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A STRATEGIC PLAN
FOR MARKETING
HOT DRY ROCK TECHNOLOGY

Federal HDR Program
Los Alamos Scientific Laboratory

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RESOURCE COMMUNITIES INC.
P.O. Box 4656 • Santa Fe, N.M. 87501 • 505-988-5508

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I. INTRODUCTION

The history of innovation has shown clearly that the transition from the demonstration of technical feasibility to the commercialization of new technologies is very difficult and rarely achieved. When the question, "Why?" is raised, many believable rationalizations are offered. No funds were available for the engineering development that was needed to turn the idea into a product. The idea was suppressed because it competed with an existing product whose return on investment had not yet been achieved. Production quantities would be too small to realize the economies of scale needed to make costs competitive. No one fully realized the innovation's true potential. It didn't fit the capital budgeting program. It has serious ownership and regulatory problems.

However, some new technologies do make it to the marketplace, even though they have the same kinds of problems experienced by those that don't make it. Somehow their problems get solved, particularly where market demand is strong and the technology is tailored to fit a niche in the market.

How do we create a situation in which market demand is strong and the technology fits a market niche? We do so by applying the marketing concept, which states that the fundamental objective of an organization should be customer satisfaction. All activities of an organization should be focused on identifying and satisfying customer needs.

Marketing emerged as the principal orientation of American business in the 1950's. Until the 1930's most business organizations were production-oriented: their fundamental objective was to produce a product, and selling that product was viewed as incidental. From the 1930's to the 1950's, business became sales-oriented. Managers realized that sales people could function more effectively if they were supported by some staff assistance. Advertising, publicity and rudimentary market research came into vogue. Sales people received more extensive training, and sales functions were coordinated more closely with other functions, particularly production. Today, most American businesses are market-oriented. They systematically determine customer wants, and organize to satisfy these wants. When customer wants change, the products change. Most market-oriented businesses have a vice president of marketing who operates on an equal level with the vice presidents of production and finance.

The orientation of most businesses evolves in the same way as American business as a whole has evolved. Young companies often

start out as production-oriented and don't become market-oriented until the production process is under control and a sales force has been developed and trained.

Application of the marketing concept is not limited to business. Today, more and more non-profit organizations and government agencies are becoming market-oriented as the competition for government and charitable funds increases.

The Federal Hot Dry Rock (HDR) Program is in a transition from production-orientation (proving the technology) to market-orientation (identifying and satisfying customer needs). The initiation of a public awareness program, this initial market research, and closer coordination between the R&D and commercialization activities have moved it squarely into the sales-oriented phase of development. But the sales phase is transitional, and it is not too early to make plans for evolution into the marketing phase.

The principal purpose of this initial marketing plan is to begin to orient the HDR program toward the market. It does so by estimating the national demand for HDR energy and then describing five major components of the market: industry, utilities, institutions, real estate and agriculture/aquaculture. It then sets targets for the most promising markets and suggests strategies that might be applied to penetrate these markets.

A related purpose of the plan is to begin to bridge the gap of common experience between technology developers and prospective buyers. The present world of HDR technology is filled with drillers, instrument developers, geologists, fracture specialists, hydrologists, economists and federal bureaucrats. The future market for HDR energy is filled with electric utility executives, public utility commissioners, regulators, producers of food and paper products, managers of manufacturing and chemical companies, capital budgeting committees, city engineers, real estate developers, state legislators and financiers. The communications channels between these worlds are few. The language, concepts and ways of doing business are different. And it's nobody's job to make sure that the transition is really made, all the way to the end.

Furthermore, no one knows where the end is, particularly if the transition must be made between the public and private sector. Questions with no answers pervade the process. How far can and should the federal government go in spending public money to encourage private investments before commercialization has been

"demonstrated?" On the other hand, how many demonstration projects will be needed before the general public can realize the benefits of public investments through widespread commercial availability of a much needed energy source? Stopping too soon limits public benefits, although the project may have advanced science and engineering; stopping too late imposes on the obligations of the public sector and needlessly wastes public money. The HDR program is now standing between the two worlds of a new technology and its markets, one familiar, one unfamiliar. Hopefully, this plan will help to smooth the transition between them.

USE OF THE PLAN

This marketing plan for HDR energy lays out a general approach to the transition from a program focusing principally on technology development to one focusing on marketing and technical assistance to potential buyers and developers of HDR energy. It includes a strategy for implementing the approach in specific market areas.

The document is designed for internal use by HDR program managers to serve a variety of functions. It recommends specific objectives to guide the commercialization effort, but it also identifies the issues involved in changing the objectives as progress toward them is made. The report can be used as the basis for program plans submitted to the Division of Geothermal Resources, as well as justification for requesting and allocating project resources. It identifies the points and issues where the technology development, institutional analysis and marketing activities within the program need to interact. This interaction will ensure that the R&D staff is aware of the concerns of decision-makers in promising markets, that the marketing team understands what it has to sell, and the institutional analysts know what specific problems have to be solved. Feedback from the marketing team to the institutional program will mobilize support for resolving issues of regulation, resource ownership, finance, leasing and economic feasibility that are raised by potential customers and resource developers. Finally, the plan can be used to measure progress toward commercialization, and it provides a basis for revising strategies as experience is gained.

ORGANIZATION OF THE PLAN

The plan is organized as follows. Chapter II, "Federal Hot Dry Rock Program Products," defines what the marketing program has to sell. Chapter III, "National Demand for Hot Dry Rock Energy," places the technology within the context of the national energy situation and suggests a rate of commercial project commitment that would be required for HDR to achieve a reasonable share of the new energy technology market. Chapter IV, "Market Profiles,"

segments the market for HDR energy into a number of sectors. It then identifies the decision makers in each market, the process and criteria they use to evaluate energy sources, and concludes with an assessment of each market's potential for choosing HDR. Chapter V, "Marketing Targets," focuses the market analysis on specific states and sets priorities for commercialization. Chapter VI, "Marketing Strategy," outlines a general approach to commercialization and suggests a management approach for implementing it. This chapter concludes with specific objectives, strategies and programs for each high priority market.

II. FEDERAL HOT DRY ROCK PROGRAM PRODUCTS*

In 1978 the Department of Energy (DOE) Division of Geothermal Energy (DGE) established the Hot Dry Rock Geothermal Energy Development Program, signifying the advance of this emerging energy technology from "basic feasibility to pre-commercialization engineering development." The program is administered jointly by DOE/DGE and the DOE Operations Office in Albuquerque, with the Los Alamos Scientific Laboratory (LASL) as principal contractor. This chapter describes the basic mission, scope and resources of the federal hot dry rock (HDR) program.

MISSION

The overall mission of the federal HDR program is "to demonstrate the technical and economic feasibility of HDR as a significant energy source and to provide a basis for its timely commercial development, if warranted." This mission is to be accomplished by 1985. The dual nature of the mission implies two program components: technical and commercial.

The technical component represents more than 90 percent of the total project manpower and cost, and has both near and mid-term objectives.

- Near-term, early 1980's: to determine the potential of the HDR resource beneath the United States in cooperation with the United States Geological Survey (USGS), focusing on the fraction available at shallow depth near load centers; to demonstrate that all requisite technologies are either already commercially available or within reach of engineering development, that is that no technological "breakthroughs" are needed.
- Mid-Term, mid 1980's: to provide a more detailed evaluation of the HDR resource potential, including a catalog of prospective sites for commercial development; to develop and demonstrate the required technologies.

The commercial component will have been addressed by the attainment of the far-term objective:

- Far-term, late 1980's and beyond: to define and conduct program activities and projects, technical and/or institutional, necessary to promote the establishment of an HDR energy industry.

*This program summary has been drawn from: LASL HDR Project Staff, HDR Geothermal Energy Development Program, Annual Report, 1978.

SCOPE

The scope of the program is very broad, embracing all activities within DOE's charter that may be necessary to achieve program objectives. Major activities include:

1. Regional exploration and site evaluation, coordinated with USGS
2. Establishment of demonstration HDR reservoirs at several geophysically representative sites, and subsequent experimental assessment of them
3. Conduct planning, marketing and institutional studies necessary for eventual commercial exploitation of the successful reservoirs, in conjunction with local industry
4. Analytical support, including data reduction and mathematical modeling for such parameters as drawdown rates and other reservoir characteristics
5. A coordinated program for development of specific down-hole equipment and instrumentation needed for high temperature HDR applications
6. Development of reservoir engineering techniques applicable to a representative variety of geologic formations
7. Environmental monitoring of each test site to both protect the ecology and assess the environmental impacts of HDR systems
8. Studies of the present and future economics of commercial HDR systems
9. Legal and institutional analyses to better define and manage the resource
10. A program of technology dissemination, including a centralized HDR information center.

LASL has planned four specific tasks to complete these activities. They are:

1. Erection of a 5 MWe electric generating station at Fenton Hill

2. Selection of a second demonstration site and construction of a direct heat plant of 20 to 50 MWt
3. Selection of ten or more prospective areas for future HDR resource development
4. Determination of the domestic potential for HDR energy.

RESOURCES

Resources available to achieve the mission are of five types: technology, R&D results, future demonstration projects, financing, and contacts with organizations that could commercialize the technology.

Technology is the primary resource, and consists of the engineering, geophysical, and other scientific instrumentation and techniques required to recover heat from an HDR reservoir. This technology has been developed for the Fenton Hill project, but much of it is directly applicable to other sites. Several technological developments, now in progress during FY 78, are expected to be nearing completion by the end of the fiscal year. Development of a high temperature downhole turbo-drilling motor is continuing and will be field tested in the Phase II drilling at Fenton Hill. Other LASL-sponsored high temperature units, such as an improved openhole packer, will be tested in the same drilling program. Major instrumentation developments include improved downhole temperature and velocity measuring units and tools for borehole gauging. Developments in fracture mapping instruments include feasibility studies and a preliminary design for a radar-based far-field mapping tool and an in situ stress measurement device, a prototype downhole acoustic transceiver unit, a high temperature downhole video system, and high temperature instrument cables.

R&D results are based on the analysis of data collected at Fenton Hill as well as conclusions derived from mathematical modeling. Although they are highly site specific, they will clearly facilitate the development of future sites. Specifically, two flow tests yielded the following encouraging results:

1. Loss of water due to permeation stabilized at less than two percent of the circulation rate, thus indicating that make-up water requirements will probably not be a major constraint at geologically similar sites.

2. Total dissolved solids stabilized at a satisfactory level, about 2000 PPM once equilibrium was achieved. No evidence of corrosion or scaling was detected in the flow loop.
3. Downhole flow impedance (directly related to the power required for pumping) decreased to a manageable 3 psi/gpm, prefiguring relatively low power consumption rates.
4. No detrimental environmental effects were observed, including effects on local aquifers and seismicity.
5. Operational constraints were minimal.
6. Actual drawdown characteristics confirmed the adequacy of the mathematical model.

The selection and development of future demonstration sites offer an opportunity for demonstrating commercial applications of HDR, as well as technological advances. Ten candidate areas will be nominated from a survey of existing resource data. From this list, the two most promising prospects will be selected for detailed geophysical investigation. Their suitability for HDR development will be assessed on the basis of subterranean geology, hydrology, heat flow, institutional and environmental constraints, and the local energy situation. These studies will be presented to the site selection committee who will then make their recommendations to the HDR program office. Final site selection is scheduled for 1980. The Site 2 pilot plant should be constructed by mid-1984, and test runs conducted in 1985 and 1986. One or two additional sites per year will be evaluated through 1986 for mid-term development.

The financial resources available to the federal HDR program are considerable. The minimum funding necessary to accomplish the program objectives has been estimated at \$145 million by the HDR Program Office through 1985. Over 50 percent of this amount will be earmarked for the design and construction of the two demonstration plants, and 10 percent will be dedicated to the institutional program.

Federal HDR program staff have already begun to contact persons and organizations that are potential users and developers of HDR energy, as well as organizations that can act as marketing agents for the technology. At present, the major industrial contacts are the subcontractors who are developing specialized instrumentation and downhole equipment that are not

commercially available. These companies are in a position to sell this new technology and thereby aid directly the development of an HDR industry. LASL has established contact with one interested electric power company, but has been less successful with direct heat users. The federal HDR staff has also maintained contact with the Geothermal Resources Council, which is composed of private firms and government agencies that are involved in geothermal energy development. The council is an important disseminator of HDR information.

III. NATIONAL DEMAND FOR HOT DRY ROCK ENERGY

As the demand for energy grows and the supply of oil and gas declines, both domestically and from imports, the proportion that each fuel will contribute to total supply is expected to change. The Energy Information Agency (EIA) projects that, by 2020, coal and nuclear will provide approximately 70 percent of our total energy requirements.* This is roughly the same proportion now supplied by crude oil, natural gas and imports. (See Exhibit III-1.)

The role of emerging technologies (enhanced oil and gas recovery, synthetics, secondary electricity generation such as combined cycle and magneto-hydrodynamic technologies, solar and geothermal) is also expected to grow substantially in the next several decades. By the year 2000, these sources must supply 21.9 quads, or 17 percent of the total forecasted consumption of 129 quads.* Although the percentage supplied by emerging technologies remains small, it represents a large increase over current levels.

These forecasts depend on three assumptions which are highly uncertain: a 4.8 percent annually compounded growth rate for coal production, an 8.3 percent growth rate for nuclear, and a world oil price of \$14.30 per barrel in 1978 and \$23.50 in 1995. The 1978 price has already been exceeded, and the 1995 price is on the verge of being exceeded by the actual July, 1979 price of \$20.64. The current price can be expected to be raised again at the next scheduled OPEC meeting in December, 1979.

The amount of energy supplied from new technologies is extremely sensitive to world oil prices. For example, if the price of oil were \$16.50 per barrel in 1995 (the low estimate), contributions from new technologies could be expected to total 3.374 quads; if the world oil price were to reach \$31.50 (the high estimate), the amount of energy supplied by new technologies would climb to 4.374 quads. Forecasts based on realistic world oil prices are not yet available. However, uncertainty in the world oil price and the sensitivity of new technology to it underscore the importance of the role that emerging technologies could play by the end of this century.

*Energy Information Administration, Annual Report to Congress, Vol. III, 1978.

US ENERGY SUPPLY TO 2020

*Others: Hydroelectric and Emerging Technologies

SOURCE: Annual Report to Congress, Vol. 3, U. S. Energy Information Administration, 1978.

ROLE OF NEW TECHNOLOGIES

The EIA has developed supply projections for emerging technologies, assuming a range of world oil prices and different levels of domestic energy supply and demand. Assuming a high world oil price, low domestic energy supply and high domestic energy demand, geothermal energy for electric generation is expected to supply .720 quads in 1995, or 14 percent of the total energy supplied from emerging technologies. (See Exhibit III-2.) In addition, geothermal and solar energy for direct heat applications is projected to supply .582 quads, or 11 percent of the total. The total of 1.302 quads includes .078 quads that come from 1978 sources, so the remaining 1.224 quads (geothermal and solar) must come from new sources.

HDR is likely to compete well with other emerging technologies because of its widespread availability, acceptable environmental effects, and its technical feasibility as demonstrated at Fenton Hill. Thus it seems conservative to project that HDR would provide at least 10 percent of the energy to be supplied by emerging technologies.

If HDR were to account for this percentage, its commercialization goal in 1995 would be .1224 quads. The HDR program office expects single near and mid-term projects to range in size from 20 to 50 MWt, yielding an annual contribution of 0.00060 to .00150 quads per project at maximum output. It follows that between 81 and 204 projects must be operating by 1995 to fulfill this goal. Moreover, if eight years lead time is required between project commitment and energy-on-line, and if a logistic curve for commercialization progress is assumed, Exhibit III-3 gives an indication of the HDR project commitment schedule for meeting the 10 percent goal. An approximate cumulative number of average-sized project commitments that would be needed to meet the 10 percent goal by 1986 is 100.

GEOHERMAL ENERGY DEVELOPMENT

This section describes the status and future of geothermal energy, focusing on hot dry rock energy. It begins with a description of the resource base, followed by a discussion of commercial applications -- all hydrothermal. The section concludes with an analysis of the factors affecting HDR commercialization.

Resource Base

There are four known types of geothermal resources: hydrothermal (steam and hot water) systems, geopressed systems, magma systems and hot dry rock.

CONTRIBUTIONS OF NEW TECHNOLOGIES: HISTORICAL AND PROJECTED

(Quadrillion Btu Per Year)

Assumptions	Historic 1977	Projected 1995				
		High Low High	High Mid Mid	Mid Mid Mid	Low Mid Mid	Low High Low
World Oil Price Supply Curve Demand Curve						
Coal Conversion		3.361	2.944	1.949	.816	.757
Geothermal for Electric Utilities	.078	.720	.451	.446	.446	.446
Waste Conversion		.110	.110	.110	.110	.104
Electricity from Renewable Resources		.311	.287	.287	.287	.311
Dispersed Technologies		.582	.582	.582	.582	.582

SOURCE: U. S. Department of Energy, Energy Supply & Demand in the Midterm, 1985, 1990, 1995,
April, 1977.

NUMBER OF PROJECT COMMITMENTS NEEDED PER YEAR THROUGH 1987

ACCORDING TO SHARE OF NEW SOURCE* SUPPLY HDR WILL CAPTURE

Percent of new sources supply, total = 1.224 quads in 1995

*Total Geothermal Electricity and Geothermal and Solar Direct Heat Market

Steam and hot water systems are formed when the source of heat, usually molten rock or magma, heats water trapped below an impermeable rock formation. If cracks and fissures exist in the geology, surface phenomena such as geysers or hot springs will signal the locations of these hydrothermal systems.

Exhibit III-4 estimates the energy thought to be recoverable from hydrothermal systems with current and near-current technologies. Of these, 95 percent comes from hot water systems, and 5 percent from steam systems. The hot water systems prevail in the West, specifically in Southern and Eastern California, Central and Northern Utah, and North Central New Mexico. Only three steam systems had been identified as of 1977 -- two in California and of course Yellowstone National Park. The Geysers steam field in California accounts for all the present geothermal electric generation capacity in the United States -- nearly 1000 MWe.

Geopressured reservoirs are the product of methane-saturated water trapped in layers of sand and shale beneath impermeable rock. They produce heat at 160°C to 200°C. The USGS estimates that 27.8 quads of heat energy are recoverable from geopressured systems in coastal areas.* All of the known geopressured deposits located in the coastal regions of Texas and Louisiana, up to 250 miles offshore. Resource estimates are generally unreliable, as drilling techniques have yet to be demonstrated successfully. The environmental effects of developing geopressured resources are also unknown.

The remaining two types of geothermal energy -- magma and hot dry rock -- are based on the heat stored in hot igneous geology, where the rock near the surface is generally silicic rather than basaltic. Inactive volcanic sites are believed to signal the presence of such deposits at depths of three to ten km. The USGS has identified 17 such formations in the Western states, 24 in Alaska, and one (basaltic) in Hawaii. (See Exhibit III-5.) Additional data, provided in part by the American Association of Petroleum Geologists, has identified significant gradients along the Atlantic Coast, New Hampshire, the Midwest from Ohio to Nebraska, and the Dakotas.

*D. E. White and D. L. Williams, "Summary and Conclusions," Assessment of Geothermal Resources of the United States - 1975, USGS, 1975.

ESTIMATES OF RECOVERABLE HYDROTHERMAL ENERGY

	Heat In Ground 18 (10 CAL)	Heat At Wellhead 18 (10 CAL)	Electric Energy (Quads)
<hr/> High Temperature Systems (over 150°C) for Electricity Generation <hr/>			
Identified Resources	257	64	
Reserves			10.5
Undiscovered Resources	1200	300	113.8
<hr/> Intermediate Temperature Systems (90° - 150°C) for Non-Electric Uses <hr/>			
Identified Resources	345	86	NA
Undiscovered Resources	1035	260	NA

SOURCE: D. E. White and D. L. Williams, "Summary and Conclusions,"
Assessment of Geothermal Resources of the United States - 1975,
 USGS, 1975.

HOT IGNEOUS SYSTEMS IN THE WESTERN UNITED STATES

SOURCE: Resource Planning Associates, Inc., Western Energy Resources and the Environment: Geothermal Energy, Environmental Protection Agency, April, 1977.

In spite of these efforts, large areas have not yet been assessed, as can be seen in Exhibit III-6. The USGS estimates the total heat that could be recovered from these systems at a maximum of 25×10^{21} calories, half of which is believed to be in the form of molten or partly molten rock at temperatures between 650°C and 1200°C . The HDR Program Management Office at Los Alamos estimates the resource to be around 7600×10^{21} calories, or more than 300 times the more conservative USGS estimate which omits much data from the East. Although estimates of the size of the geothermal resource vary widely (see Exhibit III-7), it is clear that the geothermal energy potentially recoverable from hot igneous rock greatly exceeds the energy that is recoverable from coal, natural gas, crude oil and shale combined, even by the more conservative USGS estimates.

Extent of Commercialization

Geothermal energy, specifically hydrothermal, has been commercialized in both electric and non-electric applications.

Electric generation has been accomplished by tapping steam fields and connecting to a familiar technology: the steam turbine. Lines from the wellhead transport steam to a centrifugal separator which removes dust and corrosive particles. The treated steam is then used to drive the turbine which in turn generates electricity.

Exhibit III-8 displays electric generating capacity from geothermal resources by county in 1973 and 1976. The United States and Italy have the most by far. Since then, the Geysers, developed for Pacific Gas and Electric, has increased in capacity to nearly 1000 MWe, so that it is now capable of supplying electricity to a city of 900,000.* Despite the fact that this plant is the only geothermal generator in the U. S., outside of national parks, potential for expansion is still expected to more than double the present capacity by 1985.** Although

*Jack McNamara and Edward L. Kaufman, "Hot Dry Rock Geothermal Resources and the Law," LASL, 1979.

**R. Trehan, A. Cohen, J. Gupta, W. Jacobsen, J. Leigh, S. True, Site-specific Analysis of Geothermal Development Scenarios and Requirements: Vol. II, Mitre Corporation, 1978.

PRELIMINARY GEOTHERMAL GRADIENT MAP
(PRIMARY SOURCE AAPG GRADIENT MAPS)

RECOVERABLE GEOTHERMAL AND FOSSIL FUEL ENERGY
HEAT-IN-GROUND OR RECOVERABLE RESERVES 10¹⁸ CALORIES

	1 RPA	2 EIA	3 USGS	4 LASL
Hydrothermal (above 90 C)	2,837		872	
Geopressured	7		25,600	
Hot Igneous (magma and hot dry rock up to 10km in depth)	25,000		24,100	
Hot Dry Rock only (up to 10 km in depth)				7,600,000
Coal		1,195		
Natural Gas		235		
Crude Oil		247		
Shale Oil		1,195		

SOURCES:

1. Resource Planning Associates, Inc., Western Energy Resources and the Environment: Geothermal Energy, Environmental Protection Agency, 1977.
2. Energy Information Administration, Annual Report to Congress, Vol. III, 1978.
3. USGS, Assessment of Geothermal Resources of the U. S., 1978, Circular 790.
4. LASL, Hot Dry Rock Geothermal Energy Development Program, Annual Report FY 78, 1978.

ELECTRIC GENERATING CAPACITY FROM GEOTHERMAL RESOURCES

	1973 Installed Capacity (MWe)	1976 Installed Capacity (MWe)	Growth Rate (%/YR)
United States	396	502	7.9
Italy	406	421	1.2
New Zealand	170	190	3.7
Mexico	75	75	0
Japan	33	68	24.1
Soviet Union	5.7	5.7	0
Iceland	2.5	2.5	0
Turkey	0	0.5	-
TOTAL	1089	1265	5.0

SOURCE: P. F. Kruger and C. Otte, Geothermal Energy, Stanford University Press, 1973.

not yet developed, the potential for water-dominated systems is also great. Exhibit III-9 illustrates the estimated generating capacity of significant geothermal reserves in the West.

Non-electric, or direct, applications are more widespread and better known. The 1979 total world capacity is between four and five times the electric capacity or about 7050 MW (thermal). Most of this energy is used for district heating in Iceland, greenhouse complexes in the USSR and major industrial uses in New Zealand. Exhibit III-10 identifies the type of direct application by country. In all cases the cost of geothermal utilization is below that of comparable fossil fuel energy. Thus, direct applications of geothermal heat can be expected to increase as fossil fuel costs rise and geothermal technology improves.

Direct applications in the United States are limited when compared to those of other countries. Best known are the therapeutic and bathing spas, notably Hot Springs, Arkansas, Steamboat Springs, Colorado and numerous places in the West.

Geothermal space heating has also been successful for over 40 years, the most significant applications occurring in the Warm Springs District of Boise, Idaho, and numerous buildings drawing from 400 wells in Klamath Falls, Oregon. Minor consumption can also be found in Reno, Nevada; Lakeview, Oregon; Vale, Oregon; Susanville, California; and Calistoga, California.

Industrial process heat is the third major application, and in the U. S., two projects are noteworthy: 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 dehydrating onions and other vegetables. Major developments totaling \$6 million in capital investments are in the offing: an Ore-Ida potato processing plant in Ontario, Oregon and a district heating project in Klamath Falls, Oregon.

Finally, greenhouse and aquaculture projects comprise a small but significant portion of the geothermal applications in the U. S. Their significance lies in their opening up areas not previously suitable for growing due to their cold climates. Truck vegetables, cut flowers, potted plants, and tree seedlings are the most popular greenhouse products; catfish, trout, and giant freshwater prawns are the common aquaculture products.

ESTIMATED GENERATING CAPACITY
OF SIGNIFICANT GEOTHERMAL RESERVES IN THE WEST

SOURCE: P. LaMori, "Geothermal Research and Advanced Technology," in Energy Technology III: Commercialization, 1976.

WORLDWIDE DIRECT APPLICATIONS OF GEOTHERMAL ENERGY 1979 (MWe)

Country	Space Conditioning	Aqua/Agri- culture	Industrial Process
Iceland	680	40	50
New Zealand	50	10	150
Japan	10	30	5
USSR	120	5100	0
Hungary	300	370	0
Italy	50	5	20
France	10	0	0
Others	10	10	5
USA	75	5	5
TOTAL	1245	5570	235

SOURCE: John W. Lund, "Worldwide Direct Application Review," in A Symposium of Geothermal Energy and its Direct Uses in the Eastern United States, Geothermal Resources Council, April, 1979.

Factors Affecting HDR Commercialization

As is evident from the preceding discussion, all commercial geothermal developments in the U. S. use hydrothermal resources. Although the hot dry rock resource is far more extensive, it has not yet been tapped for either electric or non-electric applications. Several factors discussed below are constraining the commercialization of HDR energy. These include the status of the technology, environmental effects, economic feasibility, financing, legal and regulatory issues, and public awareness.

Status of Technology

Whereas hydrothermal technology is well developed and available for commercial use, HDR technology has a number of hurdles to clear before it can be offered to developers as a reliable, cost-effective method for extracting useful energy. Basic feasibility has been demonstrated at Fenton Hill, but progress must be made beyond the technological achievements described in Chapter II.

The federal HDR program has identified several technological objectives that must be achieved before commercialization can occur freely. The first is to obtain reliable estimates of the magnitude, location and depth of HDR resources in the U. S. Current information has been provided by the American Association of Petroleum Geologists (AAPG), the USGS, and numerous Eastern universities. AAPG data was collected for the purpose of identifying oil and gas fields which occur in deep sedimentary basins, not in igneous formations where HDR resources occur. The USGS has collected data only for western states where there is federal land. Various universities have collected data in the East, but it is not comprehensive. The federal HDR program is attempting to remedy this situation by compiling comprehensive data on the location and nature of the resource and developing maps displaying permeability and fluid content to aid exploration. Finally, maps exhibiting orientations of stress fields in reservoir rocks will reduce uncertainties and costs in fracturing and reservoir management at known HDR sites.

Once the resources are identified further improvements in drilling, and fracturing technology will be necessary to reduce the number of drilling and fracturing attempts and thereby reduce development costs. Improved downhole motors, steering instruments, and sidetracking methods that can withstand high temperatures will be needed to improve drilling. High temperature

cements are also necessary for casing and remedial work. A variety of methods needs to be explored for fracturing and improving flow between bore holes.

Defining a reservoir by remote sensing and mapping is necessary to reduce uncertainties in fracturing and accurately drill the second borehole. In order to map the fracture quickly from the surface or from the hole, a number of downhole instruments and methods which measure stress, permeability, and natural fracture systems need more extensive development.

Control of subsequent reservoir behavior depends on refined knowledge of rock mechanics such as strength, elastic porosity, thermal conductivity and expansion, fracturing, and various aspects of thermal stress cracking. Effective loop maintenance will be improved by resolving difficulties in formation plugging, corrosion and scaling.

The reliability of data gathered as a result of the above efforts will help to refine mathematical models that predict system characteristics and performance, directly affecting a HDR developer's assessment of economic feasibility.

Environmental Effects

A second issue which affects the progress of commercialization is the uncertain environmental effects of HDR heat extraction. According to a survey of manufacturers conducted by the Conference Board in 1973, environmental regulations were the most important factor, excepting price, that manufacturers anticipated would affect their choice of fuel.*

To establish an environmental baseline, extensive environmental baseline studies were undertaken at Fenton Hill before the continuous 75-day test. The major concern was the possibility of micro-earthquakes induced by fracturing activities and by the injection of large volumes of pressurized fluid. The contamination of surface waters and subterranean aquifers, and the release of hydrogen sulfide and methane gases were also expected to be significant. Finally, biological, climatological and socioeconomic effects were to be carefully analyzed.

*The Conference Board, Energy Consumption in Manufacturing, 1974.

The results of the Fenton Hill environmental studies were extremely encouraging. After several extended operations, no adverse environmental effects and no detrimental social impacts were detected.* The logical questions to be addressed next are: to what degree are these results generalizable to other sites? Will unforeseen problems arise? Will more continuous operation disclose more critical levels of noise and thermal pollution? The accumulation of data from other sites will start to allay these concerns. If they are as encouraging as the Fenton Hill results, HDR could offer the least environmentally damaging energy source.

Economic Feasibility

The economic feasibility of HDR development is a third factor affecting commercialization. Costs of generating electricity using HDR energy have been determined only mathematically with a model developed by a research team headed by Jefferson W. Tester in 1978.** The model relates numerous technical, reservoir, and economic factors involved in the generation process. At several decision points in the reservoir lifetime, it makes decisions that maximize the present value of after-tax return. Thus, assuming certain parameters, the model describes an optimal strategy for reservoir development and management.

The model analysis "suggests grounds for at least guarded optimism as to the possibility of HDR-produced electricity in areas of the U. S. where temperature gradients are in the $\geq 40^{\circ}\text{C/km}$ range and 'competitive' busbar costs are approximately 3¢/kWh or higher." At temperature gradients greater than 50°C/km , feasibility depends on well flow rates and competitive busbar rates or not less than 3¢/kWh; at gradients in the $20^{\circ} - 30^{\circ}\text{C/km}$ range, competitive busbar rates must be higher than 3¢/kWh.

*E. L. Kaufman and C. L. B. Siciliano, Environmental Analysis of the Fenton Hill Hot Dry Rock Geothermal Test Site, LASL, May, 1979.

**J. S. Tester, G. E. Morris, R. G. Cummings, R. L. Bivens, Electricity from Hot Dry Rock Geothermal Energy: Technical and Economic Issues, LASL, January, 1979.

Although these results do not seem to impose severe constraints on HDR development, the uncertainty of achieving them comprises the greatest deterrent to commercialization. Abnormally high plant costs caused by poor geofluid quality, high interest rates, and increased rates of temperature drawdown or reservoir losses decreases the attractiveness of HDR-produced electricity when compared with other energy sources.

The economic feasibility of direct HDR application is even more difficult to assess. Comparisons with hydrothermal applications are limited because of a number of factors that contribute to cost uncertainties (such as capital costs) are dissimilar. For one specific direct hydrothermal application, district heat supplied within a radius of five miles to a population of 10,000 or more, the GIRORA Electric Computer Model developed at the New Mexico Energy Institute* estimated an internal rate of return between 14 and 16 percent, depending on hydrothermal resource temperature.

Legal and Regulatory Issues

Legal and regulatory issues pertaining to HDR fall into two basic categories: the legal definition of the resource, which has implications for ownership and development, and the complexity of leasing and permitting procedures.

The lack of a consistent definition of the resource among federal and state statutes is evidenced by the different wordings in various laws and statutes. Whereas the Geothermal Steam Act specifically mentions "heat" and "artificially injected fluids", there is no specific mention of HDR in the Geothermal Research, Development, and Demonstration Act of 1974. HDR would fall under the jurisdiction of water law in Nevada and other western states, but mineral rights need to be secured in Louisiana before HDR ownership rights are secure. In Idaho, a sui generis (neither mineral nor water) definition has been adopted. The 35 states that do not have such laws on their books will probably define the resource to protect their own interests. For example, most western states seem to be adopting

*Joseph P. Marlin, Regional Operations Research Program for Development of Geothermal Energy in the Southwest United States, New Mexico Energy Institute, January, 1979.

a legal definition that protects pre-existing surface, mineral, or water rights holders.* Eastern states have not yet fully addressed the issue. Moreover, nearly all laws neglect to cover HDR systems adequately, focusing instead on hydrothermal systems.

The lack of a legal definition of the resource has serious implications for HDR development. A state legislature or court could conceivably define HDR as public property or as property of the pre-existing water or mineral rights holders. No developer would be willing to invest the kind of capital that is required when the venture is subject to interference by pre-existing mineral and water rights claimants. Furthermore, a mechanism still must be developed for resolving conflicts among claimants, when both are protected by their respective laws.

The complexity of leasing and permitting procedures is a major contributor to the typical eight year time period between federal lease sale and production of electricity.** As an illustration of the steps that a geothermal developer must go through for federal land, pre-drilling requirements include a Preliminary Environmental Assessment prior to the issuance of a lease, lease application, Plans of Operation for all subsequent activities, a full Environmental Assessment for each plan, Application for Permit to Drill, and adherence to periodic Geothermal Resources Operational Orders issued by USGS. Review and comment is required of the BLM, Fish & Wildlife Service, Interagency Geothermal Environmental Advisory Panel, and various approvals have to be secured from USGS. In addition to this brief list, there are a myriad of state and county environmental, exploratory, drilling and operational reports and approvals.

According to the DOE, the most serious difficulties in the federal leasing/permitting procedures are the delays in issuing

*J. McNamara and E. L. Kaufman, "Hot Dry Resources and the Law," LASL, 1979.

**D. R. Lindsay, "Procedural Requirements for Developing Geothermal Resources from Leasing to Power Generation," Commercialization of Geothermal Resources, Geothermal Resources Council, November, 1978.

non-competitive leases, drilling permit delays, and discriminatory treatment of casual use lessees.* The non-competitive lease delay inhibits exploration and development of marginal and unproven resource areas, thereby curbing the growth in the number of known geothermal resource areas. The drilling permit delays of six months or more increases costs of development. Finally, requiring casual use lessees of federal land to prepare extensive documents and reports inhibits initial reconnaissance and exploration of potential resources.

Investments in geothermal development are depressed by the prospect of such requirements and delays, especially when comparable returns can be realized in shorter time through other investments. For example, oil production typically begins one or two years after lease application.** These difficulties have been widely recognized and solutions have been proposed. Perhaps by the time HDR commercialization progresses beyond the demonstration stage, these constraints will have diminished.

Financing

Financing and development of geothermal resources must resolve two basically conflicting interests: compensating the developer for unusually high risks stemming from project uncertainty, and assuring the ultimate consumer of reliable, low cost energy. Resolving this conflict necessitates a complex financing scheme that can, itself, inhibit commercialization.

The principal source of this complexity is the risk of premature failure for any reason, the most likely one being short reservoir life. According to Rogers Engineering, the producer at Roosevelt Hot Springs, Utah, an investor would require at least a 30 percent internal rate of return to be compensated for these risks.*** Moreover, geothermal development requires

*A. J. Bohner, "The Legalities of Geothermal Energy Development," Geothermal Energy Magazine, Vol. 7, No. 3, March, 1979.

**"Institutional Barriers to Geothermal Energy Development: Second Report to the Institutional Barrier Panel to the Geothermal Advisory Council," FEA, December, 1976.

**D. Nutter, Oil Conservation Division, Energy and Minerals Department, State of New Mexico, 1979.

***H. I. Rogers, "Financing and Construction of a Commercial Geothermal Power Plant in Utah," Commercialization of Geothermal Resources, Geothermal Resources Council, November, 1978.

an enormous initial investment - \$10 to \$15 million for exploration and \$100 million for a 400 MW plant using hydrothermal resources.* HDR development will require even larger capital investments.

A regulated utility is not generally in a position to assume this level of risk or invest the initial capital required for HDR development. Hence it is necessary to shift the financial risk and investment requirements to another party, or spread it among a number of different entities. The relationship between the utility and the other party or parties must be defined very carefully, lest the other parties find themselves subject to the same regulations that are imposed on the utility.

To assist in the financing of geothermal development, Congress authorized a federal loan guaranty program under the Geothermal Steam Act of 1976. This program stipulates that:

1. the project be commercially viable; i.e., that it generate sufficient income to pay all expenses and service the debt;
2. a maximum of 75 percent of project value be eligible for the guaranty;
3. the 25 percent non-guaranteed monies be committed, i.e., that they cannot be raised at the time they will be needed;
4. if the project fails for any reason, the owning entity be declared in default on the 75 percent loan before the guaranty is invoked.

Given the large amount of capital required, the level of risk involved, and the long payback period, it is difficult to raise the 25 percent that is not guaranteed by the federal government. Moreover, if the project fails for any reason, the debt structure of most corporations will not allow any corporate or subsidiary defaults without making other debt callable. This provision virtually requires the involvement of a third party who is neither the developer of the resource nor the regulated utility.

A frequent arrangement contrived to satisfy all parties has been the creation of a third entity to invest the risk

*Bob Greider, "Economics, Risks, and Size of Geothermal Projects," Commercialization of Geothermal Resources, Geothermal Resources Council, November, 1978.

capital and construct the power plant, which is the arrangement arrived at in the Phillips Petroleum's development of Roosevelt Hot Springs.* Sierra Pacific Power Company of Nevada has suggested an alternative structure wherein utilities join together in a shared project so that risk is spread sufficiently and federal program benefits are shared.** These arrangements and others are described in greater detail in the electric utility market profile.

Public Awareness

Although the publicity on geothermal energy development is widespread, the hydrothermal component has received almost all of the attention. Public awareness of HDR has been limited to a small audience of professionals in science, engineering, and industry. The 1979 Hot Dry Rock Geothermal Conference drew speakers only from LASL and its subcontractors, DOE, and two potential developers. This limited public awareness makes a technological concept seem more exotic than it really is, perpetuating skepticism among key people who might be involved in the development process. For example, public utility commissions would be more likely to view HDR plants as appropriate generating facilities if the general public demanded that the resource be developed. Commercialization is therefore inhibited until awareness can be increased among both key figures and the general public.

The federal HDR program is aware of this constraint and is planning a program which will test the acceptability of HDR development to the general public, then increase public awareness through various forms of education, and finally measure the results. The completion of this program should help to encourage HDR commercialization.

*Rogers, loc. cit.

**R. G. Richards, "A Utility's Evaluation and Potential Broad-Based Geothermal Development," Commercialization of Geothermal Resources, Geothermal Resources Council, November, 1978.

IV. MARKET PROFILES

This chapter describes potential markets for HDR energy, where a market is defined as a type of customer using an HDR energy product. An example of such a market is a utility using HDR steam to generate electricity, or a food processor using HDR heat for processing.

The chapter begins by segmenting the market by type of customer and identifying the forms of HDR energy that each would use. A detailed profile is then presented for each market segment. Each profile first identifies the key decision makers and the decision making process and criteria that apply to their energy-related decisions. Each profile concludes with an assessment of the potential for HDR energy in that market.

MARKET SEGMENTATION

The market has been segmented into five customer groups on the basis of their decision-making characteristics, financial resources and the way in which they use energy. They are: industry, utilities, institutions, real estate, and agriculture/aquaculture. The industrial market consists of seven broad groups: primary metals; textiles; stone, clay and glass; food processing; petroleum and coal products; pulp and paper; and chemicals.* The utilities market includes both investor-owned and publicly owned electric utilities. The institutional market contains public and private non-profit organizations that provide services. Real estate development for industrial, commercial and residential purposes comprises another market. And the agriculture/aquaculture market consists of businesses that do greenhouse horticulture and fish farming.

The products resulting from HDR development are both electric and non-electric. Rankine or similar cycles have been

*A potential eighth group, the mining industry, is also significant in terms of low temperature energy use and extent of operation. In particular, copper and potash drying, and sulfur extraction are potential HDR applications. This group was not addressed specifically in the industrial market profile because the market is limited to the states of New Mexico, Michigan, Arizona, Utah and Texas. However, the general characterization of industry by their decision makers and decision-making process can be extended to these mining industries. Chapter V evaluates the mining market by state, on an equal basis with other industrial markets.

used for power production with water as the working fluid, or steam vapor can be created by flashing geothermal fluid at the surface to a lower temperature. Binary cycles employ non-aqueous fluids which extract heat from the geothermal fluid via a heat exchanger. In all cases, temperatures of 150°C or greater are required to generate electricity.

Non-electric products include industrial process heat, space conditioning and district heat. Industrial process heat, as opposed to electrical or mechanical energy forms, is conventionally produced by steam or hot water for low to medium temperature applications and by direct fire for high temperature applications. The market for industrial process heat below 160°C is examined for the seven broad manufacturing groups.

Space conditioning is the heating and cooling of individual buildings, generally achieved by direct fire, electric resistance, heat pumps, steam or water distribution. Temperature requirements for hot water heating, the technology most adaptable to HDR, range between 45°C and 85°C. Hot water in this range can be used in radiator or finned tube units, or passed through a heat exchanger to serve a forced-air heating system. Cooling using steam is achieved using absorption chillers.

District heat, the third non-electric use, is the distribution of steam or hot water from a central source within a designated district for heating and cooling buildings and for industrial process use. Steam is the predominant medium in the U. S., and hot water is most common in Europe. Hot water can be transported by insulated underground pipes up to a distance of 50 miles with acceptable heat loss. Condensate and hot water returns may or may not be installed, depending on cost and environmental (water discharge) considerations. At the point of use, heat exchangers are employed to provide energy to the building or industrial consumer.

The relationship between customers and products is shown in the market segmentation matrix in Exhibit IV-1. It is useful to imagine a third dimension to the matrix which includes the 26 states where HDR resources are known to exist. Given this third dimension, it is possible to relate customers and products to specific locations. This is done in Chapter V.

MARKET SEGMENTATION MATRIX

Customers		Products		
	Electric	Non-Electric		
		Process Heat	Space Conditioning	District Heat
Industry		●		
Utilities	●			●
Institutions			●	
Real Estate			●	●
Agriculture/ Aquaculture			●	

INDUSTRY

The industrial market for HDR resources is one of the most promising. Industrial energy consumption comprises 30 percent of the total U. S. consumption, and much of it is expended in the appropriate HDR temperature range. Many industries are anxious to decrease their energy use, especially those dependent on oil or gas. In addition, industrial R&D and engineering staffs are seeking lower cost, reliable fuel sources and can readily evaluate the HDR option. Finally, industry can more easily raise the capital required for this technology than can other sectors of the economy.

The industrial market for HDR energy includes those industries falling within seven selected SIC codes, specifically, primary metals manufacturing, textile manufacturing, stone/clay/glass manufacturing, food and kindred products processing, petroleum and coal products, paper and pulp manufacturing and chemical manufacturing. These groups were selected because they represent the largest industrial contributors to the GNP and because they use substantial quantities of process heat in a temperature range that can be supplied by HDR.*

The industrial profile begins with an identification of the key decision makers in the industrial sector and continues with a discussion of the decision-making process, as it involves investment in an energy supply. It concludes with an assessment of the industrial market's potential for choosing HDR.

Key Decision Makers

In most corporations, policy is ultimately determined by top management: the board of directors, a single chief executive officer (CEO) or a management team. Although the board is legally the ultimate governing body, its role in decision making will vary considerably from one company to another. If a decision to use HDR resources involved a division facility, top division management would also have considerable influence in the decision-making process.

*Industrial space heating is not of major importance. In almost all cases, space heating comprises a small percentage of the total industrial Btu consumption, only 5.4 percent of the consumption in industries with potential geothermal application. DSS Engineers, Inc., Preliminary Research on Geothermal Industrial Complexes, March, 1978.

Clearly the role of individual decision makers in facilities planning varies from company to company, depending on the company size and management philosophy. In a survey reported in the Site Selection Handbook* 30 percent of facilities planning decisions were made by "upper managers" (including division managers), 20 percent by vice presidents, 15 percent by presidents or other CEO's, 7 percent by general managers, 5.5 percent by boards or their chairpersons, and .5 percent by architects. In terms of function, 48 percent of all such decisions are made by administrative personnel, as opposed to production, operations, real estate, finance or engineering personnel. Since a decision to use HDR would involve a major capital investment, the senior financial officer would also have an important role.

Decision-Making Process

A decision by a manufacturing firm to use HDR energy would generally involve selecting a new site, choosing an energy source, and making a substantial capital investment. Although there are some facilities that may now be located near HDR resources, it is much more likely that the decision would be made in the context of a larger decision about plant modification, expansion or relocation.

Site Selection

After the need for a new site has been established, management will identify the factors which it considers important. One study identified over 600 such factors.** These factors are weighted, either formally or informally, but in almost all cases will include availability of raw materials, labor and capital, transportation, proximity to markets, cost of development, energy supply, water supply and waste water treatment, climate, environmental regulations, community factors (location within community,

*Site Selection Handbook, supplement to Industrial Development Magazine, Conway Publications, 1978.

**Richard Preston, C. I. D., Editor, Principles of Industrial Development, American Industrial Development Council, 1976.

taxes, insurance, zoning and other legal aspects), and site factors (size, shape, topography, drainage, and soil conditions).

The next stage is analysis and recommendations, for which there is no universally applied method. Instead, the procedure used is related to the size of the firm and the management talent. A large firm may have a real estate department, but in smaller firms, the president or owner performs the analysis, market research, transportation analysis, wage comparisons, and raw material source surveys before promising sites are identified.

The third stage involves a detailed scrutiny of recommended sites, including actual site visits. Potential sites are ranked. When the locational investigation is handled personally by the firm's CEO, this ranking often results in a final choice. If it has been delegated, a detailed report will be submitted to top management for the final selection and approval. The Site Selection Handbook* reports that locational decisions are ultimately made by the CEO in 40 percent of the cases and by the board of directors or their chairpersons in 11 percent of the cases.

Choosing an Energy Supply

A decision to choose particular energy sources will be based on a great many different criteria, most of which relate to engineering considerations, cost, reliability and environmental effects. Exhibit IV-2 contains an exhaustive list of more specific criteria that a company might use. The 1973 Conference Board survey of Energy Consumption in Manufacturing** showed that, apart from energy prices, companies in nearly all industrial groups were most concerned about stiffer regulation of effluents and emissions, followed closely by fuel unavailability and service interruptions.

Both capital and operating costs are carefully evaluated in choosing an energy supply. From the capital investment perspective, the choice of a particular energy source is tantamount to

*Site Selection Handbook, Ibid.

**The Conference Board, Energy Consumption in Manufacturing, 1974.

CRITERIA FOR EVALUATING ENERGY SUPPLYA. Power Source

1. Thermal-coal, natural gas, propane, fuel oil, lignite
2. Hydroelectric
3. Other - nuclear, geothermal, solar

B. Electric Power Supply

1. Company or public agency serving area
2. Interconnection with other systems
3. Capacity - present and planned
4. Recent record of shortages or interruptions:
 - a. average number of interruptions per year
 - b. maximum duration
5. Vulnerability to natural disasters
6. Location of nearest electric substations and whether interlocking
7. Voltage phase and cycle available
8. Size of connection at proposed site
9. Two-way feed
10. Rates based on your demand for services
 - a. lighting
 - b. machine operation
 - c. air conditioning
 - d. welding
 - e. furnaces
11. Cost of extending service
12. Typical residential rates
13. Off-peak possibilities
14. Fuel adjustment provisions.

C. Gas Service

1. Suppliers
2. Capacity, present and planned, as compared with peak requirements
3. Allocation for industrial use
4. Type (natural, mixed, manufactured) and Btu value
5. Storage facilities
6. Recent record of shortages and interruptions
7. Size of connection at proposed site
8. Two-way feed
9. Industrial and residential rates, including interruptable rate

D. Coal Use

1. Suppliers
2. Cost of coal delivered, per million Btus

E. Potential For On-site Independent Energy Source

1. Gas well
2. Coal mine
3. Nuclear reactor
4. Other

F. Potential For Location In An Energy Park Complex (which includes waste recovery plant, generating stations, etc.)G. Other Specific Energy Plans

1. Alternative fuel plan
2. Cogeneration
3. Back-up system

SOURCE: Site Selection Handbook: Geo-Corporate Index, supplement to Industrial Development Magazine, Conway Publications, February, 1979.

the decision to invest in or convert to the equipment that would use this energy. In this case, the criteria for evaluating alternative energy sources are the capital investment and risk evaluation techniques discussed below.

From an operating perspective, energy costs and reliability have assumed much greater importance in the last five years. For example, it is now a primary concern in the production of basic chemicals, primary aluminum, and electronic furnace operations for ferro-alloys. It has greater-than-average importance for pulp and paper, iron casting, meat packing, and steel production.* Standard practice demands that energy costs be measured in absolute terms rather than a percentage of total manufacturing costs. Thus, a \$20,000 per year savings will attract notice, even if this amounts to only 2 percent of the total manufacturing costs.

Capital Investment Analysis

A decision to use HDR energy, whether or not it involves a new plant location, would be made in the context of the company's capital budgeting process. The first step in the capital budgeting procedure is for management to set the size of the total capital pool for a particular time period. This is determined largely by a company's financial position, required investments and other investment opportunities.

The second step is the allocation of the total capital budget among various projects. Mandatory projects that satisfy government requirements and replacement of certain equipment take priority, followed by "discretionary" investments. A more detailed breakdown of these categories, in general order of priority, might look like this:**

1. legal and safety
2. mandatory
3. completion of ongoing projects
4. maintenance of worn out equipment
5. modernization of process
6. new capacity with high expected return on investment
7. new capacity with average expected return on investment
8. other projects.

*John R. Fernstrom, Bringing in the Sheaves, Oregon State University Extension Service, June, 1973.

**DDS Engineers, Inc., Ibid.

The distinction between mandatory and discretionary categories is not clear, even in the above list, and is the function largely of the nature of the business strategy. Thus, if developing a reliable energy source is a component of the business strategy, it will be considered mandatory.

The third step is the evaluation of the proposed capital investments. J. M. Fregman* surveyed 177 companies in various sectors which reported the use of four criteria for financial appraisals. These methods are identified in Exhibit IV-3, along with the percentage of the companies reporting that use the methods and consider them important. These values are compared both to a minimum company standard and to those of other projects competing for capital. According to a DOE survey,** all companies that responded agreed that an investment which saves energy costs is evaluated by the same criteria as any other investment.

Part of the evaluation of the proposed capital investment is evaluation of risk. The DOE survey** revealed that sensitivity analyses (to determine variables most likely to affect return on investment) and use of scenarios were widely used techniques to assess risk among energy-intensive companies. To determine the extent of risk involved in a proposed project, scenarios may be constructed with input variables ranging from very optimistic to very pessimistic. Resulting rates of return are calculated for each scenario. A project whose rate of return is highly sensitive to these scenarios will be required to have a higher rate of return before approval is obtained.

The final step is top management approval. A corporate capital budgeting committee will submit the recommendations to top management based on the aforementioned evaluations.

Potential For Choosing HDR

The characteristics that set the industrial market for HDR apart from others are its locational flexibility, the relative

*J. M. Fregman, "Capital Budgeting Practices: A Survey," in Management Accounting, May, 1973.

**Energy & Environmental Analysis, Inc., Investment Risk Evaluation Techniques: Use in Energy-Intensive Industries and Implications for ERDA's Industrial Conservation Program, July, 1977.

EVALUATION OF FINANCIAL INVESTMENT CRITERIA

<u>Criterion</u>	<u>Percent Used</u>	<u>Percent Considered Most Important</u>
Discounted rate of return	71	38
Simple or discounted payback period	67	14
Simple rate of return	49	22
Net present value	20	4
Other methods	16	6

SOURCE: J. M. Fregman, "Capital Budgeting Practices: A Survey,"
Management Accounting, May, 1973.

importance of energy, and its financial flexibility. Once having made the decision to construct a new facility, the decision makers often have some latitude in choosing the site. Other potential HDR users, such as municipalities, electric utilities, and institutions are more constrained by geography and the location of their clients. Energy plays a greater-than-average role because the manufacturing process depends on it. Thus, industry has much more to gain or lose by reckoning with energy difficulties on a long-term basis, simply by virtue of the amount of energy it must have. Finally, industry has more financial flexibility than the regulated utilities, municipalities, and institutions. These other markets, which have to answer to the community or ratepayers, face a more difficult task in justifying risky capital expenditures than does industry.

In view of these points, the industrial market for process heat, taken as a whole, is one of the most promising. However, there is considerable variation within this market. The subsequent sections evaluate the potential for HDR by major industrial group according to several criteria: process heat use, energy intensiveness, total energy consumption, oil and gas dependency, R&D activity and access to capital.

Process Heat Use

Process heat is generated as direct fire or steam. Direct fire can provide temperatures above 800°C and satisfy open flame applications such as singeing, smoking, and calcining. When low temperatures are required and open flame is not, then steam is best used to supply process heat, even when temperature requirements fall below 100°C. Thus, industries that use steam are the most promising HDR candidates.

The process heat criterion has several components. First, the industry must use a substantial amount of process heat, measured both in number of Btu's and as a percentage of its total energy use. Exhibit IV-4 shows process steam use by industry for 1974. The pulp and paper industry and the chemical industry clearly generate the largest amounts of steam for processing purposes, while pulp and paper, food processing and textiles use the highest percentage of steam in their total energy consumption.

Equally important are the temperature requirements for the process heat. The temperature of a substantial portion of the process heat must fall under the potential HDR supply temperature to warrant the investment required. For example, the dried milk production process consumes 71 percent of its energy below

INDUSTRIAL PROCESS HEAT USE, 1974

<u>Industry</u>	<u>Process Steam Generation (trillion Btu's)</u>	<u>Percent of Industry's Energy Use</u>
Primary Metals*	90.0	1.9
Textiles	144.3	45.6
Stone/Clay/Glass	40.2**	3.1
Food Process	477.8	51.1
Petrol/Coal	464.1	21.0
Pulp/Paper	1549.8	69.7
Chemicals	1322.2	25.4
All Industry	4231.1	21.0

SOURCE: Energy Information Administration, End Use Consumption Data Base: Series 1 Tables, June, 1978.

*Based on steel production.

**Based on 0.2 percent of total industrial energy, DSS Engineers, Inc., Preliminary Research on Geothermal Industrial Complexes, March, 1978.

140° C, and the remaining 29 percent between 140° C and 200° C. The temperature requirements of other industrial processes are shown in Exhibit IV-5. From this analysis, it is evident that the industries most appropriate for HDR are the textile, food processing, pulp and paper, certain chemical industries such as synthetic rubbers and non-cellulosic fibers, and certain stone/clay/glass industries such as ready-mix concrete and concrete block. These industries' process heat requirements are dictated primarily by washing, cooking, and drying, and fall within the medium temperature range. In addition to temperature requirements, some industrial processes require closely controllable heat sources. For example, the dyeing process in the textile industry requires that the rate of temperature rise and fall be carefully controlled. Finally, temperature flexibility plays an important role in those industries that vary their product mix frequently.

Potential for industrial use of HDR can also be examined by comparing the energy intensiveness of the manufactured products, measured as a ratio of gross energy to value added and expressed as Btu per dollar or kWh per dollar. This indicator measures the relative importance of a reliable energy source to different industry groups. The 1972 values for the broad industrial groups are outlined in Exhibit IV-6, showing which groups are more energy intensive. All else being equal, industries with relatively high energy use per dollar added (e.g., petroleum and coal products) will spend more to reduce these costs than those with relatively low per dollar usage (e.g., food and kindred products).

Since each group is quite diverse in the specific industries which it contains, the most energy intensive group may not necessarily contain the most energy intensive industry. For example, alumina production is one of the most energy intensive industries, but does not fall within the broad group of petroleum and coal products.

A third basis for analyzing the potential for industrial HDR use is total energy consumption. The more energy an industry uses, the larger the market for HDR and the greater the potential savings. Exhibit IV-7 shows that the chemical industry is the largest energy consumer, followed closely by primary metals production.

Although this criterion is the easiest to use, it is not the best measure for comparing industries for several reasons:

1. Certain EPA requirements force some industries to install emission control systems which draw large

PERCENT PROCESS HEAT IN TEMPERATURE RANGES
(40° C to value shown)

INDUSTRY	SIC Code	60°	80°	100°	120°	140°	160°	180°	200°	275°	>275°
MINING											
Copper Concentrate	1021	0	0	0	100						
Potash	1474	0	0	0	100						
Sulphur	1477	0	0	0	0	0	0	100			
FOOD PROCESSING											
Meat packing	2011	1	99	100							
Prepared Meat	2013	0	46.2	61.5	100						
Poultry Dressing	2016	100									
Natural Cheese	2022	23	100								
Condensed Milk	2023	0	63	0	93	100					
Dried Milk	2023	0	0	42.4	66.4	70.8	0	0	100		
Fluid Milk	2026	0	0	100							
Canned Specialties	2032	0	0	16.4	68.9	100					
Canned Fruits	2033	0	0	22.7	67.6	100					
Dehydrated Fruits	2034	0	100								
Potato Dehydration granules	2034	0	19.9	0	53	0	0	0	0	100	
flakes		0	19.9	0	53	0	0	0	100		
Frozen Fruits	2037	0	0	30	100						
Wet Corn milling	2046	21.5	0	0	36.4	46.6	0	84.1	0	100	

SOURCE: EG&G Idaho, Inc., RMB&R Hydrothermal Market Penetration Analysis, Appendix B, October, 1978.

PERCENT PROCESS HEAT IN TEMPERATURE RANGES

(40° C to value shown)

INDUSTRY	SIC Code	60°	80°	100°	120°	140°	160°	180°	200°	275°	>275°
Prepared Feed pellet conditioning alfalfa drying	2048	0	0	100							
Bread & Baked goods	2051	11.6	0	0	0	0	0	0	0	100	
Beet sugar	2063	0	7.4	22.4	0	95.4	0	0	0	0	100
Soybean oil mills	2075	0	24.7	26.5	73.4	0	0	100			
Animal and marine fats	2077	0	0	0	0	0	0	0	100		
Shortening and cooking oil	2079	0	33.9	46.8	0	71.0	85.9	0	0	100	
Malt Beverage	2082	0	3.8	7.1	42.0	0	0	0	0	100	
Soft Drinks	2086	60.9	100								
TEXTILES											
Finishing Plant cotton	2261	0	0	47.3	0	100					
synthetics	2262	0	0	68.8	0	100					
LUMBER											
Sawmills and planing	2421	0	0	0	0	0	100				
Plywood drying	2435	0	0	0	0	100					
Veneer drying	2436	0	0	0	100						

SOURCE: EG&G Idaho, Inc., RMB&R Hydrothermal Market Penetration Analysis, Appendix B, October, 1978.

PERCENT PROCESS HEAT IN TEMPERATURE RANGES

(40° C to value shown)

INDUSTRY	SIC Code	60°	80°	100°	120°	140°	160°	180°	200°	275°	>275°
FURNITURE											
Wooden	2511	60	100								
Upholstered	2512	60.9	100								
PULP & PAPER											
Pulp mills	2611	0	16.3	0	0	31.7	67.4	0	91.0	0	100
Paper mills	2621	0	16.3	0	0	31.7	67.4	0	91.0	0	100
Paperboard mills	2631	0	16.3	0	0	31.7	67.4	0	91.0	0	100
Building paper	2661	0	16.3	0	0	31.7	67.4	0	91.0	0	100
Fiber boxes	2653	0	0	0	0	0	0	100			
CHEMICALS											
Alumina	2819	0	0	0	0	76.2	0	0	0	0	100
Plastic matrl.	2821	0	0	51.0	100						
Synthetic rubber	2822	3.6	50.4	100							
Cellulosic fibers	2823	0	0	0	0	0	0	0	0	100	
Noncellulosic fibers	2824	0	0	0	100						
Pharmaceutical	2834	0	.3	0	0	100					
Soaps	2841	0	0	.6	0	0	0	0	0	100	
Detergents	2841	0	0	52.2	0	0	0	99.9	0	100	
Organic chemicals-ethanol	2869	0	0	0	0	100					

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EXHIBIT IV-5

SOURCE: EG&G Idaho, Inc., RMB&R Hydrothermal Market Penetration Analysis, Appendix B, October, 1978.

PERCENT PROCESS HEAT IN TEMPERATURE RANGES
(40° C to value shown)

INDUSTRY	SIC Code	60°	80°	100°	120°	140°	160°	180°	200°	275°	>275°
Isopropanol		0	0	0	0	0	0	100			
Cumene		0	0	0	0	100					
Vinyl Chloride monomer		0	0	0	0	0	0	100			
Urea	2873	0	0	0	0	0	85.1	0	100		
Explosives	2892	0	0	83.5	0	98.7	100				
PETROLEUM/ COAL PRODUCTS											
Petroleum	2911	0	0	0	0	0	0	5	0	0	100
Paving	2951	0	0	0	0	0	0	100			
Asphalt felts	2952	0	0	0	0	0	77.1	0	0	100	
RUBBER AND MISCELLANEOUS PLASTICS											
Tires	3011	0	0	0	0	0	0	100			
Plastic products	3079	0	0	0	0	0	0	0	0	100	
LEATHER Leather tanning	3111	100									

SOURCE: EG&G Idaho, Inc., RMB&R Hydrothermal Market Penetration Analysis, Appendix B, October, 1978.

PERCENT PROCESS HEAT IN TEMPERATURE RANGES
(40° C to value shown)

INDUSTRY	SIC Code	60°	80°	100°	120°	140°	160°	180°	200°	275°	>275°
STONE/CLAY/ GLASS											
Concrete block	3271										
low pressure autoclaving		0	100								
Ready mix	3273	0	0	0	0	0	0	0	100		
Gypsum	3275	100									
Treated minerals	3295	0	0	0	0	0	52.8	100			
clay& shale		0	0	0	0	0	0	0	0	0	100
fuller's earth		0	0	0	0	0	0	0	0	0	100
kaolin		0	0	0	90						100
perlite		0	11.15								100
barium		0	0	0	100						100
FABRICATED METALS											
Galvanizing	3479	0	0	0	0	44					100
ELECTRIC MACHINERY											
Motors & Generators	3621	0	2.7					11.2			100

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EXHIBIT IV-5

SOURCE: EG&G Idaho, Inc., RMB&R Hydrothermal Market Penetration Analysis, Appendix B, October, 1978.

ENERGY INTENSIVENESS OF BROAD INDUSTRY GROUPS, 1972

<u>Industry</u>	<u>All Fuels And Electric: Gross Energy Purchased (equivalent billions of kWh)</u>	<u>Value Added (billions 1972 \$)</u>	<u>Gross Energy Per Value Added (kWh/1972 \$)</u>
Primary Metals	717.8	23.3	30.8
Textiles	106.6	11.7	9.1
Stone/Clay/Glass	382.4	12.6	30.3
Food Processing	302.2	35.6	8.5
Petroleum/Coal	467.0	5.8	80.5
Pulp/Paper	385.5	13.1	29.4
Chemicals	814.2	32.4	25.1
All Industry	3850.2	354.0	10.9

SOURCES: U. S. Department of Commerce, 1972 Census of Manufacturers:
Fuels and Energy Consumed.

U. S. Department of Commerce, Census of Manufacturers,
Vol. I, 1972.

GROSS ENERGY CONSUMPTION BY INDUSTRY

<u>Industry</u>	<u>1978 Consumption (trillion Btu's)</u>
Primary Metals	4802.3
Textiles	316.7
Stone/Clay/Glass	1301.3
Food Processing	934.7
Petroleum and Coal	3071.9
Pulp and Paper	2223.7
Chemicals	5211.0
All Manufacturing	20105.8

SOURCE: Energy Information Administration, End Use Consumption
Data Base: Series 1 Tables, June, 1978.

amounts of energy, or to introduce processes using more energy in total. This added energy consumption distorts actual process energy totals.

2. High energy prices have shifted some industries' product mixes from the more energy-intensive products to the less energy-intensive products. Thus, a company's energy consumption is distorted by rising fuel costs.

A fourth criterion for analyzing industries' potential for HDR use is oil and gas dependency. Since costs are rising and reliability of supply is declining for these sources, industries that are dependent on them will be seeking alternatives. This criterion can be measured in terms of the percentage of total Btu's consumed that are supplied by gas and oil. (See Exhibit IV-8.) Of the industrial groups analyzed, the food processing industry ranks highest, followed by stone/clay/glass and textiles.

A fifth factor, energy-related R&D activity, is indicative of an industry's propensity for innovation and its technical capability for adapting HDR to its needs. According to the Conference Board,* energy related R&D expenditures roughly correlate with total R&D expenditures. In addition, large companies are more likely to engage in energy R&D activities than small ones. Exhibit IV-9 shows the percent of companies surveyed by the Conference Board* that intended to spend R&D money to reduce energy intensiveness or develop corporate energy sources. Those that intend to develop energy sources are potential candidates for HDR energy. The largest percentage of the companies are in the petroleum and coal products, and primary metals industries, followed closely by stone/clay/glass and chemicals.

Finally, access to capital is indicative of which industries are in the best position to raise capital for investing in HDR. Capital for this purpose could be raised by selling additional stock (equity financing) or issuing bonds (debt financing), supplemented perhaps by retained earnings. Exhibit III-10 displays these indicators for seven broad industry groups. Chemical, pulp and paper and food processing have the most attractive stocks, while food processing is in the best long-term borrowing position. Petroleum, pulp and paper and food processing also retain the largest portion of their profits, relative to common equity.

*The Conference Board, Energy Consumption in Manufacturing, 1974.

OIL AND GAS DEPENDENCY BY INDUSTRY GROUP

Industry	OIL		NATURAL GAS		Percent of all Fuels Comprised by Oil and Gas
	Consumption (trillion Btu)	Percent of all Fuels in Industry	Consumption (trillion Btu)	Percent of all Fuels in Industry	
Primary Metals	322.2	7	1315.0	27	34
Textiles	62.7	19	102.1	32	51
Stone/Clay/Glass	125.5	10	696.3	53	63
Food Processing	132.3	14	475.6	51	65
Petroleum and Coal	331.8	10	1111.4	36	46
Pulp and Paper	513.8	23	414.3	19	42
Chemicals	285.2	5	2092.6	40	45
All Manufacturing	2047.3	10	7096.5	35	45

SOURCE: Energy Information Administration, End Use Consumption Data Base: Series 1 Tables, June, 1978.

ENERGY RELATED RESEARCH AND DEVELOPMENT ACTIVITY

Percent of Companies Interviewed*
that plan to spend R&D money to:

Industry	Reduce Energy Output by 1980	Develop Corporate Energy Sources by 1980
Primary Metals	97	90
Textiles	NA	NA
Stone/Clay/Glass	94	86
Food Processing	68	37
Petroleum and Coal	90	91
Pulp and Paper	87	68
Chemicals	98	83

*weighted by number of employees

SOURCE: The Conference Board, Energy Consumption in Manufacturing, 1974.

ACCESS TO CAPITAL BY INDUSTRY

<u>Industry</u>	<u>Market Value/ Book Value</u>	<u>Long Term Debt/Equity</u>	<u>Profits Retained/ Common Equity</u>
Steel	0.71	0.41	.06
Textiles	0.64	0.44	.08
Cement	0.67	0.63	.08
Food Processing	1.32	0.31	.09
Petroleum	0.97	0.62	.10
Pulp and Paper	1.68	0.49	.09
Chemicals	1.76	0.47	.07

SOURCES: The Value Line, 1976.
The Value Line, 1979.

Exhibit IV-11 summarizes the broad industrial groups according to the various criteria. The table shows where each group falls if translated linearly to a criterion scale divided into ten equal intervals, 10 being the high and one being the low. A glance at the exhibit shows that the groups vary widely in their respective strengths and weaknesses; no one group predominates. For example, the chemical industries use a great deal of energy for processing, but are less energy intensive when compared with the petroleum and coal industries. All of the groups are strong in two or three areas except for the textile groups; all are weak in several areas except for the pulp/paper and chemical groups.

The summary data are best used for identifying those issues which are crucial to an industry and to which particular attention may have to be paid in developing an HDR marketing strategy. Thus, in food processing, project resources can concentrate on alleviating oil and gas dependency by providing R&D assistance to develop new processes that bring temperature requirements even closer to the range of the HDR supply values. On the other hand, the stone/clay/glass industries may be able to use a financial boost more than R&D (technical) assistance.

Characterizing a broad industrial group such as "primary metals" or "textiles" obviously conceals characteristics of the specific industries and companies within it. A closer examination may reveal that the best candidates for HDR technology are certain subgroups of the textile industry, which by no means dominate in any particular criterion. These possibilities should be anticipated in subsequent examinations of the industrial market.

The earliest application can be expected in those companies where production processes are well suited to HDR, where R&D efforts are directed toward reducing fossil-fuel dependency, and where corporate financial policies allow a certain amount of risk investment. The pulp and paper, and chemical industries by virtue of these characteristics, their geographic dispersion, and their diverse industrial processes, are most likely to contain suitable innovative companies. Companies in the food processing industry are also good candidates in view of their present use (albeit limited) of hydrothermal energy.

SUMMARY OF INDUSTRIAL CRITERIA
BASED ON PREVIOUS EXHIBITS

(1 = low, 10 = high)

Industry	Process Steam Generation	Temperature Requirements	Energy Intensive	Total Energy Consumed	Oil/Gas Dependency	R&D Activity	Equity Financing	Debt Financing
Primary Metals	1	1	4	10	1	10	1*	7*
Textiles	1	7	1	1	6	NA	1	8
Stone/Clay/Glass	1	1	4	3	10	10	1	1**
Food Processing	3	8	1	2	10	1	7	10
Petroleum/Coal	5	3	10	6	4	10	3	1
Pulp/Paper	10	10	3	4	3	7	10	5
Chemicals	9	4	3	10	4	10	10	5

*Represented by the steel industry

**Represented by the cement industry

UTILITIES

The utilities market includes companies that generate and distribute electricity and/or district heat to their ratepayers. They may be investor-owned, municipally owned, or rural cooperatives. Investor-owned utilities serve 76.7 percent of the U. S. population; local publicly owned serve 13.5 percent; and rural electric cooperatives provide electricity to about 9.9 percent.* About a third of all public power systems generate some or all of their power, while the other two thirds purchase power at wholesale from private utilities, or federal or state power marketing agencies. Most publicly owned electric utility systems are located in the Midwest and East, although the publicly owned utilities of Los Angeles and Sacramento, California; Seattle, Washington; and Phoenix, Arizona are among the ten largest.**

Since the generation of electric power requires steam temperatures of at least 150°C, only those utilities operating near HDR resources having this temperature or higher are potential users of this resource. This effectively limits the HDR electric utility market to the western states of Washington, Oregon, California, Wyoming, Idaho, Utah, New Mexico, Arizona and Nevada, and others which purchase electricity generated in these states. (See Exhibit III-5 in Chapter III.)

Key Decision Makers

As in other industries, decision-making authority in an investor-owned utility rests with the chief executive officer and the board of directors, with the balance between the two varying from one company to another. The line departments which influence decisions on fuel mix and construction of new generating plants are Engineering/Construction, Systems Planning, Environmental and Licensing, and Finance, or their equivalents. The Systems Planning department is most influential because it is generally responsible for forecasting demand, planning future generation and distribution projects, and analyzing their economic feasibility. Since geothermal projects are complex and require a great deal of interaction between departments, the ultimate decision is made at top management levels.

In a small, municipally owned utility, the city manager structure places responsibility for the operation of the utility

*"Fact Sheet on Public Power System", American Public Power Association, Washington, D. C., no date.

**"The People's Right to Choose," American Public Power Association, Washington, D. C., April, 1978.

with the city engineer. Ultimate decision making authority rests with the city or town council. In a larger city, a superintendent, reporting directly to the mayor, is likely to take charge of the utility operation. If the system is extensive, there may be an appointed or elected utility board that separates the city council's political interests from the operation of the utility. The utility board establishes policy and may have the authority to float bonds. Rural electric cooperatives and other cooperative systems also place ultimate decision making authority in the hands of a board which then hires a general manager to operate the utility.

Criteria for Decision Making

A utility's decision to participate in the generation and sale of electricity or district heat derived from HDR resources may involve committing capital to plant construction and even resource development or simply purchasing HDR generated steam or electricity from another company. Although utilities have not become involved in the development of the HDR resource to date, several utilities are seriously considering involvement in hydrothermal projects, either singly or in joint venture. The criteria used in deciding to generate electricity or supply district heat are discussed in the subsequent sections.

Generation of Electricity

Decisions to invest in additional electricity generating capacity originate when forecasts of future demand are compared with present and planned capacity. When capacity is projected to be insufficient, one remedy may be to construct additional generating plants. The period between the determination of need for additional capacity and the start of generation ranges from three years for small fossil fuel plants, to at least ten years for a nuclear plant. A utility with a ready source of energy available will take advantage of the shorter lead time, as did Sierra Pacific Power Co. in Nevada, which made a commitment to a geothermal plant largely because of the proximity to the resource to transmission facilities.

The principal criteria used in choosing the type of generating unit are its closeness-of-fit to demand characteristics, financial feasibility, contribution to reliability through fuel diversity, environmental effects, and the public opinion and regulatory climate.

The chief criterion for selecting one type of unit over another is the set of characteristics dictated by demand. Aggregate demand curves peak on a daily and annual basis, remaining

above a baseline at all times within the period. The capacity planned to meet the growth in demand falls within a spectrum which is defined as baseload on one end and peaking on the other. Baseload plants, such as large coal and nuclear plants, have the highest capital costs and the lowest operating costs; peaking plants, such as gas plants, have the lowest capital costs and the highest operating costs; intermediate plants fall between these two extremes. A utility's generating capacity must encompass this broad spectrum in order to satisfy demand for the least cost to consumers. When there is a good fit between plant capacity and demand, baseload plants can operate at close to 100 percent capacity, thereby maximizing mechanical and thermal efficiency. This allows peaking units to remain idle except during periods of maximum load, when the level of demand justifies their higher operating costs.

In addition, to provide an appropriate baseload and peaking mix, generating capacity must also provide a reserve margin for unusually high peaks in demand, and backup in case of breakdown. Reserve margin is best made up of a number of small generating units, since incremental additions to generating capacity are the least expensive means for covering these unusual situations. For this reason, large coal or nuclear plants would not normally be constructed to increase reserve capacity, whereas geothermal and small oil or natural gas units might well be.

The second criterion for choosing the type of generating unit is financial feasibility. Capital and operating costs must be considered together to determine the most cost-effective generating plant for meeting demand. This is especially complex for investor-owned utilities due to public utility commission regulations which decrease financing flexibility.

Virtually all utilities evaluate capital investments in plant capacity with a time-weighted technique such as discounted present value analysis. Utilities that consider the feasibility of geothermal energy resources must therefore assign an expected life, usually 20 to 40 years, to the reservoir. Other contributing factors such as federal tax incentives, availability of low interest government loans, the geothermal loan guarantee and capital structure are examined in more detail in subsequent separate sections on financing expansion in investor-owned and publicly owned systems.

The third criterion for evaluating energy sources is the increase in reliability that accompanies a diverse supply of fuels. Diversifying fuel sources is a corporate policy of all utilities to avoid the adverse effects of fuel curtailments on service.

Reserve margin also increases reliability. This criterion favors the addition of geothermal units, since this type of energy is not only free from fluctuations in world fuel prices and supply, but is typically available in units of 55 MW -- a size well suited for reserve capacity.

Environmental consideration must also be weighed. More environmentally problematic choices raise costs by increasing the time required for regulatory review, requiring expensive scrubbers, meeting new federal surface mining requirements, etc. Since geothermal energy has relatively few environmental problems, its development is being pursued fairly vigorously.

All of these considerations are modified by the fifth criterion: the public opinion and regulatory climate. The state utility commission will insist that the regulated utility demonstrate that an additional generating facility is needed, that its choice is the least cost alternative to meet future demand, and that it will have minimal effect on subscriber rates. These criteria are essentially the same as those used by the utility, but with greater emphasis on the effect of a new unit on rate-payers.

District Heat

District heating systems are, for the most part, old steam systems first installed near the turn of the century when efficiency was improved by centralizing heating energy sources. Generating boilers and distribution lines were most often installed by private companies.

Since that time, many cities have bought out private district heating systems for a variety of reasons. For example, the city of Eugene, Oregon purchased the distribution network in 1962 because the utility was in financial straits caused by expensive procedures required, in part, for environmental reasons. The city could run the system more efficiently by tying it in with their electricity generating plants. Other cities may purchase privately owned systems to achieve or maintain an efficient use of energy in general. For example, shutting down a private district heating company may place an excess burden on electric or natural gas capacity, because of conversion by the affected buildings. The high cost of conversion could cause business to leave the downtown and adversely affect city finances.

In the seventies, these reasons have been outweighed by other factors which have caused cities to shy away from owning and operating district heating systems. The financial difficulties

that many cities are experiencing have discouraged them from investing in expensive utilities that could further add to the burden on their tax bases. In addition, old steam systems are now inherently inefficient, especially if plagued by heat losses due to over extended distribution and deteriorating hardware. Finally, strict environmental standards have forced generating plants away from city cores where they would be more efficiently located for cogeneration.

Although most cities that have a district heat distribution network are not interested in maintaining or improving them, there are some exceptions. These would include cities that have high density downtown areas and are pursuing a policy of attracting new residents and businesses to the downtown. As shown in Exhibit IV-11, district heating costs drop substantially as density increases. They would also have to have an adequate tax base and other sources of financing to contemplate such an investment. Expected growth also plays a role: fast growing cities can expect to recover capital expenditures more quickly than more stable communities, and so find that owning and operating their own utility involves less financial strain. Finally, they would be more likely to make this investment if they were also investing in a new electricity generating facility or were located in very close proximity to a geothermal resource.

Financing

Developing a financing scheme is a complex part of the decision-making process and varies significantly between investor-owned and publicly owned utilities.

Investor-Owned Utilities

Like most corporations, an investor-owned utility gets its capital from three basic sources: stockholders who buy shares in the company (equity financing), creditors from whom it borrows (debt financing), and reinvested earnings (internal financing). Miscellaneous external sources also supply capital for special types of projects, such as experimental projects funded by DOE. Being a very capital intensive industry, electric utilities must make use of all three primary sources. Over the long term, they also attempt to maintain their capital structure in the following general proportions: 35 percent common equity (which includes reinvested earnings), 15 percent preferred equity, and 50 percent debt securities. These proportions may vary up to 20 percent, depending on the capital market.

DISTRIBUTION COST OF DISTRICT HEAT
AS A FUNCTION OF LOAD DENSITY

SOURCE: Tomas Bruce, "An Energy Utility Viewpoint," District Heating, Swedish Trade Office, 1978.

Large capital projects such as the construction of additional generating units are financed primarily with debt capital, since it costs the company less than issuing additional shares of stock. The Securities and Exchange Commission limits the amount of borrowing by the "two-times rule" which stipulates that a company's operating earnings must be at least twice as large as the interest on its outstanding debt. Other measures are also used, such as the debt-to-equity ratio which is set by corporate policy. Relatively small amounts of internal capital are available to finance new projects since utilities' profits are strictly limited by public utility commissions.

Ratepayers contribute little to the capital budget. Rates are based on a cost base which is the "amount of money prudently invested in the existing utility plant and property less the accumulated reserve for depreciation on that plant and property,"* i.e., net plant investment. Furthermore, this plant and property is required to be "used and useful" in the generation of electricity. Although this principle does have exceptions (such as land bought for future use), it prohibits the rate base from including a new generating facility until it is producing electricity for use by the company's customers. Utilities have proposed allowing "construction work in progress" in the rate base. This would decrease the cost of new capital, but violates the "used and useful" principle. The proposal has not met with much acceptance among regulatory bodies.

Generation of capital for high risk projects is even more difficult. Most venture capital investors look for capital gains rather than dividends, and utility stocks tend to return mostly dividends. Furthermore, in case of project failure, the public utility commission may decide not to allow amortization of the capital loss in the rate base. Moreover, this decision cannot be made until failure actually occurs. Given these constraints, risk investors are justified in requiring as much as a 30 percent rate of return from a relatively high risk project such as a geothermal plant. These are some of the reasons that Public Service Company of New Mexico and the Union Oil Company would not have proceeded with their geothermal plant in the Jemez Mountains had DOE not financed 50 percent of the costs.

*Robert L. Swartwout, Utility Ratemaking in New Mexico Today, New Mexico Public Service Commission, Santa Fe, September, 1979.

Publicly Owned Utilities

Publicly owned utilities differ from the other HDR markets principally in their sources of financing. They have available both tax free revenue bonds and low interest loans from the Rural Electrification Administration (REA).^{*} State and federal grants are also available, especially for demonstrating innovative technologies.

Tax free revenue bonds are usually issued for major capital investments and must be approved by the electorate or a representative public body. Debt service and operating expenses are paid from revenues generated by the project. The tax provisions of these bonds make them marketable at lower interest rates than corporate bonds. These bonds could be used for investments in electricity generation or district heating systems. However, the bond buyer would want to be assured that the utility would not default on the bond because of insufficient revenues or a lapse in revenues. Given the perceived risks of HDR energy, it would probably be necessary to pay a somewhat higher interest rate on these bonds to make them marketable, despite their tax exempt status.

Public electric companies in rural areas have access to liberal financing from the REA under certain conditions. If owned by a municipality, the municipal population must be less than 1500. There is no limit for cooperatives. REA funded projects also have to extend service to customers who previously did not have access to a central electric system. These conditions have limited the number of municipal borrowers severely and have confined REA projects principally to distribution extensions.

The REA has started to grant loans and loan guarantees to borrowers wishing to purchase interest in generating plants^{**} and for certain improvements to existing systems, especially if the system was originally REA financed. In evaluating applications for electricity generation projects, the primary criterion is whether the utility is presently obtaining or expected to obtain power from that source, and whether that source is the best choice for serving the utility's needs.

^{*}The REA is also authorized to make low interest loans to investor-owned utilities that meet their criteria. This is rarely done in practice.

^{**}S. H. Scheibla, "Lost Generation: Investor-Owned Utilities Liquidate Plants to Survive," Barron's National Business and Financial Weekly, August 27, 1979.

Whether HDR projects can qualify for REA financing is questionable. If REA agrees that HDR is an appropriate project under the legislation governing the agency, qualified utilities will have access to 5 percent loans, or guarantees on higher interest loans obtained from the Federal Financing Bank or the borrower's own lending institution.

Arrangements with the Resource Developer

Electric utilities are accustomed to making arrangements with a second party for a supply of fuel. However, the risk associated with geothermal development makes the arrangement between the utility and the resource developer much more complicated than with a traditional fuel supplier.

Three approaches to these arrangements are promising: joint venture among several utilities to undertake their own resource development, formation of a third interim risk assuming company (IRAC), and the leveraged leasing arrangement. Although other arrangements exist, they are unsatisfactory for one reason or another. For example, if the utility constructs its own power plant which runs on steam bought from a resource developer, it does not reduce its risk. Alternatively, if a resource developer also constructs the power plant, he is exposed to regulation by the utility commission. Neither of these last two arrangements is generally satisfactory to either party and therefore will not be discussed further.

A joint venture among several utilities is the method that Sierra Pacific Power Company is considering most seriously. This approach offers the lowest incremental energy cost to the consumer, while diluting the capital exposure to all participants. Resource development would be contracted out to the resource developer, or could be undertaken directly by one or more of the participants. Once steam was on line, expensive steam rates, often more expensive than coal, would not have to be paid to a developer, thus making the geothermal unit eligible for baseload use. Capital costs incurred during exploration, drilling, and surface plant construction would be incorporated into the rate base. The principal disadvantage of this type of joint venture is that the utilities cannot take advantage of the 20 percent investment tax credit authorized in the Geothermal Steam Act of 1970, and can only utilize the usual 10 percent investment tax credit.

The interim risk assuming company (IRAC) arrangement is the alternative chosen by Utah Power and Light at their Roosevelt Hot Springs site. The IRAC would finance, construct, own, and

operate the power plant. It would purchase well head steam from the resource developer at prices compatible with market conditions, convert the steam to electricity, and sell the electricity to the utility. The most obvious advantage of this arrangement is that the utility is relieved of the investment in the plant, and therefore of the risk of the reservoir. The long term disadvantage is that the utility must pay the highest price among all arrangements, since both the developer and the IRAC must make reasonable returns on their risky investments. Public Service Company of New Mexico explored this financing arrangement in the Baca Demonstration Project, but decided against it because the parties involved could not agree satisfactorily on all aspects of financing, operation, and management. It is now most seriously considering the leveraged leasing arrangement.

Leveraged leasing, or tax leveraged leasing falls under a broader category of tax-oriented lease financing known as the finance lease. Capital intensive equipment (most commonly computers and aircraft, but in this case the generating station) is owned and leased by an equity investor. The investor borrows most of the money required for this purchase, and hence has very little of his own money invested. The equipment user (the utility) makes lease payments to the investor. The sum of these payments is equal to the initial cost of the asset plus interest. These payments plus the tax benefits will fully amortize the cost of the equipment over the term of the lease, which is non-cancellable. It is also completely "net", meaning that the equipment user is responsible for such expenses as maintenance, taxes, and insurance. The descriptor "tax leveraged" derives from the fact that the equity investor has invested only a small amount of his own money but continues to enjoy the tax benefits on 100 percent of the equipment cost. These tax benefits are shared with the equipment user in the form of lowered lease payments.

Public Service Company of New Mexico is interested in tax leveraged leasing in order to take advantage of the 20 percent investment tax credit authorized by the Geothermal Steam Act of 1970, indirectly in the form of these lowered rental payments. Without this arrangement, only a 10 percent investment tax credit would be available.

Potential for Choosing HDR

A utility's potential for choosing HDR depends on whether this resource would be used to generate electricity or district heat.

Electricity Generation

Investor and publicly owned electric utilities offer one of the most promising markets for HDR energy, especially in the West where resource temperatures are sufficiently high and hydrothermal power generation is already in operation. HDR can potentially fulfill all of the electricity generation criteria satisfactorily.

Given the standard 55 MW geothermal generating unit size and the operational uncertainties during early commercialization, utilities will most likely use an HDR plant initially to build up reserve capacity. If federal subsidies reduce first costs significantly, then the plants could also serve as peaking units. However, once the reliability of the technology has been established, HDR plants can shift into the baseload category by tying in additional units. For this to happen, operating costs will have to be competitive with other baseload units within the utility system. These costs include those associated with HDR reservoir management, such as redrilling, refracturing, and installing additional downhole equipment over the lifetime of the reservoir. Utilities will probably shift HDR plants into baseload use as soon as possible after construction to amortize high initial costs.

Financing feasibility can be expected to improve. Both investment capital and operating costs will be high initially, but will decrease steadily as operating experience is gained. Advances in exploration, drilling, and fracturing techniques will decrease development time and costs and improve subsequent reservoir management by offsetting additional redrilling and refracturing costs with increased thermal efficiency. Federal capital subsidies will continue to be important for early demonstration of HDR. The Public Service Company of New Mexico estimates that their 50 percent DOE grant advanced their hydrothermal project by five to ten years.

Financing feasibility will also improve as the number of projects in operation increases. This directly reduces operational uncertainties, such as drawdown and plugging due to scale build-up. The difficulties in raising risk capital, especially the 25 percent not guaranteed by the federal loan guaranty program, will thus be eased.

In the meantime, utilities are developing innovative schemes for financial arrangements with developers. Leveraged leasing is the best example of these efforts. Utilities are using these methods to overcome difficulties in using the federal loan guaranty and improve tax benefits.

HDR is in the strong position of diversifying the utilities' fuel dependence. This is particularly true for those utilities investing in resource development, for they will be the least vulnerable to fuel supply interruptions and price fluctuations caused by market conditions of competing fuels. HDR is also advantageous from the viewpoint of environmental concerns. This factor may prove to be the best reason for utilities' investing in HDR plants, compared with their alternatives.

District Heat

The market for district heat seems much less promising. Most utilities that have district heating systems, be they public or investor-owned, would like to be out of the business. The distribution systems need regular and costly repair; fuel costs are high; and environmental problems abound. As a result, most district heating systems lose money.

However, there are promising exceptions. The city of Eugene, Oregon is considering an expanded district heat system supplied by a geothermal electricity generating plant. A number of cities in close proximity to hydrothermal resources have begun to remodel and expand their district heating systems, most notably the Warm Springs District of Boise, Idaho and Klamath Falls, Oregon. The use of hydrothermal energy for district heating can also be found in Reno, Nevada; Lakeview, Oregon; Vail, Oregon, Susanville, California; and Calistoga, California.

These cities are unique in that they are utilizing steam from a generating plant or lie in close proximity to a geothermal resource. Research done by the New Mexico Energy Institute confirmed that, for space heating purposes, the distance between the resource and the user is of major importance in determining the return on investment in geothermal energy development. At a distance of 5, 15 and 25 miles, the rate of return falls from 12.75 to 10.0 to -0.25 percent for hydrothermal systems.

*Joseph M. Marlin, et. al., Regional Operations Research Program for Development of Geothermal Energy in the Southwest United States, New Mexico Energy Institute, Las Cruces, New Mexico, January, 1979.

Temp. &
Capacity
ignored!

In addition to proximity to the resource, several other characteristics are clearly important. These include high population density, a willingness to be innovative in capital expenditures, and adequate financial resources. Given all of these considerations, one must conclude that each potential district heat market must be examined on its own merits, and those communities that have HDR resources nearby are likely to investigate them thoroughly.

INSTITUTIONS

The institutional market consists of organizations having an educational, social, administrative or religious purpose, such as schools and universities, hospitals, government office buildings, penal institutions, and churches. These institutions may be publicly or privately owned, but are always non-profit and serve a community function. Space conditioning is the principal energy product used in this market.

This section analyzes the institutional market, beginning with an identification of the key decision makers, and proceeding with an analysis of the institutional decision-making process as it pertains to energy issues. It concludes with an evaluation of the potential for HDR energy in this market.

Key Decision Makers

Most institutions are headed by an elected board of trustees, regents or commissioners who set the policies for the organization. The board then appoints a chief administrative officer who may be titled president, superintendent, executive director or something similar. The chief administrator shoulders the primary responsibility for operating the institution.

In a small institution, energy and facilities planning matters are handled directly by the administrator; in large institutions, this responsibility may be delegated to a plant engineer, an administrative assistant, or a facilities planner. The recommendations of a plant engineer are likely to have a major influence on an energy decision, primarily as a result of his technical experience in this area. Outside consultants are also likely to play an important role in any decision to modify the space conditioning system or develop a new one. A decision to use HDR would require the involvement of the plant engineer, engineering consultants and the chief administrative officer. Recommendations would then be made to the board which would make the ultimate decision.

Decision-Making Process

Rapidly rising energy costs have had a major impact on institutional budgets, so much so that the quality of service offered has frequently suffered. For example, public school energy costs rose 48 percent nationwide between 1973 and 1975, bringing the 1975 costs to a low of \$41 per pupil in the Pacific Southwest and a high of \$92 per pupil in New England.* In a

*National Center for Educational Statistics, Educational Facilities Laboratories.

5000 pupil school district, this came to between \$205,000 and \$460,000 per year, or about 5 percent of the school operating budget. For many hospitals, energy is the largest item in the operating budget next to personnel costs. In addition, Federal Power Commission rulings, by granting certain industries the "human needs" status, forced health care institutions to compete with these industries for fuel supplies. Since energy costs are difficult to reduce or pass along to "clients," many institutions have had to eliminate staff positions, curtail supplementary activities, and make other program changes that affect the overall quality of service offered in order to pay them.

Institutional administrators would like to gain better control over their energy costs. They can accomplish this through a variety of energy conservation measures or by investing in an energy system that is less costly to operate.

Capital Costs

In the context of an existing facility, the principal criterion that institutions use to evaluate capital outlay decisions is first costs. Life cycle costing is a luxury that only moderately endowed institutions can afford to use. Capital outlays for public facilities generally require the approval and sale of a bond issue. Since state law limits the bonding indebtedness of public entities to a percentage of assessed property values, and since bond issues often must be approved by the electorate, capital budgets are extremely limited.

The approach that offers institutions the most immediate benefits for the lowest initial capital outlay is undertaking a variety of energy conservation measures. The Schools and Hospitals Grants Program of the National Energy Act has allocated \$300 million to schools (both public and private), hospitals and nursing homes for FY '79 to FY '82 for this purpose. Although converting to a more efficient energy system falls within the guidelines of the program, institutions must closely examine the savings that would result from such an investment and relate them to the conversion costs. Of course, if HDR resources were available in close proximity to the present facilities of the institution, or near satellite or expansion sites, their development could prove to be an attractive alternative to other energy conservation measures. The criteria they use to make this decision are the initial capital costs in relation to their capital budget, and service reliability.

Reliability of Service

A second criterion is reliability of service. This is particularly important for hospitals, which are liable for mishaps resulting from power outages. Institutions cannot pass losses due to interrupted service on to their "clients:" patients do not postpone illnesses, and the number of school days is fixed by state law.

Building a New Facility

In the context of building a new facility, the criteria change somewhat. As with industry, a cost effective and reliable energy source is playing an increasingly important role in the siting of non-profit institutions. However, social institutions must be located in close proximity to their clients. Political pressure also has a great deal of influence on the choice of a new site. Consequently, the site selection decision is considerably more constrained for non-profit institutions than for industry.

Potential for Choosing HDR

Institutions have only a moderate potential for using HDR for several reasons. Given the constraints on site selection, it is even more difficult for a public institution to choose a location for energy reasons than for industry to do so.

Moreover, institutions' lack of access to capital resources discourage conversion to HDR or construction of a new facility. Only institutions whose facilities are in the planning stage or whose mechanical systems are slated for replacement are likely potential users. Even still, the additional capital expenses required for HDR will have to be offset by significant savings before institutions can consider it. Large institutions may find themselves in a somewhat better position on this criterion than smaller ones.

Finally, reliability of service must be established. Both short and long-term risks are present in HDR technology. If the institution cannot be guaranteed freedom from short-term risks, then it must maintain a back-up space conditioning system which detracts from HDR feasibility. Long-term risks affect the cost of capital. However, reliability does not have to be established within the institutional market. Other markets such as industry or utilities can initially confirm reservoir performance, permitting institutions, using traditional space conditioning systems, to take advantage of this resource in the future.

REAL ESTATE

The real estate market consists of private sector developers whose principal purpose is to generate or shelter income through the conversion of land from one use to another. The developments may be buildings occupied as offices, retail stores, restaurants, hotels and motels, or residences. The market also includes developers of industrial and office parks, residential subdivisions and resort developments. The principal product for this market is space conditioning, although industrial process heat is also applicable and potentially a more important product in the context of industrial park development.

Key Decision Makers

The real estate development corporation is the private entity that most commonly invests in real estate. It can range in size from the largest hotel and motel chains down to regional shopping center and industrial park developers to a single entrepreneur. The head of the development corporation, by reason of the risk he assumes, is the ultimate decision maker. For a major project, he will head a development team consisting of an attorney, planner, engineer, market researcher, architect and financier. These team members may be part of the permanent staff in a large development corporation, but are more likely to be outside consultants in a smaller firm.

Outside of the immediate development team, the financial institution, realtor, contractor and certain regulatory agencies are also influential in the decision-making process. The regulatory agencies are really the most influential, since they must approve land use, density of development, and construction plans. State and federal regulations set additional requirements for FHA-insured projects, analyzing environmental impact, and avoiding flood prone areas.

Decision-Making Process

A developer's decision to use HDR energy for space heating purposes would be made in the larger context of a decision about the nature and location of a particular development project, how it is to be financed, and ultimately the type of space conditioning system to use.

Location and Type of Project

This decision would be based on an analysis of potential sites and projects in terms of:

- Market area: A delineation of the geographic area within which competing projects draw their customers. A breakdown into submarkets will characterize market areas according to leasers vs. purchasers, single vs. multi-story, price range, etc., and will illustrate both current trends and future growth.
- Economic trends: An analysis of employment, commerce, industry, and transportation factors that characterize potential consumers.
- Demand factors: Expected income, type of demand (office, retail, services, etc.), growth characteristics, vacancies.
- Supply factors: Competing projects, competing space inventory.
- Market conditions: Market prices and rent, market absorption, building construction costs, financial climate.

Upon completion of this preliminary analysis, the number of sites and the scope of the project will be narrowed.

The second stage is more detailed comparisons of alternative tracts and the development of preliminary plans and sketches. At this time, site features, zoning, land costs and other local issues are analyzed until a specific site is designated and the project is defined.

Financing

Almost concurrent with the site selection stage are the negotiations for land acquisition, financing and required regulatory agency approvals. A developer will decide to go ahead with a particular project largely on the basis of his own financial situation and objectives. Assuming that his financial objective is to maximize his return on investment, he will choose those projects that require relatively little cash of his own at the outset, that maximize income, and that minimize the development period.

Front end costs, which include land acquisition, site improvements, and certain amenities are the most difficult to finance. Land acquisition is generally the most significant of these, and is unique because the major source of capital is the landowner himself. The two most common arrangements are the land option

and the joint venture. The land option allows the developer to obtain use of a piece of property for a specified time, after which he must contract to buy the parcel or lose his claim. The time varies from three months to more than a year, and can be extended if the parties agree.

In a joint venture, the landowner receives equity in the project if the development proves feasible. For example, if the developer pays all expenses during the planning process as well as a fair market price for the land, as soon as income starts to flow he will grant the landowner 25 to 50 percent of the equity interest for being able to carry this land interest free.

A number of types of institutions can participate in the ensuing financial transactions, depending on the type of project. The usual sources for project financing are: savings and loans, commercial banks, life insurance companies, real estate investment trusts (REIT), pension funds, private individuals and some corporations. Negotiations with the permanent lender occur simultaneously with the planning and design of the project. Construction, or interim financing follows commitment by the permanent lender. It is usually secured from a more aggressive lender such as a REIT or union pension fund, since this financing is based on project completion as opposed to physical collateral. Finally, a "gap" loan may be granted by one or the other lenders covering the period between completion of construction and granting of permanent financing.

A financial appraisal is conducted primarily during the negotiations with the lending institution, when projections of cash flow and costs are presented. These projections are based on the market analyses and compared with figures compiled by various real estate associations.

Negotiations do not follow a set procedure, but instead, several financing alternatives are suggested until agreement by all parties has been reached. The lender, being conservative in nature, will demand that several conditions be met. These include stipulations that:

- Developer equity in the project be sufficient to reduce risk of foreclosure to an acceptable level
- The total project value not exceed a reasonable figure relative to the developer's assets
- The developer's return on investment be competitive with his other ongoing projects

- The debt service as a percentage of net income not exceed the lender's criterion.

Actual figures to be met vary with the lender and the amount of risk he is willing to take.

Choice of Space Conditioning System

Given a viable project, the next decision that relates to the use of HDR is the choice of a space conditioning system. This step is part of the detailed planning and design stage and would take into consideration both the initial capital investment and long term operating expenses.

A commonly used technique for assessing the profitability of any variation within the building is the "component parts investment analysis." The component, whether it be a potential fireplace, wall-to-wall carpet, or deluxe heating system, is isolated from the rest of the construction costs and its feasibility is measured according to some standard investment evaluation measure. These measures include discounted rate of return, payback period, net present value, and simple rate of return. The component must meet the development firm's minimum standard before it is approved as a building component. In the case of an alternative HVAC system, the expected net decrease in operating expenses must yield a minimum return on increased investment by one of these measures.

Even though a component part may prove profitable according to this technique, it may not be significant in terms of its percentage of total development costs. For example, HUD multi-unit housing costs can be broken down as follows:

Land	15%
Building construction	65%
Contracting costs	20%

Of the 65 percent building construction costs, 4.5 percent is generally spent on heating systems in low rise multi-family housing.* Thus, of the total development costs, only 3 percent

*H. Z. Rabinowitz, Building Economics, University of Wisconsin, Milwaukee, 1977.

is spent on heating systems. Variations on a 3 percent line item are not likely to attract much attention.

Operating costs are much less significant to a developer than to subsequent owners, principally because a developer does not intend to own a particular development very long. Operating costs comprise 15 to 25 percent of the gross annual income, in office and residential buildings.* The fraction of total expenses that energy costs comprise vary according to building type, but generally range near 10 per cent.

Potential for HDR

Real estate development does not in itself offer a significant market for HDR-based space conditioning, primarily because HDR does not increase the developer's return on investment in the short term. However, the development of industrial parks that utilize HDR energy for both industrial process heat and space conditioning is somewhat more promising.

To increase a real estate developer's return on investment, the use of HDR energy would have to decrease development costs, increase income, or shorten the development period. Two major contributors to development costs are the cost of money and the cost of planning, design and contracting. Unconventional design and innovative space conditioning systems will not reduce these costs and may actually increase them. If the lending institution is uncertain about reliability, back-up space conditioning systems would have to be installed, thereby increasing construction costs. If this were financially or otherwise infeasible, then the lending institution might raise its interest rate to cover its additional perceived risk. To avoid these additional costs, the developer would have to obtain assurances from the heat supplier that interruptions would not be significant and that HDR costs would be competitive. The negotiations involved in obtaining these assurances could easily lengthen the planning period and thereby increase development costs.

The developer will also want operating costs to be low and predictable, at least for the period of time that he owns the development. In the Warm Springs Water District of Boise, Idaho, the annual cost for geothermally heating an 1800 sq. ft. residence

*Rabinowitz, Ibid.

in 1978 was \$747 per year, compared with \$712, \$509 and \$471 per year for electric, gas and oil heat respectively. Geothermal heating costs are not expected to be competitive until 1982,* even for a publicly owned system. It is likely to be even more difficult for HDR to significantly reduce fuel costs within the time period that the developer intends to own the project. Until this happens, a developer would prefer to install proven, commercially available energy conservation devices.

HDR cannot expect to satisfy the developer's criterion of increasing income. The best insurance for maximum income is a thorough market analysis that predicts high and steady sale or rental income. There is no evidence that a building advertised as geothermally heated will guarantee higher paying tenants or decrease vacancies.

Finally, HDR cannot contribute to reducing development time. Financial negotiations may be protracted by unusual design and marketing features. Design and construction times may also be somewhat prolonged for the same reasons. Regulatory approvals will not be expedited, either.

Industrial parks offer a somewhat more promising market for HDR energy. Sited near a HDR resource, an industrial park could offer its occupants an economical source of process heat. In addition, heat for space conditioning would attract industries (such as electronics) which require heat for employees. The proximity of several different users would decrease distribution costs for the HDR developer. Operating costs would also be reduced if the facilities in the park were to use the heat on a 24-hour-a-day basis. These savings could be passed on to the park developer and ultimately to the occupants. If the industrial park were developed by a public body such as a municipality seeking industrial growth, the cost of land and taxes could be reduced, and regulatory restrictions could be eased.

Although all of these factors contribute to a more promising market for HDR in industrial park development, the reservations that apply to the industrial market are also applicable here.

*Charles V. Higbee, "The Economics of Direct Use Geothermal Energy for Process and Space Heat," A Conference on the Commercialization of Geothermal Resources, Geothermal Resources Council, 1978.

Companies choosing to locate in an industrial park supplied with HDR process heat must be assured of its continued reliability and economy, despite the attractiveness of other incentives offered them.

AGRICULTURE AND AQUACULTURE

The agriculture/aquaculture market consists of greenhouses and fish farms that grow horticultural products, fin fish and shell fish in controlled environments. These business enterprises use energy as a source of heat for maintaining their fish tanks and greenhouses at appropriate year round temperatures.

The mechanical systems that provide this heat are not elaborate. Winter greenhouse heating is supplied by individual fan coil units or furnaces with fans. Central coal or oil fired boilers are not common. Natural gas is generally not available in the relatively remote areas where these businesses are located, and therefore a large percentage of these businesses rely on butane and propane.

Key Decision Makers

The fish farming and horticulture industries are composed of small, decentralized businesses, headed by an owner or manager who employs a number of workers to tend the stock or crop and maintain the premises. The owner may also be assisted by business managers, accountants, and other support staff, but generally makes all decisions regarding operating policies and capital expenditures, including facilities design.

Decision Making Process

Owners of these businesses have three principal criteria in choosing an energy supply: temperature requirements, reliability and cost.

Catfish, salmon, freshwater prawn and trout are the fish most commonly grown in farms. Heat requirements vary, but in general temperatures are low and amounts moderate. For example, catfish farming requires water temperatures between 80°F and 85°F during all stages of the fish life cycle; trout farming requires heat primarily during incubation and initial life cycle stages. Temperature requirements for greenhouses are similar to those for space conditioning in other building types.

Reliability is especially important for fish farming, since a heat supply interruption of only a few hours can ruin the stock; short term interruptions are tolerable. Loss of the full fish inventory at any one time would amount to a loss of one-fourth to one-third annual production. Reliability is also

important to horticultural products, although most plants can tolerate significant temperature variations.

Most fish farms and greenhouses have little capital invested in their heating systems. This characteristic, when combined with the relatively high Btu cost of propane and butane, causes decision-makers to view energy principally as an operating expense. Capital expenditures are made mainly for equipment replacement, renovation, and increasing capacity through additions to facilities. In capital expenditure decision-making, some attempt is made to balance first costs and potential savings, using standard investment evaluation techniques such as discounted rate of return and payback period. The sophistication of the analysis depends on the management talent.

Financing these businesses, especially fish farming, is difficult. Capital requirements and operating expenses are very high, and lenders consider high density fish farming to be very risky. Fiscal management has not always been satisfactory, and consequently a number of these businesses have gone bankrupt. Greenhouses are somewhat easier to manage, but are still considered risky.

Potential for HDR

The characteristic of fish farming and greenhouse horticulture that makes them very adaptable to HDR energy is their low temperature requirements. Furthermore, their few employees and small scale allows them greater siting flexibility than manufacturing firms.

However, the industry is small and so does not provide the number of opportunities for HDR use that other markets do. For example, the market for catfish is now satisfied, so additional marketing is needed before new facilities are built and start producing more fish. Finally, both fish farming and greenhouse horticulture have unique process and siting requirements that have implications for HDR utilization.

Fish Farming

Water quality and quantity are of utmost importance. Fish Breeders of Idaho uses direct geothermal water supplied by artesian wells, which is clean enough to produce catfish of sufficiently high quality to satisfy gourmet markets. Water that is contaminated by impurities will impart the same taste to the stock. If the water lacks sufficient oxygen or has

too much dissolved ammonia, stock will develop disease. Approximately 1500 to 2000 gallons of water are needed per minute for a 12,320 cu. ft. facility with a capacity of 61,000 to 123,200 pounds. This can be a significant constraint in water scarce areas.

Fish farms are presently located in temperate regions because it is not profitable to heat waters where extreme temperatures reduce the growing season. The use of HDR energy would be most applicable in more extreme temperature regions, but extensive marketing would be required to extend this industry into new areas.

Stocking densities are high, requiring oxygen replenishment and carbon dioxide removal which is usually achieved by running water through channels connected by waterfalls. Thus, some change in elevation is necessary on the farm site to eliminate the need for pumping. This adds another constraint to the siting of fish farms.

Most processing plants are not mechanized, so most energy consumption goes toward refrigeration, which is obtained electrically. HDR use would not reduce the budget expended on electricity.

Finally, the easiest market to develop is the fresh fish market, thus complicating distribution. HDR resources in isolated locations would offset the energy advantages by aggravating the distribution problem.

Greenhouse Horticulture

HDR reserves located in arid regions can best be used to heat hydroponic greenhouses since they require only 10 percent as much water as row crops.* This limits the type of crop grown to hydroponic products.

*Kenneth L. Boren, "The Use of Geothermal Fluids to Heat a Large Greenhouse Complex," A Symposium on Geothermal Energy and its Direct Use in Eastern United States, Geothermal Resources Council, April, 1979.

Heat is not required 24 hours per day, since solar gain satisfies much of the heat load during the day. This eliminates much of the advantage offered by HDR.

Hydroponic products have distribution problems that are similar to those of fresh fish. Therefore, greenhouses need to be sited near suitable transportation routes, as well as near the HDR resource.

In summary, the aquaculture/agriculture industry has low temperature requirements that are suitable for HDR. However, because of other process requirements, distribution needs and financing constraints, it will be difficult to develop this market.

V. MARKETING TARGETS

To target HDR markets more specifically, a matrix was prepared which summarizes resource availability, oil and gas dependency, and potential markets in each of the 26 HDR resource states. (See Exhibit V-1.)

Resource availability is based on the "Preliminary Geothermal Gradient Map" prepared by AAPG. States are rated either "high" (proven resources with gradients over 36.5°C km covering at least 3000 square miles, plus other gradients over 29.2°C/km), or "medium" (proven resources with gradients over 36.5°C/km covering less than 3000 square miles, plus other gradients over 29.2°C/km). The 24 non-resource states which would be ranked "low" have not been included in the matrix.

Oil and gas dependency is a measure of a state's incentive to seek alternative energy sources. It is based on billions of Btu's of oil and natural gas consumed per capita. The high, medium, and low rankings were derived by identifying the obvious clusters that appeared in the data when plotted on a graph.

Potential markets are both electric and non-electric and are ranked high, medium or low, according to a similar procedure. The potential for electricity generation is measured according to the number of MWh's consumed in the states.

The next seven non-electric or direct heat applications are the broad industry groups discussed in the industry profile. Their potentials are measured according to the amount of Btu's consumed in the form of process steam. The choice of this unit assumes that those processes with low and medium temperature requirements (and therefore with good HDR potential) use heat in the form of process steam.

The next direct heat market is mining. Its potential is measured in terms of the number of Btu's used in drying ores, except for sulfur, where the heat energy measured is that used for extraction.

The final markets are non-industrial. Potential application for institutions is measured in terms of the number of dollars spent by state governments for education, health, and hospitals. The real estate market is measured by the dollar amount of construction contracts in the state. Agriculture/aquaculture could not be evaluated for lack of comprehensive data.

SUMMARY OF ENERGY ENVIRONMENTS AND POTENTIAL MARKETS BY STATE

SOURCE: Appendix A.

The overview presented in Exhibit V-1 identifies the most promising states. For example, California has the most "high" rankings. The next step was to determine the degree of proximity between resource and market within each state.* This correlation was considered along with other criteria brought out in the market descriptions. The final result is a division of markets according to high, medium, and low potential for HDR.

The highest category contains those markets with the highest potential for HDR application. These markets are (in order) utilities that generate electricity, food processing, stone/clay/glass industries, pulp and paper, textiles and chemicals. The second category consists of markets with promising potential, and includes the population related markets (institutions and real estate) as well as mining. Finally, the third category, those markets with the poorest potential, contain the primary metals, and petroleum and coal products industries.

UTILITIES (ELECTRICITY GENERATION)

The market for HDR energy in each state is assessed on the basis of three criteria:

- total megawatt-hours of electricity consumed
- proximity to HDR resources suitable for generating electricity
- dependence on oil and natural gas.

The first criterion was chosen on the assumption that utilities serving large markets have the greatest need for additional capacity. The states that consume the largest amount of electricity, in order, are California, Texas, Ohio, New York, Pennsylvania,

*Numerous development agencies and industrial associations were contacted, including: the State Development Board of South Carolina, Western Growers Association of California, Agricultural Council of California, New York State Department of Commerce, Tufted Textile Manufacturing Association in Dalton, Georgia, Division of Industrial Development in Richmond, Virginia, and the state industrial development departments of California, Texas, Georgia, North Carolina, Washington, New York, Arkansas and Oregon.

Michigan, Washington, Florida, Tennessee and Illinois.* Of these, the only states that have suitable HDR resources (within their borders or nearby) and that are dependent on oil or natural gas are California, Texas, and Washington. In addition, there are a number of fast growing metropolitan areas within states that consume relatively small amounts of electricity that could be served by electricity from HDR resources. These include Portland, Oregon; Phoenix, Arizona; Salt Lake City, Utah; and Denver, Colorado. Of all these markets, California is by far the most promising, particularly since its utilities are accustomed to buying interest in electric generating plants as far as 700 miles away. Although not as promising, there is also a market for HDR energy among utilities that are located close to an HDR reservoir, even if they do not meet the other two criteria. Some of these may be small investor-owned utilities or cooperatives located in remote areas. Plains Electric Cooperative in New Mexico is an example of a relatively small utility that has expressed an interest in generating electricity from HDR. The proximity of the reservoir to a utility's transmission lines will be of primary importance in these smaller markets.

FOOD PROCESSING

Food processing is one of the best industrial markets for HDR, due primarily to its low temperature application requirements, high oil and gas dependency and good access to capital. In addition, approximately 40 percent of the industry is made up of food cooperatives, which have demonstrated considerable interest in energy conservation. Exhibit V-2 lists the most promising sub-industries within this group.

Most of the industry's energy consumption is in California. Iowa ranks second, but consumes only 58 percent of the California total. Other HDR resource states where food processing is significant are Texas, Ohio and New York.

In California, processing plants are dispersed throughout the state. Some activity occurs in the southern resource area near the Imperial Valley and the desert areas to the north. However, the central valley market areas provide slightly better

*F. R. Dreysdale and Charles E. Calef, The Energetics of the USA: An Atlas, Brookhaven National Laboratory, October, 1977.

POTENTIAL FOOD PROCESSING INDUSTRIES FOR HDR ENERGY

Meat Packing
Prepared Meats
Poultry Dressing
Natural Cheese
Condensed Milk
Dried Milk
Fluid Milk
Canned Specialties
Canned Fruits/Vegetables
Dehydrated Fruits/Vegetables
Potato Dehydration
Frozen Fruits/Vegetables
Prepared Feeds
Beet Sugar
Soybean Oils
Shortening and Cooking Oils
Soft Drinks

SOURCE: EG&G of Idaho, Inc., RMRBER Regional Hydrothermal
Market Penetration Analysis, 1979.

targets by virtue of their greater number of establishments, geographic dispersion, and freedom from competition with hydrothermal energy.

The California dairy industry (condensed, dried and fluid milk) is concentrated immediately north of the Los Angeles area. However, the canning, dehydration, and frozen foods industries are scattered throughout the San Joaquin and Sacramento Valleys and along the coast. There is a slight concentration of prepared feed plants around Los Angeles and Fresno. Beet sugar, soybean, shortening and cooking oil producers are dispersed. California's meat packing industry is dispersed and small in comparison to that of Texas and Iowa.

There are a number of concentrated food processing areas in other states. In New York, the Buffalo/Syracuse HDR resource area contains a concentration of fruit and vegetable plants. And although small in comparison with other states, meat packing and peanut processing occur very near the Tidewater resource area of Virginia. In Ohio, Texas and Iowa, meat packing and animal feed plants are dispersed. Within Texas, a considerable number of other food industries are located near San Antonio. The Delmarva Peninsula of Maryland, Delaware and Virginia contains a high concentration of poultry dressing plants. Although these areas do not have as great a potential as California, together they may offer considerable promise.

STONE/CLAY/GLASS

The stone/clay/glass industry as a whole is characterized by very high gas dependency and R&D activity, poor access to capital and little process heat use. However, within the industry there are several sub-industries that are good candidates for HDR process heat. The best are ready mix concrete and concrete block, followed by kaolin and barium production. Almost all of the process heat requirements of the ready mix concrete industry fall below 60°C, and almost all of the low pressure concrete block processes require temperatures below 80°C.

The products of the concrete industry are heavy and cumbersome, necessitating production near markets, i.e., population centers. Within Texas, concrete industry activity is centered around Houston and Dallas/Ft. Worth. In California, the plants are dispersed throughout the southern half of the state: some concrete block plants can be found near San Bernardino and some ready-mix plants near Barstow, the mountains near Los Angeles, and the Imperial Valley. The Imperial Valley plants are significant because of their proximity to HDR resources. Facilities in Ohio and New Jersey are primarily near the population and transportation centers, which are not near HDR resource areas.

PULP AND PAPER

The pulp and paper industries offer good opportunities for HDR application. Many of their production processes consume at least 68 percent of their energy below 160°C. In addition, the industries spend a moderate amount of money on R&D and have fairly good access to capital. Also considered within this category, (though not formally part of it) are the furniture and veneer industries, where temperature application requirements fall below 80°C and 120°C respectively.

Georgia, Washington and Oregon lead the candidate states in pulp and paper. In Georgia these industries are concentrated in Augusta and Savannah which is an HDR resource area. Other companies are dispersed throughout most of the southern half of the state. No attempt was made to locate industries in Washington because of uncertainty about HDR resource locations. In Oregon, most of the pulp and paper companies are located in the western third of the state, near rivers and away from population centers where emissions would be most objectionable. This is probably indicative of a general pattern throughout the Pacific Northwest. If so, pulp and paper mills and HDR resources would be conveniently colocated in the Cascade Range.

Secondly, pulp and paper production states are North Carolina, where activity is concentrated in the extreme south (the closest resource area being Cape Fear), and Arkansas where the industry is dispersed. Furniture factories located in North Carolina are concentrated in the central part of the state, again unfortunately away from the coastal resource areas. In South Carolina, furniture plants in the Myrtle Beach and Charleston areas are potential candidates for HDR energy use. New York's plants are located mostly in the Adirondacks, away from the resource area, and Virginia's plants are dispersed.

TEXTILES

The textile industry is a good HDR marketing target for several reasons. It is concentrated in the south Atlantic states, an area that would contribute to the program's objective of demonstrating HDR feasibility in a variety of contexts. Its temperature requirements fall mostly below 140°C, with half of the consumption falling below 100°C in much of the industry. The textile processes requiring significant amounts of heat are texturizing, yarn dyeing, slashing (in weaving plants) and wet processing. (See Exhibit IV-5 in the industry profile.)

The geographic distribution of textile establishments is shown in Exhibit V-3. The state/market analysis (Exhibit V-1) indicates greatest potential use of HDR resources in the states of North Carolina, South Carolina and Georgia. In North Carolina, the industry is concentrated around Burlington, followed by Gastonia, Concord and Kannapolis. Unfortunately, these central locations are located far from the potential HDR resources in coastal areas. In South Carolina, most of the industry is in the north Greenville/Spartanburg area, again away from the coast. Similarly in Georgia, a high concentration of textile plants can be found in the extreme northwest Dalton area, although more of the industry is dispersed throughout the rest of the state.

In the states where textiles are less intensive, plants are located nearer population centers: Houston, Dallas/Ft. Worth and Brownsville in Texas; Bakersfield in California; and the New York/New Jersey metropolitan area. Bakersfield has the best resource gradient of these areas. Virginia's textile industry is generally dispersed throughout the southern half of the state, although not near the Tidewater resource area.

CHEMICALS

The chemical industry is comprised of a variety of sub-industries, some of which have very promising application and others which have none. As a broad industrial group, it ranks high in overall energy consumption and R&D activity. It also has good access to capital.

The best candidates in terms of temperature application are listed in Exhibit V-4. Most of the relevant chemical companies are located in Texas, particularly along the Gulf Coast. Geopressured energy may be a more appropriate geothermal resource than HDR for these companies.

One East Coast resource area that has significant chemical activity is Wilmington, North Carolina. Another possibility is the chemical plants located along the rivers in southeastern Virginia. Since there are eight other states with moderate amounts of chemical processing, and since the industries are difficult to characterize as a broad group, this market deserves close attention on a state-by-state, industry-by-industry level before more definite conclusions can be reached concerning the suitability of HDR.

MINING

The mining industry offers limited opportunities for HDR. The principal applications are drying of copper and potash ore concentrate and sulfur extraction.

DISTRIBUTION OF TEXTILE ESTABLISHMENTS

Type of Operation	Number of Establishments	1973 Shipments (million \$)	Geographical Concentration
Wollen yarn mills	101	250	Southeast New England
Wool weaving and finishing	197	565	Atlantic Coast
Cotton weaving	303	3,000	South
Knits	906	2,521	Mid & South Atlantic
Synthetic weaving	400	4,950	South Atlantic
Carpets and rugs	520	3,376	South Atlantic
Cellulosic manmade fibers	19	628	Eastern States
Noncellulosic manmade fibers	61	4,450	South Atlantic
Yarn mills, other than mentioned	424	3,000	North Carolina & Georgia

SOURCE: Intertechnology Corporation, Analysis of the Economic Potential of Solar Thermal Energy to Provide Industrial Process Heat, February, 1977.

POTENTIAL CHEMICAL INDUSTRIES FOR HDR

Alumina
Plastic Materials
Synthetic Rubbers
Noncellulosic Fibers
Pharmaceuticals
Ethanol
Cumene
Explosives

SOURCE: EG&G of Idaho, Inc., RMRB&R Regional Hydrothermal
Market Penetration Analysis, 1979.

NOTE: This list was developed from western data and may omit
some potential chemical industries in the East.

Ore drying is presently done in rotary bins at high temperatures. However, it is possible to modify this process to permit flat bed drying at HDR supply temperatures. Copper drying occurs mostly in south central Arizona (away from the main HDR resource area in that state), southwest New Mexico (close to several resource areas), and in north central Utah (away from the main HDR resource areas). Some copper drying also occurs in Michigan and Nevada. Potash drying occurs in southeast New Mexico, but not near the state's main HDR resource areas. The ore concentrate drying market with the best potential is copper drying in southwest New Mexico.

Sulfur mined by the Frasch process is extracted by injecting superheated water into wells where the heat content melts the sulfur which is then pumped to the surface in liquid form. The site specific nature of both the mining operation and the HDR resource require close proximity between the sulfur and the resources. Unfortunately, sulfur mining takes place near the salt domes along the northern Texas coast. Geopressured resources located there seems to offer more promise than HDR as an alternative energy source.

UTILITIES (DISTRICT HEAT), INSTITUTIONS, REAL ESTATE

Utilities that provide district heat, institutions, and real estate are grouped together because they are generally located in areas with high population densities. Compared with other HDR markets, these demonstrate little potential: they are not as energy intensive as electricity generation and industrial processing, and they have less access to capital. Furthermore, the most economical use of HDR for space heating is district heat, which is limited to moderately dense areas and most feasible when generated with high temperature electricity. HDR plants which produce steam at lower temperatures, are not likely to be used for cogeneration. While it is conceivable that a resource developer could supply heat for space conditioning at competitive prices to a municipality, institution or real estate development, such users would have to be very close (within two miles) of the reservoir, or would have to be an offshoot of a more energy intensive project such as an industrial park.

The best states for developing this market are those that have concentrated populations near HDR reservoirs. These are California, New York and Texas. The number of incorporated municipalities with populations of more than 25,000 is by far the greatest in California. Some potential for this market also exists in central Michigan, western New Jersey and the south Atlantic seaboard.

PRIMARY METALS

The primary metals industries are a poor marketing target for HDR resources, due to their dependence on processes requiring only a small percentage of heat in the HDR range. Less than 1.9 percent of the industry's energy consumption falls within the appropriate temperature range. In addition, the industry ranks low in oil and gas dependency.

Ohio leads the candidate states in primary metals production, but the Ohio HDR resource has been tentatively located in the non-industrialized area near West Virginia and Pennsylvania. Moreover, Ohio is not dependent on oil and gas.

Given these market characteristics, HDR could serve only as a preheating source in this sector.

PETROLEUM AND COAL PRODUCTS

The petroleum and coal product industries offer few opportunities for HDR supplied process heat due to the small percentage of process heat they use in the HDR temperature range. The only petro-chemical sub-industries that could be applicable are the production of isopropyl alcohol, ethyl alcohol, adipic acid, and acetic anhydride -- all of which are relatively steam-intensive in their production processes. However, these sub-industries are concentrated on the gulf coast of Texas where goepressured energy is a more promising alternative energy source.

CONCLUSIONS

In conclusion, the HDR markets can be grouped into three classes: definite potential, possible potential and poor potential.

The first group includes the generation of electricity for California and several industrial processes. The most promising application is electricity generation for California. The generating plants could be located in California, but also in Nevada or possibly New Mexico and Utah.

Food processing also has definite potential in California, and moderate potential in north central New York and Iowa. The stone, clay and glass industries, especially concrete block and ready-mix, are again most promising in California, followed by New Jersey and tentatively Ohio, if more widespread resources are discovered there. Pulp and paper industries are most promising near Savannah, Georgia and the Pacific Northwest. The Pacific

Northwest could become an important target area, if significant HDR resources are found near the Cascade Range. HDR applications in the southeastern textile industries are possible, but will require plants to shift or expand from inland locations to coastal areas. Individual chemical plants scattered throughout resource states have good potential, but specific areas, apart from the southern coast of North Carolina, cannot be identified without more precise resource data.

The second category consists of markets with possible potential, including institutions, real estate, and mining. Institutions and real estate developments are concentrated in California, followed by New York, Texas, Michigan, New Jersey and the South Atlantic seaboard. The potential of these markets will increase if they are associated with a more energy intensive HDR project such as an industrial park. Also within this category is mining, specifically copper ore concentrate drying, which has potential in southwestern New Mexico.

The third category, consisting of the primary metals industries and petroleum and coal products, offer relatively poor potential. If these markets have any promise, it would probably be in Ohio and Texas respectively. All three categories are summarized in Exhibit V-5.

MARKET SUMMARY

MARKET

LOCATION

DEFINITE

Electricity for California

California
Nevada
New Mexico
Utah

Food processing

California
New York
Iowa

Concrete block and ready-mix

California
New Jersey
Ohio

Pulp and paper

Savannah, Georgia
Pacific Northwest

Textiles

Southeastern coastal
areas

Chemicals

Southern coast of
North Carolina

POSSIBLE

Institutions & real estate

California
New York
Texas
Michigan
New Jersey
South Atlantic coast

Copper ore concentrate drying

New Mexico

POOR

Primary metals

Ohio

Petroleum, coal products

Texas

VI. MARKETING STRATEGY

Since marketing strategies must be designed to achieve objectives, one of the first tasks of a marketing effort is to establish objectives. The analysis of the national energy environment in Chapter III suggests, if HDR is to assume a reasonable share of energy supplied from new technology, that there must be in the order of 100 commitments for developing HDR reservoirs by 1986.

Another approach might postulate that putting operational heat plants on line is a private industry responsibility, and that federal money should be spent only for demonstration projects designed to induce private sector investments. An analysis of the decision-making criteria in Chapter IV suggests that several money-making HDR projects would have to be in operation before decision makers would have the confidence to invest in HDR reservoirs without federal assistance.

However, Department of Energy policy makers could take the position that the federal government's job is over and private industry must carry on as soon as technical feasibility has been demonstrated at two sites and studies showing economic feasibility and environmental acceptability have been completed. However, if buyers of HDR energy are not convinced by federal demonstrations that investments in the technology can be made with acceptable risks, then the total federal investment must be written off to the advancement of science, not the production of commercial energy.

The dilemma of "how far is far enough?" is a policy question that cannot be answered in a preliminary marketing plan, and may never be resolved definitively. However, we must make an heroic assumption and carry on. In general, we believe that commercialization will not occur unless at least nine private investments are made in the development of HDR reservoirs for commercial application. The nine investments should be made as follows: two in electricity generation, two in population-related applications and one in each of the five most promising industrial process heat markets: food processing, textiles, stone/clay/glass, pulp and paper, and chemical processing. Moreover, these nine investments must be geographically dispersed throughout the United States before widespread use of HDR energy can become a reality.

What can the Federal HDR Program do to achieve these objectives? This chapter describes an approach to commercialization that begins with an analysis of market needs and then tailors the technology to meet those needs. It then offers some general

management guidelines for implementing this approach. It concludes by outlining specific objectives, strategies and programs for each of the three major market areas.

HDR MARKETING APPROACH

The overall approach to marketing HDR energy is to create a market demand in advance of the full development of the technology. If this demand can be developed in the form of a significant number of customers in a variety of nationwide markets, awaiting each new technological advance and each new institutional solution, then commercialization can be accelerated and federal funds can be saved.

Such a situation is now enjoyed by solar energy technology. Industrial and residential customers across the country are waiting for payback periods to be reduced through economies of scale and standardization. In reality however, solar technologies are no more advanced than geothermal technologies. Although hot dry rock resources are not available everywhere, they have been identified in all regions of the country, concentrated in economically useful amounts. Unlike solar energy, reliability of HDR energy is not dependent on weather or advances in energy storage technologies. Marketing is needed to create a demand for HDR energy that is equivalent in its applications to the demand enjoyed by solar energy for its uses.

The marketing approach is presented in five phases:

1. Set marketing objectives
2. Develop marketing strategy
3. Develop marketing program
4. Implement marketing program
5. Maintain feedback.

These phases and their activities are shown in Exhibit VI-1.

The first phase involves establishing objectives for the commercial use of HDR energy in each of three market areas: electricity, industrial process heat and other population-related applications. These areas are described in more detail in the preliminary marketing plans.

The second phase requires the development of strategies for each market. The strategies are based on present and future energy economics in each market and are tailored to their decision making processes and criteria. All strategies postulate

HDR MARKETING APPROACH

PHASES

1. Set Marketing Objectives

2. Develop Marketing Strategy

3. Develop Marketing Program

4. Implement Marketing Program

5. Maintain Feedback

the use of a technology transfer team that introduces the HDR concept and immediately responds to concerns raised by prospective buyers and resource developers. In market areas where HDR energy is not well known, the team would not work directly with buyers and developers at first, but would work with intermediary marketing agents. These agents are local organizations whose principal interests and missions may be economic development, the use of alternative energy sources, environmental protection, industrial development and professional development. Examples include state energy agencies, state organizations for economic development, industrial associations, environmental groups promoting the use of alternative energy sources and engineering societies. These groups have their own resources and a much more detailed knowledge of local markets than the HDR program staff could develop with its limited resources.

The third phase involves developing marketing programs for each of the high priority markets identified in the second phase. These programs are both active and passive. Active programs concentrate on those markets where early adoption of HDR energy is most likely, or where HDR energy is promising but unfamiliar. Passive programs are designed to respond to requests for information from organizations in markets where early adoption is neither likely nor promising. This phase concludes with the definition of specific goals for each high priority market and the development of marketing programs designed to achieve them.

In the fourth phase programs are implemented that were developed in phase three. It begins by establishing working relationships with each of the high priority buyers, developers and marketing agents. The role of the HDR technology transfer team is to define the requirements of potential customers and developers of HDR energy to identify their concerns, and to respond to them within the context of the marketing plan. The principal activities of the team would be to resolve concerns over technical problems, assist with regulatory compliance, provide information to financing institutions on HDR reliability and feasibility, and conduct appropriate educational programs.

Phase five involves monitoring the marketing plan to evaluate progress toward the specific goals that were established in phase three, modifying the marketing activities to improve their effectiveness, and revising objectives based on an increasingly realistic assessment of the potential and difficulties of commercialization.

MARKETING MANAGEMENT GUIDELINES

Implementing the general strategy outlined above should be achieved with a technology transfer team with diverse responsibilities and skills. The team should be market-oriented, in that the senior managers should have responsibilities for the three principal HDR energy markets: electricity generation, industrial process heat and other population-related applications. Specialized skills should be available in the areas of business, finance (both public and private), regulation, economics and HDR technology. Also needed are knowledge of the engineering and economics of the six industrial processes suitable for HDR application and knowledge of the technical problems of electricity generation and transmission in the West. Geographic specialization should include knowledge of economic development issues in California, the Atlantic Seaboard, the Pacific Northwest, and the Midwest.

Coordination procedures should be established with the other HDR program activities of:

- HDR resource area identification
- Demonstration site selection
- Economic feasibility study
- Electric power commercialization at Fenton Hill
- Regulatory, legal and environmental issues.

The technology transfer team should begin with a small staff of three to five people and expand to about 15 as the HDR program makes its transition over the next seven years from technology development to commercialization. Team resources should be shifted from one market area to another as private investment commitments are made in commercial HDR reservoir development. The team should be disbanded when the nine private investments have been made in the three major market areas.

The initial team should be formed to address the industrial process heat and western electric power markets. It should also have the capability of responding to local initiatives to use HDR resources in the real estate, institutional, and agriculture/aquaculture sectors.

PRELIMINARY MARKETING PLANS

This section presents marketing objectives, strategies and programs for each of the three market areas.

*What principle or rationalization
lies behind choice of these numbers?
Why not 20 and 50 resp.?*

Electricity Generation

The objective in this market is to obtain at least two private investments in the development of HDR reservoirs for commercial electric power generation in the West by the end of 1982.

Why two?

Because geothermal resources are not new in the western electric power market, the strategy is to differentiate hot dry rock from hydrothermal sources in the minds of utility executives, resource developers and regulators. The technology transfer team would approach these decision makers directly, define their concerns about adopting HDR technology, and develop an active program to respond to them. Initial contacts would be made with 10 to 15 major utilities with the expectation that at least two of them would make commitments to HDR energy by 1982. Most of the effort would be directed toward the California market for electric power, since it is by far the largest and most promising.

The marketing program would include:

- Coordination with the ongoing USGS program to identify HDR resource areas suitable for electric power generation and transmission to load centers
- Direct support of the commercialization program for the Fenton Hill site
- Presentations to major utilities, resource developers, public utility commissions and environmental agencies
- Testimony for both state and federal legislative committees on geothermal leasing arrangements, electricity transmission policies and legal definition of the resource.

Industrial Process Heat

The objective for this market is to obtain at least five private investments in the development of HDR reservoirs for industrial process heat by the end of 1984.

Why five?

The overall strategy for this market is to introduce hot dry rock as a process heat source to at least six industries in several promising locations. They are:

1. Food processing in California, Iowa and New York
2. Textiles in South Carolina, North Carolina and Georgia
3. Stone/clay/glass industries in California, New Jersey and Ohio

4. Pulp and paper in Georgia, Washington and Oregon
5. Chemical processing principally in North Carolina
6. Copper ore concentrate drying in southwestern New Mexico.

The active pursuit of six major industries should yield at least five significant private investments by the end of 1984. Because of the difficulty of contacting the thousands of companies in these industrial sectors, initial contacts should be made with trade associations, first at the national level and then at the state and local level. The associations would act as marketing agents to introduce the HDR energy source to its members. The technology transfer team would then follow up with responses to concerns voiced by individual companies after the initial introductions have been made. The team would follow up by providing the marketing agents with technical assistance to identify and develop specific sites.

The marketing program would include:

- More detailed evaluation of the suitability of HDR energy in each of the sub-industries of food processing, textiles, stone/clay/glass, and pulp and paper
- Further investigations of the applicability of HDR energy for chemical processing
- Coordination with the national HDR resource identification program to improve the transfer team's knowledge of specific resource locations
- Initial contacts with national trade associations in all six market sectors
- Follow-up contacts with state and regional chapters of the national organizations
- Follow-up contacts with individuals companies referred to the team by state and regional associations
- Initial contacts with state economic development and energy agencies to acquaint them with the potential availability of HDR energy and to enlist their support as marketing agents
- Individual presentations to high priority manufacturing companies.

Other Markets

Other markets include real estate, institutions and agriculture/aquaculture. Space conditioning, and especially district heat, is the product relevant to these markets. District heat may also be of interest to a few utilities. The objective for these market areas is to obtain at least two private investments in the development of HDR reservoirs for commercial application by the end of 1986.

The strategy for these markets is responsive rather than active, for two reasons. First, it would be extremely difficult and expensive to reach the thousands of decision makers in these market areas. Second, the probability of finding a suitable HDR resource in precisely the right location is very small. As site-specific resources are identified, the technology transfer team would inform the appropriate state economic development and energy agencies. These agencies would then assume responsibility for informing potential development groups. If these groups become committed to developing the resource, then the technology transfer team would support their efforts upon request.

The marketing program would include:

- Coordination with the HDR resource identification projects
- Informing appropriate state agencies about the potential of the resource
- Responding to requests for support from local development organizations.

APPENDIX A

SUPPORT DATA FOR EXHIBIT V - 1

APPENDIX A

ENERGY ENVIRONMENT

State	Resource Availability ¹ (High, Medium)	Oil* Dependency ²	Natural Gas* Dependency ²
Alaska	H	.1514	.165
Arizona	H	.0360	.114
Arkansas	H	.0420	.157
California	H	.0403	.116
Georgia	M	.0397	.072
Hawaii	M	.1094	0
Idaho	H	.0532	.079
Iowa	M	.0325	.122
Maryland	M	.0944	.044
Michigan	M	.0413	.078
Nebraska	H	.0413	.152
Nevada	H	.0415	.156
New Hampshire	M	.1199	.006
New Jersey	M	.1306	.045
New Mexico	H	.0446	.370
New York	M	.0973	.038
North Carolina	M	.0445	.032
North Dakota	H	.0555	.064
Ohio	M	.0262	.097
Oregon	H	.0706	.053
South Carolina	M	.0386	.056
South Dakota	H	.0433	.051
Texas	M	.0323	.436
Utah	M	.0666	.108
Virginia	M	.0928	.040
Washington	M	.0546	.050

*Billions of Btu per capita of oil/natural gas consumed in 1972.

POTENTIAL INDUSTRIAL MARKETS³
(trillions Btu for process steam generation in 1974)

State	Primary Metals	Textiles	Stone/ Clay/ Glass	Food Processing	Petroleum/ Coal Products	Pulp/ Paper	Chemicals	Mining
Alaska	0	0	0	.56	.48	0	2.39	0
Arizona	.916	0	.29	1.84	.10	9.27	.79	934
Arkansas	.564	.87	.51	5.42	2.54	65.87	20.27	0
California	2.202	.41	3.05	50.28	81.46	38.33	32.74	0
Georgia	.082	21.39	.42	8.89	.69	137.66	8.48	0
Hawaii	0	0	.01	2.91	1.55	0	0	0
Idaho	.139	0	.10	7.15	.02	4.60	4.44	0
Iowa	.247	0	.69	29.79	.08	2.37	18.21	0
Maryland	3.291	.27	.42	7.72	1.66	7.67	5.89	0
Michigan	5.514	.87	1.84	13.69	3.84	45.58	27.43	84
Nebraska	.120	0	.23	10.42	.23	.14	6.23	0
Nevada	.125	0	.18	.26	0	0	1.68	72
New Hampshire	.042	1.00	.14	1.02	.04	16.10	.15	0
New Jersey	.781	4.97	2.76	13.64	22.74	12.76	38.23	0
New Mexico	.104	0	.12	.82	2.46	0	.66	1242
New York	3.891	3.51	1.67	21.36	4.93	34.50	18.64	0
North Carolina	.253	38.90	.70	5.57	.40	69.35	16.43	0
North Dakota	0	0	.09	3.73	1.43	0	.02	0
Ohio	12.576	1.46	3.82	21.21	22.97	37.22	41.45	0
Oregon	.688	.05	.20	4.24	.82	66.70	1.93	0
South Carolina	.059	27.04	.76	2.56	.06	61.47	6.96	0
South Dakota	0	0	.02	4.45	0	0	0	0
Texas	4.634	.96	2.86	19.47	210.55	48.65	509.63	31470
Utah	2.175	0	.26	1.74	5.25	0	.79	237
Virginia	.131	7.43	.64	5.57	2.48	72.70	20.60	0
Washington	2.829	0	.37	10.07	12.83	115.00	6.58	0

OTHER POTENTIAL MARKETS

State	Electricity ⁵ Consumption*	Institutions** ⁶	Real Estate*** ⁷
Alaska	1317	350	495
Arizona	15723	874	1725
Arkansas	14418	626	991
California	131196	7269	12960
Georgia	34392	1476	2336
Hawaii	4812	528	438
Idaho	11412	263	555
Iowa	16842	1029	1155
Maryland	24067	1566	1769
Michigan	60909	3007	3686
Nebraska	8960	393	679
Nevada	6603	217	802
New Hampshire	4350	183	317
New Jersey	41460	1661	2021
New Mexico	6060	537	725
New York	83976	6969	2699
North Carolina	43974	2138	2527
North Dakota	3177	244	424
Ohio	93962	2725	4228
Oregon	28311	729	1548
South Carolina	22830	1044	1276
South Dakota	3024	184	329
Texas	108740	4127	8683
Utah	5556	548	903
Virginia	29496	1619	2560
Washington	55911	1591	2420

*thousands of MWh 1972

**millions of \$ state government expenditures for schools and hospitals, 1976

***millions of \$ of construction contracts, 1977

SOURCES AND NOTES

1. Based on "Preliminary Geothermal Gradient Map," American Association of Petroleum Geologists. "H" indicates that the state has proven resources over 36.5 C/km on at least 3000 sq. mi. plus other gradients over 29.2 C/km. "M" indicates that the state has proven resources over 36.5 C/km on less than 3000 sq. mi. of area, plus other gradients over 29.2 C/km.
2. Frank. R. Dreydsdale and Charles E. Calef, The Energetics of the USA: An Atlas, Brookhaven National Laboratory, Associated Universities, Inc., 1977.
3. End Use Energy Consumption Data Base: Series 1 Tables, Energy Information Administration, June, 1978. Figures were obtained by multiplying the percent of energy that goes to process steam generation (Exhibit IV-3) by total energy consumption of industry in state.
4. Intertechnology Corporation, Analysis of the Economic Potential of Solar Thermal Energy to Provide Industrial Process Heat, Vol. II, February 7, 1977. All figures reflect process heat consumed in drying copper and phosphate except for Texas, which reflects process heat consumed in extracting sulfur.
5. Frank R. Drysdale and Charles E. Calef, The Energetics of the United States of America: An Atlas, Brookhaven National Laboratory, Associated Universities, Inc., October, 1977.
6. State Government Finances in 1976, Series GF 76, No. 3, U. S. Bureau of Census.
7. Dodge Construction Potentials, F. W. Dodge Division, McGraw-Hill Information Systems Company, New York.