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DIRECT APPLICATION OF
WEST COAST GEOTHERMAL RESOURCES
IN A WET CORN MILLING PLANT
SUPPLEMENTARY ANALYSES AND
INFORMATION DISSEMINATION

FINAL REPORT ADDENDUM
SEPTEMBER 17, 1981
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PREPARED FOR:

U.S. DEPARTMENT OF ENERGY

UNDER CONTRACT NO. DE-AC03-79ET27231

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DIRECT APPLICATION OF WEST COAST GEOTHERMAL RESOURCES
IN WET CORN MILLING PLANT

FINAL REPORT ADDENDUM

TABLE OF CONTENTS

<u>Section Number and Title</u>	<u>Page</u>
Table of Contents	i
List of Tables	iii
List of Figures	iv
I - SUMMARY	I-1
II - CONCLUSIONS	II-1
III - INTRODUCTION	III-1
IV - SUPPLEMENTARY ANALYSIS FOR A COAL FIRED WET CORN MILLING PLANT	IV-1
A. Description of Wet Corn Milling Process With Coal Fired Incinerator	IV-1
B. Energy Utilization	IV-10
C. Capital Cost Estimates	IV-11
D. Operating Cost Estimates and Economic Analyses	IV-14
V - SUPPLEMENTARY ANALYSIS FOR AN EAST COAST FROZEN FOOD PLANT WITH COAL FIRED BOILERS	V-1
A. Basis of Study	V-1
B. Geothermal Well Design and Capital Cost Estimates	V-2
C. Geothermal Fluid Properties and Treatment	V-5
D. Plant Hot Water Requirements	V-8
E. Geothermal Plant Description	V-10
F. Surface System Capital Costs	V-24
G. Operating Cost Estimates and Economic Analysis - Retrofit Situation	V-30
H. Operating Cost Estimates and Economic Analysis - "Grass Roots" Situation	V-46

DIRECT APPLICATION OF WEST COAST GEOTHERMAL RESOURCES
IN A WET CORN MILLING PLANT

FINAL REPORT ADDENDUM

TABLE OF CONTENTS (Continued)

<u>Section Number and Title</u>	<u>Page</u>
VI - INFORMATION DISSEMINATION ACTIVITIES	VI-1
VII - REFERENCES	VII-1
APPENDIX A - Cash Flow Analysis Sheets - Corn Milling Plant	
APPENDIX B - Cash Flow Analysis Sheets - Frozen Food Plant	
APPENDIX C - Listing of Economic Analysis Computer Program	
APPENDIX D - Letters Sent to Trade Organizations and Responses Received	
APPENDIX E - Correspondence Concerning Potential For Use of Geothermal Energy by ITT Continental Baking Company's Plants	
APPENDIX F - Correspondence with Food Engineering Magazine	

LIST OF TABLES

<u>No.</u>	<u>Title</u>	<u>Page</u>
IV-1	Electrical Power Requirements	IV-20
V-1	Geothermal Well Cost Estimates	V-4
V-2	Chemical Analysis of Water By Zone At Crisfield Airport Well	V-7
V-3	Campbell Soup Co. - Salisbury, Md. - Hot Water Usage	V-9
V-4	Heat Exchanger Data - Heat Exchanger Only System	V-14
V-5	Heat Pump Data - Geothermal Brine Temperature 150°F Heat Pump Plus Heat Exchanger System	V-15
V-6	Heat Pump Data - Heat Pump Plus Heat Exchanger System	V-16
V-7	Capital Cost (4th Qtr., 1980) - Specific Well Capacity: 1.0	V-31
V-8	Geothermal System Energy Production - Coal Savings, Electric Power Consumption, and Capital Costs (1st Qtr., 1980 Dollars)	V-34
V-9	Estimate of Intangible Drilling Costs	V-41
V-10	Frozen Food Plant Coal Fired Boiler Costs	V-50
VI-1	Trade Organizations That Requested A Written Description of Presentation	VI-3
VI-2	Trade Organizations that Verbally Expressed No Interest	VI-5

LIST OF FIGURES

<u>No.</u>	<u>Title</u>	<u>Page</u>
IV-1	Base Plant Steam and Natural Gas Distribution System	IV-3
IV-2	Geothermal System Conceptual Design - Case I	IV-7
IV-3	Combined Geothermal/Cogeneration System Conceptual Design - Case II	IV-8
IV-4	Fraction of Best-Estimate Capital Cost Retrofit of a Geothermal System to Existing Coal Fired Plants Corn Products, East Mesa, California	IV-25
V-1	Flow Schematic - Heat Exchangers Only	V-11
V-2	Geothermal Flow Schematic-Heat Pump-Heat Exchanger System - East Coast Frozen Food Plant	V-12
V-3	Campbell Soup Co. - Salisbury, Md. - Geothermal System - Conceptual Site Plan	V-20
V-4	Campbell Soup Co. - Salisbury, Md. - Geothermal Building Conceptual Layout - Heat Exchangers Only - Minimum Brine Treatment	V-21
V-5	Campbell Soup Co. - Salisbury, Md. - Geothermal Building Conceptual Layout - One Heat Pump - Max. Brine Treatment	V-23
V-6	Campbell Soup Co. - Salisbury, Md. - Geothermal System Schematic - Heat Exchangers Only	V-25
V-7	Campbell Soup Co. - Salisbury, Md. - Geothermal System Schematic - One Heat Pump	V-26
V-8	Heat Pump Cost Data	V-28
V-9	Plate Heat Exchanger Cost (1980) - Plates Titanium (Ti) or Stainless 304 (SS) Carbon Steel Frames	V-29
V-10	Geothermal Project Capital Cost - 4th Qtr., 1980 Prices	V-43
V-11	Geothermal Project After-Tax - Rate of Return	V-44
V-12	After-Tax Payback Periods	V-45
V-13	Sensitivity of Rate of Return to Fuel - Escalation Rate	V-47

LIST OF FIGURES (Continued)

<u>No.</u>	<u>Title</u>	<u>Page</u>
V-14	Sensitivity of Rate of Return to Fuel - Escalation Rate	V-48
V-15	Geothermal Project After-Tax - Rate of Return	V-51
V-16	After-Tax Payback Period	V-52

I - SUMMARY

INTRODUCTION

Under the original scope of work for this contract, Burns and Roe Industrial Services Corporation, in conjunction with Corn Products as subcontractor, conducted a study of the direct application of geothermal energy to a hypothetical new wet corn milling plant on the West Coast. A Final Report, entitled, "Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant," was issued in March 1981. The conceptual design considered application of geothermal energy to preheat waste gases, air, and makeup water streams, thereby reducing the consumption of natural gas.

In a similar effort, Burns and Roe Industrial Services Corporation, in conjunction with Campbell Soup Company (CSC), as subcontractor, conducted a study of the direct application of geothermal energy to an existing CSC frozen food plant on the East Coast (Salisbury, Maryland).

The East Coast study evaluated the engineering and economics of retrofitting the plant with a geothermal system that would produce hot process water for a variety of uses, thereby reducing fuel oil consumption. A Final Report, entitled "Direct Application of East Coast Geothermal Resources in a Frozen Food Plant," was issued in July 1980.

In an extension to the scope of the West Coast study, supplementary analyses were to be performed for both plants which would assess the economics of geothermal energy if coal had been the primary fuel rather than oil and gas.

In addition to the supplementary analyses, the work scope extension also added an information dissemination task. Under this task, the results of the final reports mentioned above were to be communicated to potential industrial users of geothermal energy and other interested parties. The intended approach was to solicit invitations to make presentations at the annual meetings sponsored by various trade organizations.

This Final Report Addendum describes all of the work performed under the scope extension, and presents the results and conclusions drawn from these efforts.

SUPPLEMENTARY ANALYSES

In the study of the West Coast Corn Milling Plant, it was found that lack of availability of commercially proven coal fired odorless gas incinerators would make it extremely unlikely that a coal fired plant would be sited in California. However, since this is not the case in other states, it was decided to proceed with the analysis anyway to assess the relative competitive position of geothermal energy versus coal. The results indicate that the investment in retrofitting a geothermal system to such a plant would have an after tax rate of return and payback period of 20 % and 5.5 years, respectively. Since an acceptable payback period for energy projects generally falls in the range of three to six years, depending on the company involved, some companies might find this investment marginally acceptable. In other states, where conventional coal fired boilers are used in corn milling plants, it may be possible to achieve better paybacks.

Regarding the East Coast frozen food plant, the after tax rate of return and payback periods have been calculated to be 11% and 10 years,

respectively, for the retrofit case, and 17% and 7 years for the "grass roots" case. Each of these cases is based on the most optimistic well temperatures and drawdowns which could reasonably be expected in the area. The "grass roots" case further takes credit for a reduction in cost of the coal fired boiler plant due to the optimistic assumption that the reliability of the geothermal supply systems could be verified to be equal to that of the boiler system in sufficient time to prevent delays in the construction of the plant. However, even with these optimistic assumptions, the payback periods and rates of return are still generally unacceptable to the food industry.

INFORMATION DISSEMINATION

A total of 30 trade organizations have been contacted to date. Responses have been received from all but 10. Five of the 20 responding indicated that they would consider us for 1982 meetings and advise of their decision.

Thus far, presentations have been given to the following groups:

- 1 - "Symposium on Innovations in Food Processing and Implications for Energy Substitution" at the University of California, Davis; April 1981.
- 2 - Presentation to Massachusetts Institute of Technology with DOE's Food Industry Advisory Panel; March 1981.
- 3 - Presentation to American Society of Heating, Refrigeration and Air Conditioning Engineers in Chicago, Illinois, January 1981.
- 4 - Presentation to ITT Continental Baking Company; New York; February 1981.

5 - Presentation to AK-SAR-BEN Section of the Institute of Food Technologists in Omaha, Nebraska, September 3, 1981.

In addition to these, a meeting with DOE's Food Industry Advisory Panel is scheduled for September 24-25, 1981 in Boise, Idaho. At this meeting, we will present the results of our previous presentations and plan future activities in disseminating information to the food industry.

II - CONCLUSIONS

The conclusions drawn from the results of the supplementary analyses performed in this study are as follows:

WEST COAST CORN MILLING PLANT

- 1 - It is highly unlikely that a wet corn milling plant in California would use coal as a heat source. Environmental regulations require incineration of odorous waste gas streams prior to discharge. Investigation during this study has indicated that there are no coal fired incinerators available which are commercially proven in this application.
- 2 - If it were hypothetically assumed that coal was being utilized in such a plant in East Mesa, a geothermal system (Case I) could be retrofitted to that plant with a resultant coal savings equivalent to 46,986 million Btu/yr. The after tax return on investment and payback period for the investment would be 20% and 5.5 years, respectively. Since an acceptable payback period for energy projects falls in the range of 3-6 years depending on the company involved, some might find the investment marginally acceptable.
- 3 - An analysis was also made of a combined geothermal/cogeneration system being added to the conventional plant design (Case II). The results showed an after tax payback period of 2.6 years and a rate of return of 39%. However, additional analyses of adding a cogeneration system alone showed a payback period and rate of return of 68% and 1.5 years, respectively. Therefore, it is concluded that, while the greater utilization of the well would undoubtedly improve the payback periods for

the geothermal portion of the investment somewhat versus Case I, the significant improvement between Case I and Case II is mostly due to the addition of cogeneration.

- 4 - In some other states, the need to incinerate odorous waste gas streams from wet corn milling plants does not exist. Many of these plants (one-third) currently use conventional coal fired boilers to produce process steam rather than waste heat from incinerators as was used in this study. Without the competition from the essentially free energy source (i.e., the waste heat leaving the incinerator), geothermal energy could be used in additional processes within a corn milling plant. This would potentially improve the well utilization and hence the economics of a geothermal system relative to those presented in items 2 and 3 above.

EAST COAST FROZEN FOOD PLANT

- 1 - Many frozen food plants currently use or are being converted to use coal fired boilers. In the case of such a plant located in Salisbury, Maryland, the after tax rate of return and payback period for a geothermal system retrofit would be 11% and 10 years, respectively. This is based on the most optimistic well temperature and drawdown which could reasonably be expected in the area plus DOE's projections of coal and electricity escalation rates. This payback period is generally unacceptable to food industry companies.
- 2 - A coal price escalation rate of 40% per year would be required to reduce the payback period to 6 years for the retrofit case.

3 - In a "grass-roots" situation, it is considered highly unlikely that a reduction in the cost of the boiler plant could be achieved due to the availability of geothermal energy. However, even if it is assumed that the reliability of the geothermal system could be verified to the extent required within schedule constraint, the rate of return and payback periods would be 17% and 7 years respectively. These are still generally unacceptable to food industry companies.

III - INTRODUCTION

A BACKGROUND

As required under the original terms of this contract, Burns and Roe Industrial Services Corporation, in conjunction with Corn Products (a unit of CPC International, Inc.) as subcontractor, has conducted a study of the direct application of geothermal energy to a new wet corn milling plant on the West Coast. A Final Report, entitled "Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant," was issued in March 1981.

A wet corn milling plant produces a variety of products, the principle ones being corn oil, corn syrup, corn starch, and animal feed.

The study evaluated the engineering and economics of utilizing the geothermal resources in East Mesa, California for a new corn processing plant. Since such plants are located close to available markets, the potential exists, with favorable economics, for another new plant in the Imperial Valley Region.

The conceptual design considered application of geothermal energy to preheat various process gas, air, and makeup water streams, thereby reducing the consumption of natural gas required.

In a similar effort (DOE Contract No. DE-AC05-79ET27228), Burns and Roe Industrial Services Corporation, in conjunction with Campbell Soup Company as subcontractor, conducted a study of the direct application of geothermal energy to an existing frozen food plant on the East Coast.

The Campbell Soup Company owns and operates a frozen food plant in Salisbury, Maryland on the Delmarva Peninsula. The plant manufactures convenience foods (TV dinners) under the "Swanson" label. The plant also contains a frozen food storage warehouse, which serves as an East Coast distribution center for their frozen food line.

The East Coast study evaluated the engineering and economics of retrofitting the existing plant for the anticipated geothermal resources of the Delmarva Peninsula. The conceptual design considered the feasibility of reducing fuel oil consumption by utilizing a heat exchanger alone or a heat exchanger in combination with a heat pump to produce hot process water from geothermal energy.

A Final Report, entitled "Direct Application of East Coast Geothermal Resources in a Frozen Food Plant," was issued in July 1980.

The geothermal studies discussed above only evaluated the use of geothermal energy versus natural gas and oil. However, some industrial firms currently burn coal. In addition, the enactment of the Powerplant and Industrial Fuel Use Act of 1978 (FUA) empowers DOE to prohibit the use of natural gas and oil. This, along with escalating costs of these fuels, will eventually result in even more plants being converted to coal in the future. Therefore, in order to make the study results applicable to a larger portion of the industrial community, the scope of the current contract was expanded to include an economic evaluation of geothermal energy utilization versus the burning of coal.

In addition, it was recognized that before the industrial community, especially the potential owners and operators of geothermal systems, will

read the final reports, they must first be made aware of their existence. Also, they must be convinced that they contain data and information which they can readily use in their decision making processes. This could best be accomplished by making concise verbal presentations at various meetings which are likely to be attended by management level representatives of industrial firms. In essence, the most effective forums would be the annual meetings sponsored by the various trade organizations. Also, presentations should be made to technical and engineering societies whose membership, once familiar with the potential benefits of geothermal energy, will be in a position to communicate these benefits to the industrial firms in the course of normal business relationships. Therefore, the scope of the present contract was further extended to include information dissemination activities.

B - STATEMENT OF WORK FOR ADDED TASKS

The following tasks were added to the contract after release of the draft Final Report on the original scope of work:

Task 5 - Supplementary Analyses of Geothermal Energy Utilization Versus Coal Firing

Previous investigations of a West Coast wet corn milling plant and an East Coast frozen food plant will be modified as required to permit an economic evaluation of geothermal energy utilization versus coal firing. Evaluations will be done for the following two (2) cases: 1) the retrofit of a geothermal system to existing coal fired plants; and 2) the inclusion of a geothermal energy system in the design stage

of a "grass roots" coal fired plant. For these supplementary analyses, it will be assumed that the wet corn milling plant and frozen food plant designs used in the earlier studies originally utilized coal in lieu of oil or natural gas. The base plant conceptual designs will be modified accordingly and order of magnitude cost estimates will be prepared as required to determine incremental costs. Their rate of return and payback periods will be calculated as in the previous tasks.

Task 6 - Information Dissemination

In conjunction with DOE, contact will be made with various trade organizations in an attempt to obtain an invitation to present the geothermal study results to the respective memberships. As a goal, a total of ten (10) invitations will be sought. Appropriate slides will then be prepared and presentations will be given at the time and place specified by each organization. The presentation will be submitted to DOE for review prior to delivery to any organization.

This addendum to the original Final Report has been prepared to cover the added tasks described above. In order to make this Final Report Addendum a self-contained volume, a considerable amount of process and analysis procedure description has been repeated from the original studies.

IV - SUPPLEMENTARY ANALYSIS FOR A COAL FIRED WET CORN MILLING PLANT

A - DESCRIPTION OF WET CORN MILLING PROCESS WITH COAL FIRED INCINERATOR

The wet corn milling processes used in this analysis were described completely in the final report (Ref. 1). Therefore, only brief descriptions are included here since the only real change is the hypothetical substitution of coal for natural gas as the primary energy source. Three processes are described in the following paragraphs. The Base Plant Process is typical of one which would be designed for an East Mesa, California site using conventional fuel sources in this case, coal. The first alternative examined, Case I, incorporates the use of geothermal resources typically found in East Mesa to provide part of the process heat load. Case II combines cogeneration with the use of geothermal energy to permit a fuller utilization of the wells.

Typical process data for a wet corn milling plant were compiled by CPC. The data were primarily related to steam and fuel utilization.

The extent of the process details provided in this report was determined, to a large degree, by CPC confidentiality requirements. More detailed data than presented in this report have been made available by CPC, but publication of the detailed data was precluded by confidentiality considerations.

Using CPC's process information, several alternative plant designs which utilized geothermal energy were developed. Then a capital cost estimate and rate of return type of economic analysis was performed to evaluate each alternative. This report describes the results and conclusions of these efforts.

1 - Base Plant Process Description

Wet corn milling plants produce a variety of products, the principle ones being corn oil, corn syrup, corn starch, and animal feed.

The overall wet corn milling process is shown in Figure IV-1. Wet milling of corn is a continuous process with all parts run as an integrated whole. No one product can be produced unless the corn grinding, finishing, and by-products departments are running at the same time.

The wet milling process consists of several distinct parts: (1) the separation process, which divides and isolates the components of the corn kernel to obtain starch as the principal end product and steepwater, oil, and feeds as by-products; (2) the hydrolysis process which converts some of the starch to syrup or dextrose; and (3) the starch modification process which changes its characteristics by physical or chemical treatment.

The scrubbed odorous gases from the gluten, germ, starch, and feed dryers for the proposed plant have to be oxidized at 1750°F in an incinerator to satisfy California EPA regulations for odor control. About 73 million Btus/hr of waste heat from the incinerator is used to generate 64,044 lbs/hr of 150 psig saturated steam in the heat recovery unit. The amount of steam generated in the waste heat recovery unit is sufficient to supply the steam requirement for the whole plant.

In the original study (1), the odorous waste gas incinerator was fossil fuel fired. In order to get design, performance, and cost information on

Figure IV-1 BASE PLANT STEAM AND NATURAL GAS DISTRIBUTION SYSTEM

coal fired incinerators for use in this study, the following incinerator manufacturers were contacted:

C&H Combustion

Nichols Engineering & Research Corp.

BRULE Pollution Control Systems

C-E Raymond Combustion

All of these suppliers said that there were no coal fired waste gas incinerators in operation nor were any being offered for sale by their respective companies. Reasons stated included uncompetitive capital costs due to the need for coal and ash handling systems and pollution control equipment, and difficulties in controlling the high incinerator temperatures (1700-2100°F) when firing coal. Due to changing fuel costs, Nichols and BRULE indicated that coal fired fluidized bed or rotary kiln type units are currently being considered however, they are still unproven for the application considered in this study.

. At first glance, the lack of commercially available and proven incinerator designs makes any analysis of coal fired corn milling plants academic. However, the use of waste heat from an odorous gas incinerator to generate process steam is not the typical approach used in wet corn milling plants, but rather a special approach used to meet stringent California environmental regulations. In fact, a representative of the Corn Refiners Association indicated that one third of the corn industry uses coal in conventional boilers to generate process steam. For the last 5 years, because of the rising cost of natural gas and fuel oil, many corn refining plants have converted to coal fired boilers. At the present time, the remaining 2/3 of the industry is approximately equally divided between burning natural gas and fuel oil.

In view of these findings, it was decided to proceed with the analysis of a geothermal system retrofitted to an existing coal fired corn milling plant. In a retrofit situation, it is likely that no credit would be given to a geothermal system due to reduction in capital costs of the existing system. Thus, the results would be valid whether the coal were burned in a conventional boiler system or in an incinerator. Elimination of the need to incinerate waste gases would open up more profitable opportunities for geothermal energy utilization in the plant due to the absence of the large waste heat source. However, in order to simplify the analysis, it was decided to limit the alternatives to those considered in Reference 1. As a first cut assessment of the economics of geothermal versus coal, this would be a conservative approach.

2 - Case I - Geothermal System Conceptual Design Description

Due to the large amounts of waste heat made available, the need to incinerate the waste gas stream at 1750°F seriously limited the amount of coal which could be displaced by the relatively low temperature geothermal energy source. Preliminary investigations indicated that, within the current state-of-the art, there were no other suitable processes available to eliminate the odor producing contaminants. Therefore, the following changes to the base plant design were explored to utilize geothermal energy: 1) preheat the odorous waste gas stream before it entered the incinerator; 2) preheat the dry air entering the starch dryer; and 3) preheat the softened makeup water entering the deaerator. The electrically driven (950 hp) steepwater mechanical vapor compression unit was replaced by a quadruple effect evaporator, heated by 150 psig saturated steam, which was made available due to geothermal preheating of both the dry air entering the starch dryer and the makeup water to the deaerator.

Figure IV-2 shows the flow sheet for Case I. An intermediate flow loop is provided to protect against contamination of products or deaerator water by geothermal fluid if heat exchanger leaks should occur.

The total amount of geothermal brine required at 335°F was 232 gpm, of which 59 gpm preheated the odorous waste gases entering the incinerator. The dry air to the starch dryer and waste gases to the incinerator were heated up to 295°F and 300°F, respectively, and the softened makeup water to the deaerator was heated up to 214°F.

Since the geothermal fluid was not concentrated in this concept, threshold treatment at 5 ppm was the pretreatment used to prevent calcium carbonate, calcium sulfate, and barium sulfate scaling. The geothermal brine reinjection temperature was 200°F which was high enough to prevent silica precipitation.

3 - Case II - Combined Geothermal/Cogeneration System Conceptual Design

Description

The second alternative concept considered involved the use of a portion of waste heat from the waste gas incinerator to generate electricity in a back pressure steam turbine. The turbine exhausted to process at 150 psig. The flow sheet for this system is shown in Figure IV-3. Geothermal energy was used in the process to replace that portion of the waste heat which was

Figure IV-2 GEOTHERMAL SYSTEM CONCEPTUAL DESIGN - Case 1

IV-7

IV-8

used to generate electricity in lieu of process steam. No additional coal was burned to produce the electricity. In addition to the steam turbine/generator cycle, the other differences between Cases I and II were as follows:

- (a) The heat recovery unit design was revised so that it would produce 56,934 lb/hr of 850 psig/825°F steam in lieu of 64,044 lb/hr of 150 psig saturated steam.
- (b) Steam from the heat recovery unit was routed to the straight, non-condensing steam turbine which exhausted to the process at 150 psig.
- (c) The 7,100 lb/hr reduction in steam flow to the process was accommodated by using geothermal energy to heat the steepwater evaporator. Approximately 2,000 lb/hr of steam would have still been available to the evaporator; however, it was judged more economical to heat the evaporator entirely by geothermal energy and divert the 2,000 lb/hr to do additional preheating of the starch dryer, thereby further decreasing the fuel consumption of that unit.
- (d) The higher steam drum pressures on the heat recovery unit increased the blowdown heat recovery to the extent that geothermal heating was eliminated.

In Case II, a total of 320 gpm of geothermal brine at 335°F was required, of which 59 gpm preheated the waste gas to the incinerator. The heat in the remainder of the brine was distributed almost equally to the starch dryer and the steepwater evaporator via the intermediate flow loop. The brine reinjection temperature was again 200°F.

B - ENERGY UTILIZATION

1 - Combustion and Flue Gas Analysis

In order to determine some potential sources for coal, we contacted the National Coal Association in Washington, D.C. They indicated that there are very few places in California that use coal. There is a coke plant and a cement plant in California which use high grade bituminous coal from Utah. They also said that all coal used in California is from Utah. The analysis of a high grade bituminous coal was obtained from the Keystone Coal Industry Manual. The proximate and ultimate analyses of the Emery County, Utah coal used for this study are as follows:

PROXIMATE ANALYSIS

Moisture	5.2%
Volatile Matter	38.2%
Fixed Carbon	50.2
Ash	6.4%
Sulfur	0.9%
High Heating Value	12,600 Btu/lb

ULTIMATE ANALYSIS

C	79.8%
H ₂	5.6%
O ₂	11.8%
N ₂	1.7%

The coal moisture free heat value was given as 12,600 Btu/lb. Based upon the moisture content in coal of 5.2 percent and ash of 6.4 percent,

the heating value was corrected to 11,138 Btu/lb. Assuming that none of the water vapor condenses and that all of the products of combustion remain in a gaseous state, the low or net heating value was calculated at 11,086 Btu/lb.

2 - Energy Utilization Comparison

The efficiency of coal firing for the incinerator and starch dryer was assumed to be 83 percent. The incinerator would be used to burn the odorous gas and, in conjunction with a waste heat recovery unit, to generate 64,000 lbs/h of 150 psig saturated steam. The saturated steam would be used as process steam for the wet corn milling plant. The amount of coal required and total Btu's differential are as follows:

	<u>Base Plant</u>	<u>Case I - Geothermal Conceptual Design</u>	<u>Case II - Combined Geothermal Conceptual Design</u>
Boiler	6523 lb/h	6195 lb/h	6195 lb/h
Starch Dryer	<u>602 lb/h</u>	<u>457 lb/h</u>	<u>284 lb/h</u>
@ 12,600 Btu/lb	89.775x10 ⁶ Btu/h	83.8152x10 ⁶ Btu/h	81.6354x10 ⁶ Btu/h
@ 7,884 h operation	70.7786x10 ¹⁰ Btu/yr	66.08x10 ¹⁰ Btu/yr	64.36x10 ¹⁰ Btu/yr
Differential	Base	46.986x10 ⁹ Btu/yr	64.186x10 ⁹ Btu/yr

C - CAPITAL COST ESTIMATES

The differential capital costs between the Case I and Case II plants and the base plant case were used in the economic evaluation. These capital costs were assumed to be the same as in the original report (Ref. 1), and are summarized below:

	<u>Base Plant</u>	<u>Case I - Geothermal Conceptual Design</u>	<u>Case II - Combined Geothermal Conceptual Design</u>
Building	-	\$ 5,465	\$ 20,656
Mechanical Equip.	-	\$ 190,915	\$ 745,404
Electrical	-	\$ 119,600	\$ 269,600
Instrumentation	-	\$ 16,000	\$ 16,000
Geothermal Wells	-	\$ 1,570,000	\$ 1,570,000
<hr/>			
Total			
Differential Cost	Base	\$ 1,901,980	\$ 2,621,660

The above differential capital costs between the geothermal and/or co-generation plants and the base plant case were used in the economic analyses described later in this report. These costs are as of the first quarter of 1980.

The capital cost estimates are based on the inclusion or modification of the following major items:

1. Civil Work - All excavation, backfill, concrete, structural steel, building construction, foundations, and pipe supports.
2. Machinery and Equipment - All major pieces of equipment, pumps, storage tanks, evaporators, heat recovery section, and preheaters.
3. Piping Systems - All major piping, filters, valves, expansion joints, insulation (2" thick with all weather jackets), and pipe hangers.
4. Electrical System - Wiring, cable, cable trays, motor control centers, motors, electric appliances, and equipment connections.

5. Instrumentation - All instruments, instrument tubing, wiring, and control panels.
6. Well - Geothermal brine production and reinjection well.

The estimates also include the cost of construction equipment needed for installation of plant equipment and machinery, i.e., cranes, hoists, and tractors. Not included in the estimates are costs for land, a spare parts inventory, and temporary housing for construction workers. A ten percent contingency factor has been applied to the final equipment capital costs to cover unexpected events.

Order of magnitude estimates of well costs at East Mesa have been obtained from several sources (2,3,4,5). They are based upon general knowledge of East Mesa conditions and well drilling history.

The cost estimates exhibit a considerable range, but do present a reasonable basis for the current study. Based upon these estimates, costs for the production and injection wells will be taken as:

Production well to 6000 ft.	\$1,000,000
Reinjection well to 3000 ft.	\$ 500,000
Downhole Production Well Pump	\$ 70,000

A detailed discussion of the sources used in deriving these well costs is presented in Reference 1, along with a detailed breakdown of all other capital costs shown above. Since there is a substantial uncertainty in these capital costs, a sensitivity analysis was performed to determine the effect of capital cost on plant economics. (See Section IV-D.) The table only shows the equipment which must be added or modified relative to the base plant.

Cost estimates were also developed for the addition of a cogeneration system only to the base plant. This arrangement was identified as Case III, and was made to assess the relative contributions of the geothermal system and the cogeneration system to the rate of return for Case II. The Case III arrangement was basically the same as Case II, except that in Case III more coal would be burned in the incinerator so that the quantity of high pressure steam produced would match the base plant 150 psig process steam production. Cost estimates for Case III were conservatively approximated at \$720,000 based upon comparisons between Case I and II.

D - OPERATING COST ESTIMATES AND ECONOMIC ANALYSIS

With the exception of the substitution of coal costs for natural gas, the operating cost estimates and economic analyses have been based on the same methodology as in Reference 1. However, the description is repeated here in an attempt to make this addendum a stand-alone document from the standpoint of review and publication.

1 - General Approach

The objective of this analysis was to assess the economic viability of constructing a Wet Corn Milling Plant at East Mesa, similar to the Corn Products Plant at Stockton, California, to utilize geothermal resources. A discounted cash flow rate of return (DCFRR) analysis technique was used to evaluate the economics of the new plant. The cash flow analysis compared the future annual expenditures required from the owner in order to operate with geothermal energy sources, for both a geothermal design and a combined geothermal/cogeneration design, and for a cogeneration only design, versus those expenditures required if he maintained the base design of the Stockton Plant.

A separate DCFRR analysis was performed for a total of nine cases. Each case was defined in terms of a specific combination of fuel escalation rates and capital costs for the three plant designs. A sample analysis sheet for one case is included in Appendix A for illustrative purposes. All cases were calculated using a computer program, and these output sheets are also included in Appendix A.

The DCFRR analysis was performed on the basis of the difference in capital and operating costs between the geothermal and cogeneration plant cases and the conventional, or "base," plant case. Thus, it was only necessary to consider those equipment and operating costs that differed between the base plant and Cases I and II and only those differences were considered in the calculation. These items are discussed in more detail below.

The reduction in annual coal costs due to the use of geothermal energy was considered as a "revenue" or positive cash flow. The annual expenditures or negative cash flows used in this study included: property taxes, insurance, maintenance (materials and labor), chemicals, and annual income taxes. The computer program used to perform the analysis had been set up to consider electric power consumption as an annual expenditure or negative cash flow. However, in the current geothermal application, electric power is a revenue or positive cash flow compared to the base case because of the elimination of the mechanical vapor recompression steepwater evaporators in both geothermal cases, and because of the electrical generation in the cogeneration case. Therefore, in applying the computer program, electric consumption was entered as a negative quantity to convert, internally in the program, from an expenditure to a revenue.

The net cash income for each year was the algebraic sum of all cash flows excluding income tax. For income tax purposes, deductions were made from the net cash income for intangible drilling costs and straight-line depreciation in order to get the taxable income. The intangible drilling cost deduction applied only in the first year of the project. The annual income taxes were then determined by multiplying the taxable income by a rate of 48.6% (considered to be a representative corporate rate). For the first year of operation only, the tax burden was reduced by subtracting the investment tax credit and the alternative energy tax credit. The income tax was then added algebraically to the net cash income to obtain the annual net cash flow.

The methods and assumptions used to determine the income tax deductions and credits discussed above will be described later. It should be noted here, however, that the net result of these deductions and credits generally was a net reduction in income taxes (i.e., a positive cash flow or "revenue") for the first year of the project (see Appendix A) which, when added to the net cash income, yielded a relatively large net cash flow for that year.

The annual discounted cash flow is simply the product of the discount (or present worth) factor and the annual cash flow.

The net present value is the algebraic summation of the discounted net cash flows for all years of the project life. The discount rate for which the net present value equals zero is the equivalent rate of return. This is determined through an iterative procedure which was performed by the BRISC computer program. A listing of this program is included in Appendix C.

2 - Project Time Frame

For purpose of the DCFRR analysis, it was necessary to assume dates for project start, plant start-up, and total operating life. Therefore, to be consistent with Reference 1, it was assumed that plant start-up would be on June 1, 1981 and that well drilling and major equipment contracts would be let during the fourth quarter of 1980. A 20-year operating life was assumed for all cases.

3 - Capital Costs Escalation

As mentioned earlier, the differential capital costs between the geothermal and/or cogeneration plants and the base plant case were used in the DCFRR calculation. These costs in Section IV C are as of the first quarter of 1980. These were increased by 5 percent to account for escalation to the fourth quarter of 1980 (i.e., 10 percent per year for a half year). The escalated fourth quarter values are shown on the Cash Flow Analysis Sheets in Appendix A.

4 - Tax Credits

Based on a telephone conversation with DOE, it was assumed for this study that the alternative energy tax credit would not apply to buildings. In order to simplify the calculations, the reasonably conservative assumption was made that, for each case, the "building" cost would include all of the Civil/Structural costs.

This analysis also assumed that the Alternative Energy Tax credit would be applied during the first year of operation. It was assumed that this deduction would be equal to 15 percent of the sum of the tangible well costs plus the total surface system cost minus the cost of buildings.

In addition to the 15% Alternative Energy Tax Credit, an Investment Tax Credit was also assumed during the first year of operation. This credit was 10% of the total project capital cost.

5 - Annual Coal Cost Savings

Coal costs used in this study are based on data received from U.S Fuel Company, Salt Lake City, Utah. The costs are based on a 0.6% sulfur coal shipped by Union Pacific Railroad from Emery County, Utah to East Mesa. The prices quoted are as follows:

Coal Price, FOB mine	=	\$23.50/ton
<u>Freight Charge</u>	=	<u>\$17.65/ton</u>
Total Price Delivered	=	\$41.15/ton

The current coal cost at \$41.15 per ton was used in this analysis. The first year unit coal cost at \$2/10⁶ Btu was based on the high heating value of 12,600 Btu/lb. Based on the projected rates from DOE mid range energy price forecasts (Reference 6) future escalation rates of 22.78 percent during the first four years, 11.04 percent between the fifth and ninth years, and 10.85 percent for all years were used in the analysis.

The annual coal cost savings was calculated by multiplying the appropriate unit cost from the preceeding paragraph by the differential coal requirements tabulated in Section IV-B-2.

6 - Annual Electric Energy Cost Savings

Geothermal system electric power requirements for each case are shown in Table IV-1.

The specific capacity of the geothermal well is defined as follows:

$$\text{Well Specific Capacity} = \frac{\text{Well Output, gpm}}{\text{Well Drawdown, ft}}$$

The drawdown is a measure of the head which must be provided by the well pump to overcome the flow resistance of the aquifer and the well. In this analysis, it was assumed that the drawdown for the production well and for the reinjection well were equal. For Case I, the drawdown head was taken as 500 ft. The geothermal flow for Case II is about 38 percent greater than for Case I. Since drawdown is directly proportional to flow, the drawdown head for Case II was taken as 690 ft. The head developed by the downhole pump was, therefore, taken as 500 ft. for Case I and 690 ft. for Case II. Power requirements for the geothermal fluid pumps were based upon these heads and the required flows, using pump and motor efficiencies provided by suppliers of downhole and reinjection pumps.

Additional power is required to overcome the surface system head losses. These requirements were met by individual pumps at the surface.

The total electric energy consumption for each case was calculated by multiplying the individual power requirements by 7,884 hours per year.

TABLE IV-1

ELECTRICAL POWER REQUIREMENTS

<u>Base Plant</u>	<u>Conceptual Design</u>	<u>Case II - Combined Geothermal/ Cogeneration Conceptual Design</u>
1. Electric Power	1. Electric Power	1. Electric Power
Steepwater Evapo. 708.4 kW	Steepwater Evap. 85 Hp	Steepwater Evap. 85 Hp
at 950 Hp		
Others 6791.6 kW	Threshold Pump 1/2 Hp	Threshold Pump 1/4 Hp
Total Purchased 7500 kW	Soft. Water Pump 7 1/2 Hp	Soft. Water Pump 7 1/2 Hp
	Geo. Brine Production	Geo. Brine Production
	Well Pump 47 Hp	Well Pump 90 Hp
	Geo. Brine Process Pump 30 Hp	Geo. Brine Process Pump 30 Hp
	Geo. Brine Reinjection	Geo. Brine Reinjection
	Well Pump 63 Hp	Well Pump 120 Hp
	Sub Total 232.75 Hp	Sub Total 332.75 Hp
	173.5 kW	248.1 kW
	Others 6791.6 kW	Others 6791.6 kW
	Total Purchased 6965 kW	Total 7040 kW
		Cogeneration 2060 kW
		Net Total Purchased 4980 kW
	2. Chemicals Threshold	2. Chemicals Threshold
	Additives 0.58 lb/hr	Additives 0.8 lb/hr

Replacing the vapor recompression steepwater evaporator of the base case with thermal units resulted in a reduction in electrical consumption for Cases I and II. Additionally, case II generates 2060 kW of electricity, while Case III generates 2318 kW for a further reduction in net electrical consumption. As a result, the electrical consumption of Cases I, II, and III represents cost savings over that of the base case. These cost savings are taken into account in the computer calculation by inputting the electrical consumptions as negative quantities.

The \$0.0497/kWh first year unit cost for electricity used in this analysis was obtained from Corn Products. The escalation rate for subsequent years was also based upon data in reference (6) to be consistent with the values used for coal. This shows a 13.3 percent per year increase in electricity rates between January 1982 and 1985 for industrial users and 9.02% per year thereafter.

7 - Annual Property Tax and Insurance Cost

The annual costs for taxes and insurance for the first year of operation were estimated to be 2 percent of the total project capital cost for each case, based upon general industrial trends. The first year cost was then escalated at 10 percent per year throughout the project life.

8 - Annual Maintenance Cost

Reference (7) presents service lives and maintenance frequencies for carbon steel domestic, irrigation, and municipal wells in various aquifers in 10 groundwater regions across the nation. Using an economic model based on performance data for metal pipes in corrosive fluid service, that study predicted the lives and maintenance frequencies of geothermal wells rela-

tive to conventional water wells. From this, it is anticipated that an expenditure of 10 percent of the replacement cost may be required every three to four years for well maintenance. An expenditure of 10 percent every three to four years is equivalent to about three percent per year for the wells.

For surface equipment of the type included in the geothermal system, annual maintenance costs are generally estimated to range from two to five percent of the capital cost.

On the basis of these figures, it was decided to use a first year annual maintenance cost (materials and labor) of three percent of the total capital cost for each geothermal case. This cost was then escalated by ten percent/year to get values for the remainder of the project life.

9 - Annual Chemical Costs

As a result of the consideration of geothermal brine chemistry, as discussed earlier, threshold additive treatment was judged to be the effective means of scale control. The threshold chemical requirements were estimated and the quantities are shown in Table IV-1. From this, chemical costs were determined, based on first quarter 1980 prices in various chemical price lists. This cost was then escalated by ten percent per year to get the cost for each year of the plant operating life.

10 - Intangible Drilling Costs

In order to estimate what percentage of the total drilling costs would be classed as intangible for income tax purposes, an analysis was made of the estimated cost breakdown provided in another study (8). This analysis

is summarized in Reference 1. The basic philosophy in the analysis was to consider the costs for all materials which could theoretically be removed from the well and reused as tangible costs. All other costs were intangible. The results of this analysis showed that 70 percent of the total well cost could be considered as intangible drilling cost. Therefore, this figure was used to determine the intangible drilling cost deduction for the year in which the well was completed. For this analysis, it was assumed that the tax reduction (i.e., positive cash flow) due to this deduction would occur in the first year of operation.

11 - Sensitivity Analysis

Runs were made to assess the sensitivity of the economic analysis results to variations in capital cost.

Capital costs, of the geothermal wells in particular, comprise an area of uncertainty in the geothermal applications. Computer runs were made to calculate how the rates of return and payback periods were affected by a change of ± 25 percent in capital costs, which was considered a reasonable range given the level of detail to which this study was carried out. In calculating values for the new curves, costs for taxes, insurance, maintenance, etc. were also increased since they were estimated as percentages of capital cost.

12 - Results of Analysis

Appendix A contains a Cash Flow Analysis Sheet for a sample case. The sample case is shown as an example of the computer calculations. The computer output sheets for all three cases are also presented in Appendix A. In addition, some of the key results are presented graphically in this section.

Figure IV-4 presents the after tax rate of return and the after tax payback period for geothermal design Cases I and II. Rate of return and payback period are each shown as a function of capital cost, with a ± 25 percent deviation from the "best estimate" capital cost.

The results indicate that, based on the "best estimate" capital and operating costs and escalation rates, the Case I geothermal plant shows an after tax rate of return of 20 percent with an after tax payback period of 5.5 years, while the Case II plant shows an after tax rate of return of 39 percent with an after tax payback period of 2.6 years. The rates of return and payback periods for Case III are 68 percent and 1.5 years respectively. This indicates that the investment in cogeneration equipment is much more economical than investment in the geothermal system when coal is the primary fuel, whereas, with oil firing, the two investments are nearly equivalent (Ref. 1). This conclusion is reasonable since a reduction in fuel costs increases savings for a cogeneration system and decreases savings for a geothermal system.

RETROFIT OF A GEOTHERMAL SYSTEM TO EXISTING COAL FIRED PLANTS
CORN PRODUCTS, EAST MESA, CALIFORNIA

Figure IV-4

In general, the maximum payback period considered acceptable for energy projects by most industrial firms falls in the range of 3-6 years. The payback periods for Cases I and II both fall within this range for the "best estimates" of the various capital and operating costs involved.

As indicated earlier, the above analyses assume that the geothermal system would be retrofitted to an existing coal fired plant. For a "grass roots" case, it might be possible to reduce capital costs of the coal fired incinerator/heat recovery system, thereby obtaining an additional credit for the geothermal system, further improving the payback periods and rate of return. However, the required heat input capacity of these units would only be decreased by about 5%. In most combustion equipment of this type, the capacity steps between model sizes in a given product line are much greater than this. Therefore, taking such a credit was considered an overly optimistic assumption at this point. Without this credit, the "grass roots" case is substantially the same as the retrofit case. Thus, no additional analysis was performed.

It should also be noted that in Case I, the amount of geothermal energy which could be profitably utilized was severely limited by the availability of large amounts of waste heat from the odorous gas incinerator which was essentially a source of free process energy. In states where conventional coal fired boilers can be used in corn milling plants, it might be possible to use geothermal energy in other of the plant processes, thereby further reducing annual coal costs by simply pumping more geothermal fluid from the same well. In such cases, with all else being equal, the payback periods and ROI's would be better than those shown on Figure IV-4.

V - SUPPLEMENTARY ANALYSIS FOR AN EAST COAST FROZEN FOOD PLANT WITH COAL FIRED BOILERS

A - BASIS OF STUDY

In a previous study (8), Burns and Roe Industrial Services Corporation (BRISC) and Campbell Soup Company (CSC) investigated the technical and economical feasibility of reducing the reliance of the CSC frozen food plant in Salisbury, MD on oil-fired boilers by retrofitting a geothermal system for the production of hot process water.

It was found in the previous study (8) that, for a range of wellhead temperatures, flow rates, and specific capacities that could be reasonably expected in the area, the payback period was less than six years, indicating that retrofitting the CSC plant with a geothermal heat source could be a viable situation. For a geothermal grass roots plant, it was estimated that payback periods would further improve by approximately one-half year. In this report, BRISC investigated the economics of a geothermal retrofit of the CSC plant, in the hypothetical case that the CSC plant had originally been equipped with coal-fired boilers. This effort was undertaken because the cost of coal on a heat value basis is, even today, only one-third to one-half the cost of oil. Thus, a plant equipped with coal-fired boilers represents an entirely different case regarding a geothermal retrofit or geothermal grass roots plant.

Because of the lower cost of coal, it was expected that substitution of it with geothermal heat would be less promising than in the case of oil-derived heat. Hence, the most optimistic of the geothermal fluid parame-

ters were considered first; i.e., a wellhead temperature of 150°F and a well specific capacity of 1.0.

B - GEOTHERMAL WELL DESIGN AND CAPITAL COST ESTIMATES

1 - General Approach

Three contractors were contacted during the study in order to obtain the design and cost data needed for the economic analysis. The three were:

1. D'Appolonia Consulting Engineers, Inc. - Pittsburgh, PA
2. Gruy Federal, Inc. - Arlington, VA
3. A.C. Schultes & Sons, Inc. - Woodbury, NJ

Very brief and general specifications were provided to all three in order to solicit their ideas on the one hand, while at the same time, insuring that comparable cost estimates would be obtained from all three. The specification was basically as follows:

No. of Wells:	1 Production Well and 1 Reinjection Well
Well Capacity:	300 gpm
Well Depth:	5000 ft. (each well)
Well Location:	Salisbury, Maryland
Scope of Supply:	All subsurface material and labor from wellhead down on a "turnkey" basis

2 - Proposed Well Designs

Each of the three contractors provided at least a verbal response to our specifications. While the general arrangement of the well was the same for all three contractors, the various dimensions varied somewhat.

The preferred design consisted of a surface casing which had the largest diameter and was placed in the top portion of the well so that the soil could support the drilling rig without collapsing into the bore.

The outer casing is placed to provide added protection against corrosion of the inner (working) casing and against pollution of any aquifers at the higher elevations. The annular space between the protective casing and the well bore would be filled with cement grout. All casings would be carbon steel.

At the levels of the producing zones, the well was completed with a stainless steel screen designed so that ground water could be extracted at high efficiency without permitting fine particles to enter the well.

Prior to placement of the screen, the area immediately adjacent to it would be underreamed and packed with gravel to further enhance the efficiency of the well.

3 - Well Cost Estimates

Table V-1 shows the estimates received from three contractors. A.C. Schultes & Sons provided cost data for about a dozen wells of varying configurations, depths, and diameters. Table V-1 indicates the range of the data they provided.

The costs shown on Table V-1 exclude the cost of the production well pump. For purposes of the economic analysis, a cost of \$53,000 was used for this pump based on estimates from submersible pump suppliers.

TABLE V-1

GEOHERMAL WELL COST ESTIMATES

	<u>GRUY</u>	<u>D'APPOLONIA</u>	<u>A.C. SCHULTES</u>
WELL DETAILS:	5000' Production Well	5000' Production Well	4000' Production Well
	5000' Injection Well	5000' Injection Well	3000' Injecton Well
	300 gpm Flow	300 gpm Flow	300 gpm Flow
	9-5/8" Inner Casing	8" Inner Casing	6" Inner Casing
	200' Slotted Liner and Gravel Pack		200' Screen and Gravel Pack
WELL COSTS:			
Production Well*	\$ 471,000	\$ 350,000	\$ 600,000 - \$ 950,000**
Injection Well	387,000	350,000	480,000 - 700,000
Miscellaneous	<u>179,000</u>	<u>100,000</u>	
TOTAL:	\$1,037,000	\$ 800,000	\$1,080,000 - \$1,650,000

* Does not include downhole pump

** Depending upon design flow capacity

For purposes of the economic analysis, the Gruy Federal estimate was used because it represented a reasonable intermediate value. In addition to the \$53,000 for a production well pump, an allowance of \$35,000 was also added to the capital cost for rig standby time during flow tests (\$5000/day). This resulted in a total 1st quarter 1980 cost for a 300 gpm well of \$1,125,000. Based on verbal information received from Gruy, the cost of a 100 gpm well would be about \$130,000 less, or \$995,000. This reduction was based on the lower cost of the tubulars and the pump. Capital costs for other well outputs were obtained from a straight line drawn through these two points. The costs from this line were increased by 5% to account for escalation between the first and fourth quarters of 1980, which was the assumed drilling period.

C - GEOTHERMAL FLUID PROPERTIES and TREATMENT

1 - Well Temperatures, Flow Rates, Drawdown, and Depth

The identification of geothermal resources along the Atlantic Coastal Plain has evolved through the work of investigators at Virginia Polytechnic Institute and State University (VPI & SU) (9).

These efforts form the primary basis for the estimation of geothermal resources in the Salisbury area applicable to the current study. The ranges of anticipated geothermal fluid properties estimated by BRISC from the results of these programs is as follows:

<u>MAX. FLOW RATE</u>	<u>TEMPERATURE</u>	<u>WELL SPECIFIC CAPACITY</u>
150 - 350 gpm	120°F - 150°F	0.1 - 1.0 $\frac{\text{Flow Rate, gpm}}{\text{Drawdown, ft}}$

Since fluid properties are site specific, unique values cannot be ascertained until a well is actually drilled. Therefore, the study in Reference 8 was done parametrically over the ranges of values indicated above. For reasons indicated earlier, this supplementary analysis of geothermal utilization versus coal firing was limited to values of 150°F and 1.0 gpm/ft for temperature and specific capacity, respectively. Thus, the values selected are at the optimistic end of the expected range. In addition, based on VPI & SU's program results, "basement" depths of 5000 ft were estimated for the Salisbury area.

2 - Geothermal Fluid Composition and Treatment

The chemical analysis for the geothermal fluid from a deep well drilled at Crisfield, Maryland, about 40 miles from Salisbury, appears in Table V-2 (10). Water chemistry at Salisbury could be expected to approximate that at Crisfield. Therefore, lacking any more site specific data, the composition of the water for the current study was taken as that for zone 1, the deepest zone, of the Crisfield well.

The principle concern in the treatment of the geothermal brine is that of scale formation. Potential problems for the Crisfield geothermal brine relate to calcium carbonate, magnesium carbonate, barium sulfate, and ferric hydroxide. Calculation of the Langelier Index, ionic strength, and solubility limits confirm that the brine is saturated with calcium carbonate and barium sulfate, high in magnesium carbonate and iron and under saturated with calcium sulfate, strontium sulfate, and silica.

Reference 8 contains an evaluation of four alternative approaches available to treat this fluid. The treatment approach that appeared to be

TABLE V-2
CHEMICAL ANALYSIS OF WATER BY ZONE
AT CRISFIELD AIRPORT WELL

Zone Depth, ft	<u>ZONE 1</u>	<u>ZONE 2</u>	<u>ZONE 3</u>
Number of Samples	4220-4148 6	4032-3901 6	3846-3798 6
<u>Metals (mg/l)</u>	<u>Mean</u>	<u>Mean</u>	<u>Mean</u>
Copper	0.433	0.290	0.242
Zinc	3.233	0.674	1.517
Boron	7.22	9.36	7.88
Chromium	0.583	0.3	0.242
Sodium	21,667	22,800	20,167
Potassium	268.3	280	348.8
Iron	36.67	8.64	14.50
Magnesium	631.2	636	649.5
Barium	4.05	10	10
<u>Others (ppm)</u>			
Total suspended solids	60.00	94	377.7
Total dissolved solids	71,793	71,511	72,089
Total residue	71,853	71,605	72,467
Calcium carbonate	16,598	10,443	14,377
Magnesium carbonate	3,557	2,264	2,244
Bicarbonates	121.2	71.0	72.2
Chlorides	39,422	37,360	34,772
Sulfates	575.2	634	804.2
Dissolved silicates	16	30.8	19.35
Nitrates	5.32	1.78	1.70
Total organic carbon	28.3	26.6	17.83
Density (gm/cc)	1.040	1.032	1.036
pH	6.36	6.52	6.69
Equivalent salinity (Calculated)	67,921	68,896	68,428

Components in minor amounts have been eliminated for clarity.

most practical and economical, and that was used for establishing costs in this study, is as follows:

- 1) Pressurization of the geothermal fluid to keep carbon dioxide in solution, and
- 2) Maintaining a closed system to keep oxygen out of the fluid, and
- 3) Threshold addition of phosphonate scale inhibitor.

D - PLANT HOT WATER REQUIREMENTS

Table V-3 shows the required process hot waterflow rate versus temperature level for the six hot water applications that were identified for consideration in the geothermal retrofit design effort. These data were provided by the Campbell Soup Plant in Salisbury, Maryland.

For each of the six hot water applications, the 24-hour average flow was determined. If a 5°F deviation in temperature is accepted, the processes may be divided into three temperature groups, namely 145, 165, and 175°F. For each of the three temperature levels, the 24-hour average flow, the maximum flow, and the minimum flow are also tabulated (Table V-3). The total average flow for all three temperatures together amounts to 207 gpm. Plant data were also available showing the instantaneous process waterflow rate versus time of day. This was plotted accumulatively against the amount produced at the average rate of 207 gpm in order to determine the size of the storage tank required. After including a margin of safety, a storage tank capable of holding 40,000 gallons of hot water was selected for this project.

TABLE V-3

CAMPBELL SOUP CO. - SALISBURY, MD
HOT WATER USAGE
24-HOUR AVERAGE FLOWS (gpm)

	<u>145°F</u>	<u>165°F</u>	<u>175°F</u>	<u>Total</u>
<u>Plant Hot Water 165°F</u>	-	95	-	
Max - 170 gpm				
Min - 70 gpm				
<u>Office Hot Water 150°F</u>	2	-	-	
Max - 5 gpm				
<u>HP Cleaning System 140°F</u>	29	-	-	
Max - 80 gpm				
Min - 10 gpm				
<u>Can Wash 160°F</u>	-	8	-	
Max - 8 gpm				
<u>Boiler Feedwater Makeup 170°F</u>	-	-	44	
Max - 56 gpm				
Min - 40 gpm				
<u>HP Cleaning System 140°F</u> (Seller's Jet Replacement)	29	-	-	
Max - 64 gpm				
Min - 16 gpm				
<u>Total Average gpm</u>	<u>60</u>	<u>103</u>	<u>44</u>	<u>207</u>
Max	149	178	70	397
Min	31	78	50	159

E - GEOTHERMAL PLANT DESCRIPTION

1 - General

Two basic plant design concepts have been considered in this study. In the first, process water is heated by the geothermal brine in heat exchangers (see Figure V-1). With a heat exchanger, however, the temperature of the process water leaving the heat exchanger will be limited to the temperature of geothermal brine minus the approach temperatures to the heat exchangers. This means that with a heat exchanger, process water temperatures will be limited to 140°F for 150°F geothermal brine. Therefore, the use of a heat pump (Figure V-2) has also been considered in order to meet the higher process water temperature requirements for cases when adequate geothermal flow rate was available. Process water storage tanks have been included in all cases in order to permit base load operation of the geothermal system at a constant average flow rate while the process water demand varies with time. Tank capacities are shown on Figures V-1 and V-2.

Part of the hot process water is used directly in the preparation of food. Thus, any chance that the geothermal brine would get mixed into the process water has to be eliminated. Therefore, in all cases, an intermediate heat exchange loop has been included establishing a clear separation between the geothermal brine and the process water.

The heat and mass balance calculations for the heat pump case were performed with the aid of a programmable calculator (TI 59) program that was developed by Westinghouse. All heat exchangers used in the systems shown on Figures V-1 and 2 are plate type units. Data for the heat exchangers

CAMPBELL SOUP CO. - SALISBURY, MD.
 GEOTHERMAL SYSTEM SCHEMATIC
 HEAT EXCHANGERS ONLY

Flow Schematic - Heat Exchangers Only

Fig. V-I

Figure V-2
Geothermal Flow Schematic-Heat Pump - Heat Exchanger System
East Coast Frozen Food Plant

are shown in Table V-4 for the Heat-Exchanger-Only System and on Table V-5 for the Heat Pumps Plus Heat Exchanger System. The data on the heat pump has been summarized in Table V-6.

2 - Process Description - Heat-Exchange-Only System (Figure V-1)

The submersible pump in the production well pumps 207 gpm geothermal brine through the geothermal heat exchanger. Threshold chemicals are added prior to the heat exchanger to avoid scaling. The maximum amount of heat is extracted from the geothermal brine by designing the heat exchanger for a brine exit temperature of 65°F. A reinjection pump puts the brine back into the ground.

The heat transferred into the intermediate loop is further transferred into the process water with the aid of a second heat exchanger. 207 gpm of 55°F process water enters this exchanger, and is heated to 140°F by the geothermal brine. Because with the intermediate loop two heat exchangers are involved in the heat transfer, the overall terminal temperature differential between brine and process water amounts to 10°F. The hot process water is stored in a 40,000 gallon storage tank for use in the plant. At the points of use, additional steam injection will be required to bring the process water up to the demand temperature.

3 - Process Description - Heat Exchangers Plus Heat Pump System (Figure V-2)

Three hot water temperature levels are required in the plant, i.e., 145, 165, and 175°F. With 150°F geothermal brine, 140°F process water can

TABLE V-4

HEAT EXCHANGER DATA
HEAT EXCHANGER ONLY SYSTEM

	<u>Brine</u> <u>Temp. °F</u>	<u>Material</u>	<u>Load</u> <u>MMBtu/hr</u>	<u>LMTD of</u>	<u>A(ft²)</u> <u>U=800</u>	
			<u>Geothermal Flow Rate</u>	→	<u>150 gpm - 207 gpm</u>	
HX 1	150	Ti	8.80	5	1594	2200
HX 2	150	SS 304	8.80	5	1594	2200

TABLE V-5

HEAT PUMP DATA
GEOHERMAL BRINE TEMPERATURE 150°F
HEAT PUMP PLUS HEAT EXCHANGER SYSTEM

	<u>Material</u>	<u>Load MMBtu/hr</u>	<u>LMTD of</u>	<u>A(ft²)</u> <u>U=800</u>
HX A	Ti	5.55	13.4	518
HX B	Ti	0.447	4.5	124
HX 1	SS 304	8.085	5	2021
HX 2A	Ti	2.55	5	638
HX 2B	SS 304	2.55	5	638

TABLE V-6

HEAT PUMP DATA
HEAT PUMP PLUS HEAT EXCHANGER SYSTEM

Geothermal Temperature	150°F
Geothermal Flow Rate, gpm	174
COP Heat Pump	3.7
Power Requirement, kW	144

be produced with heat exchangers only and without the use of heat pumps. This was close to the assumed requirement of 145°F, which is an approximation of various plant conditions. Therefore, a design including a second heat pump for producing exactly 145°F water was not considered. Instead, as shown on Figure V-2, the approach used actually consists of a Heat-Exchanger-Only type system producing 60 gpm of 140°F process water in parallel with a Heat Pump System producing 147 gpm of 165°F process water. The 175°F water is produced in the main plant by injecting additional steam in the 165°F water.

As indicated on Figure V-2, the heat pump loop also uses geothermal fluid heat exchangers. There are a number of factors that favor the use of the heat pump in combination with two heat exchangers in order to improve on the overall efficiency of a geothermal heat pump system. The cost of wells is a major cost item in a geothermal heating system. Hence, the heat available in the geothermal brine should be extracted to the fullest possible extent in order to obtain the lowest cost per unit of heat. In order to minimize the capital cost of the heat pump, heat exchangers should be used to extract this heat to the greatest extent possible within practical temperature limits. Then, the heat pump would do the rest. However, the COP of a heat pump is strongly dependent on the temperature of the geothermal brine leaving the heat pump evaporator. The lower the brine exit temperature, the lower the COP of the heat pump, and the greater the energy input required per Btu transferred.

Based on analyses performed by Westinghouse and others, the combination of the heat pump and heat exchangers HXA and HXB as shown on the schematic yields the most economical compromise between these considerations. As

indicated, the 60°F intermediate loop water is preheated in heat exchanger B with the low temperature brine leaving the heat pump. Subsequently, the intermediate loop water is further preheated to a temperature close to that of the incoming geothermal brine in heat exchanger A before it enters the heat pump where the final intermediate loop temperature of 170°F is obtained. The 170°F intermediate loop water is then used in HX1 to produce 165°F process water.

Electric power required for the heat pump is shown in Table V-6.

By adding another heat pump to the plant, all three plant water temperatures (i.e., 145, 165, and 175°F) could be obtained, thereby eliminating the need for further steam injection in the plant. However, the second heat pump would be a small one contributing only 2% of the total heat. Smaller heat pumps are of the reciprocating type in contrast to the centrifugal type that have been considered so far. Reciprocating heat pumps are relatively expensive and not as energy efficient as the centrifugal ones. Therefore, the 175°F heat pump system was not studied in any depth.

4 - Equipment Layouts and Description

GENERAL

The major pieces of equipment involved in the geothermal hot water plant are the geothermal brine treatment equipment, heat exchangers, heat pumps, storage tanks, circulation pumps, and hot process water pumps. With the exception of the tanks, all this equipment will be located inside the so-called geothermal building.

The best possible site for this building seems to be an area directly north of the high rise freezer storage building (See Figure V-3). The area

available there measures 70 x 120 feet. From there, above ground piping runs would be installed from the production well and to the reinjection well.

HEAT-EXCHANGER-ONLY SYSTEM

A layout for a Heat-Exchanger-Only case is presented in Figure V-4. There are two types of plate heat exchangers involved. The geothermal brine heat exchanger has titanium plates to avoid corrosion problems, while the second process water exchanger has standard SS 304 plates. The intermediate loop pump circulates water around in a closed loop connecting the two exchangers. Two chemical feed systems consisting of 50 gallon day-tanks and fractional horsepower, adjustable stroke, metering pumps are included.

The geothermal brine piping is urethane insulated fiber reinforced plastic pipe. The process water and intermediate loop piping is Yoloy pipe or equal. Valves are either bronze body or cast iron body with bronze trim.

Pumps have cast steel casings with bronze or stainless steel impellers. The 40,000-gallon hot process water storage is provided by two horizontal 20,000-gallon steel tanks. This is more economical than one 40,000-gallon tank, because a 40,000-gallon tank has to be field fabricated, while 20,000-gallon tanks can still be transported over the road and, hence, can be factory fabricated. The tanks are insulated and weatherproofed on the

CAMPBELL SOUP CO - SALISBURY, MD GEOTHERMAL SYSTEM CONCEPTUAL SITE PLAN

V-20

FIGURE V-3

0 100 200
SCALE 1" = 100'

CAMPBELL SOUP CO - SALISBURY, MD.
GEOTHERMAL BUILDING CONCEPTUAL LAYOUT
HEAT EXCHANGERS ONLY - MINIMUM BRINE TREATMENT

FIGURE V-4

outside and coal tar epoxy coated on the inside. The tanks are set on concrete foundations with heads penetrating the building. This way, all tank connections and instrumentation are inside the building. The 32' x 16' x 12' high building will be of cinder block construction with a flat roof. Open webbed posts will be used and will be spaced at 3 ft. Finished roof will be built up with insulation and a metal deck top with a 4 ply roof. The concrete floor will be 10" thick with wire mesh reinforcing. Metal doors will be installed for access.

HEAT PUMP PLUS HEAT EXCHANGER SYSTEM

A layout for this case is presented in Figure V-5. The heat pump, five heat exchangers, two circulation pumps, two process water pumps, as well as the chemical feed systems for dosing threshold chemicals, will be fitted into a building measuring 32' x 35' and 12' high. Because this system produces less hot process water at 140°F than at 165°F, one 15,000-gallon storage tank is required for the 140°F water and a 25,000-gallon storage tank will be required for the 165°F water.

5 - Process Water Piping

In Figure V-3, the paths are indicated for the distribution of hot process water from the geothermal building to the five user locations.

Piping carrying 165°F water will go from the geothermal building to the boiler feed water demineralizers, the plant hot water system, and the can washer. 145°F process water piping will go to the office hot water location and the HP cleaning system, following the paths of Figure V-3. If only a single temperature process water is produced in the geothermal

CAMPBELL SOUP CO - SALISBURY, M.D.
 GEOTHERMAL BUILDING CONCEPTUAL LAYOUT
 ONE HEAT PUMP - MAX. BRINE TREATMENT

V-23

FIGURE V-5

building, there will be only one combined piping system going to all five user locations.

Process water piping inside the plant will also be insulated Yolo pipe or equivalent. Geothermal brine piping is not shown in Figure V-3 due to the uncertainty of where a production well and a reinjection well can be located. However, a total of 850' of 6" insulated FRP pipe has been included in the cost estimate. Heat tracing is included to prevent this pipe from freezing up when not in use during winter time.

6 - Instrumentation

The instrumentation that is visualized for the different hot process water schemes is relatively simple. Heat pumps come equipped with their own internal controls, gauges, and safety switches. This includes a thermostat that automatically maintains the high temperature of the intermediate loop water.

Auxiliary controls consist of one or two flow control valves maintaining the process water flow rate at a preset level and one or two on-off valves controlled by the levels in the corresponding storage tanks as shown in Figures V-6 and V-7. Heat pumps, loop pumps, and geothermal brine pumps are all interlocked and their operation is also controlled by the level in the storage tanks.

F - SURFACE SYSTEM CAPITAL COSTS

1 - Quantification

Quantification take-offs for the civil/structural piping, electrical, and instrumentation were obtained from the following diagrams:

CAMPBELL SOUP CO. - SALISBURY, MD.
 GEOTHERMAL SYSTEM SCHEMATIC
 HEAT EXCHANGERS ONLY

Control Schematic - Heat Exchanger Only

Fig. V-6

CAMPBELL SOUP CO - SALISBURY, MD
 GEOTHERMAL SYSTEM SCHEMATIC
 ONE HEAT PUMP

Control Schematic - System Heat Pump

Fig. V-7

Civil/Structural	Figure V-4 - 5
Piping	Figure V-3 - 5
Instrumentation	Figure V-6 - 7

The electrical cost estimate was based on the availability of 800 amp service from an existing service that is 500 feet away from the projected geothermal building. A new motor control center is included. The production well was assumed 100 feet away and the reinjection well 700 feet away from the new geothermal building.

2 - Equipment

For all major pieces of equipment, detailed cost estimates were obtained from vendors. This included heat pumps, heat exchangers, storage tanks, hot lime reactor, and sludge centrifuge. Cost data for heat pumps and heat exchangers as a function of size are presented in Figure V-8 and V-9, respectively.

3 - Material Costs

Material costs were taken from various estimating publications such as Richardson and R.S. Means and from our "In House" cost Data Files. The costs for special items of material were solicited from vendor sources who had familiarity and experience with the product involved.

4 - Installation Cost

Installation manhours were estimated for each task. These hours were multiplied by the specific craft rate, including payroll burden, prevailing in the Baltimore, Maryland area in accordance with the latest publication

HEAT PUMP COST DATA

V-28

FIGURE V-8

PLATE HEAT EXCHANGER COST (1980)
 PLATES TITANIUM (Ti) OR STAINLESS 304 (SS)
 CARBON STEEL FRAMES

FIGURE V-9

by Richardson. Costs for foremen, supervision, construction services, supplies, and tools were included.

5 - Total Capital Cost

The total capital costs are the sum of equipment, materials, and installation costs. A minimum 10% contingency has been added as well as appropriate allowances for overhead and profit.

The capital cost data for the three 150°F cases with a specific capacity of 1.0 have been summarized in Table V-7. The basis for the capital cost data are complete detailed cost estimates that have been included as Appendices B, C, and D in Reference 8, plus additional analyses discussed in the main body of that reference.

G - OPERATING COST ESTIMATES AND ECONOMIC ANALYSIS - RETROFIT SITUATION

1 - General Approach

The objective of this analysis was to assess the economic viability of retrofitting the Campbell Soup Company's Salisbury, Maryland plant to utilize geothermal resources for the hypothetical case that the plant had been equipped with coal fired boilers. A discounted cash flow rate of return (DCFRR) analysis technique was used to evaluate the conversion of the plant. The cash flow analysis compared the future annual expenditures required from the Owner in order to convert to geothermal energy sources versus those expenditures required if he maintained the status quo (i.e., he continued to use conventional coal fired boilers).

A separate DCFRR analysis was performed for each of the three well flow rates at the geothermal brine temperature of 150°F and a specific well

TABLE V-7

CAPITAL COST (4TH QTR., 1980)
SPECIFIC WELL CAPACITY: 1.0

Case No.	Geothermal Brine		Heat Transfer Equipment	Process Water		Wells	Civil Struct.	Equipment	Piping	Brine Treatment	Instrumen- tation	Electrical	Total Cost \$
	Temp. °F	Flow gpm		Temp. °F	Flow gpm								
1	150	150	HX	140	150	1,082,000	28,100	208,500	58,700	34,800	10,100	131,200	1,553,400
2		207	HX	140	207	1,120,000	28,100	310,500	73,600	34,800	10,100	138,000	1,715,100
3		234	HP + HX	140 165	60	1,135,000	52,800	373,300	111,400	34,800	15,800	150,200	1,873,300

capacity of 1.0 (see Table V-7). The analysis sheets for each case are included in Appendix B.

The reduction in annual coal costs due to the use of geothermal energy was considered as a "revenue" or positive cash flow. The expenditures or negative cash flows as used in this study included: property taxes, insurance, maintenance (materials and labor), electric power, chemicals and annual income taxes.

The net cash income for each year was the algebraic sum of all cash flows excluding income tax. For income tax purposes, deductions were made from the net cash income for intangible drilling costs and straight-line depreciation in order to get the taxable income. The intangible drilling cost deduction applied only in the first year of the project. The annual income taxes were then determined by multiplying the taxable income by a rate of 48.6% (based on input from Campbell Soup Co.). For the first year of operation only, the tax burden was reduced by subtracting the investment tax credit and the alternative energy tax credit. The income tax was then added algebraically to the net cash income to obtain the annual net cash flow.

The methods and assumptions used to determine the income tax deductions and credits discussed above will be described later. It should be noted here, however, that the net result of these deductions and credits generally was a net reduction in income taxes (i.e., a positive cash flow or "revenue") for the first year of the project (see Appendix B) which, when added to the net cash income, yielded a relatively large net cash flow for that year.

The annual discounted cash flow is simply the product of the discount (or present worth) factor and the annual cash flow.

The net present value is the algebraic summation of the discounted net cash flows for all years of the project life. The discount rate for which the net present value equals zero is the equivalent rate of return. This is determined through an iterative procedure which was performed by a computer program developed at BRISC. A listing of this program is included in Appendix C.

2 - Project Time Frame

For purposes of the DCFRR analysis, it was necessary to assume dates for project start, plant startup, and total operating life. Therefore, it was assumed that plant startup would be on June 1, 1981 and that well drilling and major equipment contracts would be let during the fourth quarter of 1980. A 20-year operating life was assumed for all cases.

3 - Annual Coal Cost Savings

Table V-8 indicates the total amount of heat energy added to the process for each of the three cases considered.

The unit coal costs used in the analysis were obtained from two potential Maryland coal suppliers to the Campbell Soup Company. Both companies indicated a base price of \$50/ton delivered at the Campbell Soup Plant and a heating value of 12,500 Btu/lb. The future escalation rates were taken from the Federal Register as published by the Department of Energy in January 1980 (II). Assuming a 10%/year general inflation rate, the annual unit costs for coal are as follows:

TABLE V-8

GEOHERMAL SYSTEM ENERGY PRODUCTION
COAL SAVINGS, ELECTRIC POWER CONSUMPTION,
AND CAPITAL COSTS (1ST QTR, 1980 DOLLARS)

WELLHEAD TEMPERATURE - 150°F
FLOW PER WELL

	<u>150 GPM</u>	<u>207 GPM</u>	<u>234 GPM</u>
Heat to Process, MBtu/hr	6.37	8.79	10.64
Heat from Geo., MBtu/hr	6.37	8.79	9.95
Coal Saved, ton/yr	1809	2497	3021
Capital Cost (Mech., Civil, Instrumentation)	\$324,030	\$435,340	\$560,103
Well Specific Capacity, gpm/ft	1.0	1.0	1.0
Production Well Drawdown, ft	150	207	234
Reinjection Well Drawdown, ft	150	207	234
Surface System Head Loss, ft	140	140	140
Total Geo. Pump Head, ft	440	554	608
kW Well Geo. Fluid Pump Power Input	23	39	48
Intermediate Fluid Pump Power, kW	10	10	10
Water Treatment System, Electr. Input, kW	8	11	12
Heat Pump Power Input, kW	0	0	200
Total Elect. Power Input, kW	41	60	270
Total Elect. Energy Consumption, MW hr/yr	257	379	1688
Elect. System Cap. Cost, \$1000	124.9	131.4	143.1
Total Surface Sys. Cap. Cost, \$1000	448.9	566.7	703.2

<u>Date</u>	<u>Escalation & Inflation Rate, %/yr</u>	<u>Unit Cost \$/1 MMBtu</u>
January, 1980	13.85	2.319
January, 1981	13.85	2.640
January, 1982	13.85	3.006
January, 1983	13.85	3.422
January, 1984	13.85	3.896
January, 1985	13.85	4.436
January, 1986	11.76	4.958
January, 1987	11.76	5.541
January, 1988	11.76	6.192
January, 1989	11.76	6.920
January, 1990	11.76	7.734
January, 1991 - End of Project	12.08	8.669

The annual coal cost savings for each case were then obtained by combining the above unit costs with the appropriate coal savings from Table V-8 assuming the 12,500 Btu/lb heating value.

4 - Annual Electric Energy Costs

Geothermal system power requirements and annual electric energy consumptions for each case are also known on Table V-8.

The specific capacity of the geothermal well is defined as follows:

$$\text{Well Specific Capacity} = \frac{\text{Well Output, gpm}}{\text{Well Drawdown, ft}}$$

The drawdown is a measure of the head which must be provided by the well pump to overcome the flow resistance of the aquifer and the well. In this analysis, it was assumed that the drawdowns for the production well and for the reinjection wells were equal. In addition to the drawdown head for both wells, the geothermal fluid pumps must also supply the power required to overcome the surface system head loss for which a constant design value of 140 ft. of water was set for all cases. The total head requirements for the two geothermal pumps are shown on Table V-8 for each case. Power requirements for the geothermal fluid pumps were calculated using conventional pump power equations with an assumed overall (i.e., motor and pump) efficiency of 55%. The efficiency was based on information received from suppliers of downhole and reinjection pumps.

The power requirements for the intermediate flow loop pumps were calculated for 207 gpm, 140 ft. head and an assumed overall efficiency of 55%.

Power requirements for the water treatment system were estimated to be 0.5 kW per gpm for geothermal fluid treated.

Heat pump power requirements were obtained from the heat and mass balance calculations discussed in Section V-E-1.

The total electric energy consumption for each case was calculated by multiplying the sum of the above mentioned power requirements by 6250 hours per year. The results for each case are shown on Table V-8.

The January, 1980 unit costs for electricity used in this analysis were obtained from Campbell Soup Company. The escalation rates used in this study are the same as recently (Jan. 1980) published by DOE (11) and are shown below:

<u>Date</u>	<u>Escalation & Inflation Rate, %/yr</u>	<u>Unit Cost \$/kWh</u>
January, 1980		0.041
January, 1981	10%	0.045
January, 1982	15%	0.052
January, 1983	11.66	0.058
January, 1984	11.66	0.065
January, 1985	11.66	0.072
January, 1986	9.86	0.080
January, 1987	9.86	0.087
January, 1988	9.86	0.096
January, 1989	9.86	0.105
January, 1990	9.86	0.116
January, 1991 - End of Project	10.54	0.128

The annual electric costs for each case were obtained by multiplying the above rates by the appropriate yearly consumptions from Table V-8.

5 - Capital Costs Escalation

The surface equipment costs for each case in the first quarter of 1980 dollars are shown on Table V-7. These were increased by 5% to account for escalation to the fourth quarter of 1980 (i.e., 10% per year for a half year). The escalated fourth quarter values are shown on the Cash Flow Analysis Sheets in Appendix B.

6 - Tax Credits

Based on telephone conversations with DOE, it was assumed for this study that the alternative energy tax credit would not apply to buildings and heat pumps. In order to simplify the calculations, the reasonably conservative assumption was made that for each case, the "building" cost would include all of the Civil/Structural costs. To these "building" costs were added the heat pump capital costs (Figure V-8) plus the cost of the electrical system associated with heat pump installation. The sum of these costs was then increased by 5% to obtain the fourth quarter 1980 value which was deducted from the total surface system cost to get the amount used in determining the alternative energy tax credit. The tax credit was taken as 15% of this amount and was applied during the first year of operation. In addition, an Investment Tax Credit equal to 10% of the total project cost, was also applied.

This analysis also assumed that the Alternative Energy Tax credit would be applied during the first year of operation. It was assumed that this deduction would be equal to 15% of the sum of the tangible well costs plus the total surface system cost minus the costs of heat pumps and buildings.

In addition to the Alternative Energy Tax Credit, an Investment Tax Credit was also assumed during the first year of operation. This credit was 10% of the total project capital cost.

7 - Annual Property Tax and Insurance Cost

The annual costs for taxes and insurance for the first year of operation were estimated to be 2% of the total project capital cost for each

case based on information from Campbell Soup Co. This first year cost was then escalated at 10% per year throughout the project life.

8 - Annual Maintenance Cost

Reference 12 presents service lives and maintenance frequencies for carbon steel domestic, irrigation, and municipal wells in various aquifers in 10 ground-water regions across the nation. Using an economic model based on performance data for metal pipes in corrosive fluid service, that study predicted the lives and maintenance frequencies of geothermal wells relative to the conventional water wells. Conventional wells in the Atlantic Coastal Plain had a major maintenance frequency of 6-8 years. The model predicted that geothermal wells producing brines with a pH between 6 and 7 and temperatures less than 200°F would have a major maintenance frequency of one-half or 3-4 years. A major maintenance operation was defined in Reference 12 as one whose cost would be greater than 10% of the replacement cost. An expenditure of 10% every 3-4 years is equivalent to about 3% per year for the wells.

For surface equipment of the type included in the geothermal system, annual maintenance costs are generally estimated to range from 2-5% of the capital cost.

On the basis of these figures, it was decided to use a first year annual maintenance cost (materials and labor) of 3% of the total capital cost for each case. This cost was then escalated by 10% per year to get values for the remainder of the project life.

9 - Annual Chemical Costs

During the studies of geothermal brine treatment systems described in previous sections of this report, estimates of annual chemical requirements for each system were also developed. Based on these studies, it was concluded that a reasonable estimate of chemical costs would be 11.9¢/1000 gal. of brine based on first quarter 1980 prices in various chemical price lists. This cost was then escalated by 10% per year to get the costs for each year of the plant operating life.

10 - Intangible Drilling Costs

In order to estimate what percentage of the total drilling costs would be classed as intangible for income tax purposes, an analysis was made of the estimated cost breakdowns provided by Gruy and D'Appolonia. This analysis is summarized in Table V-9. The basic philosophy in the analysis was to consider the costs for all materials which could theoretically be removed from the well and reused as tangible costs. All other costs were intangible. The results of this analysis showed that 70% of the total well cost could be considered as intangible drilling cost. Therefore, this figure was used to determine the intangible drilling cost deduction for the year in which the well was completed. For this analysis, it was assumed that the corresponding tax reduction (i.e., positive cash flow) due to this deduction would occur in the first year of operation.

11 - Results of Analysis

Appendix B contains a Cash Flow Analysis Sheet for each of the 3 cases defined in Table V-7. The results of all the calculations described thus

TABLE V-9

ESTIMATE OF INTANGIBLE DRILLING COSTS

	<u>TANGIBLES</u>	<u>GRUY</u>	<u>D'APPOLONIA</u>
Tubulars		\$196,000 <u>138,000</u>	\$ 85,000 <u>85,000</u>
		\$334,000	\$170,000
Pump (modified cost)		<u>53,000</u>	<u>53,000</u>
TOTAL TANGIBLES		\$387,000	\$223,000
Total Tangible and Intangible		\$1,166,000	\$ 800,000
Pump adjustment		\$129,000-53,000 =	\$10,000-53,000 =
		- 76,000	+ 43,000
Pump test adjustment		+ 35,000	<u> </u>
Total adjusted		\$1,125,000	\$ 843,000
Tangible Drilling Cost/Total Cost Ratio		0.34	0.26
Intangible Drilling Cost/Total Cost Ratio		0.66	0.74
Avg. Intangible Cost/Total Cost Ratio			0.70

far in this section are contained on those sheets. In addition, some of the key results are presented graphically in this section.

Figure V-10 shows the total capital costs that were used in the analysis with a breakdown of the major cost categories.

The cost of the wells ranges from 50-75% of the total project cost depending on the conditions selected. It should be noted that the well cost would likely be less since the reinjection well would not be drilled to the same 5000 ft. depth as the production well.

Figure V-11 shows the after-tax rate of return as a function of the well output. The rate of return began to decline at the higher flow rates.

Figure V-12 shows the after-tax payback period for the project. As with the rate of return, the payback periods become less attractive at the higher flow rates.

In general, the maximum payback period which industrial firms will consider for energy projects is 3-6 years. As indicated on Figure V-12, retrofitting a geothermal system to the Campbell Soup Plant would not satisfy this criterion if it is assumed that the plant had coal fired boilers. This is true even though the most favorable conditions of brine temperature (150°F) and specific capacity (1.0) that realistically could be expected have been assumed. Based on this result, it was decided not to investigate any other cases with less favorable conditions.

12 - Sensitivity Analysis

Additional data (Appendix B) were developed to assess the sensitivity of the economic analysis results to energy cost escalation.

GEOHERMAL PROJECT CAPITAL COST
4TH QUARTER, 1980 PRICES

CAMPBELL SOUP CO., SALISBURY, MARYLAND

FIGURE V-10

GEOHERMAL PROJECT AFTER-TAX
RATE OF RETURN

CAMPBELL SOUP CO., SALISBURY, MARYLAND

FIGURE V-11

AFTER-TAX PAYBACK PERIODS

CAMPBELL SOUP CO., SALISBURY, MARYLAND

FIGURE V-12

As indicated by the experience of recent years, predicted coal and electricity cost escalation factors contain a substantial degree of uncertainty. The base case escalation schedule for this analysis was described earlier in this section, and was roughly equivalent to 10-14% per year through the life of the project. In order to test the sensitivity of the analysis results to escalation rates, calculations were made for four additional escalation schedules; namely, a constant 20, 30, 40, and 50% combined escalation and inflation per year throughout the entire 20 year life of the plant. The results of these calculations are shown on Figures V-13 and 14. As indicated on Figure V-14, escalation rates of 40-50%/yr would be required before the case analyzed here would pass the payback criteria established earlier.

H - OPERATING COST ESTIMATES AND ECONOMIC ANALYSIS - "GRASS ROOTS"

SITUATION

1 - Capital Cost Adjustment

Table V-8 indicates that the heat added to process ranges from 6.4-10.6 million Btu/hr depending on which of the 3 cases is considered. These energy inputs are equivalent to 6,400-10,600 lbs/hr of steam. The existing boilers at the Salisbury plant are rated at a total capacity of 41,000 lbs/hr. A rather detailed analysis of various factors such as reliability, availability, commercially available boiler sizes, etc. would be required in order to determine the amount by which the existing boiler capacity could have been reduced at the design stage if the geothermal source were available. It is quite probable that no significant reduction would have

SENSITIVITY OF RATE OF RETURN TO FUEL
ESCALATION RATE

CAMPBELL SOUP CO., SALISBURY, MARYLAND

FIGURE V-13

SENSITIVITY OF RATE OF RETURN TO FUEL ESCALATION RATE

FIGURE V-14

been made. However, in order to evaluate the potential improvement in economics for a "grass roots" geothermal plant versus the retrofit described in this report, the following optimistic analysis was performed.

It was assumed that with no geothermal source the plant would have three 20,000 lb/hr. coal fired boilers, so that with one boiler down for repairs or maintenance, the boiler plant still could produce 40,000 lb/hr. In the case of a geothermal hot water plant, it was assumed that two 25,000 -29,000 lb/hr. boilers (depending on the geothermal case involved) would suffice, because here again, with one source out, the remaining two heat sources could still supply the processing plant adequately. Prices for coal fired boilers f.o.b. factory were obtained from the E. Keeler Company. It was estimated that an installed boiler would cost between 1.5 and 2 times the f.o.b. price. A factor of two was used in the subsequent calculations in order to estimate the effects of introducing a geothermal source. The actual data are shown in Table V-10.

It was not felt that the geothermal system costs shown on Table V-7 were significantly affected by the fact that they were retrofit. Thus, the net savings would have been \$370,000 - \$450,000 of capital cost (Table V-10). The savings in capital cost of the coal fired boiler plant could be considered as a reduction in capital cost of the geothermal system of 24% in all three cases. Rates of return and payback periods for the retrofit plant and the grass roots plant are shown in Figures V-15 and V-16. Based on Figure V-16, the after-tax payback period would be on the order of 7 years.

TABLE V-10

FROZEN FOOD PLANT COAL FIRED BOILER COSTS

Potential Brine Flow	gpm	<u>150</u>	<u>207</u>	<u>236</u>
Geothermal Brine Temperature	°F	150	150	150
Heat to Process	MMBtu/hr.	6.37	8.79	10.64
Coal Saved	Ton/yr	1,809	2,497	3,021
Cost of 3 x 20,000 lbs/hr Boilers Installed	\$	1,650,000	1,650,000	1,650,000
Cost of 2 x 25,000 lbs/hr Boilers Installed	\$			1,200,000
Cost of 2 x 27,000 lbs/hr Boilers Installed	\$		1,260,000	
Cost of 2 x 29,000 lbs/hr Boilers Installed	\$	1,280,000		
Capital Saved on Boilers	\$	370,000	410,000	450,000

GEOTHERMAL PROJECT AFTER-TAX
RATE OF RETURN

CAMPBELL SOUP CO., SALISBURY, MARYLAND

FIGURE V-15

FIGURE V-16

SECTION VI

VI - INFORMATION DISSEMINATION ACTIVITIES

A - APPROACH

Burns and Roe Industrial Services Corporation's approach to the information dissemination task was as follows:

1. Identify all trade organizations in industries that were likely candidates for geothermal energy utilization. Contact these trade organizations by phone to assess their initial interest in scheduling a presentation. Follow-up letters were then sent to those groups expressing such an interest in order to formally solicit an invitation to make the presentation.
2. Respond to calls-for-papers issued by Technical Societies such as ASHRAE, Geothermal Resource Council, etc.
3. Participate with DOE's Food Industry Advisory panel in their efforts to disseminate geothermal information to industry.

B - RESULTS

The results of our attempts to find opportunities to make presentations to trade organizations has been somewhat successful.

Using a published encyclopedia of all trade organizations nationwide, about 30 appeared to represent those industrial sectors considered good candidates for application of geothermal energy.

These 30 organizations plus DOE's Food Industry Advisory Panel were contacted by phone. The Food Industry Advisory Team was formed under the

auspices of the Department of Energy to make the food industry aware of the potential for geothermal energy for process heat requirements. In nine cases, either the organization did not really deal in plant design (i.e., they were equipment manufacturers or product promoters, etc.), or they did not have any meetings scheduled for the next year or so.

Twenty-one trade organizations plus the DOE panel expressed an initial interest when contacted by phone, and subsequently they were sent a letter further explaining our objectives and summaries of the material that would be presented regarding two geothermal projects that we had worked on (1,8). As a result, there have been presentations at M.I.T., the University of California at Berkeley and at the Institute of Food Technologists meeting in September. These will be discussed further in the next subsection of this report. In addition, we submitted a paper on the Reference 1 study in response to a call-for-papers from ASHRAE. The paper was accepted and presented at the ASHRAE Semiannual Meeting in Chicago in January 1981.

Table VI-1 lists the 21 trade organizations that requested written summaries of the proposed presentations, along with the dates sent and notes on responses received to date. Appendix D contains copies of all letters sent to the trade organizations plus copies of the presentation summaries that were attached to each letter. These summaries are in the form of technical papers. Table VI-2 lists the 9 organizations that were classed as inappropriate after the initial phone contact.

TABLE VI-1

TRADE ORGANIZATIONS THAT REQUESTED
A WRITTEN DESCRIPTION OF PRESENTATION

W.O. 4862-01

	<u>DATE SENT</u>	<u>RESPONSE</u>
1. Mr. Chuck Yuska American Meat Institute Foundation Post Office Box 3556, Washington, DC 20007 703-841-2400	5/15/81	6/2, maybe
2. Mr. Ramon Billeaud American Sugar Cane League 416 Whitney Bldg. New Orleans, LA 70130 504-525-3956	5/15/81	
3. Mr. Allen Murfin Food and Energy Council 909 University Avenue Columbia, MO 65201 314-875-7155	5/18/81	6/3, no for 1981; maybe 1982
4. Dr. Fred Martin LSU - American Society of Sugar Cane Technologists Baton Route, LA 504-388-2110	5/18/81	
5. Mr. Roger Coleman Nat'l. Food Processors Assn. Washington, DC 202-331-5900	5/18/81 (See No. 16)	6/22, no
6. Mr. Steve Anderson Frozen Potato Prod. Inst. Washington, DC 202-857-0787	5/26/81	
7. Mr. Dave Bosman American Feed Manufacturers Assn. Arlington, VA 703-524-0810	5/26/81	
8. Mr. Bob Elmer American Dry Milk Institute and Whey Products Institute Chicago, IL 312-782-4888	5/26/81	
9. Mr. Lenwood Tipton Milk Industry Foundation Washington, DC 202-296-4250	6/1/81	7/28, no

TABLE VI-1 (Continued)

	<u>DATE SENT</u>	<u>RESPONSE</u>
10. Mr. Michael Olsen Food Services Research Blacksburg, VA 713-845-6651	6/1/81	
11. Mr. George Muller Sugar Industry Technologists Oak Harbor, WA 206-675-3122	6/1/81	
12. Mr. K.H. Berg Hawaiian Sugar Planters Assn. Aiea, HI 808-487-5561	6/1/81	6/9, maybe.
13. Institute of Food Technologists Chicago, IL 312-782-8424 Stan Wallen, U. of Nebraska 402-472-2814	8/14/80	9/5/80; 4/7/81, Presentation sched. 9/8/81, Lincoln, NE
14. American Frozen Food Institute McLean, VA Steve Anderson, 202-857-0787	8/5/80	9/11/80, no
15. Corn Refiners Assn. Washington, DC Kyd D. Brenner, 202-331-1634	4/9/81	7/8/81, maybe
16. National Food Processors Assn. Washington, DC Roger Coleman, 202-331-5900	(See No.5)	6/22, no
17. National Prepared Frozen Food Proc. Association Valley Stream, NY Mr. Webster, 516-825-6673	4/10/81	
18. Potato Chip/Snack Food Assn. Arlington, VA 703-920-4805		
19. United States Beet Sugar Assn. Washington, DC 202-296-4820		
20. ITT Continental Baking Co., Inc. Rye, NY A.H. Mirman 914-967-4747		1/31/81, maybe
21. U. California - Berkeley Michael Hanemann		Presentation, Davis, CA, 4/15/81

TABLE VI-2

TRADE ORGANIZATIONS THAT VERBALLY EXPRESSED NO INTEREST

Companies, Associations Contacted but Uninterested

1. American Meat Science Assn.
Chicago, IL
(Activity promotional but not involved with processing)
2. Beet Sugar Development Fdn.
Ft. Collins, CO
(No meeting in next 2 years)
3. Dehydrated & Convenience Food Council
Healdsburg, CA
(Out of existence)
4. U.S. Cane Sugar Refiners Assn.
New Orleans, LA
Dr. Margaret Clark
(Activity: pricing and marketing)
5. Food Processing Machinery Suppliers Assn.
Washington, DC
Mr. Dewey Clower
(Do not organize meetings)
6. Dairy and Food Industry Supply Assn.
Washington, DC
and
7. Dairy Industry Committee
Washington, DC
Mr. Thomson (Nos. 6 and 7)
(Only exposition of equip.; no papers)
8. American Cultured Dairy Products Inst.
Washington, DC
Mr. Rhodes
(Next meeting 10/82)
9. American Dairy Science Assn.
Champaign, IL
Mr. Cruse
(Next meeting June 1982)

C - REMARKS ON PRESENTATIONS MADE

Burns and Roe worked in coordination with EG&G Idaho in contacting various food industry organizations regarding the presentation of geothermal study results to their membership. As a result of these efforts, the following presentations were made or are planned:

1 - Presentation to the Food Industry Workshop

A presentation on the East Coast geothermal study was made to the Food Industry symposium at the University of California at Davis in April 1981 which was entitled, "Symposium on Innovations in Food Processing and Implications for Energy Substitution." In addition to our presentation, talks were given by representatives of John Inglis Frozen Food Co., Green Giant, Food Machinery Corporation, and members of the University of California Food Technology Department.

Approximately 50 people attended the symposium, many coming from food industry companies. Our presentation was last on the agenda and people were obviously in a hurry to leave so that no questions were asked after our formal talk. Therefore, it is difficult to assess under the circumstances what the actual interest level in geothermal energy was.

2 - Presentation to Massachusetts Institute of Technology (MIT)

At the request of DOE's Food Industry Advisory Panel, representatives of Burns and Roe and EG&G Idaho presented the results of the East and West Coast studies to MIT personnel to allow comparison runs to be made with the MIT-developed geothermal energy system costing program and with the results

of another study performed for DOE by MIT. Burns and Roe later participated in the writing of a detailed 10 page letter report on the presentation, analyzing discrepancies between findings of the MIT study and those of Burns and Roe and others. The reading of MIT's report and preparation of the letter report took considerably more effort than was originally planned for the presentations.

3 - Presentation to American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

A technical paper on the wet corn milling plant study (1) was prepared and presented in Chicago. A group of about 50 people were in the audience during the presentation. Several questions were asked indicating significant interest in geothermal energy as a resource.

4 - Presentation to AK-SAR-BEN Section of the Institute of Food Technologists (IFT)

A presentation was made to the IFT at their September 8, 1981 meeting in Omaha, Nebraska. The presentation covered both the corn milling plant study and the frozen food plant study. 40 - 50 people attended this meetings from companies such as:

Farmland Foods
Henningson Foods
Hormel
H. B. Fuller Co.
Skinner Macaroni
Proctor & Gamble

Swanson Center for Food Nutrition

Food & Drug Administration

Nebraska Energy Office

City of Omaha

5 - Presentation to ITT Continental Baking Company

Representatives of ITT had seen a notice in a newsletter from one of the trade organizations regarding our offer to make presentations on geothermal energy utilization. They wrote a letter requesting that we make an informal presentation to a few representatives of their company. Since their corporate offices were close to ours, it was decided to accept their invitation. After a two hour informal discussion on the results of our study, the ITT representatives seemed very interested and asked for additional information on the potential for using geothermal energy in their plants. In response to their request, we contacted DOE's regional technical assistance contractors for additional information on behalf of ITT. Appendix E contains all correspondence sent and received concerning ITT during this study.

In addition to the 5 presentations discussed above, we have also received a request from the Editor of Food Engineering Magazine to provide information on our feasibility studies for an article on the use of geothermal energy which they are considering for their October 1981 issue. As indicated by the letters in Appendix F, we have complied with their request as part of our information dissemination task. This type of exposure should be as effective as oral presentations as far as communicating with the potential industrial users is concerned.

VII - REFERENCES

- 1 - "Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant," by Burns and Roe Industrial Services Corp; for U.S. Department of Energy (DOE Contract No. DE-AC03-79ET-27231); March 1981.
- 2 - Personal Communication with Brian Boswell, WESTEC Services, Inc., San Diego, CA.
- 3 - Personal Communication with Virgil Welch, Republic Drilling, El Centro, CA.
- 4 - Personal Communication with Debra Struhsacker, Earth Science Laboratory, University of Utah Research Institute, Salt Lake City, UT.
- 5 - Chappell, R.N., et al, Geothermal Well Drilling Estimates Based on Past Well Costs, Geothermal Resources Council, Transactions, Vol. 3, September 1979.
- 6 - U.S. Department of Energy, Office of Conservation and Solar Energy, Federal Energy Management and Planning Programs; Methodology and Procedures for Life Cycle Cost Analysis. Part IX, Wednesday, January 23, 1980.
- 7 - Gass, T.E., Purdin, W.H., Armitage, DM, "Economic Impact of Using Nonmetallic Materials in Low to Intermediate Temperature Geothermal Well Construction - Volume I," National Water Well Association for Brookhaven National Laboratory, December 1979.

- 8 - "Direct Application of East Coast Geothermal Resources in a Frozen Food Plant," Final Report, June 1980. Burns and Roe Industrial Services Corporation and Campbell Soup Company.
- 9 - Special Report No. 5, A Symposium of Geothermal Energy and its Direct Usage in the Eastern United States, April 1979, Geothermal Resources Council, Davis, CA.
- 10 - Completion Report, Gruy Federal, Inc., Department of Energy Crisfield Airport No. 1 Well, Somerset County, MD, 1979.
- 11 - Federal Register, Vol. 45, No. 16, Jan. 23, 1980, 10CFR Part 436, Tables C-6/C-8, pages 5644 - 5646.
- 12 - Gass, T.E., Purdin, W.H., Armitage, D.M., "Economic Impact of Using Nonmetallic Materials in Low to Intermediate Temperature Geothermal Well Construction - Volume I," National Water Well Association for Brookhaven National Laboratory, December 1979.

APP. A

APPENDIX A

Cash Flow Analysis Sheets - Corn Milling Plant

Sample Cash Flow Analysis

CASE: I BASE CAPITAL COST

Initial Nat. Gas Escalation: 20 %

Nat. Gas Savings = 44.06 mcf/yr

Elect. Consumption = -4218 kWh/yr

Well Cost = \$1,570,000 surface system = \$331,480 Total = \$1,901,480 Buildings = \$5,465

ALL ANNUAL COSTS ARE IN \$1000

No of Years After Start	Unit Nat. Gas Cost, \$/MMBtu	Unit Elect. Cost, \$/KWH	Capital Cost	Taxes & Insurance @ 2%	Elect. Power Cost	Maintenance Cost @ 3%	Chemical Cost	Nat Gas Savings	Net Cash Income	Intangible Drilling Cost	Depreciation	Taxable Income	Tax Credit	Income Tax @ 48.6 %	Net Cash Flow	Cumulative Cash Flow
Present	3.80	.0376	-1902													
0	4.56	.0432	-1997						-1997							
1	5.472	.0497		-39.9	209.7	-59.9	-5.26	241.1	345.7	-1154	-99.8	-928.1	325.3	766.6	1112.3	
2	6.566	.0572		-43.9	241.3	-65.9	-5.79	289.3	415.0		-99.8	315.2		-153.2	261.8	1374.1
3	7.880	.0658		-48.3	272.4	-72.5	-6.36	347.2	497.4		-99.8	397.6		-193.2	304.2	1678.3
4	9.456	.0756		-53.2	319.0	-79.7	-7.00	416.6	595.7		-99.8	495.9		-241.0	354.7	2033.0
5	10.401	.0832		-58.5	350.9	-87.7	-7.70	458.3	653.3		-99.8	555.5		-270.0	385.3	
6									720.8						719.0	
7									792.2						456.0	
8									872.2						196.8	
9									957.4						51.6	
10									1055.4						591.0	
11									1160.9						645.2	
12									1277.0						704.9	
13									1404.7						770.5	
14									1545.2						842.7	
15									1699.7						922.1	
16									1869.6						1009.5	
17									2056.6						1105.6	
18									2262.3						1211.3	
19									2482.5						1327.6	
20									2717.4		Y				1455.5	

W.O. No. 4862-01 Date Book No. Page No. of
 Drawing No. Checked Calc. No. Sheet
 By Title Gas Products - Geothermal Study Approved

Burns and Roe
Industrial Services Corp.

GENERAL DATA APPLICABLE TO ALL CASES

COAL FIRED

FIRST YEAR FUEL COST, \$/MBTU	2.000
FIRST YEAR ELECTRICITY COST, \$/KWH	0.04970
TAX & INSURANCE, % OF CAPITAL COST	2.0
MAINTENANCE, % OF CAPITAL COST	3.0
INCOME TAX, % OF TAXABLE INCOME	48.6
NUMBER OF PLANT LIFE CASES	1
PLANT LIFE, YEARS	20

NUMBER OF FUEL COST CASES = 1

FUEL ESCALATION BY YEAR, IN PERCENT

YEAR	CASE 1
2	22.78
3	22.78
4	22.78
5	11.04
6	11.04
7	11.04
8	11.04
9	11.04
10	10.85

ESCALATION RATE IS CONSTANT THEREAFTER

ELECTRICITY ESCALATION BY YEAR, IN PERCENT

YEAR	RATE
2	13.3
3	13.3
4	13.3
5	9.02
6	9.02
7	9.02
8	9.02
9	9.02
10	9.08

ESCALATION RATE IS CONSTANT THEREAFTER

ANNUAL ESCALATION RATES, IN PERCENT, FOR...

TAXES AND INSURANCE -	10
MAINTENANCE -	10
CHEMICAL COST -	10

CASE I BASE CAP COST

RUN NO. 1

COAL FIRED

FUEL ESCALATION CASE NO. 1
PLANT LIFE, YRS - 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, 1010TU/YR 46,986
ELECTRIC CONSUMPTION, KWH/YR -4218
CHEMICAL COST (YR 1), \$ 5.259
CAPITAL COST, \$ 1997.1
INTANGIBLE DRILLING COST, \$ 1154
TAX CREDIT, \$ 325.3

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/1010TU	2.000	ELECTRICITY, \$/KWH	0.0497
TAXES & INSURANCE	-39.9	ELECTRICITY	209.6
MAINTENANCE	-59.9	CHEMICALS	-5.2
FUEL SAVINGS	93.9	NET CASH INCOME	198.4
INTANG DRILL COST	-1154.0	DEPRECIATION	-99.8
TAXABLE INCOME	-1055.3	TAX CREDIT	325.3
INCOME TAX	838.2	NET CASH FLOW	1036.6

YEAR	NET CASH INCOME	NET CASH FLOW
------	-----------------	---------------

1	198.4	1036.6
2	237.2	170.4
3	283.5	194.2
4	338.9	222.7
5	371.6	239.5
6	407.5	258.0
7	446.9	278.2
8	490.2	300.5
9	537.8	324.9
10	589.8	351.6
11	646.8	381.0
12	709.4	413.1
13	778.1	448.5
14	853.6	487.3
15	936.5	529.9
16	1027.5	576.6
17	1127.4	628.0
18	1237.2	684.4
19	1357.8	746.4
20	1490.3	814.5

ON NET CASH INCOME

ROI= 19.89 %

PAYBACK= 6.35 YEARS

ON NET CASH FLOW

ROI= 19.96 %

PAYBACK= 5.51 YEARS

CASE 1 -25% CAP COST

RUN NO. 1

COAL FIRED

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MBTU/YR 46,986

ELECTRIC CONSUMPTION, KWH/YR -4218

CHEMICAL COST (YR 1), \$ 5.259

CAPITAL COST, \$ 1497.8

INTANGIBLE DRILLING COST, \$ 865.5

TAX CREDIT, \$ 244

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MBTU 2,000 ELECTRICITY, \$/KWH 0.0497

TAXES & INSURANCE -29.9 ELECTRICITY 209.6

MAINTENANCE -44.9 CHEMICALS -5.2

FUEL SAVINGS 93.9 NET CASH INCOME 223.4

INTANG DRILL COST -865.5 DEPRECIATION -74.8

TAXABLE INCOME -716.9 TAX CREDIT 244.0

INCOME TAX 592.4 NET CASH FLOW 815.8

YEAR NET CASH INCOME NET CASH FLOW

1 223.4 815.8

2 264.7 172.4

3 313.7 197.6

4 372.1 227.6

5 408.1 246.2

6 447.7 266.5

7 491.2 288.8

8 538.9 313.4

9 591.3 340.3

10 648.6 369.8

11 711.5 402.1

12 780.6 437.6

13 856.5 476.6

14 939.8 519.4

15 1031.3 566.5

16 1131.8 618.1

17 1242.2 674.8

18 1363.4 737.2

19 1496.6 805.6

20 1643.0 880.9

ON NET CASH INCOME

ON NET CASH FLOW

ROI= 26.45 %

ROI= 25.18 %

PAYBACK= 4.79 YEARS

PAYBACK= 4.34 YEARS

CASE I +25% CAP COST RUN NO. 1 COAL FIRED

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MBTU/YR 46,986

ELECTRIC CONSUMPTION, KWH/YR 4218

CHEMICAL COST (YR 1), \$ 5.259

CAPITAL COST, \$ 2496.3

INTANGIBLE DRILLING COST, \$ 1442.4

TAX CREDIT, \$ 406.6

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MBTU 2.000 ELECTRICITY, \$/KWH 0.0497

TAXES & INSURANCE -49.9 ELECTRICITY 209.6

MAINTENANCE -74.8 CHEMICALS -5.2

FUEL SAVINGS 93.9 NET CASH INCOME 173.5

INTANG DRILL COST -1442.4 DEPRECIATION -124.8

TAXABLE INCOME -1393.6 TAX CREDIT 406.6

INCOME TAX 1083.9 NET CASH FLOW 1257.4

YEAR NET CASH INCOME NET CASH FLOW

1 173.5 1257.4

2 209.8 168.5

3 253.3 190.8

4 305.7 217.7

5 335.0 232.8

6 367.3 249.4

7 402.7 267.6

8 441.6 287.6

9 484.3 309.6

10 530.9 333.5

11 582.1 359.8

12 638.2 388.7

13 699.8 420.3

14 767.4 455.1

15 841.7 493.3

16 923.2 535.2

17 1012.7 581.2

18 1111.1 631.7

19 1219.0 687.2

20 1337.6 740.2

ON NET CASH INCOME

ROI= 15.32 %

PAYBACK= 8.01 YEARS

ON NET CASH FLOW

ROI= 16.29 %

PAYBACK= 6.66 YEARS

CASE II BASE CAP COST

RUN NO. 1

COAL FIRED

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS - 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, 1000TU/YR	64.186
ELECTRIC CONSUMPTION, KWH/YR	-19868
CHEMICAL COST (YR 1), \$	5.712
CAPITAL COST, \$	2752.7
INTANGIBLE DRILLING COST, \$	1154
TAX CREDIT, \$	511.8

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/100TU	2.000	ELECTRICITY, \$/KWH	0.0497
TAXES & INSURANCE	-55.0	ELECTRICITY	987.4
MAINTENANCE	-82.5	CHEMICALS	-5.7
FUEL SAVINGS	128.3	NET CASH INCOME	972.4
INTANG DRILL COST	-1154.0	DEPRECIATION	-137.6
TAXABLE INCOME	-319.1	TAX CREDIT	511.8
INCOME TAX	666.9	NET CASH FLOW	1639.3

YEAR	NET CASH INCOME	NET CASH FLOW
------	-----------------	---------------

1	972.4	1639.3
2	1118.7	641.9
3	1287.6	728.7
4	1482.9	829.1
5	1619.6	899.3
6	1769.0	976.1
7	1932.2	1060.0
8	2110.6	1151.7
9	2305.5	1251.9
10	2519.1	1361.7
11	2752.6	1401.7
12	3007.9	1612.9
13	3286.9	1756.3
14	3591.9	1913.1
15	3925.4	2084.5
16	4290.0	2271.9
17	4688.6	2476.8
18	5124.5	2700.8
19	5601.1	2945.8
20	6122.2	3213.7

ON NET CASH INCOME

ON NET CASH FLOW

ROI= 47.80 %

ROI= 39.44 %

PAYBACK= 2.51 YEARS

PAYBACK= 2.64 YEARS

CASE II -25% CAP COST

RUN NO. 1

COAL FIRED

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MBTU/YR	64.186
ELECTRIC CONSUMPTION, KWH/YR	-19868
CHEMICAL COST (YR 1), \$	5.712
CAPITAL COST, \$	2064.5
INTANGIBLE DRILLING COST, \$	865.5
TAX CREDIT, \$	383.8

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MBTU	2.000	ELECTRICITY, \$/KWH	0.0497
TAXES & INSURANCE	-41.2	ELECTRICITY	987.4
MAINTENANCE	-61.9	CHEMICALS	-5.7
FUEL SAVINGS	128.3	NET CASH INCOME	1006.8
INTANG DRILL COST	-865.5	DEPRECIATION	-103.2
TAXABLE INCOME	38.1	TAX CREDIT	383.8
INCOME TAX	365.2	NET CASH FLOW	1372.1

YEAR	NET CASH INCOME	NET CASH FLOW
------	-----------------	---------------

1	1006.8	1372.1
2	1156.5	644.6
3	1329.2	733.4
4	1528.7	835.9
5	1670.0	908.5
6	1824.4	987.9
7	1993.1	1074.6
8	2177.6	1169.4
9	2379.3	1273.1
10	2600.2	1386.7
11	2841.9	1510.9
12	3106.0	1646.6
13	3394.9	1795.1
14	3710.7	1957.4
15	4056.1	2135.0
16	4433.7	2329.1
17	4846.7	2541.4
18	5298.4	2773.5
19	5792.4	3027.4
20	6332.6	3305.1

ON NET CASH INCOME

ON NET CASH FLOW

ROI= 61.78 %

ROI= 48.85 %

PAYBACK= 1.91 YEARS

PAYBACK= 2.06 YEARS

CASE II +25% CAP COST

RUN NO. 1

COAL FIRED

FUEL ESCALATION CASE NO. 1
PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MBTU/YR	64.186
ELECTRIC CONSUMPTION, KWH/YR	-19868
CHEMICAL COST (YR 1), \$	5.712
CAPITAL COST, \$	3440.9
INTANGIBLE DRILLING COST, \$	1442.4
TAX CREDIT, \$	639.8

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MBTU	2.000	ELECTRICITY, \$/KWH	0.0497
TAXES & INSURANCE	-60.8	ELECTRICITY	987.4
MAINTENANCE	-103.2	CHEMICALS	-5.7
FUEL SAVINGS	128.3	NET CASH INCOME	938.0
INTANG DRILL COST	-1442.4	DEPRECIATION	-172.0
TAXABLE INCOME	-676.3	TAX CREDIT	639.8
INCOME TAX	968.5	NET CASH FLOW	1906.5

YEAR	NET CASH INCOME	NET CASH FLOW
1	938.0	1906.5
2	1080.8	639.1
3	1245.9	724.0
4	1437.1	822.3
5	1569.2	890.2
6	1713.6	964.4
7	1871.2	1045.4
8	2043.5	1134.0
9	2231.7	1230.7
10	2438.0	1336.7
11	2663.4	1452.6
12	2909.7	1579.2
13	3178.9	1717.5
14	3473.1	1868.8
15	3794.7	2034.1
16	4146.3	2214.8
17	4530.5	2412.3
18	4950.5	2628.2
19	5409.7	2864.2
20	5911.7	3122.2

ON NET CASH INCOME

ROI= 39.20 %

PAYBACK= 3.12 YEARS

ON NET CASH FLOW

ROI= 33.40 %

PAYBACK= 3.20 YEARS

CASE III +25% CAP CST

RUN NO. 1

COAL FIRED

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MMBTU/YR -85.9277

ELECTRIC CONSUMPTION, KWH/YR -18300

CHEMICAL COST (YR 1), \$ 0

CAPITAL COST, \$ 945

INTANGIBLE DRILLING COST, \$ 0

TAX CREDIT, \$ 233.25

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MMBTU 2.000 ELECTRICITY, \$/KWH 0.0497

TAXES & INSURANCE -18.9 ELECTRICITY 909.5

MAINTENANCE -28.3 CHEMICALS 0.0

FUEL SAVINGS -171.8 NET CASH INCOME 690.4

INTANG DRILL COST 0.0 DEPRECIATION -47.2

TAXABLE INCOME 643.1 TAX CREDIT 233.2

INCOME TAX -79.3 NET CASH FLOW 611.0

YEAR NET CASH INCOME NET CASH FLOW

1 690.4 611.0

2 767.4 417.4

3 851.2 460.5

4 941.8 507.0

5 1019.7 547.1

6 1103.9 590.3

7 1194.8 637.0

8 1292.9 687.5

9 1398.9 742.0

10 1515.5 801.9

11 1641.5 866.7

12 1777.8 936.7

13 1925.0 1012.4

14 2084.1 1094.2

15 2255.9 1182.5

16 2441.5 1277.9

17 2641.8 1380.8

18 2858.0 1492.0

19 3091.3 1611.9

20 3343.0 1741.2

ON NET CASH INCOME ON NET CASH FLOW

ROI= 83.46 % ROI= 56.95 %

PAYBACK= 1.33 YEARS PAYBACK= 1.79 YEARS

CASE III BASE CAP CST

RUN NO. 1

COAL FIRED

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MBTU/YR -85.9277

ELECTRIC CONSUMPTION, KWH/YR -18300

CHEMICAL COST (YR 1), \$ 0

CAPITAL COST, \$ 756

INTANGIBLE DRILLING COST, \$ 0

TAX CREDIT, \$ 186.6

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MBTU 2.000

ELECTRICITY, \$/KWH 0.0497

TAXES & INSURANCE -15.1

ELECTRICITY 909.5

MAINTENANCE -22.6

CHEMICALS 0.0

FUEL SAVINGS -171.8

NET CASH INCOME 699.8

INTANG DRILL COST 0.0

DEPRECIATION -37.8

TAXABLE INCOME 662.0

TAX CREDIT 186.6

INCOME TAX -135.1

NET CASH FLOW 564.6

YEAR

NET CASH INCOME

NET CASH FLOW

1 699.8 564.6

2 777.8 418.2

3 862.7 461.8

4 954.4 508.9

5 1033.5 549.6

6 1119.1 593.6

7 1211.5 641.1

8 1311.3 692.4

9 1419.1 747.8

10 1537.7 808.7

11 1666.0 874.7

12 1804.7 946.0

13 1954.7 1023.0

14 2116.7 1106.3

15 2291.8 1196.3

16 2480.9 1293.6

17 2685.2 1398.5

18 2905.8 1511.9

19 3143.8 1634.3

20 3400.8 1766.3

ON NET CASH INCOME

ON NET CASH FLOW

ROI= ##.## %

ROI= 68.39 %

PAYBACK= 1.07 YEARS

PAYBACK= 1.45 YEARS

CASE III -25% CAP CST

RUN NO. 1

COAL FIRED

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MBTU/YR -85.9277

ELECTRIC CONSUMPTION, KWH/YR -18300

CHEMICAL COST (YR 1), \$ 0

CAPITAL COST, \$ 567

INTANGIBLE DRILLING COST, \$ 0

TAX CREDIT, \$ 139.95

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MBTU 2.000 ELECTRICITY, \$/KWH 0.0497

TAXES & INSURANCE -11.3 ELECTRICITY 909.5

MAINTENANCE -17.0 CHEMICALS 0.0

FUEL SAVINGS -171.8 NET CASH INCOME 709.3

INTANG DRILL COST 0.0 DEPRECIATION -28.3

TAXABLE INCOME 680.9 TAX CREDIT 139.9

INCOME TAX -190.9 NET CASH FLOW 518.3

YEAR	NET CASH INCOME	NET CASH FLOW
------	-----------------	---------------

1	709.3	518.3
---	-------	-------

2	788.2	418.9
---	-------	-------

3	874.1	463.0
---	-------	-------

4	966.9	510.8
---	-------	-------

5	1047.4	552.1
---	--------	-------

6	1134.3	596.8
---	--------	-------

7	1228.2	645.1
---	--------	-------

8	1329.8	697.2
---	--------	-------

9	1439.4	753.6
---	--------	-------

10	1560.0	815.6
----	--------	-------

11	1690.5	882.7
----	--------	-------

12	1831.7	955.2
----	--------	-------

13	1984.3	1033.7
----	--------	--------

14	2149.3	1118.5
----	--------	--------

15	2327.7	1210.2
----	--------	--------

16	2520.4	1309.2
----	--------	--------

17	2728.6	1416.3
----	--------	--------

18	2953.5	1531.9
----	--------	--------

19	3196.4	1656.7
----	--------	--------

20	3458.6	1791.4
----	--------	--------

ON NET CASH INCOME

ON NET CASH FLOW

ROI= ##.## %

ROI= 86.96 %

PAYBACK= 0.79 YEARS

PAYBACK= 1.11 YEARS

APP. B

APPENDIX B

Cash Flow Analysis Sheets - Frozen Food Plant

GENERAL DATA APPLICABLE TO ALL CASES

REFERENCE ESCALATION RATE

REV. ESCALATION

REPRODUCTION

FIRST YEAR FUEL COST, \$/BOU 3.006
 FIRST YEAR ELECTRICITY COST, \$/BOU 0.05200
 TAX & INSURANCE, % OF CAPITAL COST 2.0
 MAINTENANCE, % OF CAPITAL COST 3.0
 INCOME TAX, % OF TAXABLE INCOME 48.6
 NUMBER OF PLANT LIFE CASES 1
 PLANT LIFE, YEARS 20

NUMBER OF FUEL COST CASES = 1

FUEL ESCALATION BY YEAR, IN PERCENT

YEAR CASE 1

2 13.85

3 13.85

4 13.85

5 11.76

6 11.76

7 11.76

8 11.76

9 11.76

10 12.08

ESCALATION RATE IS CONSTANT THEREAFTER

ELECTRICITY ESCALATION BY YEAR, IN PERCENT

YEAR RATE

2 11.66

3 11.66

4 11.66

5 9.86

6 9.86

7 9.86

8 9.86

9 9.86

10 10.54

ESCALATION RATE IS CONSTANT THEREAFTER

ANNUAL ESCALATION RATES, IN PERCENT, FOR...

TAXES AND INSURANCE = 10

MAINTENANCE = 10

CHEMICAL COST = 10

CASE 1507/150GPM/1.0

RUN NO: 1

REFERENCE ESCALATION RATES

REV. ESCALATION

RETROFIT

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, TONN/YR 39.81

ELECTRIC CONSUMPTION, KWH/YR 257

CHEMICAL COST (YR 1), \$ 8.1

CAPITAL COST, \$ 1553

INTANGIBLE DRILLING COST, \$ 757.4

TAX CREDIT, \$ 270.4

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTE)

FUEL, \$/TONN 3.006

ELECTRICITY, \$/KWH 0.0520

TAXES & INSURANCE -31.0

ELECTRICITY -13.3

MAINTENANCE -46.5

CHEMICALS -8.1

FUEL SAVINGS 119.6

NET CASH INCOME 20.5

INTANG DRILL COST -757.4

DEPRECIATION -77.6

TAXABLE INCOME -814.4

TAX CREDIT 270.4

INCOME TAX 666.2

NET CASH FLOW 686.7

YEAR NET CASH INCOME NET CASH FLOW

1 20.5 686.7

2 26.9 51.6

3 34.6 55.5

4 43.8 60.2

5 51.3 64.1

6 60.0 68.5

7 69.9 73.6

8 81.2 79.5

9 94.3 86.2

12 109.9 94.2

11 127.9 103.5

12 148.6 114.1

11 172.3 126.3

14 199.3 140.2

10 15 230.3 156.1

16 265.8 174.3

9 17 306.3 195.1

18 352.5 218.9

19 405.2 246.9

7 20 465.4 276.9

ON NET CASH INCOME

ON NET CASH FLOW

ROI= 5.35 %

ROI= 7.83 %

PAYBACK= 15.30 YEARS

PAYBACK= 12.11 YEARS

CASE 150F/207GPM/1.0

RUN NO. 1

REFERENCE ESCALATION RATES

REV. ESCALATION

FUEL ESCALATION CASE NO. 1

RETROFIT

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MBTU/YR	54.94
ELECTRIC CONSUMPTION, KWH/YR	379
CHEMICAL COST (YR 1), \$	11.1
CAPITAL COST, \$	1715
INTANGIBLE DRILLING COST, \$	784
TAX CREDIT, \$	306.9

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MBTU	3.006	ELECTRICITY, \$/KWH	0.0520
TAXES & INSURANCE	-34.3	ELECTRICITY	-19.7
MAINTENANCE	-51.4	CHEMICALS	-11.1
FUEL SAVINGS	165.1	NET CASH INCOME	48.5
INTANG DRILL COST	-784.0	DEPRECIATION	-85.7
TAXABLE INCOME	-821.1	TAX CREDIT	306.9
INCOME TAX	705.9	NET CASH FLOW	754.5

YEAR	NET CASH INCOME	NET CASH FLOW
------	-----------------	---------------

1	48.5	754.5
2	59.4	72.2
3	72.3	78.8
4	87.3	86.5
5	100.4	93.2
6	115.3	100.9
7	132.2	109.6
8	151.5	119.5
9	173.4	130.8
10	199.3	144.1
11	228.9	159.3
12	262.6	176.6
13	301.0	196.3
14	344.7	218.8
15	394.4	244.4
16	450.9	273.4
17	515.2	306.4
18	588.2	344.0
19	671.1	386.6
20	765.2	435.0

ON NET CASH INCOME

ON NET CASH FLOW

ROI= 9.30 %

ROI= 10.72 %

PAYBACK= 12.27 YEARS

PAYBACK= 10.15 YEARS

REV. 3/19/92

REFERENCE ESCALATION RATES

CASE 150F/234GPM/1.0

RUN NO. 1

REV. ESCALATION

RETROFIT

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MBTU/YR 66.5

ELECTRIC CONSUMPTION, KWH/YR 1688

CHEMICAL COST (YR 1), \$ 12.6

CAPITAL COST, \$ 1873

INTANGIBLE DRILLING COST, \$ 794.5

TAX CREDIT, \$ 330.2

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MBTU 3.006 ELECTRICITY, \$/KWH 0.0526

WATER & EFFLUENT -37.7 WASTE -37.7

MAINTENANCE -56.1 CHEMICALS -12.6

FUEL SAVINGS 129.8 NET CASH INCOME 5.8

INTANG DRILL COST -794.5 DEPRECIATION -93.6

TAXABLE INCOME -882.2 TAX CREDIT 330.2

INCOME TAX 758.9 NET CASH FLOW 764.8

YEAR	NET CASH INCOME	NET CASH FLOW
1	5.8	764.8
2	12.6	52.0
3	21.1	56.3
4	31.3	61.6
5	39.8	66.0
6	49.8	71.1
7	61.5	77.1
8	75.1	84.1
9	91.0	92.2
10	109.7	101.9
11	131.5	113.1
12	156.8	126.1
13	186.1	141.2
14	220.1	158.6
15	259.3	178.7
16	304.5	202.0
17	356.6	228.8
18	416.5	259.6
19	485.4	295.0
20	564.5	335.7

ON NET CASH INCOME

ROI= 4.39 %

PAYBACK= 16.32 YEARS

ON NET CASH FLOW

ROI= 6.66 %

PAYBACK= 13.40 YEARS

GENERAL DATA APPLICABLE TO ALL CASES

20% FUEL ESCALAT

FIRST YEAR FUEL COST, \$/MBTU 3.006
FIRST YEAR ELECTRICITY COST, \$/MBTU 0.05200
TAX & INSURANCE, % OF CAPITAL COST 2.0
MAINTENANCE, % OF CAPITAL COST 3.0
INCOME TAX, % OF TAXABLE INCOME 48.6
NUMBER OF PLANT LIFE CASES 1
PLANT LIFE, YEARS 20

NUMBER OF FUEL COST CASES = 1
FUEL ESCALATION 1Y YEAR, IN PERCENT
YEAR CASE 1

2 20

ESCALATION RATE IS CONSTANT THEREAFTER

ELECTRICITY ESCALATION BY YEAR, IN PERCENT
YEAR RATE

2 17

ESCALATION RATE IS CONSTANT THEREAFTER

ANNUAL ESCALATION RATES, IN PERCENT, FOR...

TAXES AND INSURANCE = 10

MAINTENANCE = 10

CHURICAL COST = 10

CASE 150F/150GPM/1.0 RUN NO. 1 20% FUEL ESCALAT

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, \$/MONTH 39.81

ELECTRIC CONSUMPTION, KWH/YR 257

CHEMICAL COST (YR 1), \$ 8.1

CAPITAL COST, \$ 1551

HYDRAULIC DRILLING COST, \$ 757.4

TAX CREDIT, \$ 270.4

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MONTH 3.006 ELECTRICITY, \$/KWH 0.0520

TAXES & INSURANCE -31.0 ELECTRICITY -13.3

MAINTENANCE -46.5 CHEMICALS -8.1

FUEL SAVINGS 119.6 NET CASH INCOME 20.5

HYDRAULIC DRILL COST -757.4 DEPRECIATION -77.6

TAXABLE INCOME -814.4 TAX CREDIT 270.4

INCOME TAX 666.2 NET CASH FLOW 686.7

YEAR NET CASH INCOME NET CASH FLOW

1 20.5 686.7

2 33.6 55.0

3 50.2 63.5

4 71.2 74.3

5 97.5 87.8

6 130.3 104.7

7 171.1 125.7

8 221.5 151.6

9 283.8 183.6

10 360.3 222.9

11 454.3 271.2

12 569.3 330.3

13 709.9 402.6

14 881.4 490.8

15 1090.4 598.2

16 1344.7 728.9

17 1653.6 887.7

18 2028.7 1080.5

19 2483.6 1314.3

20 3034.8 1597.6

ON NET CASH INCOME ON NET CASH FLOW

ROI= 16.88 % ROI= 16.93 %

PAYBACK= 10.24 YEARS PAYBACK= 9.08 YEARS

CASE 150F/207GPI/1.0

RHH NO. 1

20% FUEL ESCALAT

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, \$/BBL/YR 54.94

ELECTRIC CONSUMPTION, KWH/YR 379

CHEMICAL COST (YR 1), \$ 11.1

CAPITAL COST, \$ 1715

INTANGIBLE DRILLING COST, \$ 784

TAX CREDIT, \$ 306.9

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/BBL 3.006

ELECTRICITY, \$/KWH 0.0520

TAXES & INSURANCE -34.3

ELECTRICITY -19.7

MAINTENANCE -51.4

CHEMICALS -11.1

FUEL SAVINGS 165.1

NET CASH INCOME 48.5

INTANG DRILL COST -784.0

DEPRECIATION -85.7

TAXABLE INCOME -821.1

TAX CREDIT 306.9

INCOME TAX 705.9

NET CASH FLOW 754.5

YEAR	NET CASH INCOME	NET CASH FLOW
1	48.5	754.5
2	68.5	76.9
3	93.6	89.8
4	124.9	105.8
5	163.7	125.0
6	211.7	150.5
7	271.1	172.6
8	343.2	218.4
9	433.2	264.3
10	542.8	320.6
11	676.6	389.4
12	839.9	473.3
13	1038.8	575.6
14	1280.9	700.0
15	1575.0	851.2
16	1932.2	1034.8
17	2365.3	1257.4
18	2890.1	1527.2
19	3525.7	1853.8
20	4294.6	2249.1

ON NET CASH INCOME

ON NET CASH FLOW

ROI= 19.86 %

ROI= 19.34 %

PAYBACK= 8.39 YEARS

PAYBACK= 8.04 YEARS

CASE 150P/234GPI/1.0

FUEL NO. 1

20% FUEL ESCALAT

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, 18000/YR 66.5

ELECTRIC CONSUMPTION, KWH/YR 1688

CHEMICAL COST (YR 1), \$ 12.6

CAPITAL COST, \$ 1873

INTANGIBLE DRILLING COST, \$ 794.5

TAX CREDIT, \$ 330.2

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/18000 3.006

ELECTRICITY, \$/KWH 0.0520

TAXES & INSURANCE -37.4

ELECTRICITY -87.7

MAINTENANCE -56.1

CHEMICALS -12.6

FUEL SAVINGS 199.8

NET CASH INCOME 5.8

INTANG DRILL COST -794.5

DEPRECIATION -93.6

TAXABLE INCOME -882.2

TAX CREDIT 330.2

INCOME TAX 758.9

NET CASH FLOW 764.8

YEAR	NET CASH INCOME	NET CASH FLOW
1	5.8	764.8
2	20.3	55.9
3	39.1	65.6
4	63.4	78.1
5	94.4	94.0
6	133.8	114.3
7	183.5	139.8
8	245.7	171.8
9	323.5	211.8
10	420.2	261.5
11	540.2	323.1
12	688.4	399.4
13	871.2	493.3
14	1096.2	603.9
15	1372.4	750.9
16	1710.9	924.0
17	2125.2	1137.0
18	2631.6	1393.1
19	3249.6	1715.8
20	4003.1	2103.1

ON NET CASH INCOME

ON NET CASH FLOW

ROI= 16.73 %

ROI= 16.46 %

PAYBACK= 10.63 YEARS

PAYBACK= 9.67 YEARS

GENERAL DATA APPLICABLE TO ALL CASES

10% FUEL ESCAL.

FIRST YEAR FUEL COST, \$/GAL 3.406
 FIRST YEAR MAINTENANCE COST, \$/GAL 0.05267
 TAX & INSURANCE, % OF CAPITAL COST 2.0
 MAINTENANCE, % OF CAPITAL COST 3.0
 INCOME TAX, % OF TAXABLE INCOME 48.6
 NUMBER OF PLANT LIFE CASES 1
 PLANT LIFE, YEARS 20

NUMBER OF FUEL COST CASES = 1

FUEL ESCALATION BY YEAR, IN PERCENT

YEAR CASE 1

2 30

ESCALATION RATE IS CONSTANT THEREAFTER

ELECTRICITY ESCALATION BY YEAR, IN PERCENT

YEAR RATE

2 25.5

ESCALATION RATE IS CONSTANT THEREAFTER

ANNUAL ESCALATION RATES, IN PERCENT, FOR...

TAXES AND INSURANCE = 10

MAINTENANCE = 10

CHEMICAL COST = 10

CASE 150F/150GPH/1.0

RRI NO. 1

30% FUEL ESCAL.

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, 1967H/YR 39.81

ELECTRIC CONSUMPTION, 1967H/YR 352

CHEMICAL COST (YR 1), \$ 8.1

CAPITAL COST, \$ 1553

INTANGIBLE DRILLING COST, \$ 757.4

TAX CREDIT, \$ 270.4

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/1967H 3.006 ELECTRICITY, \$/1967H 0.0520

TAXES & INSURANCE -31.0 ELECTRICITY -13.3

MAINTENANCE -46.5 CHEMICALS 8.1

FUEL SAVINGS 110.6 NET CASH INCOME 20.5

INTANG DRILL COST -757.4 DEPRECIATION -77.6

TAXABLE INCOME -814.4 TAX CREDIT 270.4

INCOME TAX 666.2 NET CASH FLOW 686.7

YEAR	NET CASH INCOME	NET CASH FLOW
1	20.5	686.7
2	44.4	60.5
3	77.4	77.5
4	122.3	100.6
5	183.0	131.8
6	264.6	173.7
7	373.4	229.7
8	518.2	304.1
9	710.1	402.7
10	963.6	533.0
11	1297.7	704.8
12	1737.4	930.7
13	2314.9	1227.6
14	3072.4	1616.9
15	4064.8	2127.0
16	5363.8	2794.7
17	7062.8	3663.0
18	9283.2	4809.3
19	12183.5	6300.0
20	15969.8	8246.2

ON NET CASH INCOME

ROI= 27.96 %

PAYBACK= 7.90 YEARS

ON NET CASH FLOW

ROI= 26.66 %

PAYBACK= 7.30 YEARS

CASE 150F /207GPH/1.0

RBI NO. 1

30% FUEL ES AL.

FUEL ESCALATION CASE NO. 1
PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, \$/MONTH	54.94
ELECTRIC CONSUMPTION, KWH/YR	379
CHEMICAL COST (YR 1), \$	11.1
CAPITAL COST, \$	1715
INTANGIBLE/ DRILLING COST, \$	734
TAX CREDIT, \$	306.9

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MONTH	3.006	ELECTRICITY, \$/KWH	0.0520
TAXES & INSURANCE	-34.3	ELECTRICITY	-19.7
MAINTENANCE	-51.4	CHEMICALS	-11.1
FUEL SAVINGS	165.1	NET CASH INCOME	48.5
INTANG DRILL COST	-734.0	DEPRECIATION	-85.7
TAXABLE INCOME	-821.1	TAX CREDIT	306.9
INCOME TAX	705.9	NET CASH FLOW	754.5

YEAR	NET CASH INCOME	NET CASH FLOW
------	-----------------	---------------

1	48.5	754.5
2	54.4	84.5
3	132.8	103.0
4	194.0	141.8
5	230.9	186.1
6	395.8	245.1
7	548.5	323.6
8	750.9	427.6
9	1018.2	565.0
10	1370.7	746.2
11	1834.5	984.6
12	2443.6	1297.7
13	3242.8	1708.5
14	4290.0	2246.7
15	5660.9	2951.3
16	7454.0	3873.0
17	9797.9	5077.8
18	12859.9	6651.6
19	16857.9	8706.6
20	22075.0	11388.7

ON NET CASH INCOME

ROI= 30.85 %

PAYBACK= 7.04 YEARS

ON NET CASH FLOW

ROI= 29.04 %

PAYBACK= 6.59 YEARS

CASE 150F/234GPM/1.0

RRI NO. 1

30% FUEL ESCAL.

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, 100TH/YR 66.5

ELECTRIC CONSUMPTION, 100TH/YR 1688

CHEMICAL COST (YR 1), \$ 12.6

CAPITAL COST, \$ 1873

INTANGIBLE DRILLING COST, \$ 794.5

TAX CREDIT, \$ 330.2

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/100TH 3.006 ELECTRICITY, \$/100TH 0.0520

TAXES & INSURANCE -37.4 ELECTRICITY -87.7

MAINTENANCE -56.1 CHEMICALS -12.6

FUEL SAVINGS 199.8 NET CASH INCOME 5.8

INTANG DRILL COST -794.5 DEPRECIATION -93.6

TAXABLE INCOME -882.2 TAX CREDIT 330.2

INCOME TAX 758.9 NET CASH FLOW 764.8

YEAR	NET CASH INCOME	NET CASH FLOW
1	5.8	764.8
2	32.8	62.3
3	71.0	82.0
4	124.2	109.3
5	197.6	147.0
6	297.8	198.5
7	433.6	268.4
8	616.8	362.5
9	862.7	488.9
10	1191.3	657.9
11	1622.4	881.9
12	2211.6	1182.3
13	2983.8	1579.1
14	4005.9	2104.5
15	5356.7	2798.8
16	7139.4	3715.2
17	9489.2	4923.0
18	12583.2	6513.3
19	16653.4	8605.3
20	22003.2	11355.1

ON NET CASH INCOME

ON NET CASH FLOW

ROI= 23.27 %

ROI= 26.66 %

PAYBACK= 8.10 YEARS

PAYBACK= 7.66 YEARS

GENERAL DATA APPLICABLE TO ALL CASES 40% FUEL ESCAL.

FIRST YEAR FUEL COST, \$/1000H 3.006
 FIRST YEAR ELECTRICITY COST, \$/100H 0.05200
 TAX & INSURANCE, % OF CAPITAL COST 2.0
 MAINTENANCE, % OF CAPITAL COST 3.0
 INCOME TAX, % OF TAXABLE INCOME 48.6
 NUMBER OF PLANT LIFE CASES 1
 PLANT LIFE, YEARS 20

NUMBER OF FUEL COST CASES = 1
 FUEL ESCALATION BY YEAR, IN PERCENT
 YEAR CASE 1
 2 40

ESCALATION RATE IS CONSTANT THEREAFTER

ELECTRICITY ESCALATION BY YEAR, IN PERCENT
 YEAR RATE
 2 34

ESCALATION RATE IS CONSTANT THEREAFTER

ANNUAL ESCALATION RATES, IN PERCENT, FOR...

TAXES AND INSURANCE = 10
 MAINTENANCE = 10
 CAPITAL COST = 10

12

11

10

9

8

7

5

5

1

1

2

1

CASE 150F/150GPI/1.0 REI NO. 1 40% FUEL ESCAL.

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, \$/HHYR 39.81

ELECTRIC CONSUMPTION, KWH/YR 257

CHEMICAL COST (YR 1), \$ 8.1

CAPITAL COST, \$ 1553

INTANGIBLE DRILLING COST, \$ 757.4

TAX CREDIT, \$ 270.4

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/HHYR 3.006 FUEL TRICITY, \$/KWH 0.0520

TAXES & INSURANCE -31.0 ELECTRICITY -13.3

MAINTENANCE -46.5 CHEMICALS -8.1

FUEL SAVINGS 119.6 NET CASH INCOME 2.65

INTANG DRILL COST -757.4 DEPRECIATION -77.6

TAXABLE INCOME -814.4 TAX CREDIT 270.4

INCOME TAX 666.2 NET CASH FLOW 686.7

YEAR NET CASH INCOME NET CASH FLOW

1 20.5 686.7

2 55.3 663.5

3 106.7 92.6

4 182.0 131.3

5 291.0 187.3

6 447.7 267.8

7 671.7 383.0

8 990.6 546.9

9 1443.3 779.6

10 2084.1 1108.9

11 2989.6 1574.3

12 4267.1 2231.0

13 6067.4 3156.4

14 8602.0 4459.1

15 12167.7 6291.9

16 17180.7 8868.6

17 24225.1 12689.4

18 34120.0 17575.6

19 48014.2 24717.0

20 67518.5 34742.2

ON NET CASH INCOME

ROI= 37.93%

PAYBACK= 6.66 YEARS

ON NET CASH FLOW

ROI= 35.73%

PAYBACK= 6.31 YEARS

CASE 150F/2076PM/1.0

RUN NO. 1

40% FUEL ESCAL.

FUEL ESCALATION CASE NO. 1
PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, \$/HRTU 54.4
ELECTRIC CONSUMPTION, KWH/YR 379
CHEMICAL COST (YR 1), \$ 11.1
CAPITAL COST, \$ 1315
DEPRECIATION-DRILL COST, \$ 85.7
TAX CREDIT, \$ 306.9

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/HRTU	3.006	ELECTRICITY, \$/KWH	0.0520
TAXES & INSURANCE	-34.3	ELECTRICITY	-19.7
MAINTENANCE	-51.4	CHEMICALS	-11.1
FUEL SAVINGS	165.1	NET CASH INCOME	48.5
INTANG DRILL COST	-784.0	DEPRECIATION	-85.7
TAXABLE INCOME	-821.1	TAX CREDIT	306.9
INCOME TAX	705.9	NET CASH FLOW	754.5

YEAR	NET CASH INCOME	NET CASH FLOW
1	48.5	754.5
2	98.2	92.1
3	171.1	129.6
4	276.8	183.9
5	429.0	262.2
6	647.0	374.2
7	957.8	513.9
8	1399.2	760.9
9	2024.7	1082.4
10	2909.2	1537.0
11	4157.9	2178.8
12	5918.5	3083.8
13	8398.4	4358.4
14	11888.6	6152.4
15	16797.5	8675.6
16	23698.1	12222.5
17	33394.0	17206.2
18	47013.0	24206.3
19	66136.3	34035.7
20	92981.8	47834.3

ON NET CASH INCOME

ROI= 40.90 %

PAYBACK= 6.04 YEARS

ON NET CASH FLOW

ROI= 33.18 %

PAYBACK= 5.78 YEARS

CASE 150F/234GPH/1.0

RMI NO. 1

40% FUEL ESCAL.

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, 180BTU/YR	66.5
ELECTRIC CONSUMPTION, KWH/YR	1688
CHEMICAL COST (YR 1), \$	12.6
CAPITAL COST, \$	1873
INITIAL DRILLING COST, \$	794.5
TAX CREDIT, \$	330.2

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/180BTU	1.006	ELECTRICITY, \$/KWH	0.0526
TAXES & INSURANCE	-37.4	ELECTRICITY	-87.7
MAINTENANCE	-56.1	CHEMICALS	-12.6
FUEL SAVINGS	199.8	NET CASH INCOME	5.8
INITIAL DRILL COST	-794.5	DEPRECIATION	-93.6
TAXABLE INCOME	-882.2	TAX CREDIT	330.2
INCOME TAX	758.9	NET CASH FLOW	764.8

YEAR	NET CASH INCOME	NET CASH FLOW
1	5.8	764.8
2	45.3	63.8
3	105.6	99.8
4	195.9	146.2
5	329.3	214.8
6	524.7	315.2
7	808.7	461.2
8	1219.2	672.1
9	1809.8	975.7
10	2686.3	1411.1
11	3968.1	2133.7
12	5596.4	2922.0
13	8057.6	4187.1
14	11557.2	5985.9
15	16526.7	8540.2
16	23575.4	12163.3
17	33563.5	17297.1
18	47704.5	24565.6
19	67710.0	34848.4
20	95993.2	49336.0

OI NET CASH INCOME

OI NET CASH FLOW

ROI= 38.60 %

ROI= 36.09 %

PAYBACK= 6.82 YEARS

PAYBACK= 6.57 YEARS

GENERAL DATA APPLICABLE TO ALL CASES

50% FUEL ESCALAT

FIRST YEAR FUEL COST, \$/100TU	3.006
FIRST YEAR ELECTRICITY COST, \$/100TU	0.05200
TAX & INSURANCE, % OF CAPITAL COST	2.0
MAINTENANCE, % OF CAPITAL COST	3.0
INCOME TAX, % OF TAXABLE INCOME	48.6
NUMBER OF PLANT LIFE CASES	1
PLANT LIFE, YEARS	20

NUMBER OF FUEL COST CASES = 1

FUEL ESCALATION BY YEAR, IN PERCENT

YEAR CASE 1

2 50

ESCALATION RATE IS CONSTANT THEREAFTER

ELECTRICITY ESCALATION BY YEAR, IN PERCENT

YEAR RATE

2 42.5

ESCALATION RATE IS CONSTANT THEREAFTER

ANNUAL ESCALATION RATES, IN PERCENT, FOR...

TAXES AND INSURANCE = 10

MAINTENANCE = 10

CHEMICAL COST = 10

CASE 150F/150CPI/1.0 BUI NO. 1 50% FUEL ESCALAT

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, 1000B/HR 39.81

ELECTRIC CONSUMPTION, KWH/HR 257

CHEMICAL COST (YR 1), \$ 3.1

CAPITAL COST, \$ 1553

INTANGIBLE DRILLING COST, \$ 757.4

TAX CREDIT, \$ 270.4

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/1000B 3.006 ELECTRICITY, \$/KWH 0.0520

TAXES & INSURANCE -31.0 ELECTRICITY -13.3

MAINTENANCE -46.5 CHEMICALS -3.1

FUEL SAVINGS 119.6 NET CASH INCOME 20.5

INTANG DRILL COST -757.4 DEPRECIATION -77.6

TAXABLE INCOME -814.4 TAX CREDIT 270.4

INCOME TAX 666.2 NET CASH FLOW 686.7

YEAR NET CASH INCOME NET CASH FLOW

1 20.5 686.7

2 66.1 71.7

3 133.1 103.8

4 251.0 166.7

5 425.1 256.2

6 692.1 393.4

7 1099.2 602.7

8 1718.0 920.8

9 2655.9 1402.8

10 4074.4 2132.0

11 6216.8 3233.2

12 9448.9 4894.4

13 14320.5 7398.4

14 21658.7 11170.3

15 32706.6 16848.9

16 49332.8 25394.8

17 74345.9 38251.5

18 111966.2 57583.3

19 168535.6 86665.0

20 253582.6 130379.1

ON NET CASH INCOME

ROI= 47.43 %

PAYBACK= 5.94 YEARS

ON NET CASH FLOW

ROI= 44.55 %

PAYBACK= 5.66 YEARS

CASE 150R/207GPH/1.0

RRH NO. 1

50% FUEL ESCALAT

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MBTU/YR 54.94

ELECTRIC CONSUMPTION, KWH/YR 379

CHEMICAL COST (YR-1), \$ 11.1

CAPITAL COST, \$ 1715

INTANGIBLE DRILLING COST, \$ 784

TAX CREDIT, \$ 306.0

STATE TAX COSTS POLICY (SEE INSTRUCTIONS TO FORMS, IF DIFFERENT OTHERWISE NOTED)

FUEL, \$/MBTU 3.006 ELECTRICITY, \$/KWH 0.0520

TAXES & INSURANCE -34.3 ELECTRICITY -19.7

MAINTENANCE -51.4 CHEMICALS -11.1

FUEL SAVINGS 165.1 NET CASH INCOME 48.5

INTANG DRILL COST -784.0 DEPRECIATION -83.7

TAXABLE INCOME -821.1 TAX CREDIT 306.9

INCOME TAX -705.9 NET CASH FLOW 754.5

YEAR NET CASH INCOME NET CASH FLOW

1 48.5 754.5

2 113.1 99.8

3 214.3 151.8

4 371.4 232.5

5 613.0 356.7

6 982.3 546.5

7 1544.5 835.5

8 2397.8 1274.1

9 3689.9 1938.2

10 5643.0 2942.1

11 8591.7 4457.8

12 13039.0 6743.7

13 19741.8 10189.0

14 29838.0 15378.4

15 45038.4 23191.4

16 67915.2 34950.1

17 102334.5 52641.6

18 154107.1 79252.7

19 231965.4 119271.9

20 349031.2 179443.7

ON NET CASH INCOME

ON NET CASH FLOW

ROI= 50.57 %

ROI= 47.11 %

PAYBACK= 5.36 YEARS

PAYBACK= 5.21 YEARS

CASE 150P/2346P1/1.0

RRI NO. 1

50% FUEL ESCALAT

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, 1980/YR	66.5
ELECTRIC CONSUMPTION, KWH/YR	1688
CHEMICAL COST (YR 1), \$	12.6
CAPITAL COST, \$	1873
INTANGIBLE DRILLING COST, \$	794.5
TAX CREDIT, \$	330.2

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/1000H	3.006	ELECTRICITY, \$/KWH	0.0520
TAXES & INSURANCE	-37.4	ELECTRICITY	-87.7
MAINTENANCE	-56.1	CHEMICALS	-12.6
FUEL SAVINGS	199.8	NET CASH INCOME	5.8
INTANG DRILL COST	-794.5	DEPRECIATION	-93.6
TAXABLE INCOME	-882.2	TAX CREDIT	330.2
INCOME TAX	758.9	NET CASH FLOW	764.8

YEAR	NET CASH INCOME	NET CASH FLOW
------	-----------------	---------------

1	5.8	764.8
2	57.8	75.2
3	182.0	116.0
4	279.2	199.0
5	494.4	299.6
6	831.1	472.7
7	1353.7	741.3
8	2161.0	1156.3
9	3403.0	1794.6
10	5307.5	2773.5
11	8221.0	4271.1
12	12669.0	6557.4
13	19448.7	10032.3
14	29788.0	15446.2
15	45456.5	23410.1
16	69283.3	35657.1
17	105433.1	54260.7
18	160255.6	82416.9
19	243310.3	125107.0
20	369066.4	199745.6

ON NET CASH INCOME

ROI= 48.48 %

PAYBACK= 6.04 YEARS

ON NET CASH FLOW

ROI= 45.24 %

PAYBACK= 5.39 YEARS

GENERAL DATA APPLICABLE TO ALL CASES

REV CAP COST - "GLASS ROOTS" SITUATION

FIRST YEAR FUEL COST, \$/TBTU 3.006
 FIRST YEAR ELECTRICITY COST, \$/TBTU .
 FUEL ESCALATION, % PER YEAR 13.35
 MAINTENANCE, % OF CAPITAL COST 3.
 NUMBER OF PLANT LIFE CASES 1
 FUEL TYPE, "GLASS"

NUMBER OF FUEL COST CASES = 1

FUEL ESCALATION BY YEAR, IN PERCENT

YEAR	CASE 1
2	13.35
3	13.35
4	13.35
5	11.76
6	11.76
7	11.76
8	11.76
9	11.76
10	12.02

ESCALATION RATE IS CONSTANT THEREAFTER

ELECTRICITY ESCALATION BY YEAR, IN PERCENT

YEAR	RATE
2	11.66
3	11.66
4	11.66
5	9.36
6	9.36
7	9.36
8	9.36
9	9.36
10	10.74

ESCALATION RATE IS CONSTANT THEREAFTER

AIRIAL ESCALATION RATES, IN PERCENT, FOR...

TAXES AND DISURANCE = 10

MAINTENANCE = 10

CHEMICAL COST = 10

CASE 150P/150GPH/1.0

RUN NO. 1

REV CAP COST - 15.00% 80.75% SITUATION

FUEL ESCALATION CASE NO. 1
PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, \$/GPH/YR	39.31
ELECTRIC CONSUMPTION, kWh/YR	257
CHEMICAL COST (YR 1), \$	9.1
CAPITAL COST, \$	1193
INTANGIBLE DRILLING COST, \$	757.4
TAX CREDIT, \$	270.4

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/GPH	3.006	ELECTRICITY, \$/kWh	0.0520
TAXES & INSURANCE	-23.6	ELECTRICITY	-13.3
MAINTENANCE	-15.4	CHEMICALS	-9.1
FUEL SAVINGS	119.6	NET CASH INCOME	39.9
INTANGIBLE DRILLING COST	-757.4	DEPRECIATION	-50.1
TAXABLE INCOME	-777.4	TAX CREDIT	270.4
INCOME TAX	669.2	NET CASH FLOW	637.3

YEAR	NET CASH INCOME	NET CASH FLOW
1	39.9	637.3
2	47.3	53.0
3	57.0	53.0
4	63.4	63.9
5	73.4	69.0
6	80.8	76.9
7	102.7	81.5
8	117.3	90.9
9	133.9	97.6
10	153.6	107.7
11	175.0	119.1
12	201.4	132.2
13	230.3	147.1
14	263.2	164.0
15	300.6	183.2
16	343.1	205.1
17	391.3	229.8
18	446.0	258.0
19	509.1	289.9
20	578.5	326.1

ON NET CASH INCOME

ROI = 10.30 %

PAYBACK = 11.59 YEARS

ON NET CASH FLOW

ROI = 13.77 %

PAYBACK = 3.06 YEARS

CASE 150F/207G71/1.0

RUN NO. 1

REV CAP COST - 0.315, 20.75, 3.17, 4.11, 0.2

FUEL ESCALATION CASE NO. 1

PLATE LIFE, YRS - 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, \$/1000 54.04

ELECTRIC CONSUMPTION, kWh/yr 179

CHEMICAL COST (YR 1), \$ 11.1

CAPITAL COST, \$ 1305

INTANGIBLE DRILLING COST, \$ 784

TAX CREDIT, \$ 306.0

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/1000 1.006

ELECTRICITY, \$/kWh 0.9520

TAXES & INSURANCE -26.1

ELECTRICITY -19.7

MAINTENANCE -39.1

CHEMICALS 11.1

FUEL SAVINGS 165.1

NET CASH INCOME 69.0

INTANG DRILL COST -784.0

DEPRECIATION -65.2

TAXABLE INCOME -780.1

TAX CREDIT 306.0

INCOME TAX 636.0

NET CASH FLOW 755.1

YEAR	NET CASH INCOME	NET CASH FLOW
1	69.0	755.1
2	32.0	73.3
3	97.1	31.6
4	114.6	00.6
5	130.4	98.7
6	148.4	107.9
7	163.5	118.3
8	191.4	130.1
9	217.3	143.4
10	247.6	159.0
11	282.1	176.7
12	321.1	196.7
13	365.3	219.5
14	415.4	245.2
15	472.2	274.4
16	536.5	307.5
17	609.4	344.9
18	691.3	387.3
19	785.0	435.2
20	890.6	480.4

ON NET CASH INCOME

ON NET CASH FLOW

ROI= 14.12 %

ROI= 16.71 %

PAYBACK= 9.34 YEARS

PAYBACK= 6.81 YEARS

FUEL ESCALATION CASE NO. 1

PLANT LIFE, YRS = 20

FOLLOWING ARE IN THOUSANDS...

FUEL SAVINGS, MBTU/YR 66.5
 ELECTRIC CONSUMPTION, KWH/YR 1683
 CHEMICAL COST (YR 1), \$ 12.6
 CAPITAL COST, \$ 1423
 INTANGIBLE DRILLING COST, \$ 794.5
 TAX CREDIT, \$ 330.2

FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNLESS OTHERWISE NOTED)

FUEL, \$/MBTU	3.006	ELECTRICITY, \$/KWH	0.0520
TAXES & INSURANCE	-28.4	ELECTRICITY	-87.7
MAINTENANCE	-42.6	CHEMICALS	-12.6
FUEL SAVINGS	199.8	NET CASH INCOME	29.3
INTANG DRILL COST	-794.5	DEPRECIATION	-71.1
TAXABLE INCOME	-937.2	TAX CREDIT	330.2
INCOME TAX	737.1	NET CASH FLOW	765.4

YEAR	NET CASH INCOME	NET CASH FLOW
------	-----------------	---------------

1	29.3	765.4
2	37.4	53.8
3	43.3	50.4
4	61.3	66.0
5	72.8	72.0
6	86.0	79.3
7	101.3	86.6
8	110.0	95.7
9	139.2	106.1
10	162.3	113.2
11	199.9	132.1
12	221.0	143.2
13	256.8	166.5
14	297.7	197.6
15	344.7	211.7
16	387.8	237.8
17	427.9	265.9
18	465.0	294.0
19	500.1	322.1
20	532.2	350.2

NET CASH INCOME NET CASH FLOW
 ROI= 9.26 % ROI= 12.17 %
 PAYBACK= 12.60 YEARS PAYBACK= 2.22 YEARS

APP C

APPENDIX C

Listing of Economic Analysis Computer Program

```

10 COM P(4),S(4,40),R(5),C(40),N1(2,40)
20 COM F,E,T,M,X,L,O,B1,B2,B3,M1,Q1(2),Q2(2)
30 COM B$
40 SELECT PRINT 005
50 PRINT "ENTER COMMON IDENTIFIER FOR ALL RUNS"
60 INPUT B$
70 PRINT "ENTER FIRST YEAR FUEL OIL COST, $/GAL"
80 INPUT F
90 PRINT "ENTER FIRST YEAR ELECTRICITY COST,$/KWH"
100 INPUT E
110 PRINT "ENTER TAX & INSURANCE, % OF CAPITAL COST"
120 INPUT T
130 PRINT "ENTER MAINTENANCE, % OF CAPITAL COST"
140 INPUT M
150 PRINT "ENTER INCOME TAX, % OF TAXABLE INCOME"
160 INPUT X
170 PRINT "ENTER NO. OF PLANT LIFE CASES (4 MAX)"
180 INPUT L
190 IF L 1 4 THEN 170
200 IF L !1 THEN 170
210 PRINT USING 220, L
220 %ENTER## PLANT LIVES
230 FOR I= 1 TO L
240 INPUT P(I)
250 NEXT I
260 PRINT "ENTER NO. OF FUEL OIL COST CASES (4 MAX)"
270 INPUT O
280 IF O ! 1 THEN 270
290 IF O 1 4 THEN 270
300 PRINT "FOR EACH FUEL OIL COST CASE ENTER ESCALATION"
310 PRINT "  RATE, IN PERCENT, STARTING WITH YEAR 2."
320 PRINT "WHEN ESCALATION RATE IS TO REMAIN CONSTANT,"
330 PRINT "  ENTER 999 FOR THAT YEAR'S RATE."
340 FOR I= 1 TO O
350 PRINT USING 360,I
360 %ENTER DATA FOR CASE##
370 S(I,1)=0
380 FOR J= 2 TO 40
390 INPUT S(I,J)
400 IF S(I,J) = 999 THEN 430
410 NEXT J
420 GOTO 480
430 R(I)=J-1
440 A=J-1
450 FOR K= J TO 40
460 S(I,K)=S(I,A)
470 NEXT K
480 NEXT I
490 PRINT "ENTER ELECTRICITY ESCALATION, IN PERCENT,"
500 PRINT "  STARTING WITH YEAR 2."
510 PRINT "WHEN ESCALATION RATE IS TO REMAIN CONSTANT,"
520 PRINT "  ENTER 999 FOR THAT YEAR'S RATE."
530 C(1)=0
540 FOR I=2 TO 40
550 INPUT C(I)
560 IF C(I) = 999 THEN 590
570 NEXT I
580 GOTO 640
590 R(5)=I-1
600 A=I-1

```



```

610 FOR K=I TO 40
620 C(K)=C(A)
630 NEXT K
640 PRINT "ENTER ANNUAL ESCALATION RATES, IN PERCENT, FOR..."
650 PRINT "      TAXES AND INSURANCE"
660 INPUT B1
670 PRINT "      MAINTENANCE"
680 INPUT B2
690 PRINT "      CHEMICAL COST"
700 INPUT B3
710 STOP "POSITION PAPER"
720 SELECT PRINT 211(80)
730 PRINT "  GENERAL DATA APPLICABLE TO ALL CASES          ";B$
740 PRINT
750 PRINT USING 760,F
760 %FIRST YEAR FUEL OIL COST, $/GAL          #.###
770 PRINT USING 780, E
780 %FIRST YEAR ELECTRICITY COST, $/KWH        #.###
790 PRINT USING 800, T
800 %TAX & INSURANCE, % OF CAPITAL COST      ##.#
810 PRINT USING 820, M
820 %MAINTENANCE, % OF CAPITAL COST          ##.#
830 PRINT USING 840,X
840 %INCOME TAX, % OF TAXABLE INCOME         ##.#
850 PRINT USING 860,L
860 %NUMBER OF PLANT LIFE CASES              #
870 PRINT "PLANT LIFE, YEARS"
880 FOR I=1 TO L
890 PRINT P(I)
900 NEXT I
910 PRINT
920 PRINT USING 930, 0
930 %NUMBER OF FUEL OIL COST CASES = #
940 PRINT "FUEL OIL ESCALATION BY YEAR, IN PERCENT"
950 PRINT "YEAR";
960 FOR J = 1 TO 0
970 PRINT USING 980, J;
980 %      CASE #
990 NEXT J
1000 PRINT
1010 I=0
1020 FOR J=1 TO 4
1030 IF R(J) ! I THEN 1050
1040 I=R(J)
1050 NEXT J
1060 FOR J=2 TO I
1070 PRINT J;
1080 FOR J1=1 TO 0
1090 PRINT USING 1100, S(J1,J);
1100 %      ##
1110 NEXT J1
1120 PRINT
1130 NEXT J
1140 PRINT "ESCALATION RATE IS CONSTANT THEREAFTER"
1150 PRINT
1160 PRINT "ELECTRICITY ESCALATION BY YEAR, IN PERCENT"
1170 PRINT "YEAR", "RATE"
1180 J=R(5)
1190 FOR I= 2 TO J
1200 PRINT I,C(I)

```

```

1210 NEXT I
1220 PRINT "ESCALATION RATE IS CONSTANT THEREAFTER"
1230 PRINT
1240 PRINT "ANNUAL ESCALATION RATES, IN PERCENT, FOR..."
1250 PRINT "      TAXES AND INSURANCE = ",B1
1260 PRINT "      MAINTENANCE = ",B2
1270 PRINT "      CHEMICAL COST = ",B3
1280 STOP "POSITION PAPER"
1290 LOAD
1300 END

```

```

10  COM P(4),S(4,40),R(5),C(40),M1(2,40)
20  COM F,E,T,M,X,L,O,B1,B2,B3,M1,Q1(2),Q2(2)
30  COM B$
40  DIM Z1$(5),Z2(5),Z3(5),Z4(5),Z5(5),Z6(5),Z7(5)
50  SELECT PRINT 005
60  K9=0
70  K9=K9+1
80  PRINT "ENTER CASE DESCRIPTION"
90  INPUT A$
100 PRINT "ENTER ALL THE FOLLOWING IN THOUSANDS..."
110 PRINT
120 PRINT "ENTER FUEL OIL SAVINGS, GAL/YR"
130 INPUT D1
140 PRINT "ENTER ELECTRIC CONSUMPTION, KWH/YR"
150 INPUT D2
160 PRINT "ENTER CHEMICAL COST, $"
170 INPUT M1
180 PRINT "ENTER CAPITAL COST, $"
190 INPUT D3
200 PRINT "ENTER INTANGIBLE DRILLING COST, $"
210 INPUT D4
220 PRINT "ENTER TAX CREDIT, $"
230 INPUT D5
240 Z1$(K9)=A$
250 Z2(K9)=D1
260 Z3(K9)=D2
270 Z4(K9)=M1
280 Z5(K9)=D3
290 Z6(K9)=D4
300 Z7(K9)=D5
310 IF K9 = 5 THEN 350
320 PRINT "IF ADDITIONAL CASES, ENTER      YES  "
330 INPUT A1$
340 IF A1$ = "YES" THEN 70
350 SELECT PRINT 211(80)
360 K8=K9
370 FOR K9= 1 TO K8
380 A$=Z1$(K9)
390 D1=Z2(K9)
400 D2=Z3(K9)
410 M1=Z4(K9)
420 D3=Z5(K9)
430 D4=Z6(K9)
440 D5=Z7(K9)
450 K=0

```

```

460 FOR I=1 TO 0
470 FOR J=1 TO L
480 K=K+1
490 PRINT "CASE ";A$, "RUN NO. ";K;"          ";B$
500 PRINT
510 PRINT "FUEL OIL ESCALATION CASE NO. ";I
520 N=P(J)
530 PRINT "PLANT LIFE, YRS = ";N
540 PRINT
550 PRINT "FOLLOWING ARE IN THOUSANDS..."
560 PRINT "FUEL OIL SAVINGS, GAL/YR          ";D1
570 PRINT "ELECTRIC CONSUMPTION, KWH/YR ";D2
580 PRINT "CHEMICAL COST (YR 1), $          ";M1
590 PRINT "CAPITAL COST, $                  ";D3
600 PRINT "INTANGIBLE DRILLING COST, $      ";D4
610 PRINT "TAX CREDIT, $                   ";D5
620 PRINT
630 L1=N
640 REM L1=PLANT LIFE, YEARS
650 REM SETUP FIRST LINE
660 REM G1 IS FIRST COLUMN OF OUTPUT SHEET
670 REM G9 IS NINTH COLUMN
680 REM H1 IS TENTH COLUMN
690 REM ETC
700 G1=1
710 G2=F
720 G3=E
730 G5=-D3*T/100
740 G6=-G3*D2
750 G7=-D3*M/100
760 G8=-M1
770 G9=G2*D1
780 H1=G5+G6+G7+G8+G9
790 H2=-D4
800 H3=-D3/L1
810 H4=H1+H2+H3
820 H5=D5
830 H6=-H4*X/100
840 H7=H1+H5+H6
850 PRINT "FIRST YEAR COSTS FOLLOW (IN THOUSANDS OF DOLLARS, UNL
ESS OTHERWISE NOTED)"
860 PRINT USING 870,G2,G3
870 %FUEL OIL, $/GAL      -####.###      ELECTRICITY, $/KWH      -
####.###
880PRINT USING 890, G5,G6
890 %TAXES & INSURANCE   -####.#      ELECTRICITY      -
####.#
900 PRINT USING 910, G7,G8
910 %MAINTENANCE         -####.#      CHEMICALS      -
####.#
920 PRINT USING 930, G9,H1
930 %OIL SAVINGS        -####.#      NET CASH INCOME      -
####.#
940 PRINT USING 950, H2,H3
950 %INTANG DRILL COST   -####.#      DEPRECIATION      -
####.#
960 PRINT USING 970, H4,H5
970 %TAXABLE INCOME     -####.#      TAX CREDIT      -
####.#

```

```

980 PRINT USING 990, H6, H7
990 %INCOME TAX          -####.#          NET CASH FLOW          -
####.#
1000 PRINT
1010 PRINT USING 1030
1020 PRINT USING 1040
1030 %YEAR          NET CASH INCOME          NET CASH FLOW
1040 %-----          -----          -----
1050 I2=1
1060 PRINT USING 1070, I2, H1, H7
1070 % ##          ####.#          ####.#
1080 REM NOW FOR REMAINING YEARS
1090 N1(1,1)=H1
1100 N1(2,1)=H7
1110 FOR I2 = 2 TO 11
1120 G2=G2*(1+S(I, I2)/100)
1130 G3=G3*(1+C(I2)/100)
1140 G5=G5*(1+B1/100)
1150 G6=-G3*D2
1160 G7=G7*(1+B2/100)
1170 G8=G8*(1+B3/100)
1180 G9=G2*D1
1190 H1=G5+G6+G7+G8+G9
1200 H4=H1+H3
1210 H6=-H4*X/100
1220 H7=H1+H6
1230 N1(1, I2)=H1
1240 N1(2, I2)=H7
1250 PRINT USING 1070, I2, H1, H7
1260 NEXT I2
1270 PRINT
1280 REM CALC ROI
1290 FOR I1 = 1 TO 2
1300 I2=1
1310 I8=5
1320 T1=0
1330 FOR I3 = 1 TO 11
1340 T1=T1+N1(I1, I3)/((1+I8/100)1/2I3)
1350 NEXT I3
1360 IF I2 = 2 THEN 1420
1370 T7=T1
1380 I7=I8
1390 I2=2
1400 I8=10
1410 GOTO 1320
1420 T8=T1
1430 I9=I7+(D3-T7)*(I8-I7)/(T8-T7)
1440 IF ABS(I9-I8) ! 0.001 THEN 1490
1450 T7=T8
1460 I7=I8
1470 I8=I9
1480 GOTO 1320
1490 Q1(I1)=I8
1500 NEXT I1
1510 REM NOW CALC PAYBACK
1520 FOR I1=1 TO 2
1530 T1=0
1540 I2=1
1550 T1=T1+N1(I1, I2)
1560 IF T1 1 = D3 THEN 1590

```

```

1570 I2=I2+1
1580 GOTO 1550
1590 Q2(I1)=(I2-1)+(D3-(T1-N1(I1,I2)))/N1(I1,I2)
1600 NEXT I1
1610 PRINT " ";
1620 PRINT "ON NET CASH INCOME      ON NET CASH FLOW"
1630 PRINT " ";
1640 PRINT USING 1650, Q1(1),Q1(2)
1650      %      ROI= ##.## %      ROI= ##.## %
1660 PRINT " ";
1670 PRINT USING 1680, Q2(1),Q2(2)
1680      %PAYBACK= ##.## YEARS      PAYBACK= ##.## YEARS
1690 I1=66-28-N
1700 FOR I3= 1 TO I1
1710 PRINT
1720 NEXT I3
1730 NEXT J
1740 NEXT I
1750 NEXT K9
1760 GOTO 50
1770 END

```

APP 2

APPENDIX D

Letters Sent to Trade Organizations
and Responses Received

DIRECT APPLICATION OF WEST COAST GEOTHERMAL RESOURCES
IN A WET CORN MILLING PLANT

enclosure 1

U.S. Department of Energy

Burns and Roe Industrial Services Corporation, in conjunction with Corn Products, a Unit of CPC International, conducted a study to evaluate the engineering and economic feasibility of utilizing the geothermal resources in East Mesa, California in a hypothetical new Wet Corn Milling Plant.

Two alternative plant designs which utilized geothermal energy were developed.

Case 1 - Geothermal System Conceptual Design

The need to incinerate waste gases at 1750 F, thereby generating large amounts of waste heat, seriously limited the amount of natural gas which could be displaced by the relatively low temperature geothermal energy source. Preliminary investigations indicated that, within the current state-of-the-art, there were no other suitable processes available to eliminate the odor-producing contaminants. Therefore, in the first design alternate considered, geothermal energy was only used to preheat the odorous waste gas stream before it entered the incinerator; to preheat the dry air entering the starch dryer, and to preheat the softened makeup water entering the deaerator.

Case 2 - Combined Geothermal/Cogeneration System Conceptual Design

The second concept considered involved the use of a portion of waste heat from the waste gas incinerator to generate electricity in a back pressure steam turbine. Geothermal energy was used in the process to replace that portion of the waste heat which was used to generate electricity in lieu of process steam. No additional natural gas was burned to produce the electricity. Geothermal Energy was utilized to preheat the gas stream before it entered the incinerator; to preheat the dry air entering the starch dryer; and to preheat the corn steepwater to the evaporator.

The use of geothermal energy in Case 1 was 14.7×10^6 Btu/h (4.307×10 W), while in Case 2 the usage was 20.4×10^6 Btu/h (5.977×10 W). The total reduction in the plant's conventional energy usage would be 6.6 percent for Case 1 and 17.1 percent for Case 2. In Case 2, the cogeneration system permitted the use of more geothermal energy from the same well, thereby making a significant contribution to the return on investment for the geothermal system.

The results of the economic analysis indicated that the after-tax rate of return and simple payback periods were 28 percent and 3.8 years, respectively, for Case 1. The corresponding values for Case 2 were 46.1 percent and 2.2 years.

Enclosure 2

DIRECT APPLICATION OF GEOTHERMAL HEAT
OF A
FROZEN FOOD PLANT

Campbell Soup Company
Salisbury, Maryland

The purpose of this study for the U.S. Department of Energy was to evaluate the technical and economic feasibility of the application of geothermal heat in the Campbell Soup Frozen Food plant in Salisbury, Maryland.

Data regarding geothermal resources on the Delmarva Peninsula were collected and analyzed. These data were subsequently used to project temperatures, flow rates and drawdowns for a possible geothermal well at the Campbell Soup plant site. Chemistry of the Delmarva geothermal brine was evaluated, and two alternate brine pretreatment designs were established.

Conceptual designs were developed for use of the geothermal heat for the production of hot process water, production of steam, production of chilled water and for refrigeration. Net geothermal energy outputs and preliminary economics were established. The results of this conceptual design phase showed that only the production of hot water from geothermal heat should be further pursued in detail.

A total of 12 different geothermal hot process water designs were developed to cover the whole range of anticipated geothermal brine temperatures and flow rates. Some designs considered the use of only heat exchangers. Other designs included the use of one or more heat pumps in order to fully meet the higher temperature process water requirements. Detailed cost data were developed for each design. After-tax payback period and after-tax rate-of-returns were established at three different well drawdown levels for each of the different designs.

Payback periods were found to be attractive ranging from 3 to 6 years.

**Burns and Roe
Industrial Services Corp.**

Engineers and Constructors

P.O. Box 667 ■ 650 Winters Avenue ■ Paramus, New Jersey 07652
■ Tel. N.J. (201) 265-2000 — N.Y. (212) 563-7700 ■ Telex 13-4223 ■ Cable BRISC PARAMUS, N.J.

May 18, 1981

Mr. Charles Yuska
American Meat Institute Foundation
P.O. Box 3556
Washington, DC 20007

Dear Charles:

On May 14 I called your office and, in your absence, was advised to write this letter.

Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

Both of these studies were funded by the U.S. Department of Energy, and the results indicate very favorable economics for a range of well temperatures and flows which could reasonably be expected based on testing done to date in these areas. Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states; therefore, we feel the results of these studies may be of great interest to the members of your organization.

We would greatly appreciate the opportunity to make a presentation at one of your conferences or workshops. Of course, this would be done at our own expense.

Enclosed are two summaries that are indicative of the content and detail of the material that could be presented on either or both of the studies mentioned above. Our presentation can be tailored in both time and technical content to be informative to groups with interests in alternative energy sources, even if their individual businesses are not specifically in the frozen food or corn milling industries. In addition to presenting the results of the studies, we would describe industrial applications where geothermal energy is currently being successfully utilized. We will, in addition, outline the available Government programs that are intended to speed the acceptance and utilization of geothermal resources by industry via economic incentives.

Letter to Mr. Charles Yuska dated May 18, 1981

2

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2880.

Very truly yours,

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

**Burns and Roe
Industrial Services Corp.**

Engineers and Constructors

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May 18, 1981

Mr. Ramon Billeaud
American Sugar Cane League
416 Whitney Building
New Orleans, LA 70130

Dear Mr. Billeaud:

On May 14 I called your office and, in your absence, was advised to write this letter.

Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

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- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

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Letter to Mr. Ramon Billeaud dated May 18, 1981

2

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2880.

Very truly yours,

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

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May 18, 1981

Mr. Allen Murfin
Associate Manager
Food and Energy Council
909 University Avenue
Columbia, MO 65201

Dear Mr. Murfin:

As indicated during our phone conversation of May 15, 1981, Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

Both of these studies were funded by the U.S. Department of Energy, and the results indicate very favorable economics for a range of well temperatures and flows which could reasonably be expected based on testing done to date in these areas. Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states; therefore, we feel the results of these studies may be of great interest to the members of your organization.

We would greatly appreciate the opportunity to make a presentation at your conference in September 1981. Of course, this would be done at our own expense.

Enclosed are two summaries that are indicative of the content and detail of the material that could be presented on either or both of the studies mentioned above. Our presentation can be tailored in both time and technical content to be informative to groups with interests in alternative energy sources, even if their individual businesses are not specifically in the frozen food or corn milling industries. In addition to presenting the results of the studies, we would describe industrial applications where geothermal energy is currently being successfully utilized. We will, in addition, outline the available Government programs that are intended to speed the acceptance and utilization of geothermal resources by industry via economic incentives.

Letter to Mr. Allen Murfin dated May 18, 1981

2

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2880.

Very truly yours,

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

4862-01
T. Ammerlaan

4

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May 18, 1981

Dr. Fred Martin
Agronomy Department,
Louisiana State University
Baton Rouge, LA 70803

Dear Dr. Martin:

As indicated during our phone conversation of May 15, 1981, Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

Both of these studies were funded by the U.S. Department of Energy, and the results indicate very favorable economics for a range of well temperatures and flows which could reasonably be expected based on testing done to date in these areas. Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states; therefore, we feel the results of these studies may be of great interest to the members of your organization.

We would greatly appreciate it if you could still see an opportunity for us to make a presentation at your conference in June. Of course, this would be done at our own expense.

Enclosed are two summaries that are indicative of the content and detail of the material that could be presented on either or both of the studies mentioned above. Our presentation can be tailored in both time and technical content to be informative to groups with interests in alternative energy sources, even if their individual businesses are not specifically in the frozen food or corn milling industries. In addition to presenting the results of the studies, we would describe industrial applications where geothermal energy is currently being successfully utilized. We will, in addition, outline the available Government programs that are intended to speed the acceptance and utilization of geothermal resources by industry via economic incentives.

Letter to Dr. Fred Martin dated May 18, 1981

2

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2880.

Very truly yours,

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

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May 22, 1981

Mr. Roger Coleman
National Food Processors Association
1133 20th Street, N.W.
Washington, DC 20036

Dear Mr. Coleman:

As indicated during our phone conversation of May 20, 1981, Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

Both of these studies were funded by the U.S. Department of Energy, and the results indicate very favorable economics for a range of well temperatures and flows which could reasonably be expected based on testing done to date in these areas. Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states; therefore, we feel the results of these studies may be of great interest to the members of your organization.

We would greatly appreciate the opportunity to make a presentation at your conference in Chicago in January 1982. Of course, this would be done at our own expense.

Enclosed are two summaries that are indicative of the content and detail of the material that could be presented on either or both of the studies mentioned above. Our presentation can be tailored in both time and technical content to be informative to groups with interests in alternative energy sources, even if their individual businesses are not specifically in the frozen food or corn milling industries. In addition to presenting the results of the studies, we would describe industrial applications where geothermal energy is currently being successfully utilized. We will, in addition, outline the available Government programs that are intended to speed the acceptance and utilization of geothermal resources by industry via economic incentives.

Letter to Mr. Roger Coleman dated May 22, 1981

2

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2880.

Very truly yours,

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

Burns and Roe
Industrial Services Corp.

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May 26, 1981

Mr. Steve Anderson
Frozen Potato Products Institute
1919 Pennsylvania Ave., N.W.
Suite 603
Washington, DC 20006

Dear Mr. Anderson:

As indicated during our phone conversation of May 22, 1981, Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

Both of these studies were funded by the U.S. Department of Energy, and the results indicate very favorable economics for a range of well temperatures and flows which could reasonably be expected based on testing done to date in these areas. Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states; therefore, we feel the results of these studies may be of great interest to the members of your organization.

We would greatly appreciate the opportunity to make a presentation at one of your conferences or workshops. Of course, this would be done at our own expense.

Enclosed are two summaries that are indicative of the content and detail of the material that could be presented on either or both of the studies mentioned above. Our presentation can be tailored in both time and technical content to be informative to groups with interests in alternative energy sources, even if their individual businesses are not specifically in the frozen food or corn milling industries. In addition to presenting the results of the studies, we would describe industrial applications where geothermal energy is currently being successfully utilized. We will, in addition, outline the available Government programs that are intended to speed the acceptance and utilization of geothermal resources by industry via economic incentives.

Letter to Mr. Steve Anderson dated May 26, 1981

2

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2880.

Very truly yours,

A handwritten signature in dark ink, appearing to read 'A.C.F. Ammerlaan', with a stylized flourish at the end.

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 667 ■ 650 Winters Avenue ■ Paramus, New Jersey 07652
■ Tel. N.J. (201) 265-2000 ■ N.Y. (212) 563-7700 ■ Telex 15-4420 ■ Cable BRISC PARAMUS, N.J.

May 26, 1981

Mr. Dave Bosman
American Feed Manufacturer's Association
1701 N. Ft. Myer Drive
Arlington, VA 22209

Dear Mr. Bosman:

On May 22 I called your office and was advised to write this letter and send it to your attention.

Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

Both of these studies were funded by the U.S. Department of Energy, and the results indicate very favorable economics for a range of well temperatures and flows which could reasonably be expected based on testing done to date in these areas. Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states; therefore, we feel the results of these studies may be of great interest to the members of your organization.

We would greatly appreciate the opportunity to make a presentation at one of your conferences or workshops. Of course, this would be done at our own expense.

Enclosed are two summaries that are indicative of the content and detail of the material that could be presented on either or both of the studies mentioned above. Our presentation can be tailored in both time and technical content to be informative to groups with interests in alternative energy sources, even if their individual businesses are not specifically in the frozen food or corn milling industries. In addition to presenting the results of the studies, we would describe industrial applications where geothermal energy is currently being successfully utilized. We will, in addition, outline the available Government programs that are intended to speed the acceptance and utilization of geothermal resources by industry via economic incentives.

Letter to Mr. Dave Bosman dated May 26, 1981

2

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2880.

Very truly yours,

A.C.P. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 667 ■ 650 Winter Avenue ■ Paramus, New Jersey 07652
■ Tel. N.J. (201) 265-2000 ■ N.Y. (212) 363-7700 ■ Telex: 334023 ■ Cable: BRISC PARAMUS, N.J.

May 26, 1981

Mr. Robert Elmer
American Dry Milk Institute
130 N. Franklin Street
Chicago, IL 60606

Dear Mr. Elmer:

As indicated during our phone conversation of May 22, 1981, Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

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Letter to Mr. Robert Elmer dated May 26, 1981

2

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Very truly yours,

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

Burns and Roe
Industrial Services Corp.

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June 1, 1981

Mr. Renwood Tipton
Milk Industry Foundation
910 17th Street, N.W.
Washington, DC 20006

Dear Mr. Tipton:

As indicated during our phone conversation of May 29, 1981, Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

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Letter to Mr. Tipton dated June 1, 1981

2

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2880.

Very truly yours,

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

**Burns and Roe
Industrial Services Corp.**

Engineers and Constructors

P.O. Box 667 ■ 660 Western Avenue ■ Paramus, New Jersey 07652
■ Tel. N.J. (201) 265-2000 ■ N.Y. (212) 463-7700 ■ Telex: 13-4223 ■ Cable: BEISC, PARAMUS, N.J.

June 1, 1981

Dr. Michael Olsen
President, Food Services Research
VPI - SU
322 Wallace Hall
Blacksburg, VA 24061

Dear Dr. Olsen

As indicated during our phone conversation of June 1, 1981, Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

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4862
3 copies to client
T. Ammerlaan

Letter to Michael Olsen dated June 1, 1981

2

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2880.

Very truly yours,

A handwritten signature in dark ink, appearing to read 'A.C.F. Ammerlaan', written in a cursive style.

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

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June 1, 1981

Mr. George Muller
Sugar Industry Technologists
P.O. Box DD
Oak Harbor, WA 98277

Dear Mr. Muller:

I have tried several times to contact you by phone. Having been unsuccessful, I decided to go ahead and send you this letter. Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

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Letter to Mr. George Muller dated June 1, 1981

2

Thank you for your consideration and cooperation in this matter.
If any additional information is required in order to evaluate this
request, I may be reached at the following phone number: (201) 265-
2000, extension 2880.

Very truly yours,

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

**Burns and Roe
Industrial Services Corp.**

Engineers and Constructors

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■ Tel. N.J. (201) 265-2000 — N.Y. (212) 563-7700 ■ Telex 13-4223 ■ Cable BRISC PARAMUS, N.J.

June 1, 1981

Mr. K.H. Berg, President
Hawaiian Sugar Planters Association
P.O. Box 1057
Aiea, HI 96701

Dear Mr. Berg:

I have tried several times to contact you by phone. Having been unsuccessful, I decided to go ahead and send you this letter. Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant.

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Letter to Mr. K.H. Berg dated June 1, 1981

2

Thank you for your consideration and cooperation in this matter.
If any additional information is required in order to evaluate this
request, I may be reached at the following phone number: (201) 265-
2000, extension 2880.

Very truly yours,

A.C.F. Ammerlaan
Project Engineer

ACFA/jlh

Enclosure

File

13

P.O. Box 687 • 611 Veterans Avenue • Paramus, New Jersey 07652
Tel. NJ (201) 262-8800 • N.Y. (212) 771-0257 • Telex 270-700-000 • Cable BR 80 000 U.S.A.

August 14, 1980

Mr. George Foster
Director of Field Services
Institute of Food Technologists
221 North LaSalle Street
Chicago, Illinois 60601

Dear Mr. Foster:

I have been a bit late in compiling the enclosed abstracts which we discussed in our recent phone conversation.

Burns and Roe Industrial Services Corporation has recently completed two studies on the utilization of geothermal energy within the food industry;

- a) Direct Application of Geothermal Heat to a Frozen Food Plant
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant

Both of these studies were funded by the U.S. Department of Energy and the results indicate very favorable economics for a range of well temperatures and flows which could be considered as reasonable expectations based on testing done to date in these areas. Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states, therefore, we feel the results of these studies may be of great interest to the members of your organization.

The enclosed abstracts are indicative of the scope and detail of the subject matter. Our presentations would be in a viewgraph format and can be modified in both time and technical content to be informative to large groups with interests in energy conservation. We will, in addition, attempt to outline the risks involved and the government programs available to lessen these risks.

Recalling our conversation, I believe it was your initial intent to incorporate the subject matter and availability of these presentations in an ongoing news letter to your various regional groups. If after your review of the enclosed, you have any other ideas as to how this material can be conveyed to interested members within your organization, please give me a call.

Thank you for your consideration and cooperation in this matter. I may be reached at 201-262-8800.

Very truly yours,

George J. Stephens

George J. Stephens
Deputy Director
Engineering Services

GJS:mb
Enclosure

Ray Castillo

13

See attached resumes

P.O. Box 667 ■ 650 Winters Avenue ■ Paramus, New Jersey 07652
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Director of Field Services
Institute of Food Technologists
221 North LaSalle Street
Chicago, Illinois 60601

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Thank you for your consideration and cooperation in this matter. I may be reached at 201-262-8800.

Very truly yours,

George J. Stephens
Deputy Director
Engineering Services

GJS:mb
Enclosure

DIRECT APPLICATION OF WEST COAST GEOTHERMAL RESOURCES
IN A
WET CORN MILLING PLANT

U.S. Department of Energy

Burns and Roe Industrial Services Corporation, in conjunction with Corn Products, a Unit of CPC International, conducted a study to evaluate the engineering and economic feasibility of utilizing the geothermal resources in East Mesa, California in a hypothetical new Wet Corn Milling Plant.

Two alternative plant designs which utilized geothermal energy were developed.

Case 1 - Geothermal System Conceptual Design

The need to incinerate waste gases at 1750 F, thereby generating large amounts of waste heat, seriously limited the amount of natural gas which could be displaced by the relatively low temperature geothermal energy source. Preliminary investigations indicated that, within the current state-of-the-art, there were no other suitable processes available to eliminate the odor producing contaminants. Therefore, in the first design alternate considered, geothermal energy was only used to preheat the odorous waste gas stream before it entered the incinerator; to preheat the dry air entering the starch dryer, and to preheat the softened makeup water entering the deaerator.

Case 2 - Combined Geothermal/Cogeneration System Conceptual Design

The second concept considered involved the use of a portion of waste heat from the waste gas incinerator to generate electricity in a back pressure steam turbine. Geothermal energy was used in the process to replace that portion of the waste heat which was used to generate electricity in lieu of process steam. No additional natural gas was burned to produce the electricity. Geothermal Energy was utilized to preheat the gas stream before it entered the incinerator; to preheat the dry air entering the starch dryer; and to preheat the corn steepwater to the evaporator.

The use of geothermal energy in Case 1 was 14.7×10^6 Btu/hr (4.307×10^3 W) while in Case 2 the usage was 20.4×10^6 Btu/hr (5.977×10^3 W). The total reduction in the plant's conventional energy usage would be 6.6 percent for Case 1 and 17.1 percent for Case 2. In Case 2, the cogeneration system permitted the use of

more geothermal energy from the same well, thereby making a significant contribution to the return on investment for the geothermal system.

The results of the economic analysis indicated that the after-tax rate of return and simple payback periods were 28 percent and 3.8 years, respectively, for Case 1. The corresponding values for Case 2 were 46.1 percent and 2.2 years.

DIRECT APPLICATION OF GEOTHERMAL HEAT
OF A
FROZEN FOOD PLANT

Campbell Soup Co.
Salisbury, Maryland

The purpose of this study for DOE was to evaluate the technical and economic feasibility of the application of geothermal heat in the Campbell Soup Frozen Food plant in Salisbury, Maryland.

Data regarding geothermal resources on the Delmarva Peninsula were collected and analyzed. These data were subsequently used to project temperatures, flow rates and drawdowns for a possible geothermal well at the Campbell Soup plant site. Chemistry of the Delmarva geothermal brine was evaluated and two alternate brine pretreatment designs were established.

Conceptual designs were developed for use of the geothermal heat for the production of hot process water, production of steam, production of chilled water and for refrigeration. Net geothermal energy outputs and preliminary economics were established. The results of this conceptual design phase showed that only the production of hot water from geothermal heat should be further pursued in detail.

A total of 12 different geothermal hot process water designs were developed to cover the whole range of anticipated geothermal brine temperatures and flow rates. Some designs considered the use of only heat exchangers. Other designs included the use of one or more heat pumps in order to fully meet the higher temperature process water requirements. Detailed cost data were developed for each design. After-tax payback period and after-tax rate-of-returns were established at three different well drawdown levels for each of the different designs.

Payback periods were found to be attractive ranging from 3 to 6 years.

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

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April 29, 1981

Dr. Stanley Wallen
Institute of Food Technologists
116 Filley Hall
University of Nebraska
Lincoln, NE 68583

Dear Dr. Wallen:

In response to your letter of April 7, 1981, we accept your invitation to make a presentation at your Section Meeting of September 8, 1981 on the use of geothermal energy in wet corn milling and frozen food plants.

As indicated during our phone conversation of April 10, 1981, Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant

Both of these studies were funded by the U.S. Department of Energy, and the results indicate very favorable economics for a range of well temperatures and flows which could reasonably be expected based on testing done to date in these areas. Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states, therefore, we feel the results of these studies may be of great interest to the members of your organization.

Enclosed are two summaries that are indicative of the content and detail of the material that will be presented on both of the studies mentioned above. As indicated in these summaries, the methods used to incorporate geothermal energy

Letter to Dr. Stanley Wallen
April 29, 1981
Page 2

into these processes are rather conventional. Therefore, our presentation should be informative to any group with interests in alternative energy sources, even if their individual businesses are not specifically in the frozen food or corn milling industries.

As you requested, we will plan for a total presentation of 30-45 minutes to a group of 50-60 people. In addition to presenting the results of the studies, we will indicate some industrial applications where geothermal energy is currently being successfully utilized. We will, in addition, outline the available Government programs that are intended to speed the acceptance and utilization of geothermal resources by industry via economic incentives.

Our presentation generally relies on the use of visual aids such as slides and/or overhead view graphs. Based on our discussions, it is my understanding that you would be able to provide either or both of these.

We greatly appreciate the opportunity to make this presentation at your meeting. Within the next few weeks, I will contact you to finalize arrangements for the presentation. In the meantime, if any additional information is needed, please let me know. I may be reached at the following number: (201) 265-2000, extension 2879.

Very truly yours,

Raymond M. Costello, P.E.
Project Manager

RMC/mk
Enclosures

cc: HSullivan) All w/o att.
EPeterson) DOE
WToth - EG&G Idaho
PNardone
HGitterman
JWMorton
JARocco
AKo
MKnebel
TAmmerlaan
REvans - Wash.
~~File 4062-01~~
db

See attached response

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 667 ■ 650 Winters Avenue ■ Paramus, New Jersey 07652
 ■ Tel. N.J. (201) 262-8800 — N.Y. (212) 736-0257 ■ TWX 710-990-6615 ■ Cable BRISC PARAMUS, N.J.

August 5, 1980

Mr. Michael Brown, Vice President,
 American Frozen Food Institute
 1919 Pennsylvania Avenue
 Suite 603
 Washington, D.C. 20006

cc: HGitterman
 JWMorton
 JARocco
 GStephens
 EPeterson, Wash.
 REvans, Wash.

~~File~~
 db

Dear Mr. Brown:

As we discussed during our phone conversation today, Burns and Roe Industrial Services Corporation and Campbell Soup Company have recently completed a study regarding the conversion of an existing East coast frozen food plant to utilize geothermal energy. The study was funded by the U.S. Department of Energy, and the results indicated very favorable economics for a range of well temperatures and flows which could be considered as reasonable expectations based on testing done to date in the area.

Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states. Therefore, we feel that the results of this study may be of great interest to the members of your organization, and we would welcome the opportunity to make a presentation during the Energy Workshop Program you are planning for your Annual Meeting in October.

Enclosed is a paper entitled, "East Coast Geothermal Resources - Direct Application in the Frozen Food Industry". This paper indicates some of the information we would present. In addition, we would attempt to outline the risks involved, and the government programs available to lessen their impact. If you wish, we would be glad to make a preliminary presentation at the September 5, 1980 meeting of your Energy Council in Washington, D.C. so that they might better be able to judge the suitability of the presentation for the program they are planning.

Burns and Roe
Industrial Services Corp.

Letter to Mr. Michael Brown
August 5, 1980
Page 2

Thank you for your consideration and cooperation in this matter. If any additional information is required, I may be reached at the following phone number:
201-262-8800, extension 266.

Very truly yours,

A handwritten signature in cursive script, reading "Raymond M Costello".

Raymond M. Costello, P.E.
Project Manager

RMC/mk
Enclosure

EAST COAST GEOTHERMAL RESOURCES
DIRECT APPLICATION in the FROZEN FOOD INDUSTRY

Anton C.F. Ammerlaan, Raymond M. Costello, Martin E. Knebel
Burns and Roe Industrial Services Corporation

Robert J. Czarnecki
Campbell Soup Company

ABSTRACT

Several shallow wells and one deep well recently drilled in the Atlantic Coastal Plain have indicated the existence of warm water geothermal resources. A detailed study of the direct application of this geothermal energy for the production of hot process water was conducted for an existing frozen food plant on the Delmarva Peninsula, Maryland. Several cases with and without the application of heat pumps were considered. Payback periods were found to be attractive, ranging from 3 to 6 years, for the range of well conditions; temperature, flow, drawdown, indicated by the previous test well drilling program.

These efforts form the primary basis for the estimation of geothermal resources in the Salisbury area applicable to the current study.

The deep test well at Crisfield measured a temperature in the order of 135°F at an actual basement depth of about 4200 feet. (Gruy 1980)

Therefore, 135°F was selected as a likely median for this project, with a lower level of 120°F and a higher level of 150°F taken as the extremes for a matrix type approach.

The principle concern in the treatment of the geothermal brine is that of scale formation. (see Table 1)

Calculation of the Langelier Index, ionic strength and solubility limits indicate that the brine is saturated with calcium carbonate and barium sulfate, high in magnesium carbonate and iron and substantially under saturated with calcium sulfate, strontium sulfate and silica.

The methods of treating the geothermal brine that appear to be most practical and economical, and that were used for establishing costs are: 1) Pressurization of the geothermal fluid to keep carbon dioxide in solution; 2) Maintaining a closed system to keep oxygen out of the fluid; 3) Threshold addition of phosphonate scale inhibitor.

The possibility remains that a more severe treatment might be required than the threshold chemical treatment. Therefore, as an alternate for a worst possible case, hot lime treatment was also considered.

Hot Water Usage

Hot water requirements throughout the frozen food plant were investigated. Major hot water user points are listed in Table 2. Three distinct temperature levels were established, i.e. 145 F, 165 F and 175 F. Hot water requirements vary considerably during the course of a 24-hour day. Maximum and minimum flow rates are included in Table 2. Total hot water usage for each of the three temperature levels were established including the daily minimum and maximum flow rates that have to be anticipated.

INTRODUCTION

The Campbell Soup Company owns and operates a frozen food plant in Salisbury Maryland on the Delmarva Peninsula. This area along the Atlantic Coastal Plain has been identified as having the potential for warm water geothermal resources.

Consideration of the plant data resulted in four potential applications of geothermal heat which were explored in concept, namely production of hot water, production of steam, production of chilled water and refrigeration.

The production of hot water from geothermal heat showed sufficient economic promise to justify a further detailed technical and economical analysis, which is the subject of this paper.

Geothermal Fluid, Properties and Treatment

Based in part upon the heat flow data obtained from a shallow well drilling program, a Selection Committee of the DOE Division of Geothermal Energy chose a site at Crisfield, Maryland for a deep test well to basement. The test well was drilled during mid 1979, and temperatures and core samples were obtained and reported.

Table 1
Chemical Analysis of Water by Zone
at Crisfield Airport Well
(Gruy 1980)

Zone depth, ft	Zone 1 4220-4148
Metals (mg/l)	Mean
Boron	7.22
Sodium	21,667
Potassium	268.3
Iron	36.67
Magnesium	631.2
Barium	4.05

Others (ppm)

Total dissolved solids	71,793
Total residue	71,853
Calcium carbonate	16,598
Magnesium carbonate	3,557
Bicarbonates	121.2
Chlorides	39,422
Sulfates	575.2
Dissolved silicates	16
Nitrates	5.32
Total organic carbon	28.3
pH	6.36

Table 2 - SUMMARY OF HEAT EXCHANGER AND HEAT PUMP CASES

HEAT EXCHANGER CASES				
	125°F	135°F	145°F	Total
2" HX 125°F	-	36	-	
Max - 170 gpm				
Min - 70 gpm				
1" HX 135°F	2	-	-	
Max - 5 gpm				
1" HX 145°F	29	-	-	
Max - 30 gpm				
Min - 10 gpm				
2" HX 150°F	-	3	-	
Max - 3 gpm				
1" HX 175°F	-	-	44	
Max - 35 gpm				
Min - 40 gpm				
1" HX 140°F	29	-	-	
Max - 64 gpm				
Min - 10 gpm				
Total Exchanger gpm	60	103	44	207
Max	109	178	70	357
Min	31	73	50	154

Table 3 - Summary Heat Exchanger and Heat Pump Cases

	GEOTHERMAL FLOW (MAX) GPM	PROCESS WATER TEMP °F	GEOTHERMAL HEAT EXCHANGER W. 300/4	TOTAL 1000
HX 125°F	207	110	5.7	52
HX 135°F	207	120	3.3	30
HX - 1 HP	304	125	9.3	85
HX - 2 HP	340	125 + 155	10.3	98
HX - 3 HP	346	125 + 155 - 175	11.0	100

Geothermal Hot Water Plant

Heat for hot process water can be extracted from the geothermal brine by means of heat exchangers. With a heat exchanger, however, the temperature of the process water leaving the heat exchanger will be limited to the temperature of geothermal brine minus the approach temperature to the heat exchanger. This means that with a heat exchanger, process water temperatures will be limited to 110° to 140°F. Therefore, the use of heat pumps has also been considered in order to meet more closely the plant process water temperature requirements. Process water storage tanks have been included to level out the substantial variation, in hot water demand.

Part of the hot process water is used directly in the preparation of food. Any chance that the geothermal brine would get mixed into the process water has to be eliminated. Therefore, in all cases, an intermediate heat exchange loop has been included establishing a clear separation between the geothermal brine and the process water.

Heat exchangers are all plate type heat exchangers, because they allow the lowest approach temperatures. A realistically achievable approach temperature of 5°F was assumed in all cases.

Flow schematics for a heat exchanger only case, a one heat pump case and a two heat pump, two temperature levels case are shown in Figure 1-3. The last case is also typical for a 3 heat pump, three temperature levels case.

Process design data for the different heat exchanger and heat pump cases have been summarized in Table 3. It shows total hot water requirement of 11 MM Btu/hr or approximately 11,000 lbs/hr of steam. If only heat exchangers are applied, between 52 and 80% of this heat demand can be satisfied with geothermal heat depending on the temperature of geothermal brine. By including between 1 and 3 heat pumps, steam requirements can be reduced to 0 to 15% of the present steam requirements for hot process water.

Capital Cost

For all major pieces of equipment, detailed cost estimates were obtained from vendors. This included heat pumps, heat exchangers, storage tanks, hot lime reactor and sludge centrifuge. Material costs were taken from various estimating publications such as Richardson and R.S. Means and from our "In House" cost Data Files. The costs for special items of material were solicited from vendor sources who had familiarity and experience with the product involved. Installation manhours were estimated for each task. These hours were multiplied by the specific craft rate, including payroll burden, prevailing in the Baltimore, Maryland area in accordance with the latest publication by Richardson. Costs for foremen, supervision, construction services, supplies and tools were included.

Figure 1. Flow Schematic. Heat Exchangers Only

Figure 2. Flow Schematic. One Heat Pump

Figure 3. Flow Schematic. Two Heat Pumps

The total capital costs are the sum of equipment, materials and installation costs. A minimum 10% contingency has been added as well as approximate allowances for overhead and profit.

Economic Analysis

The capital costs for the project are shown on Figure 4. The electrical system costs, which are not shown directly on Figure 4, are a function of well specific capacity (Specific Capacity = Output, gpm/Drawdown, ft). Therefore, the total project costs are shown for various specific capacities. For any particular case, the electrical system cost can be obtained by subtracting the Mechanical + Civil + Well costs from the corresponding total capital cost. It should be noted that the well costs shown are based on the assumption that the reinjection well is drilled to the same depth as the production well, which is probably a conservative assumption.

All of the key operating costs and economic analysis parameters used in this study are summarized on Table 4. The fuel oil and electricity costs are typical of those used by Campbell Soup Co. for evaluating energy projects.

The data on Figure 4 and Table 4 was used to determine after-tax payback periods and discounted cash flow rate of returns (ROR) for each case. The payback periods for each case are shown on Figure 5 and the ROR's are shown on Figure 6. The broken portion of each curve represents the transition range between the cases without heat pumps and those with heat pumps. As indicated on Figure 5 and 6, the payback periods and ROR's become less attractive at the higher flow rates, especially with lower specific capacities (i.e. higher drawdowns). In addition to the extra capital costs and power requirements associated with the heat pumps, this effect is also due to the quite significant amount of power required to pump the water out of the production well and into the reinjection wells.

Conclusions

In general, the maximum payback period which industrial firms will consider for energy projects is 3-6 years. As indicated on Figure 5, for specific capacities of 0.5 and higher, the Campbell Soup Co. geothermal project would satisfy this criteria for a range of well temperatures and flows which could be considered as reasonable expectations based on testing done to date on the Delmarva Peninsula. For well head temperatures of 120°F to 130°F, the project would not meet the criteria regardless of flow rate if the specific capacity were 0.1 or less, and the economics would be marginal at best for values in the range of 0.1 to 0.5.

References

Gruy Federal Inc., Jan. 1980, Crisfield No. 1 Well Final Report, Part II Well Test Analysis

TABLE 4. OPERATING COSTS AND ECONOMIC ANALYSIS PARAMETERS

DATE	END OF PROJECT YEAR	FUEL OIL COST \$/GAL	ELECTRICITY COST \$/KWH
1/1/80		0.50	0.091
5/1/81	0		
5/1/82	1	0.98	0.052
5/1/83	2	1.22	0.062
5/1/84	3	1.46	0.075
5/1/85	4	1.58	0.090

↓
AFTER YEAR 4, THESE COSTS WERE ESCALATED AT 10% PER YEAR

OTHER COSTS AND PARAMETERS

- PROJECT LIFE • 1 YEAR CONSTRUCTION, 20 YEARS OPERATION
- OPERATING HOURS • 5250 HRS/YR
- BOLLER EFFICIENCY (SALISBURY) • 50%
- GEOHEMAL PUMP EFFICIENCY • 55% (OVERALL)
- PRODUCTION AND REINJECTION WELLS • 5000 FT.
- ANNUAL CHEMICAL COST • 11.94/1000 GAL • 10%/YR ESCALATION
- ANNUAL INSURANCE AND TAX COST • 2% OF CAPITAL COST • 10%/YR ESCALATION
- ANNUAL MAINTENANCE COST • 3% OF CAPITAL COST • 10%/YR ESCALATION
- INCOME TAX REDUCTIONS
- INTANGIBLE DRILLING COSTS • 70% OF TOTAL WELL CAPITAL COST
 - DEPRECIATION • STRAIGHT-LINE TO ZERO SALVAGE
- INCOME TAX CREDITS
- INVESTMENT TAX CREDIT • 10%
 - ALTERNATIVE ENERGY TAX CREDIT • 15% OF TANGIBLE WELL COST • SURFACE EQUIPMENT COST (EXCLUDE HEAT PUMPS AND BUILDINGS)
- INCOME TAX RATE • 48.5%

Figure 5 - CAMPBELL SOUP CO., SALISBURY, MARYLAND
AFTER-TAX PAYBACK PERIODS Figure 4 - CAMPBELL SOUP CO., SALISBURY, MARYLAND
GEOHEMAL PROJECT CAPITAL COST BREAKDOWN
4TH QUARTER, 1980 PRICES Figure 6 - CAMPBELL SOUP CO., SALISBURY, MARYLAND
GEOHEMAL PROJECT AFTER-TAX
RATE OF RETURN

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 667 ■ 650 Western Avenue ■ Paramus, New Jersey 07652
■ Tel. N.J. (201) 265-2000 — N.Y. (212) 373-4700 ■ Telex 13-4223 ■ Cable BRISC P

April 9, 1981

Mr. Kyd Brenner
Corn Refiners Association
1001 Connecticut Avenue, Northwest
Washington, D.C. 20036

cc: WToth - EG&G Idaho
HSullivan - DOE
EPeterson - DOE
PNardone
HGitterman
JWMorton
JARocco
REvans - Wash.
~~File 4862-01~~
db

Dear Mr. Brenner:

As I indicated during our phone conversation today, Burns and Roe Industrial Services Corporation and Corn Products (a unit of CPC International) have recently completed a study on the utilization of geothermal energy in a wet corn milling plant.

This study was funded by the U.S. Department of Energy and the results indicate very favorable economics for a range of well temperatures and flows which could reasonably be expected in various areas in this country. Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states, therefore, we feel the results of these studies may be of great interest to the members of your organization.

We would greatly appreciate the opportunity to make a presentation during your organization's Summer Business Meeting in Chicago. Of course, this would be done at our own expense.

The enclosed summary is indicative of the material that could be presented on the study mentioned above. Our presentation can be tailored in both time and technical content to be informative to groups with interests in alternative energy sources. In addition to presenting the results of the studies, we would describe industrial applications where geothermal energy is currently being successfully utilized. We will, in addition, outline the available Government programs that are intended to speed the acceptance and utilization of geothermal resources by industry via economic incentives.

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number:
(201) 265-2000, extension 2879.

Very truly yours,

Raymond M. Costello
Raymond M. Costello, P.E.
Project Manager

RMC/mk

Enclosure

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 667 ■ 650 Winters Avenue ■ Paramus New Jersey 07652
■ Tel. N.J. (201) 265-2000 --- N.Y. (212) 563-7700 ■ Telex 13-4223 ■ Cable BRISC PARAMUS. N.J.

April 9, 1981

Mr. Roger Coleman, Vice President
and Director of Public Communications
National Food Processors Association
1133 20th Street, Northwest
Washington, D.C. 20036

Dear Mr. Coleman:

As indicated during our phone conversation of April 7, 1981, Burns and Roe Industrial Services Corporation has recently completed the following two studies on the utilization of geothermal energy within the food industry:

- a) East Coast Geothermal Resources - Direct Application in the Frozen Food Industry
- b) Direct Application of West Coast Geothermal Resources in a Wet Corn Milling Plant

Both of these studies were funded by the U.S. Department of Energy and the results indicate very favorable economics for a range of well temperatures and flows which could reasonably be expected based on testing done to date in these areas. Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states, therefore, we feel the results of these studies may be of great interest to the members of your organization.

We would greatly appreciate the opportunity to make a presentation during a conference or workshop at your Annual Meeting in Chicago next January. Of course, this would be done at our own expense.

Enclosed are two summaries that are indicative of the content and detail of the material that could be presented on either or both of the studies mentioned above. Our presentation can be tailored in both time and technical content to be informative to groups with interests in alternative energy sources, even if their individual businesses are not specifically in the frozen food or corn milling industries. In addition to presenting the results of the studies, we would describe industrial applications where geothermal energy is currently being successfully utilized. We will, in addition,

Letter to Mr. Roger Coleman
National Food Processors Association

April 9, 1981
Page 2

outline the available Government programs that are intended to speed the acceptance and utilization of geothermal resources by industry via economic incentives.

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2879.

Very truly yours,

Raymond M. Costello, P.E.
Project Manager

RMC/mk
Enclosures

**Burns and Roe
Industrial Services Corp.**

Engineers and

P.O. Box 667 ■ 650 Winters Avenue ■ Paramus, New Jersey 07652
■ Tel. N.J. (201) 265-2000 — N.Y. (212) 563-7700 ■ Telex 13-4223 ■ Cable PRISC F

April 10, 1981

cc: WToth - EG&G Idaho
HSullivan - DOE
EPeterson - DOE
PNardone
HGitterman
JWMorton
JARocco
REvans - Wash.
~~File 1062-01~~
db

12

Ms. Margaret Webster, Executive Director
National Prepared Frozen Food Processors
Association
Box 594
Valley Stream, New York 11582

Dear Ms. Webster:

On April 7th I called your office and, in your absence, was advised to write this letter.

Burns and Roe Industrial Services Corporation and Campbell Soup Company have recently completed a study regarding the conversion of an existing East coast frozen food plant to utilize geothermal energy. The study was funded by the U.S. Department of Energy, and the results indicated very favorable economics for a range of well temperatures and flows which could be considered as reasonable expectations based on testing done to date in the area.

Other investigations have indicated that there are either known or potential geothermal energy resources in 37 states. Therefore, we feel that the results of this study may be of great interest to the members of your organization.

We would greatly appreciate the opportunity to make a presentation during one of your Quarterly Dinner Meetings. We understand that the next available meeting may be January, 1982. Of course, this would be done at our own expense.

Enclosed is a paper entitled, "East Coast Geothermal Resources - Direct Application in the Frozen Food Industry". This paper indicates some of the information we would present. In addition to presenting the results of the study, we would include a brief discussion on the nature of the resource locations where it is known or expected to exist, and industrial plants where it is currently being successfully utilized. In addition, we will outline the available Government programs that are intended to speed acceptance and utilization of geothermal energy by industry via economic incentives.

Letter to Ms. Margaret Webster
National Prepared Frozen Food
Processors

April 10, 1981
Page 2

Thank you for your consideration and cooperation in this matter. If any additional information is required in order to evaluate this request, I may be reached at the following phone number: (201) 265-2000, extension 2879.

Very truly yours,

A handwritten signature in cursive script, reading "Raymond M Costello".

Raymond M. Costello, P.E.
Project Manager

RMC/mk
Enclosure

DIRECT APPLICATION OF WEST COAST GEOTHERMAL RESOURCES
IN A WET CORN MILLING PLANT

Enclosure 1

U.S. Department of Energy

Burns and Roe Industrial Services Corporation, in conjunction with Corn Products, a Unit of CPC International, conducted a study to evaluate the engineering and economic feasibility of utilizing the geothermal resources in East Mesa, California in a hypothetical new Wet Corn Milling Plant.

Two alternative plant designs which utilized geothermal energy were developed.

Case 1 - Geothermal System Conceptual Design

The need to incinerate waste gases at 1750 F, thereby generating large amounts of waste heat, seriously limited the amount of natural gas which could be displaced by the relatively low temperature geothermal energy source. Preliminary investigations indicated that, within the current state-of-the-art, there were no other suitable processes available to eliminate the odor-producing contaminants. Therefore, in the first design alternate considered, geothermal energy was only used to preheat the odorous waste gas stream before it entered the incinerator; to preheat the dry air entering the starch dryer, and to preheat the softened makeup water entering the deaerator.

Case 2 - Combined Geothermal/Cogeneration System Conceptual Design

The second concept considered involved the use of a portion of waste heat from the waste gas incinerator to generate electricity in a back pressure steam turbine. Geothermal energy was used in the process to replace that portion of the waste heat which was used to generate electricity in lieu of process steam. No additional natural gas was burned to produce the electricity. Geothermal Energy was utilized to preheat the gas stream before it entered the incinerator; to preheat the dry air entering the starch dryer; and to preheat the corn steepwater to the evaporator.

The use of geothermal energy in Case 1 was 14.7×10^6 Btu/h (4.307×10 W), while in Case 2 the usage was 20.4×10^6 Btu/h (5.977×10 W). The total reduction in the plant's conventional energy usage would be 6.6 percent for Case 1 and 17.1 percent for Case 2. In Case 2, the cogeneration system permitted the use of more geothermal energy from the same well, thereby making a significant contribution to the return on investment for the geothermal system.

The results of the economic analysis indicated that the after-tax rate of return and simple payback periods were 28 percent and 3.8 years, respectively, for Case 1. The corresponding values for Case 2 were 46.1 percent and 2.2 years.

Enclosure 2

DIRECT APPLICATION OF GEOTHERMAL HEAT
OF A
FROZEN FOOD PLANT

Campbell Soup Company
Salisbury, Maryland

The purpose of this study for the U.S. Department of Energy was to evaluate the technical and economic feasibility of the application of geothermal heat in the Campbell Soup Frozen Food plant in Salisbury, Maryland.

Data regarding geothermal resources on the Delmarva Peninsula were collected and analyzed. These data were subsequently used to project temperatures, flow rates and drawdowns for a possible geothermal well at the Campbell Soup plant site. Chemistry of the Delmarva geothermal brine was evaluated, and two alternate brine pretreatment designs were established.

Conceptual designs were developed for use of the geothermal heat for the production of hot process water, production of steam, production of chilled water and for refrigeration. Net geothermal energy outputs and preliminary economics were established. The results of this conceptual design phase showed that only the production of hot water from geothermal heat should be further pursued in detail.

A total of 12 different geothermal hot process water designs were developed to cover the whole range of anticipated geothermal brine temperatures and flow rates. Some designs considered the use of only heat exchangers. Other designs included the use of one or more heat pumps in order to fully meet the higher temperature process water requirements. Detailed cost data were developed for each design. After-tax payback period and after-tax rate-of-returns were established at three different well drawdown levels for each of the different designs.

Payback periods were found to be attractive ranging from 3 to 6 years.

1
June 2, 1981

A.C.F. Ammerlaan
Project Engineer
Burns and Roe Industrial
Services Corp.
P.O. Box 667
650 Winters Avenue
Paramus, NJ 07652

Dear Mr. Ammerlaan:

Thank you for your letter of May 18. I have referred it to Deven Scott who is the staff contact for the AMI Energy Committee.

Mr. Scott will confer with members of his committee to determine if there is interest in a presentation on utilization of geothermal resources.

Sincerely,

Charles Yuska
Director
Convention & Meetings

cc: D. Scott

CY:pw

Manager:
L. McFate

Associate Manager:
Allen E. Murfin

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Asst. Dean for Research and Extension
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Gainesville, FL 32611

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Professor, Ag Engineering Dept.
Oregon State University
Corvallis, OR 97331

W. J. Spinabella, Midwest Repr.
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Marshfield, MO 65706

Ivan L. Winsett, Southeast Repr.
Executive Director
Georgia Electrification Council, Inc.
Ag Engineering Center
Atlanta, GA 30602

Organization Representatives:
Robert Griffin—EEI
R. A. Pence—NRECA
John Barringer—REA

Food and Energy Council

409 Vandiver West-Suite 202
Columbia, Missouri 65201 (314) 875-7155

June 3, 1981

Mr. A. C. F. Ammerlaan
Project Engineer
Burns and Roe Industrial Services Corp.
P. O. Box 667
Paramus, New Jersey 07652

Dear Mr. Ammerlaan:

Thank you for your letter of May 18, 1981, and your interest in the Food and Energy Council.

I received your letter and copies of your study summaries upon my arrival at the Dupont Plaza Hotel in Washington, D.C. As I indicated to you, during our May 15, 1981, phone conversation, our Conference Committee met in Washington, D.C., Wednesday, May 20, therefore I had the opportunity to submit your proposal to them at that time.

Members of our committee felt that representatives of food processors would have an interest in your presentation, unfortunately, our 1981 Conference agenda is firm and does not provide the flexibility to include another presentation. I will keep your letter and summaries in my active file and it is possible that we could schedule your participation in our 1982 Conference.

Obviously, it will be several months before we begin to develop our program for the 1982 Conference. I would appreciate your keeping me informed of your progress in regard to geothermal resources and its application to the food and energy industries.

I regret that we cannot accommodate your request to make a presentation at our 1981 Conference due to commitments we have already made.

Again, thank you for your interest in the Food and Energy Council. I shall contact you should we plan an appropriate meeting or Conference prior to our 1982 Annual Conference.

Sincerely,

Allen E. Murfin
Associate Manager

cdc

cc: Dorman Miller
Preston Johnson

National Food Processors Association

1133 Twentieth Street N.W., Washington, D.C. 20036
Telephone 202/331-5900

5 + 16
—

June 22, 1981

Mr. A. C. F. Ammerlaan
Burns and Roe Industrial Services Corp.
P. O. Box 667
Paramus, New Jersey 07652

Dear Mr. Ammerlaan:

Roger Coleman asked me to investigate the matters in your letter of May 22 concerning utilization of geothermal energy in the food industry, and particularly your offer to make a presentation on that subject at the industry's 1982 convention.

On the basis of our study of the question, we have to decline your offer.

Members of this Association reporting on their energy conservation have achieved huge energy savings through more efficient utilization of conventional fuels. Of course the industry and the Association are alert to possibilities for energy conservation through all practical means. We have been cognizant of DOE investment in geothermal applications, but cognizant at the same time that geothermal energy is generally available in only a few locations, generally not where there is canning.

The industry and the Association are being flooded with energy saving designs of all sorts. Most of these are past the conceptual stage.

We thank you for your offer but have no basis on which to accept.

Sincerely,

Leonard K. Lobred

LKL/bd

Executive Offices

MILK INDUSTRY FOUNDATION • INTERNATIONAL ASSOCIATION OF ICE CREAM MFRS.

July 28, 1981

Mr. A.C.F. Ammerlaan
Burns and Roe Industrial
Services Corporation
P.O. Box 667
Paramus, New Jersey 07652

Dear Mr. Ammerlaan:

Mr. Tipton has asked me to respond to your letter which outlines the results of two studies on the utilization of geothermal energy within the food industry. The length of time needed to respond has been spent having members of our Environmental Task Force review your letter and provide some input.

Geothermal energy appears to have some application in dairy processing, but utilization is very site specific, i.e., the plant must be located close to the geothermal heat source. Since there would not be wide spread interest in this program, perhaps you would want to contact one of the trade journals to see if they would be interested in publishing the results of your process. Several journals which you might contact are Dairy Record (747 Third Avenue, New York, New York 10017, 212/838-7778) and Dairy Field (Gorman Publishing Company, O'Hare Plaza, 5725 E. River Road, Chicago, Illinois 60631, 312/693-3200).

Thank you for providing this information to us for review and we wish you success with this process.

Sincerely,

Austin T. Rhoads
Administrative Assistant

ATR/lvd

HAWAIIAN SUGAR PLANTERS' ASSOCIATION, 99-193 AIEA HEIGHTS DRIVE, AIEA, HAWAII
MAILING ADDRESS: P.O. BOX 1057, AIEA, HAWAII 96701, TELEPHONE: (808) 487-5561

Don J Heinz
Vice President-Director
Experiment Station

June 9, 1981

Mr. A. C. F. Ammerlaan, Project Engineer
Burns and Roe Industrial
Services Corp.
P. O. Box 667
Paramus, New Jersey 07652

Dear Mr. Ammerlaan:

Your letter addressed to Mr. Berg has been referred to me.

I have sent copies of your letter to members of the industry and they will contact you directly if they are interested in the services you offer.

Sincerely yours,

Don J Heinz

DJH:hb

cc: R Costello

INSTITUTE OF FOOD TECHNOLOGISTS

(312) 782-8424 CALVERT L. WILLEY, EXECUTIVE DIRECTOR

September 5, 1980

George J. Stephens
Burns and Roe
Industrial Services Corp.
P.O. Box 667
650 Winters Ave.
Paramus, NJ 07652

Dear Mr. Stephens,

Just a note to acknowledge receipt of your letter of Aug. 14, and to let you know that I didn't have room in the up-coming issue of Spotlight (September) to include your program items.

I will, however, include an announcement in the next issue (probably November). I plan to use your name and phone number in the announcement so Sections that might be interested can contact you, but obviously this won't be until after November.

Cordially yours,

George R. Foster

George R. Foster, Dir. of Field Services
GRF:pg

Institute of Food Technologists

AK-SAR-BEN SECTION

April 7, 1981

Mr. George J. Stephens
Burns and Roe Industrial
Service Company
P.O. Box 667
Paramus, NJ 07652

Dear Mr. Stephens:

In the December issue of the Institute of Food Technologists' Section Spotlight Newsletter it was mentioned that you can present talks about the use of geothermal energy in wet corn milling and/or frozen food plants. As Chairman-elect and therefore Program Chairman for the Ak-Sar-Ben Section of IFT, I would like to formally request that you make a presentation at one of our Section meetings during the 1981-82 school year. Our section meets on the second Tuesday of each month from September through May. We already have programs scheduled for the October, December and March meetings.

Please let me know if you can make a presentation at any of the other meetings. Beforehand, I must tell you we do not have a budget to cover expenses of guest speakers.

Thank you for considering this request.

Respectfully,

Stan Wallen

Dr. Stan Wallen
Secretary

SW:ep

402-472-2814
116 Filley Hall
University of Nebraska
Lincoln, Nebraska 68583

Institute of Food Technologists

AK-SAR-BEN SECTION

September 10, 1981

Mr. Ray Costello
Burns and Roe Industrial
Services Corp.
P.O. Box 667
Paramus, NJ 07652

Dear Mr. Costello:

On behalf of the Ak-Sar-Ben Section of the Institute of Food Technologists, thank you very much for your fine presentation, "The Use of Geothermal Energy in Wet Corn Milling and Frozen Foods Plants" at our Section's regular monthly meeting.

Sincerely,

Stan Wallen
Chairman-elect
Ak-Sar-Ben Section, IFT

14

BURNS AND ROE, INC.
Record of Telephone Conversation

Date 9/11/80 Time _____

To be confirmed () Yes
() No

From Name <u>R. M. Costello</u> Company or Dept. <u>BRISC</u>	To Name <u>Steve Anderson</u> Company or Dept. <u>American Frozen Food Institute</u> <u>(202) 857-0787</u>
Subject(s) Discussed <u>Geothermal Presentation at AFFI Energy Workshop</u> <u>(Las Vegas, October 22, 1980)</u>	
Remarks <p>Mr. Anderson advised that the Energy Council of the AFFI had decided not to include the geothermal energy presentation in the program of subject meeting. Their feeling was that the membership already has significant involvement in geothermal energy through such projects as OreIda foods, and that they were adequately informed on the current status of the technology.</p> <p>In further discussion, Mr. Anderson indicated that the council's objective was to focus the workshop towards more <u>current</u> problems such as incremental gas pricing, etc. and that they did not want to dilute their efforts in these areas by offering too wide of a spectrum of topics at the meeting. Their general feeling is that technologies such as geothermal, solar, etc. are still developmental in nature, and do not offer immediate solutions to these current problems.</p> <p>I inquired whether AFFI would assist in informing their membership about a separate seminar on geothermal energy if DOE was willing to host and pay the costs involved to hold the conference. He said that there was a possibility, as long as it was non-commercial in nature, and that he would present our request at the council's next meeting (October 22, 1980) if I wrote him a letter. I told him that I would pursue this option with DOE.</p> <div style="text-align: right; margin-top: 20px;"> </div> <p style="margin-top: 20px;">RMC/mk</p>	

Distribution: HGitterman; GStephens; MKnebel; Eric Peterson, DOE.
cc: File 4062-01
db

**Corn
Refiners
Association,
Inc.**

15
1001 Connecticut Avenue, N.W.
Washington, D.C. 20036
(202) 331-1634

Executive Offices

July 8, 1981

Mr. Raymond M. Costello, P.E.
Project Manager
Burns and and Roe
Industrial Services Corporation
P.O. Box 667
650 Winters Avenue
Paramus, New Jersey 07652

Dear Mr. Costello:

Earlier this year we discussed the possibility of Burns and Roe making a presentation to a committee of the Corn Refiners Association on geothermal energy.

Currently we have not scheduled a meeting of the appropriate committee for any time in the near future, so we haven't quizzed the members on their interest in such a presentation. However, prior to the next meeting we will do so, and let you know of the degree of their interest.

Sincerely,

Kyd D. Brenner
Director of Public Affairs

KDB/rrk

BURNS AND ROE, INC.
Record of Telephone Conversation

Date 3/27/80 Time _____

To be confirmed () Yes
() No

From	To
Name <u>Michael Hanemann</u>	Name <u>R. M. Costello</u>
Company or Dept. <u>U.C. Berkeley</u>	Company or Dept. <u>BRISC</u>
Subject(s) Discussed <u>Geothermal Energy Technology Presentations -</u> <u>Under Contract 4862-01 - West Coast Geothermal Study</u>	
Remarks <p>Mr. Hanemann called to confirm his invitation for Burns and Roe to make a presentation on Geothermal Energy at the "Symposium on Innovations in Food Processing and Implications for Energy Substitution".</p> <p>Enclosed is the agenda for this meeting which is to be held on April 15, 1981 at University of California, Davis campus. This presentation will be made as part of the subject work order.</p> <p style="text-align: center;"> </p> <p>RMC/mk</p>	

Distribution: PCDisario, PNardone, HGitterman, JWMorton, JARocco, JPasquarelli,
~~_____~~ Tammerlaan, REvans (Wash.)
db

21

UNIVERSITY OF CALIFORNIA
GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS

SYMPOSIUM ON INNOVATIONS IN FOOD PROCESSING
AND IMPLICATIONS FOR ENERGY SUBSTITUTION

April 15, 1981
10:00 a.m. - 3:00 p.m.
Faculty Club, University of California, Davis

AGENDA

1. Introduction.
Eric Thor and Michael Hanemann, U.C. Berkeley
2. What's going on and where are we headed in the frozen food business?
Eugene Boone, President, John Inglis Frozen Foods Co.
3. The question now is not whether the retortable pouch will be a part of the frozen and canned fruit and vegetable business, but when will it replace the No. 10 can and the frozen institutional package?
Austin J. Hayden, former Senior Vice President, Green Giant, current Vice President, Experience Incorporated
4. Update on equipment available and being developed for processing food into the retortable pouch.
Ric A. Houtzer, Food Machinery Corporation
5. Update on research being conducted by the University of California on food processing.
Sherman Leonard, Food Technology Department, U.C. Davis
6. Report on the recently completed U.C. economic study on processing and marketing frozen vegetables. The study evaluated the effects of rising energy cost on each "stage" of growing, processing, distributing, and retailing of frozen vegetables and potential substitutes for the present method. The substitutes evaluated were the retortable pouch and geothermal energy.
Martin O. Stern, project leader, U.C. Berkeley
7. Potential for geothermal energy in food processing in the United States.
Ray Costello, Burns and Roe Industrial Services, Inc., New Jersey

ITT

**ITT Continental
Baking Company Inc.**

Executive Offices

P.O. Box 731
Rye, New York 10580
(914) 967-4747

671-0358

January 31, 1981

George J. Stephens
Burns & Coe Industrial Service Co.
P.O. Box 667
Paramus, NJ 07652

Dear Mr. Stephens:

I have read from a publication of the IFT that your corporation is under contract with the DOE regarding feasibility and engineering of geothermal energy in food processing.

I am interested in obtaining more information on this subject and look forward to hearing from you.

Thank you.

Very truly yours,

A handwritten signature in cursive script, appearing to read "A.H. Mirman".

A.H. Mirman

AHM/pf

DE 1011
FEB - 2 1981
J. A. [unclear]

APP E

APPENDIX E

Correspondence Concerning Potential for Use
of Geothermal Energy by
ITT Continental Baking Company's Plants

ITT

**ITT Continental
Baking Company Inc.**

Executive Offices

P.O. Box 731
Rye, New York 10580
(914) 967-4747

91-0358

January 31, 1981

George J. Stephens
Burns & Coe Industrial Service Co.
P.O. Box 667
Paramus, NJ 07652

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I have read from a publication of the IFT that your corporation is under contract with the DOE regarding feasibility and engineering of geothermal energy in food processing.

I am interested in obtaining more information on this subject and look forward to hearing from you.

Thank you.

Very truly yours,

A handwritten signature in dark ink, appearing to read "A.H. Mirman".

A.H. Mirman

AHM/pf

cc: H. Stephens
File

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 667 ■ 690 Wether Avenue ■ Fairmont, New Jersey 07424
■ Tel. NJ (201) 265-2000 ■ N.Y. (212) 563-7700 ■ Telex 11 1313 ■ Cable BRINC PARAMUS, N.J.

March 11, 1981

Applied Physics Laboratory
Johns Hopkins University
Johns Hopkins Road
Laurel, MD 20810

Attention: Mr. Fletcher Paddison

Dear Fletcher:

One of our clients, ITT Continental Baking Company, Inc., has requested that we investigate the feasibility of utilizing geothermal energy in one or more of their plants around the country. We are writing to request your help in this regard under the DOE's Technical Assistance Program.

Our primary aim at this point is to define which of the plants are located in areas having either known or potential geothermal resources that may be of use. Typically, ITT's bakeries utilize about 50 gpm of process water which they must raise in temperature from 60° to 150°F. The process water is used on a once-through basis, that is, it is either wasted or consumed within the process. We recognize that these process water loads are relatively low, and that some consideration of using a common well for several neighboring plants in an industrial park setup may be required to achieve attractive economics.

Enclosed is a list showing the locations of the ITT plants in the geographical area for which you provide assistance. Any help you could provide in identifying the locations with the greatest potential and in assessing overall economics would be greatly appreciated. Please respond as soon as possible regarding your ability to comply with our request. If you have any further questions, please contact me at (201) 265-2000, extension 2879.

Very truly yours,

Raymond M. Costello, P.E.
Project Manager

RMC/mk
Enclosure

ITT CONTINENTAL BAKING COMPANY

City

Chicago, IL
Davenport, IA
Detroit-Hostess, MI
Detroit-Wonder, MI
Hammond (Gary), IN
Indianapolis, IN
Milwaukee, WI
Minneapolis, MN
Rochester, MN
Schiller Park
Toledo, OH
Waterloo, IA

ITT CONTINENTAL BAKING COMPANY

City

Dallas, TX
Kansas City, MO
Little Rock, AR
Oklahoma City, OK
Omaha, NE
St. Louis, MO
Sioux City, IA
Tulsa, OK
Wichita, KS

Russelville, AR

ITT CONTINENTAL BAKING COMPANY

City

Akron, OH
Buffalo, NY
Cleveland, OH
East Brunswick, NJ
East Hartford, CT
Jamaica/Bronx, NY
Natick, MA
Norristown, PA
Paterson, NJ
Utica, NY

ITT CONTINENTAL BAKING COMPANY

City

Cincinnati, OH
Clarksdale, MS
Columbus, OH
Dayton, OH
Memphis, TN
Pittsburgh-Braun/ (Wheeling), PA
Raleigh, NC
Richmond, VA
Rome, NY
Tampa, FL
Washington-Wonder

Crozet, VA
Gwaltney, Smithfield, VA

cc: J. Stephens
~~file~~
db

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 667 ■ East Witten Avenue ■ Paramus, New Jersey 07652
■ Tel. N.J. (201) 265-2000 ■ N.Y. (212) 563-7700 ■ Telex: 174477 ■ Cable: BRISC PARAMUS, N.J.

March 11, 1981

EG&G, Idaho, Inc.
P.O. Box 1625
Idaho Falls, ID 83401

Attention: Mr. Bill Toth

Dear Bill:

One of our clients, ITT Continental Baking Company, Inc., has requested that we investigate the feasibility of utilizing geothermal energy in one or more of their plants around the country. We are writing to request your help in this regard under the DOE's Technical Assistance Program.

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Enclosed is a list showing the locations of the ITT plants in your area. Any assistance you could provide in identifying the locations with the greatest potential and in assessing overall economics would be greatly appreciated. Please respond as soon as possible regarding your ability to comply with our request. If you have any further questions, please contact me at (201) 265-2000, extension 2879.

Very truly yours,

Raymond M. Costello, P.E.
Project Manager

RMC/mk
Enclosure

ITT CONTINENTAL BAKING COMPANY

City

Denver, CO

Odgen, UT

Salt Lake City, UT

cc: G. Stephen
~~John~~
db

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 567 ■ 150 Western Avenue ■ Paramus, New Jersey 07652
■ Tel. N.J. (201) 265-2000 ■ N.Y. (212) 563-7700 ■ Telex 13-4277 ■ Cable BRISC PARAMUS, N.J.

March 11, 1981

Geo-Heat Utilization Center
Oregon Institute of Technology
Klamath Falls, OR 97607

Attention: Mr. Paul Lienau

Dear Paul:

One of our clients, ITT Continental Baking Company, Inc., has requested that we investigate the feasibility of utilizing geothermal energy in one or more of their plants around the country. We are writing to request your help in this regard under the DOE's Technical Assistance Program.

Our primary aim at this point is to define which of the plants are located in areas having either known or potential geothermal resources that may be of use. Typically, ITT's bakeries utilize about 50 gpm of process water which they must raise in temperature from 60° to 150° F. The process water is used on a once-through basis, that is, it is either wasted or consumed within the process. We recognize that these process water loads are relatively low, and that some consideration of using a common well for several neighboring plants in an industrial park setup may be required to achieve attractive economics.

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Very truly yours,

Raymond M. Costello, P.E.
Project Manager

RMC/mk
Enclosure

ITT CONTINENTAL BAKING COMPANY

City

Beverly Hills, CA
Los Angeles, CA
San Diego, CA
San Pedro (DiCarlo's), CA

GEO-HEAT CENTER

Oregon Institute of Technology

Klamath Falls, Oregon 97601

503/882-6321 Ex. 267

Paul J. Lienau, Director

March 18, 1981

Ray Costello
Burns & Roe
P.O. Box 667, 650 Winters Avenue
Paramus, NJ 07652

Dear Ray:

I don't know of any resources within reasonable depths, for the temperatures you noted. In the general Los Angeles area there are oil wells with temperatures above 300°F, but of course they probably are not co-located with a bakery, and drilling to those depths is not justified for such a small use.

There are warm, (60's to high 80's °F) wells in the San Diego area. I'm not very familiar with that area, but I understand warm wells seem to be co-located with faults, (of which there are many).

Water source heat pumps might be a good bet. A Westinghouse Templifier will provide up to 148°F water on a single stage, but I don't know what inlet temperature is required in the size range you need. Call Dick Niess for more information, (703) 886-0711.

Heat recovery seems the most obvious solution. Surely a bakery has some stacks that could be used to recover heat from, (I'm sure you thought of that), if baking and water heating occur at the same time or could be scheduled to do so.

For more information on resource temperatures in the Los Angeles area you might contact the following:

Don Lande
Division of Oil and Gas
Los Angeles, CA

Bill Adent
USGS
Los Angeles, CA

Forest Bacon
California Water Resources
Sacramento, CA

You need to supply exact location, i.e. street address, before anyone can be of much help.

Sorry I couldn't be of more help.

Sincerely,

Gene Culver
Associate Director

GRUY FEDERAL, INC.

CONSULTANTS IN ENERGY SYSTEMS

2001 JEFFERSON DAVIS HIGHWAY, SUITE 701
ARLINGTON, VIRGINIA 22202 703/892-2700

March 27, 1981

Mr. Raymond Costello
Burns and Roe
Industrial Services Corporation
P.O. Box 667
Paramus, NJ 07652

Dear Ray:

Fletcher Paddison passed on to us a copy of your letter to him dated March 11, 1981, which requested information concerning geothermal potential. Gruy Federal currently has a technical assistance contract with the Department of Energy to provide geologic and hydrologic assistance to potential geothermal users. We provide our data directly to the user and to the Applied Physics Laboratory for their engineering/economic analyses.

We are working on several other requests at the present time. However, we should be able to provide you a preliminary appraisal of the potential for elevated subsurface temperatures in several weeks. Estimates of actual temperatures, possible flow rates, and the potential for groundwater based heat pumps will require somewhat more time.

Feel free to contact us if you have any questions.

Sincerely yours,

Joel Renner
Project Manager

cc: Fletcher Paddison

THE GRUY COMPANIES—SINCE 1950

DALLAS • HOUSTON • ARLINGTON • BARTLESVILLE • CORPUS CHRISTI • PITTSBURGH

GRUY FEDERAL, INC.

CONSULTANTS IN ENERGY SYSTEMS

2001 JEFFERSON DAVIS HIGHWAY, SUITE 701
ARLINGTON, VIRGINIA 22202 703/892-2700

May 20, 1981

Mr. Raymond M. Costello
Burns and Roe
P.O. Box 667
650 Winters Avenue
Paramus, New Jersey 07652

Dear Ray:

Joel Renner of our office asked me to respond to your request for geologic and hydrologic technical assistance in evaluating the geothermal potential at the list of I.T. & T. plants listed in your 3/11/81 letter to F. C. Paddison. Since your primary goal is to identify those locations with the greatest potential, I have carefully reviewed the entire list and selected three plant locations that coincide with thermally elevated regions as defined in the literature. As you know, the data are limited. However, these three plants offer the best potential based on the present state of knowledge. The thermal data and general hydrologic conditions are listed below.

Additional information and detailed interpretation of hydrologic conditions are possible but will require considerably more effort.

Please contact us for any further discussion you think would be helpful.

Sincerely,

J. Edward Tillman
Senior Geologist

JET:dls

cc: F. C. Paddison, JHU/APL

THE GRUY COMPANIES—SINCE 1950

DALLAS • HOUSTON • ARLINGTON • BARTLESVILLE • CORPUS CHRISTI • PITTSBURGH

Pittsburgh, PA to Wheeling, WV

This region overlies a thick sequence of nearly flat lying Paleozoic sediments on the western limb of the Appalachian Basin. Guffanti and Nathenson (1980) have reviewed thermal data from deep drill holes in this area and have concluded that much of this region has a temperature gradient above 25°C/km for the first two kilometers of depth. Based on a mean annual shallow ground water temperature of 12°C, one can then estimate probable temperatures at 1 to 2 km of 37°C to 62°C. The economics of drilling suggests that this is the range of depths that one is most interested in for geothermal development.

To utilize this thermal energy, naturally occurring ground water is necessary as a heat transfer medium. Although little is known of the regional occurrences of ground water at these depths, a substantial amount of drilling has occurred in this area for oil and gas exploration and gas storage projects. Thus the stratigraphy and approximate depths to various rock units are known. Limited information is also available for brines (saline waters up to 300,000 ppm) which are commonly encountered in sandstone traps associated with oil and gas fields. Less saline waters may occur in other areas such as in carbonate rocks, along the Knox unconformity or in fracture and fault zones. Although less is known about their occurrences, they may prove to be more attractive targets due to their less corrosive nature and the possibility that they are parts of more extensive convective hydrothermal systems.

The oil and gas fields of southwestern Pennsylvania are grouped into two categories. The shallow-sand oil and gas fields produce from Upper Devonian or younger rock units. The main producer of the deeper-sand gas fields is the Lower Devonian Oriskany sandstone which occurs at 6000 feet below sea level in the Pittsburgh area. Very little water occurs in the Upper Devonian formations except for the Hundred Foot Sand. Water production even in this unit can be highly variable. Gas shows are commonly dry, while oil shows usually occur with copious amounts of water. In Allegheny County (which includes Pittsburgh) one well produced a ratio of 90 barrels of water to 1 barrel of oil (Lyttle, 1950). This variability is the result of erratic cementation of the sand and the lenslike forms of these offshore sandbar deposits. Core tests of the permeability of these rocks reveal that the values vary irregularly through a vertical section of the sands from 50 to 1000 md. (Sherrill and others, 1941). Other productive horizons in the shallow-sand gas fields are the Mississippian age Murrys ville, Berea, Big Injun and Mountain sands and the Pennsylvania Salt sands.

The Oriskany Sandstone is probably the best water producer in southwest Pa. Three wells in Clearfield County, where the Oriskany occurs at greater depth, east of Pittsburgh, indicate (as shown below) that this unit is attractive for thermal brine production.

<u>Well Owner</u>	<u>Aquifer Depth</u>	<u>Static water level below landsurface</u>
Manufacturer's Light & Heat	7370	Flowing at surface
New York State Natural Gas	7267-7291	800 ft
F. C. Deemer	7528-7550	900 ft

Buffalo, New York

This region has long been recognized as an area of some of the higher geothermal gradients in the eastern United States. The A.A.P.G. gradient map of North America (Kinney, 1976) reveals a thermally anomalous region underlying Buffalo and parts of western New York. The most comprehensive set of data for this area is contained in a regional investigation by Hodge (1980) and his students from SUNY-Buffalo. Their work reveals that the sedimentary section is about 1 km thick (basement occurs at a depth of about 1 km below the ground surface) and that the best approximation of the geothermal gradient is $29^{\circ}\text{C}/\text{km}$ (based only on wells greater than 750 meters deep). Assuming an average surface temperature of 10°C , the temperature in the lowest units of the sedimentary section is probably approximately 40°C .

Few data are available on the production characteristics of these sedimentary rocks. An investigation of the permeability of the basal Cambrian sandstone and dolomite sequences was conducted by Waller et al (1978). This work revealed that permeability is due mainly to natural fractures and thus is variable and commonly very low. The best way to evaluate water availabilities is by the reports of saline waters from wells. Of the deep units, the Cambrian Galway Formation has produced the most water. Some wells have multiple shows of water within the Galway. The Galway Formation was reported to yield 35 bbl/hour (25 gpm) of connate water from the Tyler well (Kreidler, 1945) 70 km east of Buffalo in Genesee County.

Dallas, Texas

Dallas lies within the Balcones and Luling-Mexico-Talco fault zone where warm subsurface waters from large regional aquifers are presently being used for direct heat applications. Dallas coincides with the $40^{\circ}\text{C}/\text{km}$ temperature gradient to 2 km contour generated from a review of deep drill holes in this area by Guffanti and Natheson (1980). However, more detailed work by Woodruff et al (1979) indicates that the water temperatures in the most productive Cretaceous Aquifers in the immediate area of Dallas are somewhat less than this. The average shallow ground-water temperature for this area is 20°C (65°F).

The three aquifers that possess the greatest potential are the Trinity, the Paluxy, and the Woodbine. All three presently provide local municipalities with potable water at elevated temperature. The top of the Trinity aquifer is approximately 2700 ft below the surface and is about 200 ft thick. Water levels in wells into this unit are 600 ft below the surface. Permeabilities are high and a great deal of production from this aquifer has occurred. Water quality is 1000 ppm. The temperature of water in this aquifer in the Dallas area is (56°C) 100°F although locally it has cooled down due to extensive pumping.

P.O. BOX 1625, IDAHO FALLS, IDAHO 83415

April 14, 1981

Mr. Raymond M. Costello, P.E.
Burns and Roe, Inc.
P.O. Box 667
Paramus, New Jersey 07652

ITT CONTINENTAL BAKING COMPANY AND GEO-RESOURCES - IAE-36-81

Dear Mr. Costello:

Mr. Bill Toth has asked me to respond to your request for information. A preliminary survey of geothermal resource indications at Denver, Ogden and Salt Lake City shows that a relatively deep unproven resource may exist in the Denver area and thermal springs exist at Ogden and Salt Lake City sites. Spring data is summarized:

Ogden, UT	Temperature (°C)	Salinity-TDS (ppm)
Utah Hot Springs	60	21,600
Ogden Hot Springs	57	8,650
Salt Lake City, UT		
Beck's Hot Springs	56	13,900
Wasatch Hot Springs	42	7,295

Depth to the resource will likely vary according to local faulting structure and distance from observed phenomenon. Estimates of depth should be based on geo-hydrologic features and data pertaining to specific sites.

It is suggested that specific sites of interest, especially sites of existing baking plants, be investigated through contact with appropriate State Resource Team personnel and University of Utah Research Institute, Earth Science Laboratory personnel. You may wish to contact:

Ms. Debbie Struhsacker
UURI-ESL
420 Chipeta Way, Suite 120
Salt Lake City, UT 84108
(801) 581-5283

Mr. Richard Pearl
Colorado Geological Survey
1313 Sherman Street, Room 715
Denver, CO 80203
(303) 839-2611

R. M. Costello
April 14, 1981
IAE-36-81
Page 2

In the event you determine a site or sites which seem to warrant further investigation regarding the feasibility of using geothermal energy in the baking facilities, we will address a subsequent request for assistance in the feasibility evaluation.

The relatively low heat loads understood to be served in the baking facilities indicate additional users or uses should be sought to spread geothermal resource development costs, and reduce the net unit cost of geothermal energy developed.

If I can be of further assistance, please call this office at (208) 526-1836.

Yours truly,

I. A. Engen
Geothermal Program Office

jd

cc: Richard Pearl, CGS
Debbie Struhsacker, UURI

APP R

APPENDIX F

Correspondence with Food Engineering Magazine

Food Engineering NORTH AMERICA
Food Engineering INTERNATIONAL
Food Engineering Master ANNUAL PROFILED CATALOG

James Russo
Editor, Food Engineering
North America

RECEIVED

MAR 20 1981

March 18, 1981

Mr. George J. Stephens
BURNS AND ROE INDUSTRIAL SERVICE COMPANY
P.O. Box 667
Paramus, NJ 07652

Dear Mr. Stephens:

Can you send us information about the feasibility studies that you conducted about use of geothermal energy for a corn wet milling plant, and a frozen food plant.

We would like to review the material for a possible article on the subject.

Sincerely,

James R. Russo
Editor

JRR/ef

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 667 ■ 660 Winton Avenue ■ Paramus, New Jersey 07652
■ Tel. N.J. (201) 265-2000 — N.Y. (212) 663-7780 ■ Telex 13-4223 ■ Cable BRISC PARAMUS, N.J.

March 20, 1981

Mr. James R. Russo, Editor
Food Engineering
Chilton Way
Radnor, PA 19089

Subject: Feasibility Studies - Use of Geothermal
Energy for a Wet Corn Milling Plant
and Frozen Food Plant

Dear Mr. Russo:

We are in receipt of your letter of March 18, 1981 to our Mr. George J. Stephens requesting information about the feasibility studies conducted by Burns and Roe Industrial Services Corporation relative to the use of geothermal energy for a wet corn milling plant and a frozen food plant.

Enclosed is a copy of the "Summary" of each of these two reports.

If you require any additional information, do not hesitate to contact the undersigned.

Very truly yours,

Raymond M. Costello,
Project Manager

RMC/mk
Enclosures

G. Stephens
file
✓

Burns and Roe
Industrial Services Corp.

Engineers and Constructors

P.O. Box 667 ■ 650 Winters Avenue ■ Paramus, New Jersey 07652
■ Tel. N.J. (201) 265-2000 — N.Y. (212) 563-7700 ■ Telex 13-4223 ■ Cable BRISC PARAMUS, N.J.

September 3, 1981

cc: PCDisario
PNardone
HGitterman
JWMorton
JARocco
~~File 4862-01~~
db

Mr. R. Dannar 215-964-4455
Food Engineering Magazine
Chilton Way
Radnor, PA 19089

Dear Bob:

As you requested during our telephone conversation today, I have enclosed some information on geothermal energy to supplement the papers previously sent to you. I believe the enclosed material will be sufficient for you to prepare a basic introductory primer on "What is Geothermal Energy?". The enclosed material includes the following:

- U.S. Department of Energy, Geothermal Energy;
- Excerpt from an ASHRAE Report entitled, "Direct Application of Geothermal Energy";
- Two diagrams extracted from other Reports showing typical geological formations in geothermal fields.

I hope this will be of some help to you in preparation of your article. If you have any questions, please do not hesitate to give me a call.

Very truly yours,

Raymond M. Costello, P.E.
Project Manager

RMC/mk
Enclosures

P.S. It would be greatly appreciated if I could have a copy of the magazine.