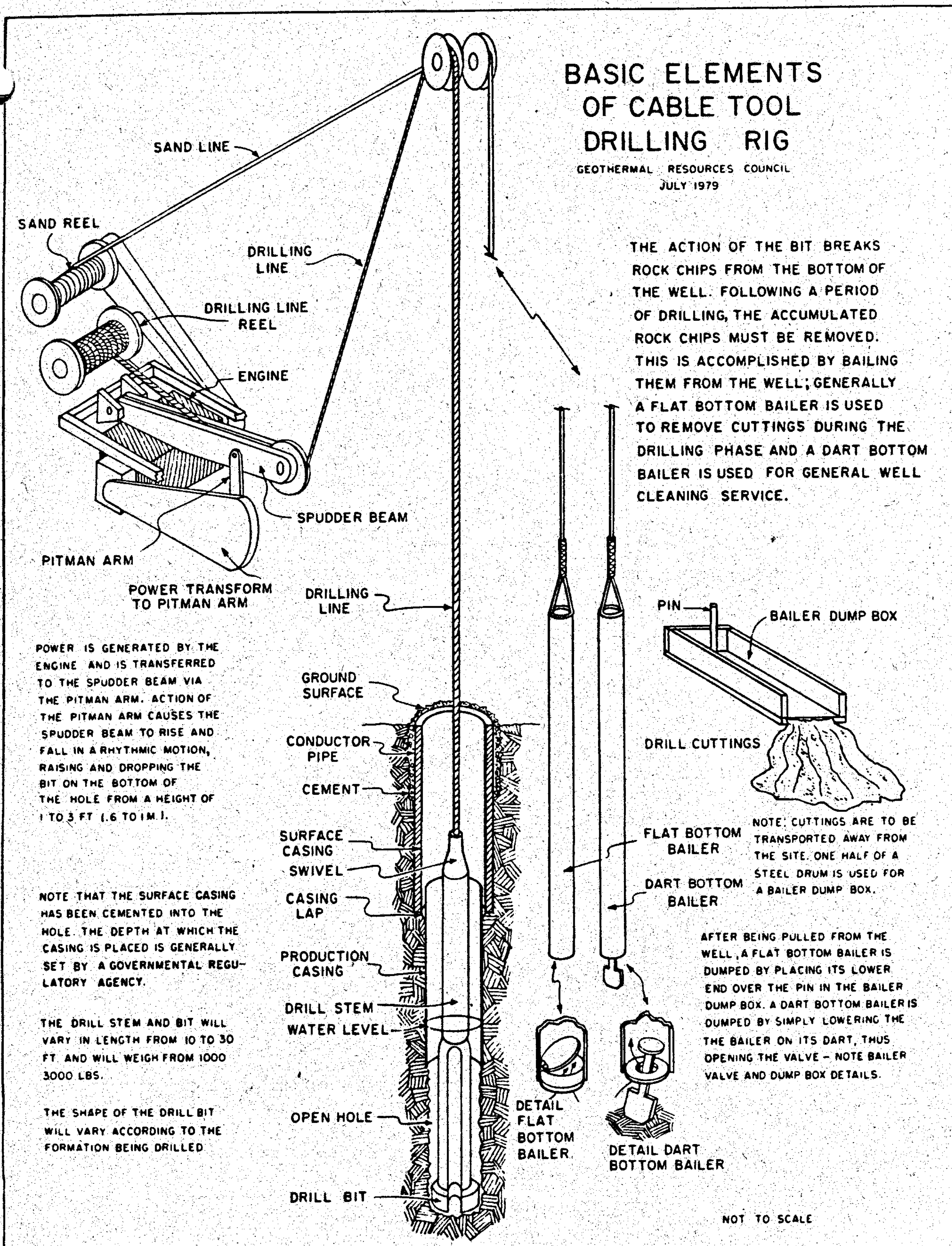
   o Pump Requirements

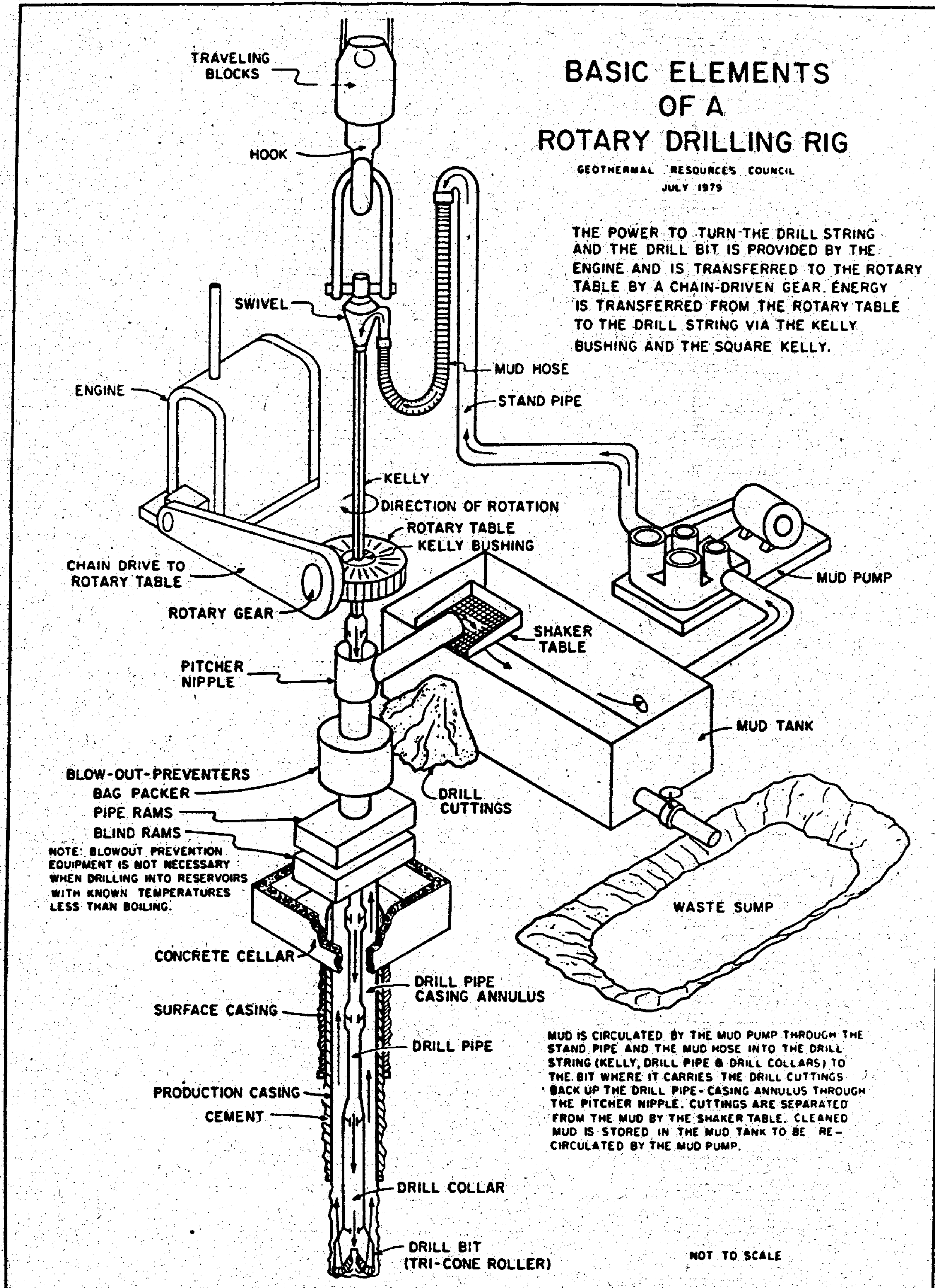
3. Well Field Performance

   o Mutual Interference

4. Operation and Maintenance

D. <u>Costs</u>


BASIC ELEMENTS OF CABLE TOOL DRILLING RIG
GEOTHERMAL RESOURCES COUNCIL
JULY 1979
SAND LINE
SAND REEL
DRILLING LINE
DRILLING LINE REEL
ENGINE
SPUDDER BEAM
PITMAN ARM
POWER TRANSFORM TO PITMAN ARM
DRILLING LINE
THE ACTION OF THE BIT BREAKS ROCK CHIPS FROM THE BOTTOM OF THE WELL. FOLLOWING A PERIOD OF DRILLING, THE ACCUMULATED ROCK CHIPS MUST BE REMOVED. THIS IS ACCOMPLISHED BY BAILING THEM FROM THE WELL; GENERALLY A FLAT BOTTOM BAILER IS USED TO REMOVE CUTTINGS DURING THE DRILLING PHASE AND A DART BOTTOM BAILER IS USED FOR GENERAL WELL CLEANING SERVICE.
POWER IS GENERATED BY THE ENGINE AND IS TRANSFERRED TO THE SPUDDER BEAM VIA THE PITMAN ARM. ACTION OF THE PITMAN ARM CAUSES THE SPUDDER BEAM TO RISE AND FALL IN A RHYTHMIC MOTION, RAISING AND DROPPING THE BIT ON THE BOTTOM OF THE HOLE FROM A HEIGHT OF 1 TO 3 FT (.6 TO 1 M.).
GROUND SURFACE
CONDUCTOR PIPE
CEMENT
SURFACE CASING
SWIVEL
CASING LAP
PRODUCTION CASING
DRILL STEM
WATER LEVEL
OPEN HOLE
DRILL BIT
PIN
BAILER DUMP BOX
DRILL CUTTINGS
NOTE: CUTTINGS ARE TO BE TRANSPORTED AWAY FROM THE SITE. ONE HALF OF A STEEL DRUM IS USED FOR A BAILER DUMP BOX.
FLAT BOTTOM BAILER
DART BOTTOM BAILER
NOTE THAT THE SURFACE CASING HAS BEEN CEMENTED INTO THE HOLE. THE DEPTH AT WHICH THE CASING IS PLACED IS GENERALLY SET BY A GOVERNMENTAL REGULATORY AGENCY.
THE DRILL STEM AND BIT WILL VARY IN LENGTH FROM 10 TO 30 FT. AND WILL WEIGH FROM 1000 3000 LBS.
THE SHAPE OF THE DRILL BIT WILL VARY ACCORDING TO THE FORMATION BEING DRILLED
AFTER BEING PULLED FROM THE WELL, A FLAT BOTTOM BAILER IS DUMPED BY PLACING ITS LOWER END OVER THE PIN IN THE BAILER DUMP BOX. A DART BOTTOM BAILER IS DUMPED BY SIMPLY LOWERING THE THE BAILER ON ITS DART, THUS OPENING THE VALVE - NOTE BAILER VALVE AND DUMP BOX DETAILS.
DETAIL FLAT BOTTOM BAILER
DETAIL DART BOTTOM BAILER
NOT TO SCALE


BASIC ELEMENTS
OF A
ROTARY DRILLING RIG
GEOTHERMAL RESOURCES COUNCIL
JULY 1979
THE POWER TO TURN THE DRILL STRING AND THE DRILL BIT IS PROVIDED BY THE ENGINE AND IS TRANSFERRED TO THE ROTARY TABLE BY A CHAIN-DRIVEN GEAR. ENERGY IS TRANSFERRED FROM THE ROTARY TABLE TO THE DRILL STRING VIA THE KELLY BUSHING AND THE SQUARE KELLY.
TRAVELING BLOCKS
HOOK
SWIVEL
ENGINE
MUD HOSE
STAND PIPE
KELLY
DIRECTION OF ROTATION
ROTARY TABLE
KELLY BUSHING
CHAIN DRIVE TO ROTARY TABLE
ROTARY GEAR
MUD PUMP
SHAKER TABLE
PITCHER NIPPLE
MUD TANK
BLOW-OUT-PREVENTERS
BAG PACKER
PIPE RAMS
BLIND RAMS
DRILL CUTTINGS
NOTE: BLOWOUT PREVENTION EQUIPMENT IS NOT NECESSARY WHEN DRILLING INTO RESERVOIRS WITH KNOWN TEMPERATURES LESS THAN BOILING.
WASTE SUMP
CONCRETE CELLAR
DRILL PIPE CASING ANNULUS
SURFACE CASING
DRILL PIPE
MUD IS CIRCULATED BY THE MUD PUMP THROUGH THE STAND PIPE AND THE MUD HOSE INTO THE DRILL STRING (KELLY, DRILL PIPE & DRILL COLLARS) TO THE BIT WHERE IT CARRIES THE DRILL CUTTINGS BACK UP THE DRILL PIPE-CASING ANNULUS THROUGH THE PITCHER NIPPLE. CUTTINGS ARE SEPARATED FROM THE MUD BY THE SHAKER TABLE. CLEANED MUD IS STORED IN THE MUD TANK TO BE RE-CIRCULATED BY THE MUD PUMP.
PRODUCTION CASING
CEMENT
DRILL COLLAR
DRILL BIT (TRI-CONE ROLLER)
NOT TO SCALE

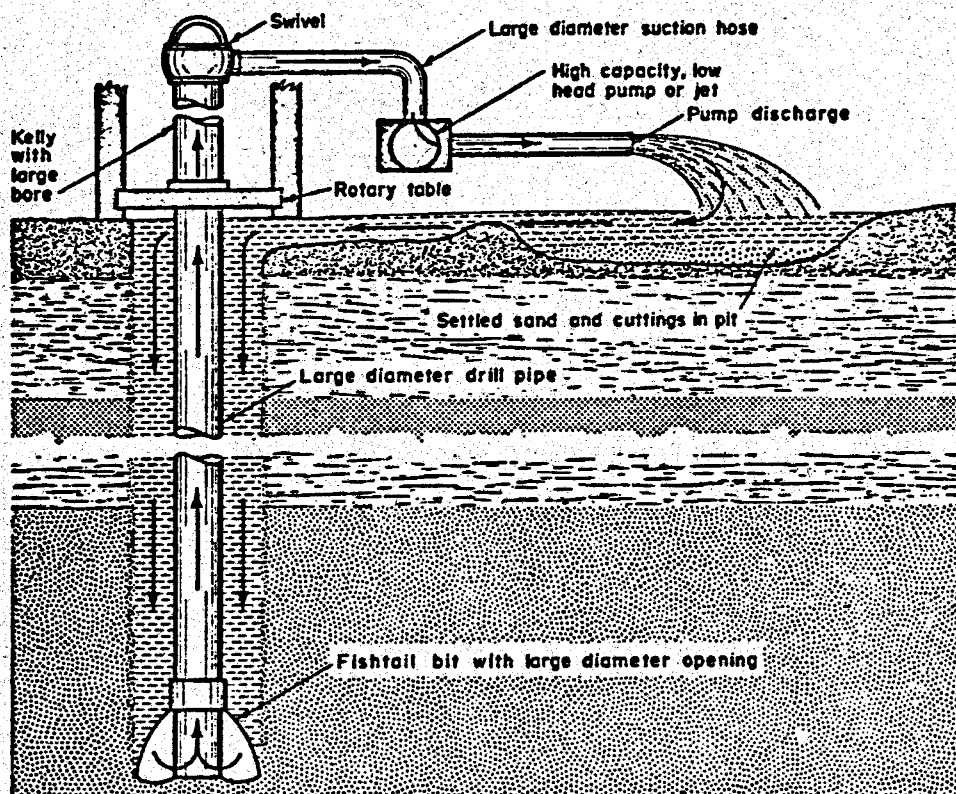
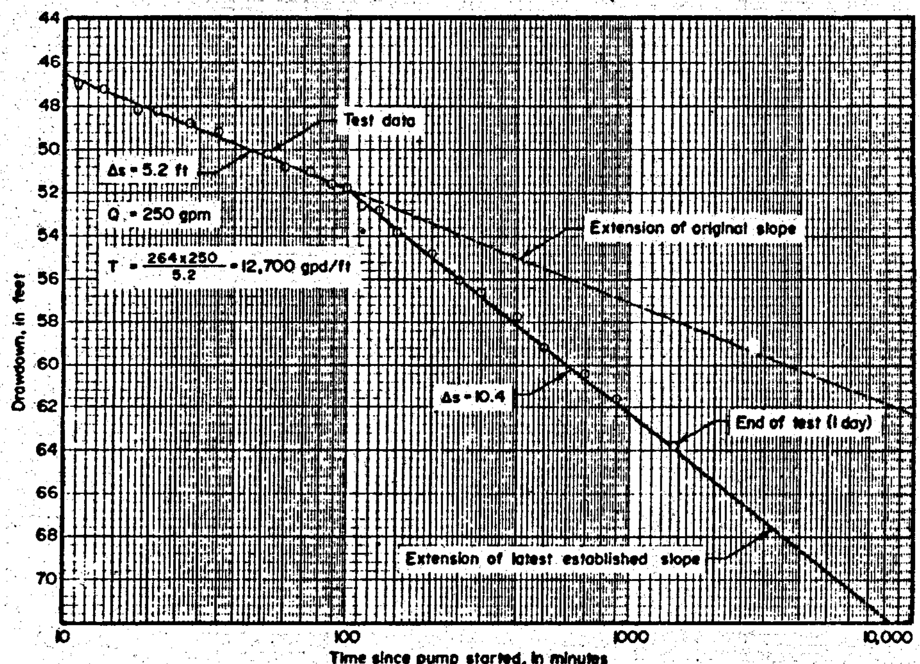
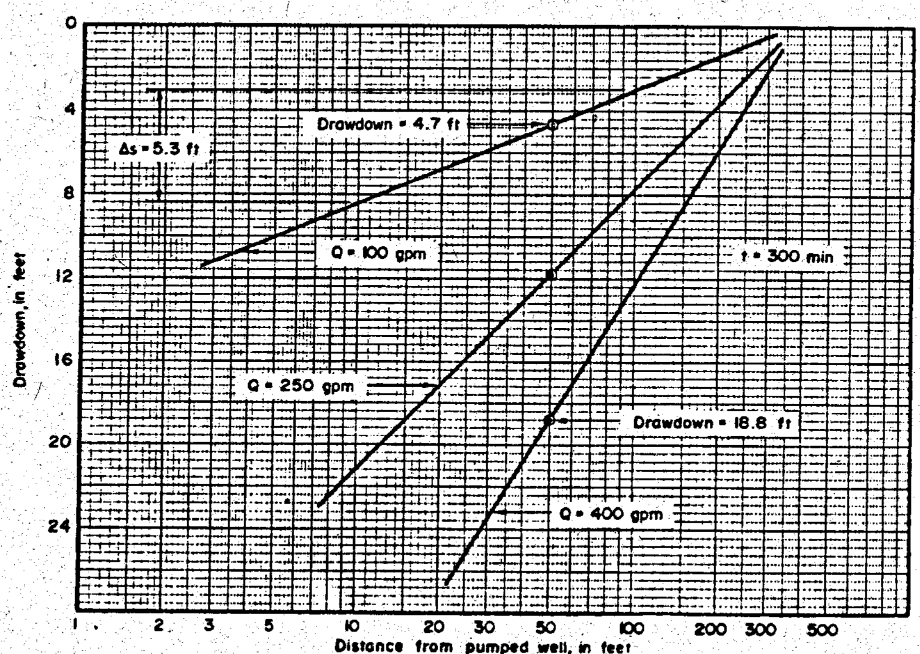


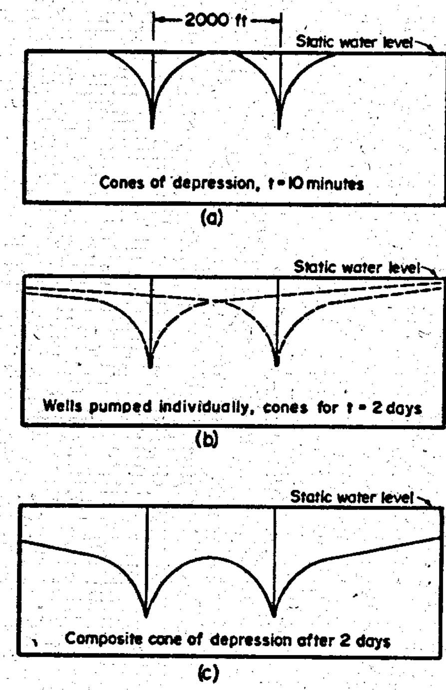
Figure 179. Basic principles of reverse-circulation, rotary drilling are shown by this schematic diagram. Cuttings are lifted by upflow inside drill pipe.



Time - Drawdown Relationship



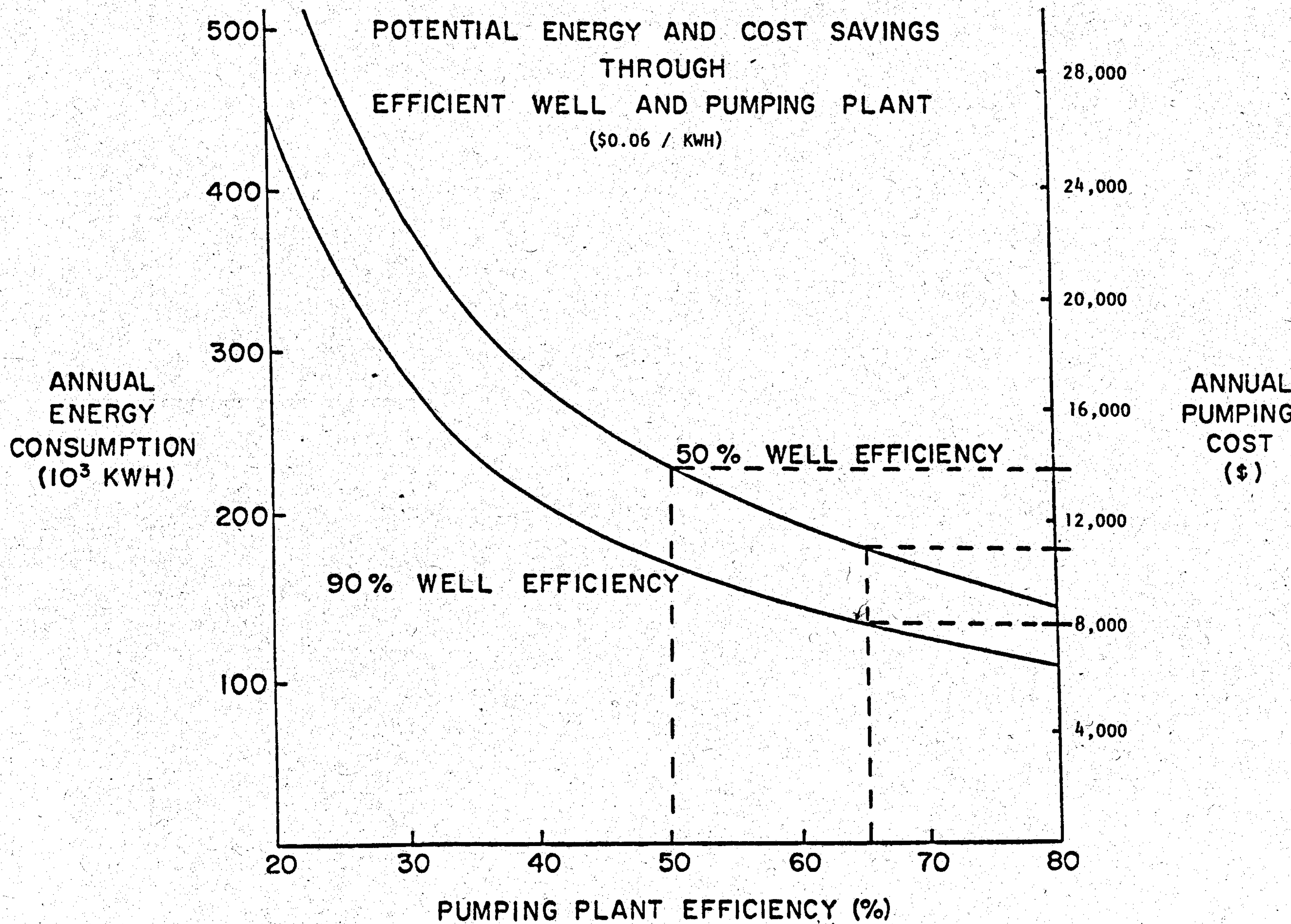
Distance - Drawdown Relationship



Assumed conditions

T = 50,000 gpd per ft   d = 12 inches
S = 5 x 10^{-4} Q = 500 gpm

Mutual Pumping Interference


POTENTIAL ENERGY AND COST SAVINGS
THROUGH
EFFICIENT WELL AND PUMPING PLANT
($0.06 / KWH)
ANNUAL ENERGY CONSUMPTION (10^3 KWH)
500
400
300
200
100
ANNUAL PUMPING COST ($)
28,000
24,000
20,000
16,000
12,000
8,000
4,000
50 % WELL EFFICIENCY
90 % WELL EFFICIENCY
20
30
40
50
60
70
80
PUMPING PLANT EFFICIENCY (%)

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