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**PROSPECTS FOR
GEOTHERMAL COMMERCIALIZATION IN
THE CHEMICAL INDUSTRY**

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INTRODUCTION

This is one of four reports on studies conducted by the Earl Warren Legal Institute on the prospects for commercialization of geothermal energy in selected industries, including greenhousing, potato and onion processing, and certain segments of the lumber and chemical processing industries.¹ These particular industries were selected for study from a number of possibilities suggested in the Institute's earlier survey of existing and potential users,² and from a review of existing engineering and economic feasibility work undertaken by others. Our objective in these studies has been to identify and analyze specific legal, economic and institutional barriers to the direct use of geothermal energy as perceived by firms representing each of the industries selected. The results reported here are based upon extensive personal interviews conducted systematically with substantial numbers of decision-makers representing varied segments of each industry studied.

We focused in this study upon a number of areas considered directly relevant to a particular chemical firm's decision to use or not to use geothermal energy for its commercial needs. These areas include: 1) Current fuel uses and problems, and future fuel concerns; 2) Firm decision-making processes, including managerial and financing conventions; 3) Perceived commercial potential

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1. See also: Prospects for Geothermal Commercialization in the Greenhouse Industry; Prospects for Geothermal Commercialization in the Lumber Industry; Prospects for Geothermal Commercialization in the Potato and Onion Industry. Earl Warren Legal Institute, 1979-80. In addition to these industry reports, the Institute intends to publish a fifth report synthesizing the results of its work and analyzing its overall implications for government policy.
 2. See: Second Interim Report on Legal and Institutional Considerations in the Commercialization of Geothermal Resources for Direct Uses, submitted to the Department of Energy, February 22, 1979.

for geothermal energy in the industry and mechanisms for stimulating interest;
4) The potential institutional frameworks for user involvement in geothermal development; and 5) The role that government might most effectively play in stimulating user development.

We hope that this report will present a useful description of the chemical industry's approach to the possibility of geothermal use, the major factors likely to influence individual decisions in this area, and suggestions to guide both the government and the private developer in encouraging rational development of geothermal resources.

I. SELECTION OF FIRMS FOR IN-DEPTH SURVEY

In order to focus our investigation of institutional barriers in the chemical industry upon segments of the industry whose process requirements appear most suited to near-term geothermal use, we began by reviewing economics and engineering feasibility studies already undertaken in the industry. Based on our review of the literature, we selected for in-depth study three chemical products identified as potential beneficiaries of moderate-temperature resources: nitrogen fertilizer;³ chlorine caustic soda;⁴ and certain inorganic salts.⁵

Although nitrogen fertilizer production has been shown to be a technologically viable candidate for geothermal use, our study proved to be restricted by the fact that the domestic fertilizer industry is experiencing a serious decline due to low ammonia prices and competition from imports. We obtained the names of many companies from a TVA "Directory of Fertilizer Plants" for 1974 and 1976, but soon found that numerous plants had closed or were restricting production. Accordingly, from a prospective list of 19 currently operating companies, only two appeared to merit in-depth study which might illuminate institutional factors relevant to DOE's interests.

To identify caustic soda producers, we examined "The Directory of Chemical Producers, USA" published annually by Stanford Research Institute. We also consulted Thomas's Register, a listing of manufacturers organized by products, and a

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3. See: R.B. Sherwood and K.L. Newman, "Engineering and Economic Feasibility of Utilizing Geothermal Heat from the Heber Reservoir for Industrial Processing Purposes at Valley Nitrogen Producers, Inc., El Centro Agricultural Chemical Plant." Western Service, Inc., Report to DOE, Sept. 1977.
 4. See: C.C. Hornburg, B. Lindal, "Preliminary Research on Geothermal Energy Industrial Complexes: Final Report," DSS Engineers, Inc., A report to DOE, March 1978.
 5. See: S.C. May, D.J. Basuiro, et. al., "Application of Geothermal Resources in Evaporation Crystallization Industry," Bechtel Corporation, Report to DOE, October 1977.

"State Directory of Manufacturers," organized by industry, for each western state. These sources indicated that only ten plants were located in the western United States. We contacted nine firms for a preliminary telephone survey, and selected six for in-depth interviews.

To identify potential interviewees engaged in the production of inorganic salts, we also consulted the SRI "Directory of Chemical Producers, USA." We initially contacted all listed producers with plants in the western states to determine the type of evaporators and crystallizers used in their operations. We eliminated those who used solar ponds. Of the remaining five firms we conducted lengthy interviews with three.

For the chemical industry as a whole, we contacted 18 companies by telephone for a preliminary survey, and selected 11 for in-depth interviews. Those 11 firms are described in detail in Section III below.

II. BACKGROUND ON THE CHEMICAL INDUSTRY

Nitrogen fertilizers.

This sector includes the production of ammonia, ammonium nitrate, and urea. Value of shipments increased from \$808 million in 1972 to \$2,600 million in 1978, or about a three-fold increase. In 1978, 7% of product shipments were exported and 17% of consumption was imported. TVA statistics indicate that in 1977 there were 97 plants in the U.S. owned by 59 ammonia companies, and a capacity of 21.8 million tons annually.⁶ The western states have 12% of U.S. ammonia capacity. The average size of an ammonia plant in the U.S. is 224,000 tons annual capacity.

Ammonia capacity has increased more than 20% in the past four years and more is under construction. But capacity in other countries is also up. The U.S. ammonia industry operated in 1978 at about 70% capacity, and a number of high cost plants, particularly those in California, have closed down. The major problem is the high cost of energy and of hydrogen feedstock which is usually obtained from natural gas. Imports of ammonia from countries with indigenous energy sources such as Mexico, U.S.S.R., Canada, and Trinidad, have hurt the U.S. ammonia industry, and it is no longer able to compete on the world ammonia market. Thus, the U.S., which until 1974 was a net exporter of ammonia, has become a net importer of ammonia. According to the TVA, 24 U.S. ammonia plants were shut down in 1978. John Douglas of TVA forecasts a 3% annual growth rate of nitrogen fertilizer consumption in the U.S. between 1977 and 1990.⁷ Some of that growth will

6. These figures include plants whose major products are ammonia, ammonium nitrate or urea as well as those which produce small amounts of ammonia, as a by-product of the production of other chemicals, primarily for captive use.

7. "Musings on the U.S. Fertilizer Industry, 1990," TVA paper presented at the Fertilizer Institute World Fertilizer Conference, San Francisco, CA, Sept. 13-16, 1978.

be taken up by increased imports. Thus, while there will be some growth in ammonia production in the U.S., it will be much lower than in the past two decades. About four years ago, ammonia was in short supply worldwide. Consequently, 20% (15 million tons annually) more capacity has been added to worldwide ammonia capacity in the past two years, but there is currently an excess capacity globally of 10 million tons annually and this gap is expected to widen during the next few years.

Imported ammonia is available on the U.S. Gulf coast for as little as \$75/ton, with most going for \$85/ton. It costs \$120 (with a 20% ROI) to produce one ton of ammonia of which \$41 represents natural gas feedstock costs and \$21, energy costs. The energy and feedstock costs are \$62 alone and the breakeven (0% ROI) is \$89, which is greater than the cost of imported ammonia.⁸

Alkalies and chlorine

This subsector includes chlorine, caustic soda, and soda ash. Chlorine and caustic soda are frequently produced jointly.

In 1974 there were 48 alkali and chlorine plants in the U.S. owned by 28 companies. Ten of those plants were in the western states. The four largest companies produced 54% of the shipments by value. The eight largest produced 79% and the 20 largest 97%.

In 1975, chlorine-caustic plants in the U.S. had a capacity of 31,500 tons/day. Capacity has continued to increase while production has remained relatively stable, ranging between 10.3 and 10.9 million tons of chlorine annually. As a consequence, chlorine-caustic soda production was about 80% of capacity in 1978.

Approximately 13,000 people are employed in the chlorine and alkalies

8. Oil and Gas Journal, Jan. 1, 1979, pp 36-38.

industry. About 10% of the production is exported, and only a small amount is imported. The value of shipments increased from \$823 million in 1972 to \$1,975 million in 1978, nearly a 2½-fold increase. However, between 1967 and 1972 chlorine-caustic soda production grew at an annual rate of 7% and the Department of Commerce forecasts a growth rate of only 2% through 1983.⁹ According to the Department of Commerce, one of the major problems facing the chlorine-caustic soda industry will be the availability of adequate supplies of fuel and electric power and their inflated cost to producers. In addition, the banning of chlorinated chemicals by the government has affected the demand for chlorine, and the displacement of caustic soda with soda ash has likewise affected the demand for caustic soda.

Miscellaneous inorganic chemicals

This category includes inorganic salts, e.g., hydrochloric, sulfuric and boric acid. In 1972 there were 384 plants in the U.S. owned by 166 companies, with 58 plants located in the western states. The four largest companies produced 27% of the output, the eight largest 46% and the 20 largest, 70%.

The value of shipments has increased from \$3.8 billion in 1972 to \$8.5 billion in 1978 for a more than two-fold increase. There are 75,000 people employed in this industry. About 20% of production is exported with about 17% of consumption being imported. However, most of the foreign trade is concentrated in a few products in this category (alumina, aluminum hydroxide, uranium compounds, and potassium compounds).

The Department of Commerce forecasts a 3% annual growth rate for the next four years. The industry currently has adequate capacity except for a few products in short supply such as sodium chlorate, boric acid, and hydrochloric acid. The demand for boric acid is expected to continue to be high. Most

9. U.S. Department of Commerce, 1979 U.S. Industrial Outlook

of the growth in demand has been attributed to the use of boric acid as a fire retardant for cellulose insulation and bedding.

III. THE FIRMS SURVEYED

A. STATEMENT ON CONFIDENTIALITY OF INDUSTRY INTERVIEW DATA

In the course of its study of potential geothermal users, the Earl Warren Legal Institute conducted personal interviews with representatives of over 50 firms in four selected industries.¹⁰ During our initial contacts with these representatives, many expressed strong reluctance to be interviewed regarding company activities because of concerns over disclosure of business information which they or others in their companies might consider proprietary or otherwise confidential. Accordingly, in order to obtain the cooperation necessary to accomplish its task, the Institute assured each respondent that information regarded by the company as confidential would be respected as such by Institute staff members.

In many instances, interviewees prefaced the actual interview with a blanket request for confidentiality. In other instances, respondents indicated during the course of the interview that particular information was confidential and/or proprietary. In all cases, the Institute staff accepted such requests for confidentiality without reservation.

Because so many respondents expressed concern over confidentiality, and because of the difficulty of separating responses on the wide range of topics covered into confidential and non-confidential categories, we decided to eliminate specific attribution in our published reports analyzing the interview data collected. All information is accordingly attributed to interviewees and companies by a fictitious reference, rather than by actual names. In this way, we have been able

10. See Introduction page iii.

to include in the reports all substantive information in which the public has a legitimate interest, while honoring the respondent firms' expectations of confidentiality and preserving the integrity of representations made on behalf of the Earl Warren Legal Institute.

B. FIRM BACKGROUND

The following tables are a convenient reference for basic data on the companies in our survey. Table 1 lists firms alphabetically and Table 2 lists firms by size. Clarification of some categories of information may be helpful. We interviewed representatives from all of the largest chemical companies in the United States. However, in comparing the size of one company with another we chose an arbitrary distinction. Companies with over \$1 billion in sales were designated as large; between \$500 million and \$1 billion, medium; and below \$500 million, small. Three of the categories in Table 1 - Age of Plant, Stated Growth Philosophy, and Stated Roles in Innovation - describe the subjective responses of interviewees to our questions. The remaining categories are self-explanatory.

Table 1. FIRM BACKGROUND

Company	Size	Relevant Plant Locations	Stated Role in Innovation	Stated Growth Philosophy
Acme Chemical Company	Small	California	F	F
Best Fertilizer Company	Small	California	L	R
Cooper Corporation	Large	California New Mexico	n/a	n/a
Dependable Chemical Co.	Large	Washington Nebraska	L	R
Earnest Chemical, Inc.	Large	California Wyoming Nevada	F	K
Friendly Corporation	Large	Louisiana California	A	K
Good Salt & Chemical Co.	Medium	California Texas	L	n/a
High Grade Chemical Corp.	Large	New Mexico Maine	L	K
Industrious, Inc.	Medium	Washington Oregon	A	K
Just Salt & Chemicals, Inc.	Small	California	L	F
Keen Chemicals	Large	California Texas, Michigan Louisiana	F	n/a

Key: Stated Role in Innovation

F = Forefront
A = Average
L = Let Others Do It

n/a = No answer

Stated Growth Philosophy

F = Faster than others in industry
K = Keep up with industry
R = Reduce production
N = No growth (status quo)

Table 2 COMPANIES BY SIZE

Firm	Products	# of Employees	Net Income	Sales
LARGE				
Keen Chemicals	industrial chemicals (chlorine, caustic soda) agricultural chemicals specialty chemicals	53,500	575.2 M	\$6.887 B
Dependable Chemical Co.	nitrogen fertilizer ammonia nitro liquid urea nitrate	30,000	710.5 M	
Friendly Corporation	aluminum ag. chemicals (chlorine, caustic soda), refrac- tories, real estate	26,865	145.5 M	\$2.47 B
Cooper Corporation	petroleum, coal, nuclear, chemicals	n/a	118.1 M	\$2.07 B
High Grade Chemical Corp.	nitrogen fertilizer, indust. and organic chem. coal, natural gas, electro chemicals, explosives	9,942	120.1 M	\$1.364 B
Earnest Chemical, Inc.	industrial chemicals (boric acid, chlorine, soda ash, caustic soda)	n/a	126 M	\$1.32 B
MEDIUM				
Industrious, Inc.	chemicals (chlorine, caustic soda, sodium chl. hydrochloric acid), health supplies, precision equip.	13,970	45 M	\$921.4 M
Good Salt and Chemical Co.	salt, pharmaceuticals, specialty chemicals	10,800	36.9 M	\$656.7 M
SMALL				
Best Fertilizer Company	nitrogen fertilizer, ammonia	800		\$125.2 M
Acme Chemical Company	soap boric acid, cleaning chemicals borax	2,000		
Just Salt and Chemicals, Inc.	salt	n/a		\$11 M

C. DESCRIPTION OF FIRMS

A. Acme Chemical Company

The Acme Chemical Company is a wholly-owned subsidiary of an international resource company based outside the United States.

Acme's origin dates back to the discovery of borax in the California desert during the late 19th century. The company has operated its present mine since 1927, introducing open pit mining and refining facilities in 1957. The refinery's capacity was expanded by about 35% between 1975 and 1979, and a new boric acid plant was built during that time.

Acme also operates a California refinery and soap plant which produces chemicals, soap and boric acid, and an Iowa soap plant which produces cleaning products. Total employment at the firm's three sites is about 2,000.

The firm's growth history for the past 15 years is one of rapid expansion, and the company is now one of the world's largest borax producers. Present growth philosophy is to expand production and grow faster than the industry. The company considers itself at the forefront of innovation.

No financial data is publicly available for Acme, and the interviewee considered such data confidential.

We interviewed a staff assistant in Acme's operations department who has been with the company for 18 years. As assistant to the corporate energy coordinator, he is the company's de facto energy manager.

B. Best Fertilizer Company

Best Fertilizer is organized and operates as a cooperative. The company is in difficult financial condition, having suffered a \$53.7 million loss in 1978 due to high energy and feedstock (natural gas) costs and low ammonia prices. Sales in 1978 were \$125.2 million. A total of 800 people are employed by the firm.

The firm began the year 1978 operating five ammonia plants; by the time of our interview in May 1979, only one plant remained in operation. That plant was built between 1966 and 1969, and the interviewee describes it as fairly up-to-date.

The plant normally operates 24 hours a day, 7 days a week, year-round, except for normal shutdown periods of from two to four weeks for maintenance. In 1978, the plant closed for two months for maintenance and to reduce inventories.

Our respondent described the last five to fifteen years growth history as very poor. The company intends to reduce its output over the next few years because production costs are rising, while the selling price is falling due to foreign competition in ammonia.

The firm is in no financial position to undertake any innovation or expansion. An outside engineering firm studied the possible conversion of one plant to geothermal energy. They proposed a demonstration project which would have replaced a steam-driven, cooling tower pump with a geothermally-driven pump. Although the federal government would have supplied \$1.2 million of the \$3 million total cost, Best was not interested.

At Best Fertilizer we spoke with the vice president for engineering and manufacturing, and with the production manager. The vice president has been with the firm for many years. The production manager has been with Best for four years, and has been in the field for 25 years.

C. Cooper Corporation

Cooper Corporation is a diversified resource company involved in petroleum, coal, nuclear power and chemicals. The firm has three chemical plants. Its California plant produces potash, soda ash, sulfates, borax, and borax compounds; its New Mexico plant, potash; and its Nevada operation, maganese dioxide, ammonium perchlorate and sodium chlorate.

The company's 1978 sales exceeded \$2 billion, with a net income of over \$118 million. Total sales were down 4% from 1977. About 18% of total sales were from chemicals and fertilizer.

We conducted interviews with the vice president for exploration at Cooper's corporate headquarters and with three chemical engineers working in various capacities at the firm's California chemical complex. All three of these engineers have been with Cooper for over fifteen years.

D. Dependable Chemical Company

Dependable Chemical Company is a division of a large diversified resource and petro-chemical company, whose 1978 net income from worldwide operations exceeded \$710 million. The firm employs 30,000 people.

Our interview focused on the fertilizer component of Dependable Chemical Company's operation. The company currently operates two fertilizer plants. Its Washington plant produces only nitrogen fertilizer (anhydrous ammonia); 1978 production was 145,000 tons, and employment was between 55 and 60 persons. Its Nebraska plant produced 320,000 tons of ammonia and 155,000 tons of 32% nitro-liquid and urea nitrate.

The Washington plant, constructed in 1958, operates continuously, except for two shutdown periods of seven to ten days each during October or November. During the renovation period the plant's catalysts are changed, its heat exchangers are re-tubed and its boilers inspected.

The Nebraska plant was constructed in 1965. Renovation occurs yearly, but involves less than the older Washington plant.

Dependable intends to reduce fertilizer production because of a general depression in the industry. The company reports that fertilizer production costs have increased ten times in 13 years, while the price of ammonia fertilizers has remained the same; it recently shut down two Texas fertilizer plants considered inefficient. The firm does not view itself as a technological innovator in fertilizer production.

Our interview was conducted with the vice president of the fertilizer division and with a process and engineering advisor in fertilizers. The former has spent 30 years in management with Dependable at various locations, and the latter has been an engineer at headquarters for 17 years.

E. Earnest Chemical, Inc.

Earnest Chemical, Inc. and its subsidiaries manufacture and sell chemicals and chemical-related products for a wide variety of end uses. It operates manufacturing facilities in 29 states, Canada, Europe, Latin America, and the Pacific basin. The company had net sales of \$1.32 billion and net earnings of \$126 million in 1978, and employed over 13,000 persons worldwide.

Our interview focused on the firm's Industrial Chemical Division with specific reference to its plants in California, Wyoming, and Nevada. The California plant produces boric acid; the Wyoming plant produces soda ash from natural deposits; and the Nevada plant manufactures chlorine and caustic soda. All plants operate continuously using three shifts.

Industrial chemicals are basic commodities and as such have not experienced rapid growth in demand or production. The firm develops some new technology on its own, but will adopt technology from many sources. The company regards itself as at the forefront of technology in specialty chemicals such as fire retardants or chlorinated hydrocarbons. The respondent indicated that the Diamond Shamrock Corporation has the best technology for chlorine caustic soda production.

Our respondent at Earnest has a degree in chemistry from Cal Tech. Prior to becoming west coast plant manager for the Industrial Chemicals Division, he was director of manufacturing and plant manager at a California plant.

F. Friendly Corporation

Friendly Corporation manufactures or markets a variety of commodities within five broad divisions: aluminum, agricultural chemicals, refractories, industrial chemicals and real estate. In 1978, net income was \$145.5 million on sales of \$2.47 billion and the company employed almost 27,000 persons, making it one of the largest aluminum companies in the U.S.

The agricultural chemicals division produces various types of fertilizers in its 19 plants. Chlorine and caustic soda are produced in three Louisiana plants which also manufacture aluminum or alumina. Caustic soda is used in converting bauxite to alumina. Much of Friendly's caustic soda production is used in its own operations, but the bulk of it is sold to other firms. Chlorine caustic soda production is a continuous process which goes on 24 hours a day, every day.

Friendly seeks to maintain its position within the industry. The firm spent almost \$15 million on research and development in 1978. In California the company operates an industrial research facility to develop new chemicals and equipment, and to improve the maintenance and reliability of existing equipment.

Our interviewee, the manager of energy technology, is an industrial engineer with 30 years of employment as an energy engineer for Friendly. He was chief utilities engineer until 1957, when he went to the International Division to look for new energy opportunities. When a new energy division was created in 1974, he became head of energy technology, with responsibility to pursue long range technology for energy conservation.

G. Good Salt and Chemical Co.

Good Salt and Chemical Co. manufactures and sells salt and pharmaceutical, household and specialty chemical products worldwide. In 1978, its income was \$36.9 million on sales of \$656.7 million; the corporation had approximately 14,700 stockholders and 10,800 employees.

Good Salt has eleven salt plants located in nine states in the U.S. These plants, which mine and produce consumer and industrial salts, range in age from the oldest plant erected in 1875 to the newest constructed in 1959. Most of the older plants have been or will be renovated.

Salt production has grown at about 2% per year in the last fifteen years. Production technology is relatively unsophisticated: well drilling and salt evaporation are its major elements.

Our interviewee is the firm's director of engineering. Prior to joining Good Salt 15 years ago, he worked on radio technology for the Navy.

H. High Grade Chemical Corp.

High Grade Chemical Corporation operates in five general product areas: fertilizers, animal products, energy, industry, and chemicals. Specific products include phosphate and nitrogen fertilizers, animal feed ingredients, pharmaceuticals, coal, natural gas, uranium-oxide, electrochemicals, explosives, and industrial and organic chemicals. The firm operates some 46 plants in the U.S. employing almost 10,000 persons. In 1978 the company's net income was \$120.1 million on sales of \$1.364 billion.

Most company plants operate 24 hours a day, seven days a week. The plants normally shut down one day a month, and two to three weeks every one to three years for maintenance and renovation. They vary in age and sophistication: the firm's New Mexico plant, for example, was last renovated in 1935 and still uses an older technology, while its chlorine-caustic soda plant in Maine was renovated in 1968 and is considered quite up-to-date.

The firm has grown at about 7% to 9% per year over the last few years. This rate is considered "not that great" by the respondent, but is sufficient to keep up with the rest of the industry. The company prefers to let others be the innovators.

Our respondent is currently energy coordinator for the fertilizer group. His background is in chemical engineering and he has been employed by the firm for 23 years.

I. Industrious, Inc.

Industrious, Inc. is organized into three divisions, producing chemicals, and precision equipment, respectively. In 1978, the chemical division accounted for about 70% of the firm's \$921.4 million in sales and \$45 million in net earnings. In that year, the company's shareholders numbered 23,600, and its employees, almost 14,000.

Major chemical products include chlorine, caustic soda, sodium chlorate and hydrochloric acid. Among these chemicals, the company's plants in Kentucky, Michigan, Washington, and Oregon all produce chlorine-caustic soda (co-products of the same process) in continuous operations, 24 hours a day, year-round. The plants are of varying ages, with the Michigan plant dating from 1905, and the Oregon plant, from the early 40's (although chlorine/caustic soda production there began in 1960).

Over the past ten years, the company's sales have increased 125% and its net earnings, 263%. Its growth objective is to maintain its place within the industry, and Industrious regards its role in innovation as average for the industry.

We interviewed the company's director of energy and environmental affairs. Trained as a chemical engineer, he began his career with Industrious 42 years ago as a plant engineer in Michigan. He then became assistant manager of operations before moving into the corporate engineering staff, and was named to his current position in 1975.

J. Just Salt & Chemicals, Inc.

Just Salt & Chemicals, Inc. is a subsidiary of a major privately held grain trading corporation. Little financial data is available about the firm, but we are informed that annual revenues are approximately \$11 million. The parent company has little input into decisions made within the chemical and salt division.

Just Salt produces salt at four California locations. The largest of these plants produces a million tons annually; the other three each produce approximately 300,000 tons annually. Salt for industrial use is evaporated in solar ponds; salt for human consumption is refined in evaporators and dryers which operate 24 hours, six days a week, 12 months a year. Only the company's largest plant, built around 1910 and recently renovated, employs this equipment.

The company's output has grown at about 10% annually over the last ten years, which it regards as faster than the industry average. The firm does not view itself as technologically innovative, preferring to leave innovation to others.

Our interviewee has been with Just Salt for only six months. He is a senior project engineer, and the firm's energy manager.

K. Keen Chemicals

Keen Chemicals is one of the largest chemical producers in the U.S., with 1978 sales of \$6.887 billion and net income in excess of \$575 million. The company has approximately 136,700 shareholders and operates with 53,500 employees worldwide, of whom 32,000 work in the U.S. Historically, Keen has been known as a manufacturer of industrial chemicals, but is now rapidly expanding into specialty and agricultural chemicals and other end use products.

Keen's chlorine-caustic soda plants are located in California (1500 employees), Texas (5,000 employees), Louisiana (2,000 employees), and Michigan (7,000 employees). All these plants operate around the clock, every day, using three shifts.

Sales have averaged 15.3% annual growth over the past ten years, and net income has increased at 16% annually over the same period. The company develops all of its own processes, but occasionally buys some small pieces of technology. It considers itself to be in the forefront of technical innovation, with a 1978 research and development budget of \$231 million.

We spoke with Keen's manager for business development, who has been with the company for 32 years.

IV. ANALYSIS OF SURVEY DATA

A. FUEL SITUATION

In order to realistically assess commercialization opportunities in the chemical industry, current patterns of fuel usage for which geothermal energy might substitute were examined. Relevant inquiries began with the types of fuels used and the terms upon which they are purchased. We then sought to determine the ratio of energy costs to total production costs and the degree of concern felt by firms regarding anticipated price increases for current energy sources, since this information indicates the weight likely to be placed on geothermal's potential advantage as a cheaper energy source. Apart from on-going cost considerations, we also examined the firms' ability to tolerate fuel supply interruptions and the precautions considered necessary to prevent this, in order to determine the importance of reliability as a factor influencing the decision whether to employ geothermal resources.

1. FUEL SOURCES, USES, AND COSTS

The main energy needs among the chemical companies interviewed are for process steam heat and other process heat, for powering equipment, and for space heat.

Natural gas is the preferred energy source for most needs in the chemical sectors studied. All companies interviewed use natural gas for steam generation. One of these, Cooper Corporation, uses gas only as a supplemental source, and six firms (C,E,G,I,J,K) also use oil to generate steam (although two of these, C and G, use it only for back-up). Three firms (C,G,K) use coal for steam production.

For other process heat, six firms (A,B,C,D,H,J) use natural gas; one, Just Salt, uses oil; two (C and K) use coal; and five (C,D,E,I,K) use electricity.¹¹

Only Earnest mentioned space heating as an energy use, and it uses both natural gas and oil for this purpose.

Actual fuel costs vary by type of fuel, by type of fuel contract and by region. The data we were able to obtain on these costs appears in Appendix A. Different product mixes for the firms interviewed result in considerable variation in the proportion of total costs attributable to energy costs, estimated by interviewees as follows:¹²

10% and growing	(G)
10-15% (of operating costs)	(A) 60% for drying and dissolving 40% for fusing
10-20% (of costs)	(J) 25¢/therm to generate heat 30¢/therm to generate steam
18.75% (of sales)	(K) Approximately \$1.5 billion/ year
30-40% (of operating costs)	(I)
37.5% (of operating costs)	(D) 50% for feed stock; 75% of cost per ton is gas, and half of this is process heat.
40-50% (of costs)	(C)
85% (of operating costs)	(B)

When matched against products produced, this data indicates that table salt is on the low end of energy use, while nitrogen fertilizer is on the high end (partly because of feed stock needs for which geothermal energy will not substitute).

2. FUEL SUPPLY INTERRUPTION

Chemical companies generally have a limited tolerance for interruptions in fuel supplies used for process heat, since many of their products are manufactured in a continuous production process rather than a batch operation,

11. C and K generate their own electricity from coal.

12. Firms E,F and H did not respond to this question.

and since most of their plants are highly integrated. Four of the companies interviewed stated unequivocally that any unscheduled interruption in their operations would be intolerable (A,B,H and K). For Keen, a one-day plant shutdown would result in four weeks' loss of production. Best Fertilizer would incur \$70,000 in restart costs following a shutdown. High Grade Chemical Corporation would need several days to restart their ammonia plants, but only a few hours to restart a caustic soda plant.

For similar reasons, four other companies stressed their considerable efforts to minimize scheduled downtime for normal maintenance and repairs. Friendly never shuts down more than one-third of its operations at a time. Cooper tries to limit shutdowns to no more than a week at a time, during which maintenance activities are conducted around the clock; even then, their excess capacity permits production to continue at about 95% of normal. Dependable schedules all shutdowns during a period when the plant is closed for a mandatory annual state inspection, when it ceases production entirely for several days or longer.

The two table salt producing firms have a somewhat higher tolerance for shutdowns. Just Salt can allow for one day a week. Good Salt and Chemical does not regard shutdowns per se as a critical problem, but keeps a small inventory, and therefore needs relatively continuous operations.

Because of their limited tolerance for fuel supply interruptions, many of these companies make some provision for back-up fuel supplies. Of the companies surveyed, eight reported having some sort of back-up system. Five companies (B,E,G,H and K) have back-up for natural gas; two (A and H) back up electrical power; one (J) backs up diesel; and one (I) did not specify which fuel it backs up.

The main back-up fuel is oil, relied upon by five companies (A,B,E,G and K). Acme Chemical has five million gallons of oil storage capacity (a two months' supply) to substitute for natural gas used in its boilers; it also maintains a portable generator to provide back-up electricity for certain critical operations. Best Fertilizer reported that the California PUC requires an oil-fired back-up capability for natural gas-fired boilers at one of the company's plants; the company invested \$1 million in a million-gallon oil storage tank, but has never filled it. Best also has an electric back-up system for certain steam driven turbines. Earnest and Good Salt both maintain fuel oil back-up for their plants with interruptable gas. High Grade Chemicals keeps a back-up energy supply at all its plants because of interruptions in gas and electricity supply. Keen, which uses a variety of fuels at its plants and whose spokesman stressed the need for guaranteed supplies to ensure continuous operations, employs fuel oil, natural gas and coal back-up systems.

Only three firms reported that they had recently experienced fuel supply interruptions. At Acme, electric line damage in January 1979 caused outages ranging from one to four weeks. Cooper's natural gas supply has been interrupted periodically since 1968. Best Fertilizer experienced minimal interruptions in gas supply during 1977. Two firms stated that they had suffered no recent fuel supply interruptions (D and J), and the rest did not mention supply interruptions (E,F,G,H and I).

3. FUTURE FUEL SUPPLY CONCERNS

As one indicator of possible future actions with respect to energy supplies, chemical firms were asked what type of energy problems they anticipated in coming years. Cost was the predominant concern of most companies (A,B,C,D,F

and G). Only one company (B) anticipated critical supply problems, while four others (D,E,I and J) expressly disavowed this concern.

Probable responses to anticipated cost increases were about evenly divided among chemical firms. Five preferred to concentrate on conservation efforts (A, D,E,G and I).¹³ Six firms (A,C,F,G,H and K) - mostly representing very large companies already in the energy business (C and G) or those in a position to seek energy independence (F,H,K) - reported active current efforts to find alternative energy sources.

The range of alternatives under consideration is broad. Cooper and Good Salt have been looking at coal, although an engineering study of Good Salt's Kansas plant concluded that the economics were poor. High Grade Chemical has a solar project in progress in New Mexico, motivated largely by its need to reduce particulate pollution from its existing evaporation system. Friendly is exploring for more gas and monitoring geopressure potential in Louisiana; it is also following geothermal drilling in Hawaii, where the company has access to a potential resource, but is looking for an electric quality resource.

From these responses it is fair to conclude that chemical companies in these sectors expect to meet future fuel concerns with increased conservation efforts and development of high-temperature alternatives. Their present thinking does not encompass low or moderate temperature geothermal resources for direct applications.

13. Industrious, however, also indicated it would pass on higher costs as long as possible.

B. FIRM DECISION MAKING

1. MANAGERIAL STRUCTURE AND DECISION MAKING

To assist in focusing possible initiatives, we sought to determine what levels and which members of a firm play important roles in decisions affecting energy use. For this purpose, various inquiries were directed to the organizational structure and decision-making process of the chemical companies studied.

Managerial structure

All but one of the firms surveyed are large corporations. Their annual sales vary from \$125 million to \$6.8 billion. One company (B) is operated as a cooperative. Corporate management is typically organized in a three-tiered structure: headquarters; division (or group); and plant. In one case (C), the divisions are separate subsidiaries for bookkeeping purposes but not for decision-making purposes. Two companies have foreign divisions which are managed separately (E and K). Two of the smaller firms (A and B) have a two-tiered structure consisting of headquarters and plant management.

Seven companies reported that they had planning groups in their management structure. Four (D, F, H and I) placed this function only at headquarters, while three (A, B and J) had planning groups at each management level. Four companies did not mention planning functions.

Six of the eleven firms surveyed employed an energy manager or advisor. Two companies (E and I) direct all energy use and conservation matters from headquarters. Industrious Co., a multipurpose firm, focuses its energy management functions in its chemical division, which makes up 70% of the company and is its biggest energy user. Friendly Corporation has a headquarters-based division

(created in 1974) whose sole function is energy management and conservation technology; it is assisted by energy coordinators at all plants who collect statistics and report on energy use. Companies C and H have division-level energy managers who can draw on headquarters resources or hire outside consultants.

Three firms (B,D and G) reported that they did not have separate energy managers, but assign concerns to production executives and process engineers. Two firms did not indicate how energy matters were managed in their companies (J and K).

Decision-making

With these structures as background, the process by which decisions to use geothermal energy might be made in the chemical companies was explored. We sought to determine who would play key roles in initiating geothermal proposals, who would make important recommendations concerning such proposals, and who would have responsibility for final decisions. Responses as to five hypothetical projects were as follows:

Project	FINAL DECISION			
	Depends on Cost	HQ	Division	Plant
Open new plant	5	5	1	-
Location of new plant	5	5	1	-
Expand existing plant	6	4	1	-
Retrofit to re-equip existing plant	6	3	2	-
What energy to use	5	4	2	-

Responses clearly indicated that most decisions will be made at the headquarters level on most types of projects suggested, even among companies which suggested that project cost would determine the locus of decision-making. Cooper Corporation's spokesmen stated that, although cost was the determining factor, all the projects named probably would be referred to headquarters for final approval.

Good Salt and High Grade Chemical both indicated that projects over \$1 million would be decided at the top. Those firms indicating that the plant managers had some authority to decide on a project (F,G and H) limited that authority to between \$10,000 and \$50,000. The data suggests overall that decisions on the kinds of projects which may involve geothermal use or development will rarely be made at the division or plant level.

One company is an exception. High Grade Chemical, one of the larger companies in our survey, allows its divisions to decide on projects up to \$1 million.

In order to focus on the actual decision process likely to influence geothermal decisions, the following question was asked: "Suppose geothermal energy resources were available and that your company has some interest in them. Which personnel at what level would a) initiate a proposal, b) make important recommendations, and c) make a final decision either to retrofit an existing plant or to locate a new plant near the resource?"

It appears almost equally likely that geothermal proposals will be initiated at any of the three levels of management. Eight companies indicated that such projects could be initiated at the plant level by either the plant manager or engineering staff. Eight companies named someone at the division level: either the division head (six firms); process engineers (two firms); vice president for operations (one); vice president for finance (one); or the energy advisor (one). At headquarters, the chairman (one firm); corporate energy manager (two); corporate engineering staff (one); vice president for business development (two); or the vice president for marketing and supply (one), were named as possible initiators of projects. The full range of responses were as follows:

WHO INITIATES AND RECOMMENDS ON GEOTHERMAL PROJECT

HQ	Position	Initiates	Important Recommendation
	President		A,B,F,H
	Chairman	C	
	Exec. Committee		A,F,K
	V.P. Finance		G,F
	V.P. Bus. Develop.	H,K	
	V.P. Mktg. & Supp.	B,J	B
	Corp. Energy Mgr.	E,F	A,F
	Corp. Engineering	I	B,I
	Operations Mgr.		K
Division	Division Head	C,D,E,F,I,K	C
	V.P. Operations	G	
	V.P. Finance	G	G
	Energy Advisor	H	
	Process Engineers	D,H	
Plant	Manager	A,B,C,D,G,H,J,K	A,B,C,D,F
	Engineers	A,D,G,H	A,D,J

Several points stand out when one examines these responses. First, plant managers in the chemical industry occupy an important position as initiators of technical innovation. This may be especially true in the case of retrofit projects. As one respondent put it: "You pretty much have to get plant acceptance. They have been able to stop projects because they are hammer-and-chisel mechanics who don't want to work with equipment they don't understand."

It seems equally clear that engineering staff and energy advisors at all levels would have significant involvement in initiating geothermal projects: seven different companies named engineering or energy staff members at some level as project initiators. Division heads would also play a significant role in initiating a geothermal project: six companies named this position as important to the initiation process.

At the stage of recommending for or against geothermal projects, the focus splits between headquarters and plant. Six companies named the plant manager or plant engineers as important reviewers of projects, while seven other companies pointed to headquarters personnel:¹⁴ the president (four); chairman (three); executive committee (three); vice president of finance (two); vice president of marketing and supply (one); corporate energy manager (two); and operations manager (one). Only two companies mentioned someone at the division level.

The general comments by interviewees on corporate decision-making were also revealing. Almost everyone remarked upon its complexity, and many pointed out that any large or new project must achieve a favorable consensus among many people at all levels. Keen Chemical noted, for example, that its own exploration of potential for geothermal use at one of its existing facilities involved a long series of local plant and division feasibility inquiries before it ever went to headquarters.¹⁵ Industrious Company noted that building a new plant requires a series of decisions involving assessment of markets, raw materials, energy supply, environmental considerations, zoning, total costs and many other factors necessitating the input of many people.

2. INVESTMENT PROJECT APPRAISAL

In addition to exploring the managerial structure of chemical firms, the procedures for appraising investment projects were examined. The theoretical literature on project appraisal contains a number of investment criteria of varying sophistication. Since the criteria can lead to different

14. Some companies named more than one person, therefore the number of choices is greater than seven.

15. The project was eventually abandoned because "The economics didn't work out. It might have been feasible to pipe the resource 15 miles but not the required 37."

conclusions when applied to the same project, it is necessary to know which criteria a firm actually employs. The firms were asked what financial criteria are employed for "normal" non-energy-related projects, and whether the criteria differ according to the nature of the project - e.g., replacing equipment at an existing plant, expanding production capacity at an existing plant, or opening an entirely new plant. All of the respondents indicated that the criteria employed would not differ among these types of investment projects. Firm I indicated it did not employ any general criteria for investment project appraisal but that more risky projects required a higher return. The responses of other firms are shown below:

Investment Project Appraisal

Payback Period

B	1 year
G*	3 years or less
H*	12 years or less

Return on Investment or Discounted Cash Flow

A	15% after-tax ROI
C	DCF with 10-20% discount rate (rate depends on need for project)
D	Above 25% ROI
E	10% minimum after-tax ROI
F	13-15% internal rate of return
G*	19-20% after-tax ROI (1978 = 15.4%)
H*	DCF with 10-12% discount rate Target ROI varies with interest rates.
J	15% after-tax ROI
K	DCF with 12% discount rate. Aim to cover cost of borrowing and taxes and earn return of 6-8%.

*two criteria are employed

It can be seen that only one firm, Best Fertilizer, the smallest company in the survey, employs the payback criterion exclusively, and in that case

the very short one year payback requirement is the result of the company's current precarious financial position. Two other companies use the payback criterion, but along with all the remaining firms they employ the return on investment or discounted cash flow criteria as well. The hurdle rates range from 10% to 25%, although there are no obvious correlations with firm size or product market.

A follow-up question pertained specifically to the appraisal of a hypothetical geothermal energy investment project. Would the company employ either a different type of financial criterion or a different hurdle rate in evaluating such a project? Although no firm would use different appraisal criteria, responses to this question showed a distinct variation in attitude toward energy projects. Four firms (A,F,I,K) implied they might be more lenient in evaluating an energy saving investment project. Three firms (D,E and G) said they might require a higher return because they perceived significant risk.

C. COMMERCIALIZATION POTENTIAL FOR GEOTHERMAL ENERGY

Dissemination of information on geothermal energy technology, costs and uses obviously is essential to commercial development of the resource. The institute's survey accordingly attempted to determine how much is now known about geothermal potential in the chemical industry, what information would be most useful to encourage future use, and where technical information and financial assistance might most effectively be directed in these sectors of the industry.

1. CURRENT KNOWLEDGE

All firms surveyed had some knowledge of geothermal energy and had heard of some commercial applications and resource sites, but the kind and

degree of knowledge varied greatly. Just Salt was aware only of power generation at The Geysers, while several others, firms B,C,G,F and K, had actively investigated the possibility of using geothermal in their own chemical production operations.¹⁶ However, the primary interest and knowledge was in using geothermal energy to produce electricity for chemical production processes, as distinguished from the direct application of heat from low or moderate temperature geothermal resources.

The same qualification applies to the respondents' knowledge of the costs of developing geothermal resources. Firms B,C,D,G and K had seen cost figures, but in all cases except B's, the figures pertained to the development of high temperature, electricity-quality resources.

Knowledge about government programs to accelerate geothermal development was much more limited. Only firms B,D and F indicated any knowledge of existing programs. The other firms, including C,G and K, which have had an active interest in geothermal, were apparently unaware of government commercialization efforts.

The firms' actual experiences with geothermal energy covered a wide gambit. Best Fertilizer worked with an engineering firm, under DOE sponsorship, to study the cost and feasibility of converting its plant in the Imperial Valley, California, to direct geothermal heat. Although the results showed that geothermal was feasible, the idea was ultimately rejected because the company could not justify the capital expense of conversion in the face of the depressed conditions in the fertilizer industry. Good Salt and Chemical once operated

16. In addition, Dependable Corporation's Resource Division is currently involved in geothermal exploration in western Nevada and southwest Utah, with DOE assistance. However, the goal is to find resources for geothermal power production not connected in any way with the company's chemical plants.

several geothermal wells as a pilot project in the same general area. However, extensive corrosion problems and concern over well pressures caused the company to cap the wells, which reportedly have subsequently been sold.

Keen reported that it had studied the feasibility of piping hot water from a resource in the area of The Geysers to its chemical plant located 37 miles away. The studies showed that the high cost of a 37-mile pipeline would make geothermal use in the plant uneconomic, although piping fluids 15 miles or less might be feasible.

Cooper has been carrying out a geothermal exploration program near its southern California plant. So far it has discovered a 150°F resource that it has not considered worth developing, even though water of that temperature could be used in some plant processes.

Friendly has been in contact with both DOE and an independent resource company concerning development of potential resources underlying company property in Hawaii for geothermal power generation, and is also very interested in geopressurized resources in Louisiana.

When asked about possible uses for geothermal in their operations, H and J mentioned that geothermal heat could be directly used in evaporators and dryers. Acme, the borax/boric acid producer, suggested that geothermal could be used in its wet processors, for both dissolving minerals and maintaining needed heat. C,H and K indicated that geothermal could supply some of the steam requirements for the production of caustic soda and other products, although probably only if the temperature of the water is at least 300°F.

To a large extent these responses are misleading, however. While the respondents were willing to discuss the theoretical applicability of geothermal, other parts of the interview make clear that only in table salt production,

among those sectors of the chemical industry studied, is there real potential for geothermal direct uses at this time.

Unlike industrial chemicals such as caustic soda, table salt is generally produced in separate facilities rather than in multi-product complexes. Total energy needs, for evaporation and drying of the salt, are now met by steam at 280°F and 340°F in the two plants included in the study (G and J) and could be met by geothermal at the same or lower temperatures. Just Salt reported that it is studying the redesign of its equipment to allow for the use of lower temperatures in both evaporators and dryer, with the dryer possibly operating on exhaust heat from the evaporator.

The production of industrial chemicals, on the other hand, generally takes place in integrated chemical complexes, where many processes require very high temperatures. The companies are unlikely to become involved with geothermal for direct uses which could fill only the lower temperature portion of their needs, but are much more likely to focus their efforts on fuels for the production of electricity or other very high temperature energy, and on the recovery of waste heat from other processes for the low temperature requirements.

The third sector of the industry included in the study, nitrogen fertilizer production, could use geothermal but firms are unwilling to consider new capital investments considering the present depressed condition of the industry.

The lack of real interest in geothermal direct uses is underscored by the responses to our question concerning when, if ever, the respondents expected geothermal direct uses to become important in their segment of the industry. C expects that direct uses may have local importance in some areas; G (a table salt producer) predicts that direct uses will become significant in

10 to 20 years. B,C,I and K doubt direct uses will ever become important to the chemical industry, and E,F, and K see potential for electric generation only.

2. FACTORS INFLUENCING THE DECISION TO EMPLOY GEOTHERMAL RESOURCES

In order to probe further the basis for any resistance to geothermal use, the respondents were asked to identify specific problems which they could foresee in using the resource in their operations. Only one firm, Cooper Chemical, anticipated no problems. Other firms, however, mentioned a variety of possible problems, as follows:

Problem	Firms	Total
Availability	A,E,G,I,J	5
Cost	B,F,G,H,I	5
Insufficient temperature	D,E,F,G	4
Reliability	B,H	2
Corrosion	D	1
Regulatory	K	1

It goes without saying that availability of the resource in the right location is critically important. When asked whether they would be willing to move existing operations to another location specifically to take advantage of available geothermal energy, none of the companies responded positively. Only two (F and K) acknowledged any possibility of locating a new plant near a resource, and the former would consider only an electric-quality resource.

To determine the basis for these responses, we asked firms to rank the factors which influence their choice of plant location. The main factors were raw material supply, accessibility to markets and energy supply. The range of responses follows:

FACTORS IMPORTANT IN CHOOSING A PLANT SITE

FACTORS	Most Important	Very Important	Important	TOTAL	Not Important
Raw material supply	4	4	1	9	-
Location close to product market	2	6	-	8	-
Energy supply	2	4	-	6	-
Labor supply	1	1	-	2	-
Cost	1	-	-	1	-
Water supply	1	-	-	1	-
Environmental regulations	-	1	-	1	-
State/local business taxes	-	-	-	-	1
Climate	-	-	-	-	-

Raw material supply is the most important factor in site selection among those surveyed, largely because of high transportation costs for bulky materials. These costs also account for the importance of location close to a product market, the second most frequently selected factor. The energy-intensive nature of chemical production accounts for the emphasis placed on energy supply. Furthermore, in the nitrogen fertilizer industry, the fact that natural gas is a primary raw material as well as an energy source also weighs heavily.

The regulatory environment for geothermal utilization was identified as a problem by only one firm, which had recently lost a major battle with a state government over plant location.

In order to separate the uncertainty associated with the availability of a geothermal resource and to explore further the manner in which other factors would be assessed in the chemical industry, we asked this question: If a geothermal resource were discovered near your plant and you were offered the opportunity to use it, what factors might influence your decision whether or not to accept this offer? The following factors were mentioned:

NUMBERS OF RATINGS RECEIVED BY ALTERNATIVE DECISION FACTORS

FACTOR	Most Important	Very Important	Important	TOTAL	Not Important
Capital cost	5	4	-	9	-
Operating cost	3	4	-	7	-
Reliability (minimal down time)	-	2	1	3	1
Compatibility with existing equipment	-	2	-	2	1
Availability of a long-term fuel contract	-	2	-	2	-
Ease of maintenance	1	-	-	1	-
Familiarity of the technology	-	-	-	-	1

Combining these responses with those concerning anticipated problems, we can conclude that the three main obstacles to commercializing low temperature geothermal energy in the chemical industry, apart from resource availability, are:

a. Cost: Many companies believe that geothermal is not economically competitive with alternatives such as coal, the recovery of waste heat from internal operations, and other conservation measures. In addition, the fertilizer firms, for which geothermal might be particularly cost-effective, are unable to contemplate any capital expenditures for new energy sources because of the depressed state of the industry.

b. Insufficient temperature: Low temperature needs in the chemical industry are usually a small fraction of total energy requirements, particularly in multiproduct firms and, as one respondent noted, "These needs can be met more economically by capturing waste heat than by going into a risky geothermal venture."

c. Reliability: Shutdowns can be exceedingly costly to chemical producers whose processes are complex, highly integrated and difficult to restart. The prospect of geothermal temperature or pressure drop is therefore of considerable concern.

The ratings tabulated above also raise another issue. Since the ratings for capital and operating costs are somewhat different, we speculated that these may represent two separate dimensions of investment project evaluation. In many engineering-economic studies, the convention is to combine annualized capital cost and operating cost in a single total annual cost figure, which is used to evaluate the investment project. Perhaps this is mistaken; some firms may have distinct preferences between capital and operating costs. This hypothesis was borne out by the responses we received to the following question: When confronted with two alternative investment projects, having the same total annual cost, but with project "A" having high annualized capital cost and low operating cost and project "B" having low capital and high operating cost, would you prefer one over the other?

Six of the companies were not indifferent between the two projects. Three firms (E,F and J) would prefer the first project. Earnest's spokesman stressed the company's desire to take advantage of tax incentives for capital investment. Friendly cited its capacity to finance high capital cost projects internally. Just Salt, on the other hand, was concerned about high labor costs. Three firms (B,D and H) would prefer the second project. Best Fertilizer was concerned to minimize debt, and Dependable preferred the flexibility inherent in a project with lower front-end costs.

Of the companies (A,C,G and K) which were indifferent between the two types of project, Cooper and Good Salt focussed entirely on bottom-line costs, and Keen was not averse to high front-end costs.

Following analogous reasoning, it is not unreasonable to suppose that reliability of an energy source may represent a separate and less elastic dimension of preference from its cost. To the extent that this is so, policies

which focus exclusively on cost incentives, or which assume a commercialization timetable based on projected cost increases for conventional fuels, may fail to address the true concerns of their intended beneficiaries.

In order to probe this question, the respondents were asked whether their firms would simply factor the costs of temporary shutdowns in with other operating costs, or whether they would take account of them separately in evaluating an investment in an energy source.

Three firms said that they would factor shutdowns into bottom-line costs (A,E, and J). For Acme, these costs would include installation of a back-up system if geothermal reliability were in question. Earnest suggested that shutdowns could be "worked around" by scheduling them into maintenance and processing schedules.

Five firms (C,D,G,H and K) would consider reliability independent of costs. Not surprisingly, these firms were among those which were most averse to the possibility of unscheduled plant shutdowns. Dependable observed that shutdowns not only destroy efficiency, but also increase equipment breakdown.

We next asked whether maintenance needs would be evaluated independently or simply factored into bottom-line costs. Six companies would view maintenance simply as an element of overall cost (A,B,E,H,J and K). Two companies would view it separately (B and D). We also asked about the costs of installing a back-up fuel system; all of the companies said that they would just factor those into overall costs.

In short, there is strong evidence that capital and operating costs represent separate dimensions of preference for many firms in evaluation of investment projects, and that reliability is another, distinct dimension of preference. These findings have clear implications as to the nature and specificity

of information which government must make available to potential commercial users. In addition, the importance of reliability as a decision factor suggests the need to focus not only information but R&D efforts in this direction.

3. FINANCING A GEOTHERMAL INVESTMENT PROJECT

In order to ascertain the importance of financing mechanisms for project appraisal, a brief examination of how firms might expect to finance a geothermal investment project was conducted. Respondents were asked to suppose a suitable geothermal resource was discovered in the vicinity of a company plant and that they had accepted a supplier's offer to provide geothermal fluids. They were then asked how they would finance the retrofit of the plant to utilize geothermal energy and if this financing arrangement would differ from that used to finance a similar investment project not involving a new type of energy.

Only one firm (H) indicated it would treat a geothermal investment project differently from others, using internal funds exclusively, because of a greater perceived risk. Internal funds, however, were the preferred financing method for other firms (A,B,C,D,E,F,K), in any event, although Best indicated that short-term debt would also be an important source, and Acme and Earnest also viewed both short and long-term debt as significant financing mechanisms. Keen and Friendly suggested that, in addition, debentures would be an important funding source for them.

When asked how the companies might finance front-end costs of resource development if geothermal energy were discovered near their plants, those responding (A,C,D,F) indicated they would use the same mechanisms as for retrofitting a plant.

4. GENERAL SOURCES OF INFORMATION ON TECHNOLOGY

The discussion above has focused on what chemical respondents know or need to know about geothermal energy if they are seriously to consider its use. This section examines the sources normally relied upon by industry to obtain needed information on new technology in general, and on alternative energy developments in particular. The responses indicate that internal research and development is easily the single most important technical resource for new technology in general and for alternative energy.

New technology. Eight firms mentioned company research and development as a source for new technology, and six of these cited it as their most important source. The importance of this source appears largely to be a function of company size; the larger chemical companies are able to support and rely on substantial research and development departments, while Best Fertilizer, the smallest firm in the sample, specifically indicated that its own research was not an important source of information.

Consistent with the industry's reliance on company-supported research, there seems to be little sharing of information among firms in these sectors. Only High Grade Chemical mentioned others in the industry as its most important source of new technological information. Earnest and Friendly considered others in the industry a good source of information, but both firms maintain large research and development departments. Trade associations were less important sources of information. Only Best Fertilizer and Just Salt, Inc., neither of which has an internal research department, viewed trade associations as an information source. Trade journals were mentioned by firms A, H and I.

Only three firms (B, C, D) listed government as a technological information source. Best and Dependable specifically mentioned the TVA fertilizer

Research Organization, although Dependable did not regard TVA as a particularly important source.

In addition to these sources, Industrious Company noted that its patent department monitors new patents as a way of keeping abreast of technological developments.

Alternative energy sources. To determine whether access to energy technology would involve any different considerations than access to other technologies, the respondents were asked where they would initiate inquiries into possible alternate energy sources. Five firms (B,C,D,G,K) would begin with their own staff, though firm B would also approach others in the industry, and has been contacted by outside consultants. Firms A and G have also been approached by consultants, and would utilize their services in this area.

For energy information, Earnest Chemical and Friendly Corp. would both turn to government agencies. Friendly's respondent was invited to a DOE workshop on geothermal development in Hawaii and was favorably impressed by the information provided and the conduct of the program.

High Grade Chemical Corp. indicated that it was continuously considering alternative energy sources and makes inquiries of any source which appears interesting.

D. POTENTIAL INSTITUTIONAL FRAMEWORK

Most of the inquiries directed to chemical firms related to their potential roles as end-users of geothermal energy. However, in many cases geothermal use may depend on institutional arrangements between end-users and other entities contemplating resource development and/or distribution. To determine the need for such institutional arrangements, and to identify structures which

might be acceptable to firms in the chemical industry, the following questions were asked:

- 1) To what extent and under what conditions would the firms be willing to undertake resource development for their own use?
- 2) Would they require full control over a geothermal source, or would they be willing to purchase geothermal heat supplied through a distribution system?
- 3) Would those which controlled a resource be willing to act as suppliers of excess heat to other end-users?

1. PARTICIPATION IN RESOURCE DEVELOPMENT

One possible development arrangement would be for an industrial or commercial end-user to initiate and carry out development of a resource for its own use, either alone or with partners. Accordingly, the respondents were asked to comment on their firms' willingness to participate in various stages of geothermal development -- from lease acquisition, to basic exploration, to production well development at a proven geothermal field. Firms indicating an interest in any of these development phases were asked whether they would expect to act alone or in joint ventures with other parties, such as resource companies, other end-users, or outside investors. Their responses are summarized as follows:

Willingness to Become Involved in Resource Development

Willing to consider exploration and development	A,C,D,F,G,H,J,K
Interested in electric-quality resources only	D,F
Not interested in exploration or development	B,E
No response	I

Only two of the firms would foreclose any participation in geothermal development. Several have been involved in geothermal exploration in the past. C and D have explored on their own for geothermal resources, C for a resource to be used directly in one of its chemical plants, and D for power generation resources through the company's resource development division. G and K have participated in joint venture geothermal explorations, and F is considering an arrangement with a resource company for drilling on its own property in Hawaii. H would be unlikely to consider development unless a resource is identified near an existing plant or new plant site, and although it could use low-temperature geothermal in evaporators at its potash plant in New Mexico, it would not want to drill at that site because of the risk of intrusion of water into its mines.

However, the most salient fact is that because of the high temperature requirements of many segments of the chemical industry, exploration has focused on a search for high temperature geothermal resources, and low and moderate temperature resources are not of major interest to most of the firms studied.

2. NEED FOR CONTROL OVER SUPPLY

An alternative to user participation at the development stage would be an arrangement under which the user has no development or production functions, but merely purchases geothermal heat from an independent supplier, in the same way that it purchases other types of energy.

An important determinant of the feasibility of a retail distribution structure in the chemical industry is the extent of the firms' perceived need for control over a geothermal energy service. Accordingly, we asked whether respondent firms would be willing to tie into a geothermal distribution system controlled by others. The responses are summarized below.

Need for Control Over Supply

Would need to be sole user	None
Willing to hook up to a distribution system	A,B,C,D,E,F,G, H,J,K
No response	I

All of the firms responding expressed their willingness to be served by a distribution system, although Acme and Friendly would prefer to be the sole users, if they had that option, in order to assure supplies to meet their high energy needs.

As mentioned above, most of the firms are probably not sufficiently interested to undertake the development of geothermal resources that could supply only their low temperature heat requirements. However, if geothermal energy were available without the need for involvement in resource development, chemical companies would be likely to consider using it in their processes wherever it could supply the necessary quality of heat economically.

3. WILLINGNESS TO ACT AS SUPPLIERS

Even where a firm's primary interest in geothermal is to meet its own process needs, both internal economic considerations and broader policy objectives may be served by the distribution of excess fluids or spent heat to downstream users. Downstream distribution by the primary user would be a means to recoup a portion of high front-end development costs. From a policy perspective, the general disinclination of many industrial and commercial users to engage in resource development, and the possibility of premature disposal of useable fluids suggests that distribution systems will be necessary to promote beneficial use of the resource.

In order to assess the potential role of primary users as resource distributors, we asked whether firms which might control a geothermal resource would be interested in extending their activities to include sales of surplus heat to other end-users. Sales to one or two nearby plants or to a municipality were suggested as one level of activity; initiating the creation of a heating district or an industrial park was offered as another possibility. Whatever their anticipated level of involvement, firms were asked how the prospect of public utility regulation would affect their interest in distributing excess heat, and whether they would consider distribution if such activities were likely to subject them to such regulation.

Willingness to Act as Suppliers

Willing to supply one or two other companies	A,B,C,D,F,G,J
Willing to also consider setting up heating dis- trict or industrial park	A,B,J
Not willing to sell to others	H
No response	E,I,K

Only High Grade indicated that it would probably be unwilling to sell its surplus heat to others, even though this could admittedly cut its energy costs. The other firms generally would be willing to sell to at least a few other companies (although Just would not sell to a competitor). A,B and J would also consider setting up a heating district or industrial park if there were sufficient excess fluids. However, C points out that the energy needs in this industry are so great that it is highly unlikely that there would be any excess heat.

F mentioned that it has had experience with a joint electricity distribution system in Louisiana, where one company built a power plant and the other companies collectively own the transmission system.

Only Just Salt would definitely still be interested in becoming a distributor if it were to be regulated as a public utility. B, D and F would no longer be interested. A and G indicated they were not sure, since they did not know what regulation would entail.

E. THE ROLE OF GOVERNMENT

1. EVALUATING EXISTING PROGRAMS

Only two firms (B and F) had ever heard of any government program to encourage geothermal development. Both of these companies had been approached by outside consultants to participate in demonstration projects. Both extensively explored the proposals, but ultimately rejected them on economic grounds. Otherwise, all firms were uninformed about government geothermal commercialization efforts.

When existing programs were explained to the interviewees and they were asked to evaluate them, four firms were positive about the guaranteed loan program; five thought demonstration projects were valuable; and eight supported tax incentives as a good approach. However, a number of interviewees were altogether hostile to government involvement in commercialization projects.

We also asked the respondents for their views of the credibility of government demonstration projects; one of these, Earnest Chemical, is currently participating in a solar demonstration project. One respondent indicated that he might accept the results of a demonstration project, but only after probing

deeply into how it was done. Another firm would have less confidence in a government-sponsored project than if the private sector were running a project on its own.

Given the positive responses mentioned above, more information on actual government programs should be made available, even though the ultimate interest of the chemical industry in geothermal direct use is likely to be very limited.

2. RECOMMENDATIONS FOR FUTURE PROGRAMS

Following our inquiries about knowledge of existing programs, we asked what kinds of commercialization programs representatives of the chemical industry would like to see implemented. The following table shows the ratings given to the 15 types of programs suggested. However, since no clear pattern emerged it may be more enlightening to note individual comments on different types of programs.

Evaluation of Suggested Government Programs

Program	Most Important	Very Important	Important	TOTAL	Not Important	Opposed
Investment-tax credits	2	1	3	6	1	-
Accelerated depreciation	2	-	2	4	-	-
Direct subsidies	-	-	-	0	-	1
Loan guarantee	-	-	2	2	-	-
Loan forgiven if project unsuccessful	-	-	-	0	-	-
Subsidy becomes loan if project successful	-	1	-	1	-	-
Provide testing facilities	-	-	-	0	1	-
Feasibility studies (PRDA)	-	1	-	1	-	-
Cost-share industry research and development	-	1	-	1	-	-
Demonstration projects (PON)	-	1	2	3	-	-
Resource identification	-	1	1	2	-	-
Resource development	-	1	-	1	-	1
Information dissemination on resources and technology	-	2	-	2	-	-

There were many complaints about government involvement in private industry and four respondents (B,C,D, and K) felt the government should do absolutely nothing for commercialization. High Grade Chemical had considered participating in a government sponsored demonstration project on fluidized bed combustion, but had decided against it because of bureaucratic paper work requirements. Keen Chemical noted that the private sector develops technology better and faster than the government; and in Dependable's view, if geothermal energy is economic it will get developed by the private sector.

On the positive side, Industrious Company suggested that many corporate people take a stance against government which they really do not believe, since they acknowledge that the government has to develop many new technologies, where industry just will not take the risks. In line with this thinking, Friendly Corporation favored demonstration projects for risky technology but with as limited government involvement as possible. Earnest Chemical remarked that the private sector is motivated so predominantly by profit that government is essential to the development of new energy resources.

Federal vs State Programs. Only five companies expressed a preference for either state or federal administration of programs in which they might participate. C,G and K would prefer working with the federal government. Good Salt felt the federal government was more knowledgeable and provided consistency for those working in many states; Keen had had great difficulty with one state government (though less with others) and so preferred the federal government. D and J would prefer state government; Just Salt thought the state was more efficient.

The real difficulty in eliciting substantive responses in the chemical industry to possible government programs, however, is that industry members do not take seriously the possibility that low temperature geothermal resources can

make any significant impact on their high overall energy requirements. From their perspective, therefore, expenditure of government funds in this area is both uninteresting and objectionable.

V. CONCLUSIONS

A. CURRENT FUEL CONCERNS

- All firms interviewed use natural gas exclusively or in combination with other fuels to generate steam for process heat, and half use natural gas directly for some portion of process heat. Therefore, geothermal energy will most likely displace gas if used widely in the industry.
- The ratio of energy costs to total costs varies widely in the chemical industry, depending on the product mix. Generally, however, salt production has the lowest energy requirements, between 10-20% of total costs, and nitrogen fertilizer the highest between 37-85%. Caustic soda producers put 18-50% of total costs into energy. The nitrogen fertilizer figures, however, must be considered in light of the fact that about half the cost of energy is for feed stock for which geothermal energy is not a substitute.
- Unscheduled interruptions in fuel supply would cause substantial economic loss for most chemical companies. They place great importance, therefore, upon the reliability of their energy supplies, and most provide back-up (usually fuel oil) for their primary fuels. Consequently, assurances of reliability of geothermal energy will be important to chemical companies' consideration of geothermal use. The salt producers may be an exception. They can tolerate more shutdown because their production processes are more simple both in terms of technology and product mix.

- Chemical producers are concerned about the rising cost of energy, but much less about available supply. In response to high cost many are pursuing conservation methods. Those looking for alternatives tend to be large companies who are already in the energy business or who, in order to maintain energy independence, already produce it for their own consumption. Furthermore, this latter group has need for high temperature resources and does not see direct use of geothermal energy as a significant potential solution to energy problems.
- If fuel availability becomes a serious problem, more companies will need to think about alternatives, but at present few firms have experienced fuel supply interruptions, and those which have do not consider them unusual or important.

B. DECISION MAKING

- The management structure of all chemical firms we studied is fairly complex, usually with three levels of management responsibility. However, final decisions on projects involving geothermal energy use will almost universally be made at headquarters. This is the case, both because the resource and technology are relatively new, and because it is anticipated that its use would be sufficiently costly to put it beyond the financial level of responsibility usually allowed lower levels of management.
- The decision-making process on whether or not to use geothermal energy, on the other hand, will have complexity commensurate with

the structure of the company. In initiating a geothermal project, plant managers and plant engineers will play a very significant role. They are expected to initiate technological innovation. Division heads also frequently initiate technical projects as do engineers at all levels. Important recommendations are solicited from plant managers and plant engineers on the one hand and a variety of headquarters staff including presidents, financial advisors, and executive committees. If any particular group should be singled out as most influential it is probably the engineering staffs. They would be the first consulted by others in the company concerning feasibility. However, the greater the awareness and enthusiasm of plant management personnel and top executives, the more likely it is a project will succeed. Introduction of new technology is a political as well as technical process in any large firm.

- Most investment projects in the chemical industry are evaluated by a combination of payback (from one to twelve years) and a return on investment or discounted cash flow (10-25% hurdle rates) criteria. Geothermal energy investment projects would be evaluated with the same criteria, but some firms will treat such projects more leniently if they promise energy savings while others will treat them more strictly to account for risk.

C. COMMERCIALIZATION POTENTIAL FOR GEOTHERMAL ENERGY

1. ATTITUDE TOWARD GEOTHERMAL

- People in the chemical industry know about the energy potential of geothermal resources, however, the primary knowledge and interest focuses on electric rather than direct use potential. For most chemical companies, the possibility of meeting their low temperature needs with geothermal energy is unexciting because, on the whole, their high temperature needs are the greatest part of energy costs.
- Almost half of the respondents thought geothermal energy would never be an important resource in their industry. A few thought high temperature resources might be.

2. ANTICIPATED PROBLEMS

- Chemical producers anticipate several significant problems with use of geothermal energy. a) Availability of the resource in the right location is one of the predominant concerns. No company is willing to relocate an existing facility to utilize geothermal and only two would think about locating a new plant near one. Plant location is strongly influenced by availability of raw materials, primarily because transportation of bulky materials is very costly. Energy availability is another big factor in plant location, but to make it cost effective relative to other considerations, the resource must

be capable of supplying much more extensive needs than is possible with moderate temperature geothermal. b) The cost of developing resources is considered an equally important problem. When compared to savings by conservation or use of other alternatives such as coal, many chemical producers feel geothermal is not competitive. Capturing waste heat, for example, is considered by far, a more cost effective way to satisfy low temperature needs than going into a risky geothermal venture. c) Insufficient temperature has already been noted as an anticipated problem.

- Only one firm mentioned the regulatory environment as a potential problem for using geothermal energy. Part of the reason for this may be that the chemical companies are very large and fairly sophisticated with regulatory problems which they encounter all the time. They may simply take them as a matter of course, rather than as a special problem related to geothermal energy.
- While reliability of a resource is considered very important by most firms because shutdowns are costly, back-up systems are common and considered part of the overall costs. If reliability could be assured by back-up then it is not a problem. Otherwise, it will be a major concern.

3. FINANCING

- For various reasons most companies have a preference between projects with high front end costs and low operating costs and

ones with low front end and high operating costs. Low front end costs give more investment flexibility which is seen as advantageous by all the fertilizer producers, who are now facing a declining market. High front end costs, on the other hand, give significant tax advantages which are attractive to some, especially if they have large capital reserves. Consequently, both adequate total cost information and a break-down of capital and operating costs will be essential to chemical producers' decisions whether or not to use geothermal energy.

- Financing of a geothermal project would not be considered differently than any other investment project by the large majority of chemical producers. Internal funds are the preferred financing method of most firms, although a few would use short and/or long-term borrowing, and two mentioned debentures as an important funding source.

4. INFORMATION NETWORKS

- In the chemical industry, by far the most important source of information on all types of technology is internal research and development. This remains true whether the technology is energy related or not. Some companies are more sophisticated than others in this regard, and the companies which are in the energy business are often way ahead in the alternative energy field.. However, the extensive energy needs of the industry make it impossible for any but the smallest firms to do without internal research on energy resources.

- Since engineering staff would be an important and influential element in the decision to use geothermal energy, information on its current uses and technical feasibility studies for potential uses will have to be given to them. Some rely on trade journals to keep abreast of new technology, so this is one important means of communication. One energy manager we spoke with appreciated and benefited from DOE workshops on geothermal energy to which he had been invited, and he suggested this as another important line of communication.

D. POTENTIAL INSTITUTIONAL FRAMEWORK

- Among chemical producers there is a general preference for using geothermal energy through a distribution system developed by others. Although there is considerable experience with energy resource development in the chemical industry, and most companies are theoretically willing to consider such involvement, their lack of enthusiasm for low temperature geothermal will probably prevent them from engaging in its development.
- If they controlled a geothermal resource, most chemical producers are also theoretically willing to supply others with surplus fluids. However, the possibility that such activity might be regulated as a public utility totally discouraged all but one company. This points out the serious barrier utility regulation would present to user development involving downstream distribution.
- The prospect of supplying a few others near a resource developed by a chemical producer was acceptable to about one-third of the

respondents, but only outside the public utility framework. Only three firms would consider setting up an industrial park.

E. THE ROLE OF GOVERNMENT

- The overwhelming majority of chemical producers interviewed knew nothing of existing government programs to promote geothermal development. Therefore, if government is to encourage development in the chemical industry, high priority must be given to disseminating available information to industry members who might benefit from the substantial efforts already under way by DOE.
- When existing programs were explained, tax incentives received the most favorable responses. There was moderate support for guaranteed loans and demonstration projects, and about half the respondents indicated that they find government involvement in demonstration projects to a large degree credible. Overall, there is a fair amount of hostility to government involvement in an area considered to be the purview of the private sector. This attitude is tempered by a few who believe that risk taking will be limited in private industry and that this is the role of government.
- No pattern of preference for particular programs developed from our interviews because the industry generally does not think it will be interested or involved in developing geothermal energy. Similarly, between federal and state government there was little preference for who should administer programs, although one firm felt the federal government would provide greater consistency to those working in many states and another felt state government was more efficient.

Appendix A

IV.A Fuel

1. Fuel Sources, Uses, and Costs

a. Fuel uses and sources

Steam generation

All companies

Natural gas (C: only for supplemental steam)

(C,E,G,I,J,K)

Oil (C and G: only for back-up)

(C,G,K)

Coal

Other process heat

(A,B,C,D,H,J)

Natural gas

(J)

Oil

(C,K)

Coal

(C,D,E,I,K)

Electricity (C and K: self-generation from coal)

Equipment power

(A,B,E,H,I)

Purchased electricity

(C)

Self-generated electricity

Space heating

(E)

Natural gas and oil

A.1. b. Fuel price and type of contract

Costs of Fuels for Specific Chemical Companies by Type of Fuel

<u>Company</u>	<u>Price</u>	<u>Type of Contract/Comments</u>
<u>NATURAL GAS</u>		
A	\$2.73/1,000 cu ft, but variable	Uninterruptible, use 16 million cu. ft./ day
B	\$2.23/1,000 cu. ft.	Interruptible, supplier wants 15% increase
C	\$0.2269/therm, but variable	Interruptible, annual contract
D	Variable	Multi-year contract
F	---	20-30 year contract, almost up
G	Variable	Some interruptible, 5 year contract with Shell Oil
H	Variable	Some interruptible, 5-10 year contract in N.M., continual with local utilities in Fla. & gas from own fields in La.
I	Variable	Interruptible
J	Variable	Interruptible, annual contract
K	Fixed and variable rates	
<u>OIL</u>		
C	Spot prices	
E	\$2.50/M BTU's	
I	Fixed or variable contract price	
J	Spot prices	
<u>COAL</u>		
C	Variable	Annual and long-term contract
F	Can't say	Long term contract
G	Between \$1.32 and \$3.48/M BTU's depending on state	Spot market purchase
K	Fixed and variable	
<u>ELECTRICITY</u>		
A	3.4¢/kwh, (variable)	Uninterruptible, use about 500,000 kwh/day
B	2.3¢/kwh	Uninterruptible
F	n/a	Interruptible, hydroelectric in the northwest
H	n/a	From local utility

A.1. c. Energy costs compared to total costs

- (A) 10-15% of operating costs
60% for dissolving and drying
40% for fusing
- (B) 85% of operating costs
- (C) 40-50% of costs
- (D) 37.5% of operating costs
50% of fuel for feed stock
75% of cost is gas; half of this is
process heat
- (G) 10% and growing
- (I) 30-40% of operating costs
- (J) 10-20% of costs, 25¢/therm to generate
heat, 30¢/therm to generate steam
- (K) 18.75% of sales or approx. \$1.5
billion/year

2. Fuel Supply Interruptions

a. Comments

- (A) None scheduled
- (B) \$70,000 restart cost
- (C) Usually limit shutdown to no more than
a week at a time and conduct maintenance
around the clock.
- (D) Schedules shutdowns for 20 days each year
- (G) Shutdowns not critical, but have small
inventory and need continuous operation
- (H) Several days to restart ammonia plant;
several hours to restart casutic soda
plant
- (J) Can allow shutdown one day a week
- (K) One shutdown day loses 4 weeks' production

A.2. b. Back-up arrangements

<u>Company</u>	<u>Primary fuel</u>			<u>Back-up fuel</u>		
	<u>gas</u>	<u>elec</u>	<u>deisel</u>	<u>type</u>	<u>capacity</u>	<u>time</u>
A		X		oil elec generation	5 mil gal n/a	1 month
B	X			oil elec generation	1 mil gal n/a	
E	X			oil		
G	X			oil		
H	X	X				
I	not specified					
J			X			
K	X			gas, coal, & oil		

c. Recent experience of fuel supply interruptions?

(A)	1979 electric line damage caused outages for from one to four weeks
(B)	Minimal gas supply interruptions since 1968
(C)	Periodic natural gas interruptions since 1968
(D and J)	No interruptions
(E,F,G,H,I)	None

3. Future Fuel Supply Concerns

a. Future concerns

(A,B,C,D,F,G,H)	Cost increases
(B)	Supply problems
(D)	Not concerned about availability, but price
(E)	Hoping government will solve the problem, but anticipates 25-year supply.

A.3. a. (I)
(continued)

Can and will pass on rising costs for a long time

(J)

Only supply shortage would prompt search for alternatives; not anticipated.

b. What responses to problems?

(A,D,E,G,I)

Conservation. E is trying to recover waste heat in most plants, co-generating and selling excess to utility in one and investigating recovery processes at another. I has been convinced of serious problem for years and thinks conservation is the answer.

(A,C,F,G,H,K)

Alternative energy resources. A has been contacted by solar consulting firm and is trying to get government grant to pursue. C is looking for geothermal at one plant location. H has solar project in New Mexico to replace high cost and pollution problems of existing evaporators. Also has looked at cooling tower waste heat in Nevada. K is looking at everything, including geothermal.

(B)

Fight rate increase or go under

Appendix B

B. Firm Decision Making

1. Managerial Structure and Decision Making

a. Firm Structure

(C,D,E,F,G,
H,I,J,K)

Three tiered (Headquarters, Division,
Plant)

(A,B)

Two tiered (Headquarters, Plant)

(E,K)

Separate Foreign Division

b. Planning group or energy advisers?

Level	Planning Groups	Energy Advisers
HQ	A,B,D,F,H,I,J	E,I,F
Division	J	C,H
Plant	A,B,J	
	(C,E,G,K) No Answer	(B,D,G) - None (J,K) - No Answer

c. Where are decisions made on four projects?

PROJECT	FINAL DECISION			
	DEPENDS ON COST	HQ	DIVISION	PLANT
Open New Plant	5	5	1	0
Location of New Plant	5	5	1	0
Expand Existing Plant	6	4	1	0
Retrofit to Re-equip Existing Plant	6	3	2	0
What Energy to Use	5	4	2	0

B.1. d. Who would initiate and make important recommendations on a geothermal project?

HQ	Position	Initiates	Important Recommendation
	President		A,B,F,H
	Chairman	C	
	Exec. Committee		A,F,K
	V.P Finance		G,F
	V.P. Business Develop.	H,K	
	V.P. Mktg. & Supply	B,J	B
	Corp. Energy Mgr.	E,F	A,F
	Corp. Engineering	I	B,I
	Operations Mgr.		K
Division	Division Head	C,D,E,F,I,K	C
	V.P. Operations	G	
	V.P. Finance	G	G
	Energy Advisor	H	
	Process Engineers	D,H	
Plant	Manager	A,B,C,D,G,H,J,K	A,B,C,D,F
	Engineers	A,D,G,H	A,D,J

2. Investment Project Appraisal

- a. What investment criteria are employed for "normal" non-energy projects?

Payback Period

B	1 year
G*	3 years or less
H*	12 years or less

B.2. a. Return on Investment or Discarded Cash Flow
(continued)

A	15% after-tax ROI
C	DCF with 10-20% discount rate (rate depends on need for project)
D	Above 25% ROI
E	10% minimum after-tax ROI
F	13-15% internal rate of return
G*	19-20% after-tax ROI (1978 = 15.4%)
H*	DCF with 10-12% discount rate (target ROI varies with interest rates)
J	15% after-tax ROI
K	DCF with 12% discount rate. Aim to cover cost of borrowing and taxes and earn return on 6-8%

(*two criteria are employed)

b. Investment criteria for geothermal project different?

(A,F,I,K)	More lenient if energy saving
(D,E,G)	Require higher return to cover risk

Appendix C

C. Commercialization Potential for Geothermal Energy

1. Knowledge of Geothermal Energy

a. Know of potential as a source of energy?

Yes All

b. Heard of Commercial Application?

Yes B,C,D,E,F,G,H,I,J,K

B - greenhouse, packing house, home heating

E - Geysers, Salton Sea

G - Geysers, Salton Sea, New Zealand

H - greenhouse, Geysers, Mexico, Italy

I - Geysers, Italy

J - Geysers

(C,D,G,K) Have done some exploration

c. Seen cost figures for geothermal exploration, drilling or installation?

Yes B,C,D,G,K. B had engineering study done of possible direct use. The rest were involved in exploration for possible electric uses.

d. Know of existing government programs to accelerate commercial development?

Yes B (PON/PRDA), D, F (workshops)

No A,J

No answer C,E,G,H,I

e. Ever considered using geothermal energy?

Yes B,C,D,F,G,K

No A,E,H,I,J

(B) An engineering firm did feasibility study with DOE grant on converting fertilizer plant.

C.1. e. (C)
(continued)

Exploring now near existing complex for all temperatures.

(D) Drilling with DOE in western Nevada and testing a reservoir in south-western Utah. Looking for electric potential.

(F) Working with DOE and a resource company for Hawaii electric potential and interested in geopressurized resource in Louisiana though controlling the latter is a problem.

(G) Had wells in Salton Sea but closed down because couldn't solve corrosion problems.

(K) Is exploring Napa area for electric potential. Also considered direct use but discarded idea because too expensive to pipe the distance needed.

f. Know of possible uses for geothermal energy in chemical industry?

(C) Replace hydrocarbons burned to generate steam.

(H,J) Use in evaporators and dryers for salt extraction, but J worried about flooding salt mines.

(H) Use in chlorine and caustic soda production.

g. When, if ever, will geothermal energy be an important resource in the chemical industry?

(G) Between 10-20 years

(C) Of local importance in some areas

(E,F,K) Only high temperature resources

(B) Only in a plant designed for it

(B,C,I) Never

C.2. Factors Influencing the Decision to Employ Geothermal Resources

a. Problem(s) anticipated in using geothermal energy in your business.

None	(C) The company can use a wide range of temperatures and is energy efficient. Since there is geothermal available near one of their large complexes it is an obvious choice.
(A,E,G,I,J)	Availability near existing plants
(B,G,F,H,I)	Costs
(D,E,F,J)	Insufficient Temperature
(B,H)	Reliability
(D)	Corrosion
(K)	Regulatory

b. Willing to relocate existing facilities to take advantage of geothermal energy?

No	All
----	-----

c. Willing to locate a new plant near a resource?

Yes	(F,K) Friendly said resource would have to be capable of generating electricity. K tried but was unsuccessful due to state regulatory problems (related to chemicals, not geothermal).
Don't Know	A
No	B,C,D,E,G,H,J
No Answer	I

e. Future plant plans?

Yes	(A,D,E,F) A had plans in Alaska but stalled by federal land control; D won't expand fertilizer plant because it is shaky but will open other plants; E and F have no specific plans but are always looking.
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C.2. d. No
(continued)

B,H

No Answer

C,F,G,I,K

e. Factors important in choosing a plant site.

FACTORS	SMI*	VI*	I*	TOTAL	NI*
Raw Material Supply	4	4	1	9	-
Location Close to Product Market	2	6	-	8	-
Energy Supply	2	4	-	6	-
Labor Supply	1	1	-	2	-
Cost	1	-	-	1	-
Water Supply	1	-	-	1	-
Environmental Non-Degradation Area	-	1	-	1	-
State/Local Business Taxes	-	-	-	-	1
Climate	-	-	-	-	-

*SMI = Single Most Important, VI = Very Important, I = Important, NI = Not Important

f. Assuming resource availability, which factors influence a decision whether or not to use geothermal?

FACTOR	SMI*	VI*	I*	TOTAL	NI*
	(5)	(4)			
Capital Cost	A,B,C,D,F	E,G,H,J		9	
	(3)	(4)			
Operating Cost	C,D,F	A,E,G,J		7	
		(2)			
Reliability (Minimal Down Time)		D,H	J	3	A
Compatibility		(2)			
with Existing Equipment		A,D		2	A
Availability of a		(2)			
Long-Term Fuel Contract		A,H		2	
Ease of Maintenance	J			1	
Familiarity of the Technology				0	A

*SMI = Single Most Important, VI = Very Important, I = Important, NI = Not Important

- C.2. g. Considering two projects with the same annualized costs, "A" = high capital/low operating and "B" = low capital/high operating, which would you prefer?

(E,F,J) Project "A". E liked low operating costs and wanted to take advantage of tax incentives for capital investments. F was able to finance high capital costs projects internally and J worried about high labor costs.

(B,D,H) Project "B". B wanted to minimize debt and D preferred flexibility of a low front end cost project.

(A,C,G,K) No preference. C and G said only bottom line costs are a concern. K doesn't mind high front end costs.

(I) No answer.

- h. If you would experience periodic, temporary shutdowns, would you factor it into costs or account for it separately?

(A,E,J) Factor into costs. A would install backup if sys- was unreliable. E said that shutdowns can be worked around.

(C,D,G,H,K) Take account separately. C can't afford total shut- down and would have to install back up. D said shut- downs destroy efficiency and increase equipment break- down. G said smooth operations are more efficient. K felt reliability an important consideration.

(B,F,I) No response.

- i. Would maintenance needs be factored into costs or considered separately?

(A,B,E,H,J,K) Factor into costs.

(B,D) Take account separately.

(F,G,I) No answer.

- j. If you had to install a back up system, would you factor it into costs or account for it separately?

All Factor into costs.

3. Financing a Geothermal Investment Project

- a. If resource available how would you finance a retrofit?

Internal Funds

(A,B,C,D,E,F,H,K)

C.3. a. Short-Term Debt
(continued)

(A,B,E)

Long-Term Debt

(A,E,F,K)

Dentures

(F,K)

b. Is this different from "normal" project financing?

No A,B,C,D,E,F,K

Yes H might borrow for some projects but not for geothermal which is high risk.

C.4. General Sources of Information on Technology

a. Most important source of information on new technology?

(A,C,D,E,F,G,I,K)	Company R&D
(H,E,F)	Others in industry
(B,J)	Trade associations
(A,H,I)	Trade journals
(I)	Technical meetings
(B,C,D)	Government. <u>B</u> and <u>D</u> specifically mentioned TVA Fertilizer Research Organization.
(I)	Own patent department

b. If looking for alternative energy, where do you make first inquiries?

(B,C,D,G,K)	Company staff
(B)	Others in industry
(A,G)	Outside consultants. Both companies have been contacted by these
(E,F)	Government. <u>F</u> has attended DOE workshop on geothermal in Hawaii.
(H)	Always looking
(I,J)	No answer

Appendix D

D. Potential Institutional Framework

1. Willingness to Become Involved in Resource Development

Willing to consider exploration and development A,C,D,F,G,H,J,K

Interested in electric-quality resources only D,F

Not interested in exploration or development B,E

No response I

2. Need for Control Over Supply

Would need to be sole user None

Willing to hook up to a distribution system A,B,C,D,E,F,G,H,J,K

No response I

3. Willingness to Act as Suppliers

Willing to supply one or two other companies A,B,C,D,F,G,J

Willing to also consider setting up heating district or industrial park A,B,J

Not willing to sell to others H

No response E,I,K

4. Still Willing to Supply Others if Regulated as a Public Utility?

Yes J

No B,D,F

Unsure A,G

Appendix E

E. The Role of Government

1. Evaluating Existing Programs.

a. Aware of government programs

yes	B,F
no	A,C,D,E,F,H,I,J,K,L

b. Rating of Existing Programs

GLGP

favorable	J
moderately positive	A,B,G
no response	C,D,F,I
unfavorable	K

PON/PRDA

favorable	A,B,E,F,J
no response	C,D,I
unfavorable	K

Tax Incentives

favorable	A,B,C,E,G,H,J,K
no response	D,F,I

c. Government Demonstration Projects Credible?

yes	A,B,E,F (E participating in solar demonstration project.)
sometimes	C,H,K (H said if you can sit down and discuss undocumented decisions, i.e., TVA coal conversion)
no answer	D,G,I,J

E.2. Recommendations for Future Programs

a. What should the government do?

PROGRAM	SMI*	VI*	I*	NI*	GOOD	BAD
Investment Tax Credit	G,H	A		B (a coop)	C,E,K	
Accelerated Depreciation	G,H				A,K	
Direct Subsidies						A
Loan Guarantees					A,G	
Loan Forgiven if Unsucessful						
Subsidy Becomes Loan		A				
Provide Testing Facilities				K		
PRDA		A				
Cost Share Research & Development		A				
PON		A			E,F	
Resource Identification		J	D			
Resource Development		J				A
Information on Resources		A,J				
Information on Technology		J				

*SMI = Single Most Important, VI = Very Important, I = Important
 NI = Not Important

b. Prefer Federal or State programs

No preference	A,B
Federal	C,G,K (G said that federal government is more knowledgeable and if company is working in a number of states, it prefers consistency. K said some states worse than others)
State	D,J (J said state more efficient)
No answer	E,F,H,I