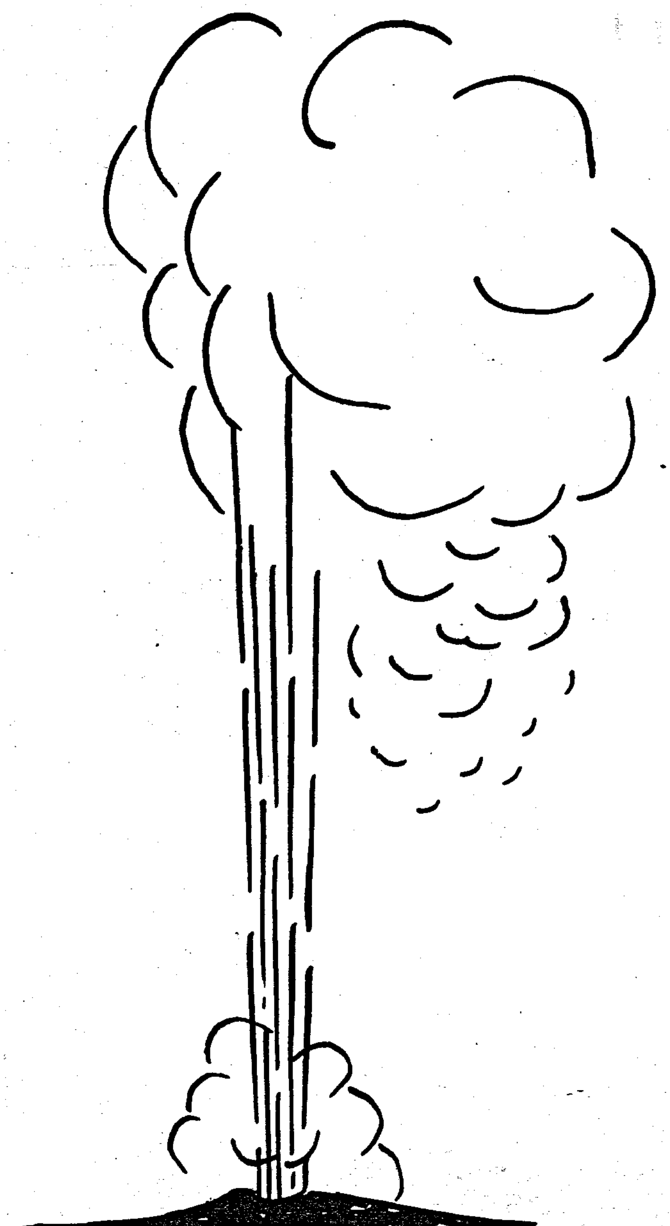
455
4/17/81 T.S.

Dc. 2539

MASTER

DOE/RA/50108-T1



MARKET STUDY FOR DIRECT UTILIZATION OF GEOTHERMAL RESOURCES BY SELECTED SECTORS OF ECONOMY

August 1980

Work Performed Under Contract No. AC01-80RA50108

Sterling Hobe Corporation
Washington, D.C.

U. S. DEPARTMENT OF ENERGY

Geothermal Energy

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DISCLAIMER

"This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."

This report has been reproduced directly from the best available copy.

Available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161.

Price: Printed Copy A11
Microfiche A01

DOE/RA/50108-T1
Distribution Category UC-66g

MARKET STUDY FOR DIRECT UTILIZATION OF GEOTHERMAL RESOURCES BY SELECTED SECTORS OF ECONOMY

Prepared for

U.S. Department of Energy
Energy Technology
Contract DE-AC01-80RA50108

Prepared by

Sterling Hobe Corporation
1747 Pennsylvania Avenue, N.W.
Suite 350
Washington, D.C. 20006

August 1980

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

TABLE OF CONTENTS

LIST OF TABLES

Table No.

EXECUTIVE SUMMARY

INTRODUCTION

This report presents a comprehensive analysis of industrial markets potential for direct use of geothermal energy by a total of six industry sectors:

1) Food and kindred products
2) Tobacco manufactures
3) Textile mill products
4) Lumber and wood products (except furniture)
5) Chemicals and allied products
6) Leather and leather products.

Based upon an earlier report prepared by Sterling Hobe Corporation,[1/] these six industry sectors were chosen for a detailed analysis of industrial markets potential for direct use of geothermal energy. Five chapters and two Appendices comprise this report.

Chapter 1 presents a brief statement regarding sectors of the economy and major manufacturing processes which can readily utilize direct geothermal energy

Chapter 2 summarizes previous studies on plant location determinants and provides appropriate empirical data on plant locations. Chapter 3, critical to this report, presents location determinants and potential for direct use of geothermal resources.

1/ The Direct Thermal Utilization of Geothermal Resources by Industry prepared for U.S. Department of Energy, Energy Technology, by Sterling Hobe Corporation, Washington, D.C., August 1979.

(The data was gathered through interviews with 30 senior executives in the six sectors of economy selected for study.)

Chapter 4 presents probable locations of plants in geothermal resource areas. Chapter 5 presents our recommendations for geothermal resource marketing. Appendix A presents factors which impact on industry location decisions. Appendix B presents industry executives interviewed during the course of this study.

Direct Application of Geothermal Energy to Manufacturing Operations

Increasing energy shortages combined with rapidly rising prices have resulted in increasing requirements for assured energy sources at realistic price levels.

Among the various energy sources geothermal energy is widely available in the United States, and can be expected to meet a significant amount of the current energy demand.

Among the various uses of geothermal energy its direct use is especially attractive, requiring relatively modest capital expenditures as well as operating expenses. Further, as the data in Table 1 indicates, numerous manufacturing processes exist where the direct use of geothermal energy can be applied. Table 1 identifies 234 such processes.

In terms of industry sectors where direct use of geothermal energy is feasible, a total of 76 sectors can be identified (Table 2). The heavy concentration of these sectors in the six industries analyzed for this study is especially significant in Food and Kindred Products, Chemicals and Allied Products, Textile Mills, and Lumber and Wood Products sectors.

Plant Location Determinants

Significant theoretical development of plant location determinants has been ongoing in the United States as well as abroad for many years. Subsequent to E. M. Hoover's original work on factors that determine plant location, it has become increasingly clear that the number of such factors are large and their interrelationships complex. It has also become clear that while certain plant location determinants can be modified by specific policies such as local tax structures, others are beyond change, i.e., the availability of raw materials. Plant location determinants change over time due to changes in products, raw materials, production technologies and transportation systems.

Generally, plant location decisions include:

- New branch plants;
- Relocations; and
- New firms.

In the first two cases, an existing firm must deal with an expansion issue, or an economically inefficient location. A decision must be made to expand at its present location, find an alternate or new location, i.e., relocate; or its present location and expand in a newly located branch plant. Regardless of the type of plant, various studies have indicated two common factors in almost all location decisions:

(1) Firm attempts to locate the plant where profits will be maximized;

(2) Location decision is made by upper management.

The most common methodology used for research of plant location decisions has been relatively crude, and generally depends on either the use of questionnaires or of interview case studies. In the former, the questionnaire is usually mailed to selected firms that have located, asking the decisionmaker to identify and rank or weigh those factors that were important to the firm's location decision. In those using interview case studies, (questionnaires can also be used but supplementally) an interviewer sits down with the decision-maker and guides or explains any item not completely understood. In addition, the firm's transportation costs, labor costs, and related items are usually discussed in detail. The case study approach serves to secure a higher degree of validity to the answers of the decisionmaker.

The critical point in both methods is the use of various location determinants. While the listing of the determinants vary from one study to another, Table ES-3 presents a typical listing of plant location determinants.

In order to determine the importance of plant location determinants for the six industries selected for this study, several of the completed studies that have included empirical data on this issue have been analyzed. The results are as follows:

Food and Kindred Products

Critical location determinants for this sector are:

1) Location in metropolitan suburban area
2) Population of 100,000 or more

3) Availability of contract trucking

4) Availability of public refrigerated warehousing

5) Highway access

6) Scheduled rail service

7) Piggy back facilities

8) Industrial water supply processed

9) Natural gas service

10) Industrial water processing

11) Solid waste disposal

12) Electricity.

Tobacco

Tobacco manufacturing sector has only five critical location determinants:

1) Plant size of 1-4 acres

2) Contract trucking

3) Highway access

4) Electricity

5) Low wage rates.

Textiles

Textile sector has the following nine critical plant location determinants:

1) Air passenger service

2) Contract trucking

3) Local industrial development group

4) Pool of trained workers

5) Highway access

6) Scheduled rail service

7) Industrial water supply (processed)

8) Electricity

9) Low wage rates.

Lumber and Wood Products

This sector has seven critical plant location determinants:

1) Non-metropolitan area location

2) 1-4 acres of plant site size

3) Fire protection

4) Contract trucking

5) Highway access

6) Scheduled rail service

7) Low wage rates.

Chemicals and Allied Products

Surprisingly, this very large and complex industry sector has only five critical plant determinants:

1) Plant site size of at least 5 acres

2) Fire protection

3) Contract trucking

4) Highway access

5) Scheduled rail service.

Leather and Leather Products

Seven critical plant location determinants characterize this sector:

1) Non-metropolitan area location
2) Contract trucking services
3) Highway access
4) Scheduled rail service
5) Piggyback facilities
6) Industrial water supply (processed)
7) Low wage rates.

Clearly the data presented above has shortcomings and limited in coverage. Nevertheless this information provides a degree of knowledge regarding plant location determinants.

In summary, the data analyzed suggest that accessibility to market areas via highway, rail and piggyback facilities is an important consideration for all six industries included in this report.

Low labor rates are equally important to textiles and leather and leather products sector. In the case of Food and Kindred Products industry--surely as important a sector because of its size and growth potential, and proximity to large population concentration--market area is an important plant location determinant.

Finally, in the case of chemicals and allied products, critical plant location determinants are relatively few, principally because the production economics of scale in this industry are large and therefore this industry can and does provide its own services as well as create the economic environment in which it operates.

The distribution of industry is directly related to the factors that individual firms list as being important. Fortunately, excellent although dated empirical data exist to analyze this issue. The data is contained in computer printouts maintained by Economic Development Administration (EDA) of the Department of Commerce.

From the computer printouts maintained by EDA, a total of 24 four-digit SIC industry sectors have been pinpointed that correspond to the six major industry sectors selected for this study. Table 4 (in the text) enumerates the sectors selected.

In general terms, the data clearly indicate that accessibility by truck rather than railroad, water or air transport is critical to all industry sectors. Conversely, accessibility *per se* and not the distance or time spent in delivering goods to the market areas is most important in the other sectors (excluding Food and Kindred Products).

The implication of this finding is that except for Food and Kindred Products sector, the location of a firm can be considerably distant from the market areas, provided the location has outstanding accessibility. Among the modes of transport, trucking is dominant followed by rail.

Location in industrial parks is apparently of marginal importance to most industry sectors. Except for Food and Kindred Products sector, availability of public water systems is also relatively unimportant.

The single plant location characteristic that requires additional emphasis is the large size of plant sites utilized by the Chemicals and Allied Products sector. For example, 75 percent of plants in the industrial chemicals, i.e., SIC 2818, category were located on plant sites 51 acres or larger, and 50 percent were located on sites 100 acres or larger.

Thus, the availability of large parcels of appropriate industrial land is of critical importance to the Chemical and Allied Product sector, and to lesser but still significant extent for the Textiles and Lumber and Wood Products sectors.

In conclusion, our analysis of location decision focuses upon those components of general, long-run entrepreneurial decision processes having a direct or indirect bearing upon the selection of regions, localities, and sites for the pursuit of a firm's activities. The locational and non-locational decision-making components are highly intertwined, and the process by which general internal and external location conditions are mutated into more or less influential location factors is complex and not completely understood.

The history of the firm, the level of production, number and location of already established plants belonging to the firm, availability of and access to capital funds, ownership structure of the firm, competence, roles and personalities of top managers, attitudes and behavior of competitors, contractors, labor unions, chambers of commerce and local development corporations, government policies, and general economic conditions supply examples for internal and external conditions. In any decision process linked to a location selection, many of these conditions remain unconsidered due to their actual or perceived relative insignificance or due to sheer neglect or ignorance; other conditions are indirectly, implicitly, or unconsciously introduced at various stages of the decision process, thus imposing constraints upon the effectiveness of those conditions which are being explicitly and consciously considered. In a large corporation, hardly any individual will be in a position to state with ultimate authority which considerations have been responsible for specific directions and discriminating selections at specific junctions or in specific corporate departments during the usually lengthy location-decision procedure. This complexity can perhaps be approached by identifying stages within the decision process on the basis of crucial thresholds which can be reached in the evolution of spatial and non-spatial constraints for specific, locationally significant variables. Personal interviews with key executives who have the responsibility and the authority to make plant location decisions perhaps offer one of the best methods for identifying this important data.

Prior to reporting the results of our interviews with the senior executives of 30 firms, a summary review of seven regional studies in which plant locations were the principal objective is presented. These studies, while dated and at times contradictory, do provide useful information regarding the plant location determinants in general. Table 5 presents the major plant location determinants found in the seven studies summarized. The information contained in this table clearly suggests that proximity to market (and market availability), low transportation services costs and low labor costs are the three principal plant location determinants. The fourth determinant is supply of raw materials.

In terms of the six industries covered in this report, this means that for Textiles, Chemical and Allied Products and for leather sectors, all of which have nationwide markets, location in any geothermal resource area could be a very attractive proposition, assuming that other plant location requirements can be satisfied. In the case of the Food and Kindred Products sector, plant location must be in close proximity to population concentrations which serve as market areas for the food products produced. The location of plants in Tobacco and Lumber and Wood Products sectors is governed by raw material availability.

Plant Location Determinants: Results of Interviews With Industry Executives

Before considering specifics of individual plant location determinants, several general issues that have a major impact on the Department of Energy marketing effort for direct utilization of geothermal energy should be discussed.

The first issue pertains to the question as to who within an industrial/manufacturing firm determines the location of a new plant and/or chooses to utilize geothermal resources as a source of energy for the plant. Interviews indicate that such decisions are made at a very high level in the corporate structure of the firm. While such decisions are in actuality the result of a committee meeting, the principal member of such committee is usually a senior Vice President for Corporate Planning of the firm. The committee itself, in addition to the Vice President for Corporate Planning, often includes the Chief Executive Officer of the firm, the Vice President for Engineering or Chief Scientist, the Treasurer, and the Vice President for Operations or his equivalent.

The implication of this hierarchical decisionmaking to the direct geothermal energy marketing effort by the Department of Energy is clear: any and all marketing efforts should be directed at the senior executive level of all firms considered candidates for direct use of geothermal energy.

The second issue resulting from our interviews is that of familiarity of the senior executives with DOE programs encouraging the utilization of the nation's geothermal resources in general, and with the Geothermal Loan Guaranty Program (GLBP) in particular. Our interviews indicate beyond any doubt that the industry is almost completely unaware of the Department's efforts to promote direct use of geothermal resources.

While it cannot be claimed that the 30 senior executives interviewed are representative of typical senior executives in the industry, the absence of familiarity on their part with the Department of Energy's programs for geothermal energy utilization is alarming.

The final general issue that requires consideration is that of technical knowledge of direct utilization of geothermal resources (as opposed to institutional/government related issues) on the part of these senior executives who were interviewed.

In this regard, our interviews indicate that most of the senior executives are again not familiar with the technical feasibility of utilizing geothermal resources as a source of energy in the operations of their plants.

Food and Kindred Products

The principal plant location determinant in the Food and Kindred Products sector is close proximity to the consumer markets. According to our interviews, the specific site for a new facility must be immediately accessible to a major highway network which serves the market area.

Energy supply and cost considerations are indeed important to Food and Kindred Product firms and many have an engineering task force evaluating all energy supply options including geothermal resources; however, these energy issues remain secondary with regard to a location of new facilities. Assuming that an appropriate location can be determined which has geothermal resource, a firm in this sector would certainly investigate the feasibility of direct geothermal resource application.

The principal current factors that militate against use of direct geothermal energy are as follows:

- Lack of engineering experience with geothermal energy sources by firms' engineers;

- Considerable initial capital requirements for the development of geothermal resources as compared to conventional energy sources;

- Potential impacts on environment from geothermal resource use and the need for various permits from Federal and state environmental offices.

- Absence of interest by Federal government to encourage geothermal resource use.

According to many executives interviewed, geothermal plants create a risk factor which the managers of Food and Kindred Product firms prefer to ignore until the geothermal resource development costs are firmly established.

In the opinion of many executives the current Geothermal Loan Guaranty Program (GLGP) does not offer sufficient inducement for a firm to develop geothermal resources for a new production facility.

A closely related concern expressed by almost all of those interviewed in the Food and Kindred Products sector was that the in-house engineering staffs of food manufacturing firms as a rule are relatively poorly equipped to undertake the necessary design and construction of geothermal energy facilities.

In summary, according to many of the executives interviewed, the principal plant location determinant for Food and Kindred Products sector is immediate accessibility to the market. If this criterion is satisfied and geothermal resources exist on the site, food processing firms would be interested in utilizing these resources providing that:

- Federal government undertakes additional engineering effort to establish feasibility of the direct geothermal energy use;

- Initial capital costs of geothermal resource development are well established and reasonable;

- A pool of engineering knowledge exists which can render technical assistance in the design and development of direct geothermal utilization facilities.

Tobacco

The cardinal plant location determinant for tobacco sector is close proximity to the raw materials, i.e., tobacco growing areas. However, the utilization of geothermal resources by a tobacco processing firm faces several other obstacles, including:

- Absence of experience regarding geothermal resource development by the in-house engineering staff of tobacco processing firms;
- Unknown initial capital costs of geothermal resource development;
- Potential environmental issues resulting from geothermal resource use.

In summary, the obstacles to the introduction of direct use of geothermal energy in the Tobacco manufacturing sector are almost identical to those of the Food and Kindred Products sector.

Textile Mill Products

All of the senior executives interviewed in the Textile Mill Product sector clearly identified low labor rates and/or non-union labor as the principal plant location determinant.

Lumber and Wood Products

Lumber and Wood Products Sector offers good opportunity for direct utilization of geothermal resources in kiln drying and related applications.

The principal determinant of whether or not firms in this industry will use geothermal resources in their operations is the location of such resources. All of the saw mill operations are located on sites carefully selected to minimize transportation costs of raw logs to the saw mill. If geothermal resources are available at the selected sites, utilization of geothermal resources will be given considerable consideration. However, if geothermal resources are not readily available at the site selected for mill operations, it is not likley that the mill site will be moved to a location where geothermal resources are available. The principal reason is the ability of most well-designed lumber mills to be self sufficient in their energy demands by utilizing tree bark and wood scrap for their heat requirements.

In summary, Lumber and Wood Products sector offers good opportunity for the direct utilization of geothermal resources. The principal obstacle to increased use of geothermal resources by firms in this sector is their supply of bark and wooden scrap which can be used to meet the firm's energy requirements. However, these by-products have their own utility in the manufacture of plywood, wallboard and other products. The technology trends in this industry favor utilization of these by-products. If direct utilization of geothermal energy appears feasible in this sector, firms will utilize this energy source.

However, all of those interviewed expressed significant doubts about the current state-of-art in the direct utilization of geothermal resources. All of those interviewed also suggested that additional Federal government-supported demonstration programs should be undertaken to establish feasibility of direct geothermal resources use as well as to establish firm capital requirements.

Chemicals and Allied Products

Chemicals and Allied Products sector presents an excellent potential for direct use of geothermal resources in their plants. Energy supply and/or cost is not, however, the principal plant location determinant.

According to our interviews, the principal plant location determinants in this sector, in order of importance, are as follows:

- Accessibility to the markets by both rail and truck and access to waterborne transport (both ocean and inland waterways);
- Nearby availability of raw materials and/or access to suppliers of raw materials;
- Availability of skilled labor force or labor pool that can be trained in the necessary skills;
- Location in relatively close proximity to the markets (In practical terms, this means East Coast; Midwest centered in Chicago area and California.)

The accessibility to the various modes of transportation is clearly the dominant location determinant and its importance was stressed by almost all of those interviewed.

The importance of proximity to raw material supply as a location determinant was emphasized by those firms which produce bulk chemicals. Those chemical and allied product firms which principally manufacture industrial and consumer end-products, however, stressed the importance of proximity to markets as the plant location determinant.

Several factors militate against adoption of direct geothermal resource utilization by the Chemical and Allied Products sector. The first is the fact that most of the expansion in this industry during the past decade has taken place by additions to the existing plants rather than construction of "greenfield" facilities. This occurrence is the direct result of various environmental regulations which effectively prohibit construction of new plants.

Another factor that works against use of direct geothermal energy is the presence of technological risks that such undertakings may present. These risks are especially high because of the limited large-scale operations with direct utilization of geothermal resources. However, unlike the case of Food and Related Products sector, or Tobacco, all of those interviewed maintain that their in-house engineering staffs could successfully design and operate direct geothermal resource utilization facilities.

Finally, several of those interviewed expressed the need for an explicit understanding, i.e., a formal agreement, between a firm and the Federal government that in the event a firm undertakes a direct geothermal utilization project, the Federal government would not interfere with the operation in any way, and that the Federal government would not treat the facility as a test demonstration project.

In summary, location of chemical and allied products plants is determined by factors such as access to transportation facilities of all modes and accessibility to raw materials and markets. Energy supply and/or cost is not the principal plant location determinant. Our interviews suggest that this sector offers good opportunity for direct geothermal resource application provided the industry is made aware of these opportunities for geothermal resource utilization.

Leather and Leather Products

Leather and Leather Products sector offers only marginal opportunities for direct use of geothermal resources. First, the cost of energy in leather tanning, processing and shoe manufacture is not an important consideration. Second, the concentration of the leather tanning and shoe manufacturing operations is in the Chicago region and in New England. Both regions are devoid of geothermal resources.

While there is a concentration of leather and leather products industry in Tennessee, a region which has geothermal resource potential, our interviews clearly established the very depressed status of this industry with essentially no projected capital spending for new facilities or renovation of existing plants.

While the large number and complexity of new plant location determinants make it very difficult to project future new plant locations in the geothermal resource regions on the basis of our interviews we have attempted to do so. The results of our projections are presented in Table ES-6. However, it must be emphasized that these projections are highly putative and should be regarded only as indication of the order of magnitude of the number of future new plant locations.

CONCLUSIONS AND RECOMMENDATIONS

Our interviews with the 30 senior industry executives and a survey of pertinent documents unmistakably indicate a general and pervasive absence of knowledge about the Department of Energy's geothermal energy program.

This absence of knowledge of the various program elements that comprise the Department's geothermal energy policy and activities is unfortunate because it hinders acceptance of the Department's geothermal resource utilization marketing effort by industry. Fortunately this lack of knowledge can be readily overcome by the Department of Energy if certain programs and activities are undertaken.

Findings and Recommendations: Location of Geothermal Resource Regions

Almost all of the senior executives interviewed had at best only limited knowledge regarding the spatial boundaries and locations of geothermal resource regions in the United States. Most of those interviewed pointed to the California and Nevada area as the only regions which contain geothermal resources of sufficient quality and quantity to be used by industry.

Our recommendation is that Department of Energy prepare a comprehensive document which clearly delineates the geothermal resource regions in the United States with appropriate additional information related to this resource. We further recommend that this document be mailed to appropriate senior executives (such as Vice

Presidents for Corporate Planning) of the major industrial firms in the nation.

Feasibility of Direct Use of Geothermal Resources

As noted, most of the executives we interviewed professed ignorance concerning the feasibility of direct use of geothermal resources.

Our recommendation is that the Department of Energy prepare a concise statement on this issue supported by appropriate bibliography and contact person for further information in the Department. We also recommend that this statement be distributed as above.

Policies and Activities of Department of Energy With Regard to the Geothermal Energy Utilization

None of the executives we interviewed had a clear understanding of the Department of Energy's policies and activities with regard to the geothermal energy development. None were aware of the Geothermal Loan Guaranty Program (GLGP); none were familiar with the Geothermal Steam Act of 1970 (PL91-581) or Geothermal Energy Research, Development and Demonstration Act of 1974 (PL 93-410) or the activities of the Interagency Geothermal Coordinating Council.

Such knowledge on the part of executives is mandatory in order to prepare them for any marketing effort.

Our recommendation is that the Department of Energy prepare a document that presents this information in a concise and clear manner and distributes this document to the appropriate executives. At a minimum, a fact sheet on these issues with appropriate references for the more detailed and comprehensive information should be prepared and distributed. We also recommend that the Department of Energy create an industry liaison responsibility in the Department, and that the existence of this information source is disseminated throughout the industry.

Further Marketing Activities

In this report, five industry sectors were identified as potential candidates for direct use of geothermal resources:

1) Food and Kindred Products;
2) Tobacco;
3) Textile Mills;
4) Lumber and Wood Products; and
5) Chemicals and Allied Products.

In order to accelerate this marketing activity, our recommendations are:

That the Department of Energy prepare a document summarizing its geothermal energy program and assistance it can render to the industry, and to distribute this document to the senior executives of the major firms in the five sectors of industry. Concurrently, Department of Energy personnel should seek personal meetings with selected executives of the firms in these five sectors in order to present before them the Department's policies with regard to the geothermal energy development. The Department of Energy should also, on the basis of this report, identify site-specific locations within geothermal resource areas and prepare and distribute fact sheets on such locations to the industry. An alternate approach would be for the Department to engage for this task a professional organization with expertise in industrial site location. Finally, we recommend that the Department of Energy organize a conference for industry executives to explain the geothermal utilization policies and activities of the Department of Energy. Judging from an awareness level of those interviewed, the Department of Energy might address several areas of concern with potential industry users of geothermal energy. These areas concern seed money for various successful prototype operations and subsequent distribution of capital costs requirements information. Industry needs assurances that geothermal energy usage will be profitable. Details on full-scale financing must be available upon which industry executives can base their decisions. Included with these financial data should be a basic plan to alleviate fears that industry could not cope with environmental requirements from other sectors of government. Environmental controls must be explained in terms of simplicity, and assurances given that industry will be able to meet these requirements economically and relatively quickly. Also, assurances that the government would serve in an advisory capacity would lend strong credibility to the Department's program.

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement °F	°C
10	1011	Iron Ore	Pelletizing of Concentrates	2350-2500	(1288-1371)
	1021	Copper Concentrate	Drying	250	(121)
12	1211	Bituminous	Drying (including lignite)	150-250	(66-104)
14	1442	Sand and Gravel		None	
	1474	Potash	Drying Filter Cake	250	(121)
	1475	Phosphate Rock	Calcining	1400-1600	(760-871)
			Drying	450	(232)
	1477	Sulfur	Frasch Mining	325-340	(163-171)
	2011	Meat Packing			
	2013	Sausages and Prepared Meats	Scalding, Carcass Wash, and Cleanup	140	(60)
			Singeing Flame	500	(260)
			Edible Rendering	200	(93)
			Smoking/Cooking	155	(68)
	2016	Poultry Dressing	Scalding	140	(60)
	2022	Natural Cheese	Pasteurization	170	(77)
			Starter Vat	135	(57)
			Make Vat	105	(41)
			Finish Vat	100	(38)
			Whey Condensing	160-200	(71-93)
			Process Cheese Blending	165	(74)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
20	2023	Condensed and Evaporated Milk	Sbabilization	200-212	(93-100_
			Evaporation	160	(71)
			Spray Drying	350-400	(177-204)
			Sterlization	250	(121)
	2026	Fluid Milk	Pasteurization	162-170	(72-77)
	2032	Canned Specialities			
		Beans	Precook (Blanch)	180-212	(82-100)
			Simmer Blend	170-212	(77-100)
			Sauce Heating	190	(88)
			Processing	250	(121)
	2033	Canned Fruits and Vegetables	Blanching/Peeling	180-212	(82-100)
			Pasteurization	200	(93)
			Brine Syrup Heating	200	(93)
			Commercial Sterlization	212-250	(100-121)
			Sauce Concentration	212	(100)
	2034	Dehydrated Fruits and Vegetables	Fruit & Vegetable Drying	165-185	(74-85)
		Potatoes	Peeling	212	(100)
			Precook	160	(71)
			Cook	212	(100)
			Flake Dryer	350	(177)
			Granule Flash Dryer	550	(288)
	2037	Frozen Fruits & Vegetables	Citrus Juice Concentration	190	(88)
			Juice Pasteurization	200	(93)
			Blanching	180-212	(82-100)
			Cooking	170-212	(77-100)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
20	2046	Wet Corn Milling	Steep Water Evaporator	350	(177)
			Starch Dryer	120	(49)
			Germ Dryer	350	(177)
			Fiber Dryer	1000	(538)
			Gluten Dryer	350	(177)
			Steepwater Heater	120	(49)
			Sugar Hydrolysis	270	(132)
			Sugar Evaporator	250	(121)
			Sugar Dryer	120	(49)
	2048	Prepared Feeds	Pellet Conditioning	180-190	(82-88)
			Alfalfa Drying	400	(204)
	2051	Bread and Baked Goods	Proofing	100	(38)
			Baking	420-460	(216-238)
	2062	Cane Sugar Refining	Mingler	125-165	(52-74)
			Melter	185-195	(85-91)
			Defecation	160-185	(71-85)
			Revivification	750-1110	(399-599)
			Granulator	110-130	(43-54)
			Evaporator	265	(129)
	2063	Beet Sugar	Extraction	140-185	(60-85)
			Thin Juice Heating	185	(85)
			Lime Calcining	1000	(538)
			Thin Syrup Heating	212	(100)
			Evaporation	270-280	(132-138)
			Granulator	150-200	(66-93)
			Pulp Dryer	230-280	(110-138)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement °F	°C
20	2075	Soybean Oil Mills	Bean Drying	160	(71)
			Toaster Desolvenitzer	215	(102)
			Meal Dryer	350	(177)
			Evaporator	225	(107)
			Stripper	212	(100)
	2077	Animal and Marine Fats	Continuous Rendering of Inedible Fat	330-350	(166-177)
	2079	Shortening and Cooking Oil	Oil Heater	160-180	(71-82)
			Wash Water	160-180	(71-82)
			Dryer Preheat	200-270	(93-132)
			Cooking Oil Reheat	200	(93)
			Hydrogenation Preheat	300	(149)
			Vacuum Deodorizer	300-400	(149-204)
	2082	Malt Beverages	Cooker	212	(100)
			Water Heater	180	*82)
			Mash Tub	170	(77)
			Grain Dryer	400	(204)
			Brew Kettle	212	(100)
	2085	Distilled Liquor	Cooking (Whiskey)	212	(100)
			Cooking (Spirits)	320	(160)
			Evaporation	250-290	(121-143)
			Dryer (Grain)	300-400	(149-204)
			Distillation	230-250	(110-121)
	2086	Soft Drinks	Bulk Container Wash	170	(77)
			Returnable Bottle Wash	170	(77)
			Nonreturnable Bottle Warming	75-85	(24-29)
			Can Warming	75-85	(24-29)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
21	2111	Cigarettes	Drying	220	(104)
			Rehumidification	220	(104)
	2141	Tobacco Stemming and Redrying	Drying	220	(104)
22	2261	Finishing Plants, Cotton	Washing	200	(100)
			Dyeing	200	(100)
			Drying	275	(135)
	2262	Finishing Plants, Synthetic	Washing	200	(93)
			Dyeing	212	(100)
			Drying and Heat Setting	275	(135)
24	2411	Logging Camps		None	
	2421	Sawmills and Planing Mills	Kiln Drying of Lumber	300	(140)
	2435	Plywood	Plywood Drying	250	(121)
	2436	Veneer	Veneer Drying	212	(100)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
25	2511	Wooden Furniture	Makeup Air and Ventilation	70	(21)
			Kiln Dryer and Drying Oven	150	(66)
	2512	Upholstered Furniture	Makeup Air and Ventilation	70	(21)
			Kiln Dryer and Drying Oven	150	(66)
26	2611	Pulp Mills			
	2621	Paper Mills			
	2631	Paperboard Mills			
	2661	Building Paper	Pulp Digestion	370	(188)
			Pulp Refining	150	(66)
			Black Liquor Treatment	280	(138)
			Chemicals Recovery-Calcining	1900	(1038)
			Pulp and Paper Drying	290	(143)
	2653	Solid and Corrugated Fiber Boxes	Corrugating and Glue Setting	300-350	(149-177)
28	2812	Alkalies and Chlorine	Mercury Cell (to be phased out by 1983)		
			Diaphragm Cell	350	(177)
	2865	Cyclic Intermediates	Ethylbenzene	350	(177)
			Styrene	250-350	(121-177)
			Phenol	250	(121)
	28195	Alumina	Digesting, Drying, Heating	280	(138)
			Calcining	2200	(1204)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
28'	2821	Plastic Materials and Resins	Polystyrene, suspension process		
			Polymerizer Preheat	200-215	(93-102)
			Heating Wash Water	190-200	(88-93)
	2822	Synthetic Rubber	Cold SBR Latex Crumb		
			Bulk Storage	80-100	(27-38)
			Emulsification	80-100	(27-38)
			Blowdown Vessels	130-145	(54-63)
			Monomer Recovery by Flashing and Stripping		
			Dryer Air Temperature	150-200	(66-93)
			Cold SBR, Oil-Carbon Black Masterbatch		
			Dryer Air Temperature	150-200	(66-93)
			Oil Emulsion Holding Tank	80-100	(27-38)
			Cold SBR, Oil Masterbatch		
			Dryer Air Temperature	150-200	(66-93)
			Oil Emulsion Holding Tank	80-100	(27-38)
	2823	Cellulosic Man-made Fibers	Polyester	550	(288)
			Nylon	535	(279)
			Acrylic	250	(121)
			Polypropylene.	540	(282)
	2824	Noncellulosic Fibers	Rayon	212	(100)
			Acetate	212	(100)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement °F	°C
28	2834	Pharmaceutical Preparations	Autoclaving & Cleanup	250	(121)
			Tablet and Dry-Capsule Drying	250	(121)
			Wet Capsule Formation	150	(66)
	2841	Soaps and Detergents	Soaps:		
			Various Processes in Soap Mfg.	180	(82)
			High-Temperature Processes	490	(254)
			Spray Drying	500	(260)
			Detergents:		
			Various Low-Temperature Processes	180	(82)
			High-Temperature Processes	500	(260)
			Drum-Dried Detergents	350	(177)
			Spray-Dried Detergents	500	(260)
	2869	Organic Chemicals, N.E.C.	Ethanol	200-250	(93-121)
			Isopropanol	200-350	(93-177)
			Cumene	250	(121)
			Vinyl Chloride Monomer	250-350	(121-177)
	2873	Urea	High-Pressure Steam-Heated Stripper	375	(191)
			Low-Pressure Steam-Heated Stripper	290	(143)
	2892	Explosives	Dope (Inert Ingredients)		
			Drying	300	(149)
			Wax Melting	200	(93)
			Nitric Acid Concentrator	250	(121)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement ^{o}F	^{o}C
28	2892	Explosives (cont'd)	Sulfuric Acid Concentrator	200	(93)
			Nitric Acid Plant	200	(93)
			Blasting Cap Mfg.	200	(93)
29	2922	Petroleum Refining	Crude Distillation		
			Atmospheric Topping	650	(343)
			Vacuum Distillation	440-800	(227-427)
			Thermal Operations	555-1010	(291-543)
			Catalytic Cracking	1125	(607)
			Delayed Coking	900	(482)
			Hydrocracking	515-810	(268-432)
			Catalytic Reforming	925	(496)
			Catalytic Hydrorefining	700	(371)
			Hydrotreating	700	(371)
			Alkylation	45-340	(7-171)
			Hydrogen Plant	1600	(871)
			Olefins and Aromatics	1200	(649)
			Lubricants	Unavail.	--
			Asphalt	Unavail.	--
			Butadiene	250-350	(121-177)
	2951	Paving Mixtures	Aggregate Drying	275-325	(135-163)
			Heating Asphalt	325	(163)
	2952	Asphalt Felts and Coatings	Saturator	400-500	(204-260)
			Asphalt Coating	300-400	(149-204)
			Drying (Steam)	350	(177)
			Sealant	300-400	(149-204)
30	3011	Tires and Inner Tubes	Vulcanization	250-340	(121-171)
	3079	Plastics Products	Blow-Molded Bottles		
			High-Density Polyethylene	425	(218)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
31	3111	Leather Tanning and Finishing	Bating	90	(32)
			Chrome Tanning	85-130	(29-54)
			Retan, Dyeing, Fat Liquor	120-140	(49-60)
			Wash	120	(49)
			Drying	110	(43)
			Finishing Drying	110	(43)
32	3211	Flat Glass	Melting	2300-2700	(1260-1482)
			Fabrication (inc. Tempering and Laminating)	1470-2000	(799-1093)
			Annealing	930	(499)
	3221	Glass Containers	Melting-Firing	2700-2900	(1482-1593)
			Conditioning	1500-2000	(816-1093)
			Annealing	1200	(649)
			Post Forming	1200	(649)
	3241	Hydraulic Cement	Drying	275-325	(135-163)
			Calcining	2300-2700	(1260-1482)
	3251	Brick and Structural Tile	Brick Kiln	2500	(1371)
	3255	Clay Refractories	Refractories Firing	3300	(1816)
	3271	Concrete Block	Low-Pressure Curing	165	(74)
			Autoclaving	360	(182)
	3273	Ready-Mix Concrete	Hot Water for Mixing Concrete	120-190	(49-88)
	3274	Lime	Calcining	1800	(982)
	3275	Gypsum	Kettle Calcining	330	(166)
			Wallboard Drying	300	(149)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
32	3295	Treated Minerals	Expanded Clay and Shale Bloating Process	1800	(982)
			Fuller's Earth Drying and Calcining	1100	(593)
			Kaolin		
			Calcining	1900	(1040)
			Drying	230	(110)
			Expanded Perlite		
			Drying	160	(71)
			Expansion Process	1600	(871)
			Barium		
			Drying	230	(110)
33	3312	Blast Furnaces and Steel Mills	High-Termperature Uses	2700	(1482)
	3321	Ferrous Castings	Gray Iron Foundries (73% of heat)		
	3322		Malleable Iron Foundries (10% of heat)		
	3323		Steel Foundries (17% of heat)		
			Melting in Cupola Furnaces	2700	(1482)
			Mold and Core Prep.	300-475	(149-246)
			Heat Treatment and Finishing	900-1800	(482-982)
			Pickling	100-212	(38-100)
	3331	Primary Copper	Smelting and Fire-Refining	2000-2500	(1095-1371)
	3333	Primary Zinc	Pyrolytic Reduction	2400	(1300)
	3334	Primary Aluminum	Prebaking Anodes	2000	(1093)
34	3479	Galvanizing	Cleaning, Pickling	130-190	(54-88)
			Galvanizing (melting) zinc	850	(454)

TABLE ES-1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement °F	°C
36	3621	Motors and Generators	Drying and Preheat	150	(66)
			Baking	350	(177)
			Oxide Coat Laminations	1500-1700	(816-927)
			Annealing	1500	(816)
37	3711	Motor Vehicles	Baking-Prime and Paint Ovens	250-300	(121-149)
28	2816	Inorganic Pigments	Drying Chrome Yellow	200	(93)

TABLE ES-2

INDUSTRY SECTORS WHERE DIRECT USE OF
OF GEOTHERMAL ENERGY IS FEASIBLE

SIC	Industry
101	Iron Ore Mining
102	Copper Ore Mining
121	Bituminous Coal Mining
144	Sand and Gravel
1474	Potash
1475	Phosphate Rock Mining
1477	Sulfur Mining
201	Meet Processing
2016	Poultry Processing
202	Natural Cheese
2023	Condensed and Evaporated Milk
2026	Fluid Milk
203	Canned Fruits and Vegetables
2034	Dehydrated Fruits and Vegetables
2037	Frozen Fruits and Vegetables
2046	Wet Corn Milling
2048	Prepared Foods
2051	Bread and Baked Goods
2062	Cane Sugar Refining
2063	Beet Sugar
2075	Soybean Oil Mills
2077	Animal and Marine Fats
2079	Shortening and Cooking Oil
2082	Malt Beverages
2085	Distilled Liquor
2086	Soft Drinks
21	Tobacco
2261	Finishing Plants, Cotton
2262	Finishing Plants, Synthetic
2411	Logging Camps
2421	Sawmills and Planning Mills
2435	Plywood
2436	Veneer
2511	Wooden Furniture
2512	Upholstered Furniture
2611	Pulp Mills
2621	Paper Mills
2631	Paperboard Mills
2661	Building Paper
2653	Paper Boxes

Page 1 of 2

TABLE ES-2

INDUSTRY SECTORS WHERE DIRECT USE OF
OF GEOTHERMAL ENERGY IS FEASIBLE

SIC	Industry
2812	Alkalies and Chlorine
2865	Cyclic Intermediates
2819	Alumina
2816	Inorganic Pigments
2821	Plastic Materials and Resins
2822	Synthetic Rubber
2823	Cellulosic Manmade Fibers
2824	Noncellusoc Fibers
2834	Pharmaceutical Preparations
2841	Soaps and Detergents
2869	Organic Chemicals (N.E.C.)
2873	Urea
2892	Explosives
2911	Petroleum Refining
2951	Paving Mixtures
2952	Asphalt Felts and Coatings
3011	Tires and Inner Tubes
3079	Plastic Products
3111	Leather Tanning and Finishing
3211	Flat Glass
3221	Glass Containers
3241	Hydraulic Cement
3251	Brick and Structural Tile
3255	Clay Refractories
3271	Concrete Block
3273	Ready-Mix Concrete
3274	Lime
3275	Gypsum
3295	Treated Minerals
3312	Blast Furnace and Steel Mills
3321	Ferrous Castings
3331	Primary Copper
3333	Primary Zinc
3334	Primary Aluminum
3479	Galvanizing
3621	Motors and Generators
3711	Motor Vehicles

TABLE ES-3

TYPICAL LISTING OF PLANT LOCATION DETERMINANTS

Determinant
I. Geographic Preference:
(1) Central city of a metropolitan area
(2) Metropolitan suburban area
(3) Non-metropolitan area
II. Industrial Park Preference:
III. Community Size Preference
(1) Under 25,000 population
(2) 25,000-49,000
(3) 50,000-99,000
(4) 100,000-249,999
(5) 250,000-499,000
(6) 500,000-999,999
(7) 1,000,000 or more
IV. Plant Site Size Preference:
(1) Less than one acre
(2) 1-4 acres
(3) 5-20 acres
(4) 21-50 acres
(5) 51-100 acres
(6) Over 100 acres

TABLF ES-3

Determinant

V. Community Attributes Considered in Plant Location

(1) Air passenger service
(2) Local industrial bonds
(3) Vocational training facilities
(4) Higher educational facilities
(5) Tax incentives or tax holidays
(6) Fire protection
(7) Contract trucking
(8) Public warehousing
(9) Public refrigerated warehousing
(10) Police protection
(11) Local industrial development group
(12) Pool of trained workers
(13) Pool of unskilled workers
(14) Lenient industrial zoning
(15) Strict industrial zoning

VI. Plant Site Features

(1) Highway access
(2) Scheduled air freight service
(3) Water transportation
(4) Scheduled rail service
(5) Piggy back facilities (rail)
(6) Industrial water supply (processed)
(7) Industrial water supply (raw)
(8) Natural gas service
(9) Industrial sewage processing
(10) Solid waste disposal
(11) Soil load-bearing capabilities
(12) Electricity

VII. Low Wage Rates

TABLE ES-4

INDUSTRY SECTORS SELECTED FOR MANUFACTURING PLANT CHARACTERISTICS

SIC Code	Sector
2086	Bottled and Canned Soft Drinks
2256	Warp Knit Fabrics
2256	Circular Knit Fabrics
2272	Tufted Carpets and rugs
2295	Vinyl Coated Fabrics
2432	Softwood Plywood
2432	Nonwood-face Plywood
2432	Softwood Veneer
2815	Cyclic (coal tar) intermediates
2815	Synthetic Organic Dyes
2818	Miscellaneous Acyclic Chemicals
2819	Synthetic Ammonia
2821	Thermoplastic Resins
2824	Noncellulosic Synthetic Fibers
2833	Synthetic Organic Medicinal Chemicals
2834	Pharmaceutical Preparations
2834	Vitamins, Nutrients
2842	Specialty Cleaning Products
2844	Perfumes, etc.
2844	Miscellaneous Cosmetics
2879	Agricultural Insecticidal Preparations
2899	Miscellaneous Chemicals

TABLE ES-5

PLANT LOCATION DETERMINANTS FROM SELECTED STUDIES

Study	Plant Location Determinants	
Glen E. McLaughlin and S. Robock	1. Market Orientation (45%). 2. Raw Material Availability (30%). 3. Low labor costs (25%).	
Wilbur R. Thompson and I. Mattila	1. Consumer Demand and Market Orientation. 2. Low labor cost. Note that Thompson and Mattila indicate that local taxes has no significant impact on industry location.	
Benjamin Chinitz and R. Vernon	1. Market Orientation	
Robert Lichtenberg	1. Low transportation cost and market orientation (51%). 2. External economics (15%). 3. Historical factors (14%). 4. Low labor costs (81%).	
Harvey Perloff, et al	1. Market Orientation. 2. Agglomeration. 3. Labor. 4. Climate.	
Victor Fuchs	1. Raw material availability (including climate). 2. Low labor cost.	
The Fantus Company, Inc.		Weighted Score
	Transportation:	
	Services	53
	Costs	41
	Proximity to customers	46
	State manpower training assistance	31
	Labor cost advantage	24
	Low cost electric power	24
	Urban orientation	24
	Proximity to raw materials	11

TABLE ES-6

PROBABLE NUMBER OF NEW PLANT FACILITY LOCATIONS IN GEOTHERMAL RESOURCE REGIONS, 1986-1990

Industry Sector	Geothermal Resource Regions			
	Southeastern U.S.	Gulf States	California	Total
Food & Kindred Products	15-20	5	10-15	30-40
Tobacco	2-3	-	-	2-3
Textile Hill Products	6-8	-	-	6-8
Leather & Leather Products	-	-	-	-
Chemical & Allied Products	2-4	3-6	2-3	7-13
Lumber & Lumber Products	6-10	-	-	6-10

INTRODUCTION

This report presents a comprehensive analysis of industrial markets potential for direct use of geothermal energy by a total of six industry sectors:

1) Food and kindred products
2) Tobacco manufactures
3) Textile mill products
4) Lumber and wood products, except furniture
5) Chemicals and allied products
6) Leather and leather products.

These six industry sectors were selected for detailed analyses of industrial markets potential for direct use of geothermal energy, based on an earlier report prepared by Sterling Hobe Corporation.[1/] It was determined that they represent sectors of economy with some growth potential and/or manufacturing activities of these sectors and are located in geothermal resource regions.

This report is comprised of 5 chapters and 2 appendices. Chapter 1 presents a brief statement regarding the sectors of economy and major manufacturing processes that can readily utilize direct geothermal energy. Chapter 2 discusses Plant Location Determinants and related data. Chapter 3 presents additional information about plant location determinants for the six industry sectors, and most important, the results from

---

1/ The Direct Thermal Utilization of Geothermal Resources by Industry. Prepared for U.S. Department of Energy, Energy Technology, Sterling Hobe Corporation, Washington, D.C., August 1979.

our interviews with selected industry executives who expressed their views of utilizing direct geothermal resources in their existing or future plants. This data is central to our report Chapter 4 presents probable locations of plants in geothermal resource areas in the 1980 to 1990 period. Chapter 5 presents our recommendations for geothermal resource marketing.

Appendix A presents factors which impact on industry location decisions. Appendix B presents industry executives interviewed during the course of this study.

This report was prepared by Sterling Hobe Corporation; Ivars Gutmanis was the principal author.

We are grateful for assistance provided to us throughout this project by Dr. Fred Abel and his colleagues from the Department of Energy. We are also grateful for the cooperation provided to us by the numerous industry executives listed in Appendix B to this report.

CHAPTER I

DIRECT APPLICATION OF GEOTHERMAL ENERGY TO MANUFACTURING OPERATIONS

Ever increasing energy shortages, combined with rapidly rising prices, have resulted in increasing requirements for assured energy sources at realistic price levels.

Among the various energy sources, geothermal energy is widely available in the United States, and can be expected to provide a significant amount of current energy demand.

Among the various uses of geothermal energy, the direct use of such energy is especially attractive, requiring relatively modest capital expenditures as well as operating expenses. Further, as the data in Tables 1 and 2 indicate, the number of manufacturing processes where the direct use of geothermal energy can be applied is large.

Table 1 identifies 234 processes where direct geothermal energy applications are feasible. Further, for 26 such processes, temperature requirements are very low, i.e., the heat is used to evaporate water and/or to dry material.

In terms of industry sectors where direct use of geothermal energy is feasible, 76 sectors can be identified (Table 3). These sectors are heavily concentrated in the six industries analyzed in this study.

This concentration is especially significant in Food and Kindred Products and Chemcials and Allied Products sectors (Table 4). However, other sectors of industry are also very

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
10	1011	Iron Ore	Pelletizing of Concentrates	2350-2500	(1288-1371)
	1021	Copper Concentrate	Drying	250	(121)
12	1211	Bituminous	Drying (including lignite)	150-250	(66-104)
14	1442	Sand and Gravel		None	
	1474	Potash	Drying Filter Cake	250	(121)
	1475	Phosphate Rock	Calcining	1400-1600	(760-871)
			Drying	450	(232)
	1477	Sulfur	Frasch Mining	325-340	(163-171)
20	2011	Meat Packing			
	2013	Sausages and Prepared Meats	Scalding, Carcass Wash, and Cleanup	140	(60)
			Singeing Flame	500	(260)
			Edible Rendering	200	(93)
			Smoking/Cooking	155	(68)
	2016	Poultry Dressing	Scalding	140	(60)
	2022	Natural Cheese	Pasteurization	170	(77)
			Starter Vat	135	(57)
			Make Vat	105	(41)
			Finish Vat	100	(38)
			Whey Condensing	160-200	(71-93)
			Process Cheese Blending	165	(74)

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
20	2023	Condensed and Evaporated Milk	Sbabilization	200-212	(93-100_
			Evaporation	160	(71)
			Spray Drying	350-400	(177-204)
			Sterlization	250	(121)
	2026	Fluid Milk	Pasteurization	162-170	(72-77)
	2032	Canned Specialities			
		Beans	Precook (Blanch)	180-212	(82-100)
			Simmer Blend	170-212	(77-100)
			Sauce Heating	190	(88)
			Processing	250	(121)
	2033	Canned Fruits and Vegetables	Blanching/Peeling	180-212	(82-100)
			Pasteurization	200	(93)
			Brine Syrup Heating	200	(93)
			Commercial Sterlization	212-250	(100-121)
			Sauce Concentration	212	(100)
	2034	Dehydrated Fruits and Vegetables	Fruit & Vegetable Drying	165-185	(74-85)
		Potatoes	Peeling	212	(100)
			Precook	160	(71)
			Cook	212	(100)
			Flake Dryer	350	(177)
			Granule Flash Dryer	550	(288)
	2037	Frozen Fruits & Vegetables	Citrus Juice Concentration	190	(88)
			Juice Pasteurization	200	(93)
			Blanching	180-212	(82-100)
			Cooking	170-212	(77-100)

TABLE 1. INDUSTRIAL PROCESSES HEAT REOUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement °F	°C
20	2046	Wet Corn Milling	Steep Water Evaporator	350	(177)
			Starch Dryer	120	(49)
			Germ Dryer	350	(177)
			Fiber Dryer	1000	(538)
			Gluten Dryer	350	(177)
			Steepwater Heater	120	(49)
			Sugar Hydrolysis	270	(132)
			Sugar Evaporator	250	(121)
			Sugar Dryer	120	(49)
	2048	Prepared Feeds	Pellet Conditioning	180-190	(82-88)
			Alfalfa Drying	400	(204)
	2051	Bread and Baked Goods	Proofing	100	(38)
			Baking	420-460	(216-238)
	2062	Cane Sugar Refining	Mingler	125-165	(52-74)
			Melter	185-195	(85-91)
			Defecation	160-185	(71-85)
			Revivification	750-1110	(399-599)
			Granulator	110-130	(43-54)
			Evaporator	265	(129)
	2063	Beet Sugar	Extraction	140-185	(60-85)
			Thin Juice Heating	185	(85)
			Lime Calcining	1000	(538)
			Thin Syrup Heating	212	(100)
			Evaporation	270-280	(132-138)
			Granulator	150-200	(66-93)
			Pulp Dryer	230-280	(110-138)

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
20	2075	Soybean Oil Mills	Bean Drying	160	(71)
			Toaster Desolvenitzer	215	(102)
			Meal Dryer	350	(177)
			Evaporator	225	(107)
			Stripper	212	(100)
	2077	Animal and Marine Fats	Continuous Rendering of Inedible Fat	330-350	(166-177)
	2079	Shortening and Cooking Oil	Oil Heater	160-180	(71-82)
			Wash Water	160-180	(71-82)
			Dryer Preheat	200-270	(93-132)
			Cooking Oil Reheat	200	(93)
			Hydrogenation Preheat	300	(149)
			Vacuum Deodorizer	300-400	(149-204)
	2082	Malt Beverages	Cooker	212	(100)
			Water Heater	180	*82)
			Mash Tub	170	(77)
			Grain Dryer	400	(204)
			Brew Kettle	212	(100)
	2085	Distilled Liquor	Cooking (Whiskey)	212	(100)
			Cooking (Spirits)	320	(160)
			Evaporation	250-290	(121-143)
			Dryer (Grain)	300-400	(149-204)
			Disti-lation	230-250	(110-121)
	2086	Soft Drinks	Bulk Container Wash	170	(77)
			Returnable Bottle Wash	170	(77)
			Nonreturnable Bottle Warming	75-85	(24-29)
			Can Warming	75-85	(24-29)

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
21	2111	Cigarettes	Drying	220	(104)
			Rehumidification	220	(104)
	2141	Tobacco Stemming and Redrying	Drying	220	(104)
22	2261	Finishing Plants, Cotton	Washing	200	(100)
			Dyeing	200	(100)
			Drying	275	(135)
	2262	Finishing Plants, Synthetic	Washing	200	(93)
			Dyeing	212	(100)
			Drying and Heat Setting	275	(135)
24	2411	Logging Camps		None	
	2421	Sawmills and Planing Mills	Kiln Drying of Lumber	300	(140)
	2435	Plywood	Plywood Drying	250	(121)
	2436	Veneer	Veneer Drying	212	(100)

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
25	2511	Wooden Furniture	Makeup Air and Ventilation	70	(21)
			Kiln Dryer and Drying Oven	150	(66)
	2512	Upholstered Furniture	Makeup Air and Ventilation	70	(21)
			Kiln Dryer and Drying Oven	150	(66)
26	2611	Pulp Mills			
	2621	Paper Mills			
	2631	Paperboard Mills			
	2661	Building Paper	Pulp Digestion	370	(188)
			Pulp Refining	150	(66)
			Black Liquor Treatment	280	(138)
			Chemicals Recovery-Calcining	1900	(1038)
			Pulp and Paper Drying	290	(143)
	2653	Solid and Corrugated Fiber Boxes	Corrugating and Glue Setting	300-350	(149-177)
28	2812	Alkalies and Chlorine	Mercury Cell (to be phased out by 1983)		
			Diaphragm Cell	350	(177)
	2865	Cyclic Intermediates	Ethylbenzene	350	(177)
			Styrene	250-350	(121-177)
			Phenol	250	(121)
	28195	Alumina	Digesting, Drying, Heating	280	(138)
			Calcining	2200	(1204)

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
28	2821	Plastic Materials and Resins	Polystyrene, suspension process		
			Polymerizer Preheat	200-215	(93-102)
			Heating Wash Water	190-200	(88-93)
	2822	Synthetic Rubber	Cold SBR Latex Crumb		
			Bulk Storage	80-100	(27-38)
			Emulsification	80-100	(27-38)
			Blowdown Vessels	130-145	(54-63)
			Monomer Recovery by Flashing and Stripping		
			Dryer Air Temperature	150-200	(66-93)
			Cold SBR, Oil-Carbon Black Masterbatch		
			Dryer Air Temperature	150-200	(66-93)
			Oil Emulsion Holding Tank	80-100	(27-38)
			Cold SBR, Oil Masterbatch		
			Dryer Air Temperature	150-200	(66-93)
			Oil Emulsion Holding Tank	80-100	(27-38)
	2823	Cellulosic Man-made Fibers	Polyester	550	(288)
			Nylon	535	(279)
			Acrylic	250	(121)
			Polypropylene.	540	(282)
	2824	Noncellulosic Fibers	Rayon	212	(100)
			Acetate	212	(100)

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
28	2834	Pharmaceutical Preparations	Autoclaving & Cleanup	250	(121)
			Tablet and Dry-Capsule Drying	250	(121)
			Wet Capsule Formation	150	(66)
	2841	Soaps and Detergents	Soaps:		
			Various Processes in Soap Mfg.	180	(82)
			High-Temperature Processes	490	(254)
			Spray Drying	500	(260)
			Detergents:		
			Various Low-Temperature Processes	180	(82)
			High-Temperature Processes	500	(260)
			Drum-Dried Detergents	350	(177)
			Spray-Dried Detergents	500	(260)
	2869	Organic Chemicals, N.E.C.	Ethanol	200-250	(93-121)
			Isopropanol	200-350	(93-177)
			Cumene	250	(121)
			Vinyl Chloride Monomer	250-350	(121-177)
	2873	Urea	High-Pressure Steam-Heated Stripper	375	(191)
			Low-Pressure Steam-Heated Stripper	290	(143)
	2892	Explosives	Dope (Inert Ingredients)		
			Drying	300	(149)
			Wax Melting	200	(93)
			Nitric Acid Concentrator	250	(121)

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
28	2892	Explosives (cont'd)	Sulfuric Acid Concentrator	200	(93)
			Nitric Acid Plant	200	(93)
			Blasting Cap Mfg.	200	(93)
29	2922	Petroleum Refining	Crude Distillation		
			Atmospheric Topping	650	(343)
			Vacuum Distitlation	440-800	(227-427)
			Thermal Operations	555-1010	(291-543)
			Catalytic Cracking	1125	(607)
			Delayed Coking	900	(482)
			Hydrocracking	515-810	(268-432)
			Catalytic Reforming	925	(496)
			Catalytic Hydrorefining	700	(371)
			Hydrotreating	700	(371)
			Alkylation	45-340	(7-171)
			Hydrogen Plant	1600	(871)
			Olefins and Aromatics	1200	(649)
			Lubricants	Unavail.	--
			Asphalt	Unavail.	--
			Butadiene	250-350	(121-177)
	2951	Paving Mixtures	Aggregate Drying	275-325	(135-163)
			Heating Asphalt	325	(163)
	2952	Asphalt Felts and Coatings	Saturator	400-500	(204-260)
			Asphalt Coating	300-400	(149-204)
			Drying (Steam)	350	(177)
			Sealant	300-400	(149-204)
30	3011	Tires and Inner Tubes	Vulcanization	250-340	(121-171)
	3079	Plastics Products	Blow-Molded Bottles		
			High-Density Polyethylene	425	(218)

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement °F	°C
31	3111	Leather Tanning and Finishing	Bating	90	(32)
			Chrome Tanning	85-130	(29-54)
			Retan, Dyeing, Fat Liquor	120-140	(49-60)
			Wash	120	(49)
			Drying	110	(43)
			Finishing Drying	110	(43)
32	3211	Flat Glass	Melting	2300-2700	(1260-1482)
			Fabrication (inc. Tempering and Laminating)	1470-2000	(799-1093)
			Annealing	930	(499)
	3221	Glass Containers	Melting-Firing	2700-2900	(1482-1593)
			Conditioning	1500-2000	(816-1093)
			Annealing	1200	(649)
			Post Forming	1200	(649)
	3241	Hydraulic Cement	Drying	275-325	(135-163)
			Calcining	2300-2700	(1260-1482)
	3251	Brick and Structural Tile	Brick Kiln	2500	(1371)
	3255	Clay Refractories	Refractories Firing	3300	(1816)
	3271	Concrete Block	Low-Pressure Curing	165	(74)
			Autoclaving	360	(182)
	3273	Ready-Mix Concrete	Hot Water for Mixing Concrete	120-190	(49-88)
	3274	Lime	Calcining	1800	(982)
	3275	Gypsum	Kettle Calcining	330	(166)
			Wallboard Drying	300	(149)

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
32	3295	Treated Minerals	Expanded Clay and Shale Bloating Process	1800	(982)
			Fuller's Earth Drying and Calcining	1100	(593)
			Kaolin		
			Calcining	1900	(1040)
			Drying	230	(110)
			Expanded Perlite		
			Drying	160	(71)
			Expansion Process	1600	(871)
			Barium		
			Drying	230	(110)
33	3312	Blast Furnaces and Steel Mills	High-Termperature Uses	2700	(1482)
	3321	Ferrous Castings	Gray Iron Foundries (73% of heat)		
	3322		Malleable Iron Foundries (10% of heat)		
	3323		Steel Foundries (17% of heat)		
			Melting in Cupola Furnaces	2700	(1482)
			Mold and Core Prep.	300-475	(149-246)
			Heat Treatment and Finishing	900-1800	(482-982)
			Pickling	100-212	(38-100)
	3331	Primary Copper	Smelting and Fire-Refining	2000-2500	(1095-1371)
	3333	Primary Zinc	Pyrolytic Reduction	2400	(1300)
	3334	Primary Aluminum	Prebaking Anodes	2000	(1093)
34	3479	Galvanizing	Cleaning, Pickling	130-190	(54-88)
			Galvanizing (melting zinc	850	(454)

TABLE 1. INDUSTRIAL PROCESSES HEAT REQUIREMENTS, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Application Temperature Requirement	
				°F	°C
36	3621	Motors and Generators	Drying and Preheat	150	(66)
			Baking	350	(177)
			Oxide Coat Laminations	1500-1700	(816-927)
			Annealing	1500	(816)
37	3711	Motor Vehicles	Baking-Prime and Paint Ovens	250-300	(121-149)
28	2816	Inorganic Pigments	Drying Chrome Yellow	200	(93)

TABLE 2. INDUSTRIAL PROCESSES HEAT REQUIREMENTS TO EVAPORATE WATER AND/OR DRY MATERIAL, BY INDUSTRY SECTOR

SIC Group	Four Digit SIC Group	Description	Process/Use	Minimum Application Temperature Requirements	
				°F	°C
10	1021	Copper Concentrate	Drying	250	(121)
12	1211	Bituminous Coal	Drying (incl. lignite)	150-250	(66-104)
14	1474	Potash	Drying Filter Cake	250	(121)
	1475	Phosphate Rock	Drying	450	(232)
20	2046	Wet Corn Milling	Starch Dryer	120	(49)
			Sugar Dryer	120	(49)
	2048	Prepared Feeds	Alfalfa Drying	400	(204)
	2063	Beet Sugar	Evaporation	270-280	(132-138)
			Pulp Dryer	230-280	(110-138)
	2075	Soybean Oil Mills	Meal Dryer	350	(177)
	2082	Malt Beverages	Grain Dryer	400	(204)
	2085	Distilled Liquor	Evaporation	250-290	(121-143)
21	2111	Cigarettes	Drying	220	(104)
			Rehumidification	220	(104)
	2141	Tobacco Stemming and Redrying	Drying	220	(104)
28	2841	Soaps and Detergents	Soaps: Spray Drying	500	(260)
			Detergents: Spray-Dried Detergents	500	(260)
			Drum-Dried Deterg.	350	(177)
32	3271	Concrete Block	Low-Pressure Curing	165	(74)
	3295	Treated Minerals	Kaolin: Drying	230	(110)
			Expanded Perlite: Drying	160	(71)
			Barium: Drying	230	(110)

TABLE 3

INDUSTRY SECTORS WHERE DIRECT USE OF GEOTHERMAL ENERGY IS FEASIBLE

SIC	Industry
101	Iron Ore Mining
102	Copper Ore Mining
121	Bituminous Coal Mining
144	Sand and Gravel
1474	Potash
1475	Phosphate Rock Mining
1477	Sulfur Mining
201	Meat Processing
2016	Poultry Processing
202	Natural Cheese
2023	Condensed and Evaporated Milk
2026	Fluid Milk
203	Canned Fruits and Vegetables
2034	Dehydrated Fruits and Vegetables
2037	Frozen Fruits and Vegetables
2046	Wet Corn Milling
2048	Prepared Foods
2051	Bread and Baked Goods
2062	Cane Sugar Refining
2063	Beet Sugar
2075	Soybean Oil Mills
2077	Animal and Marine Fats
2079	Shortening and Cooking Oil
2082	Malt Beverages
2085	Distilled Liquor
2086	Soft Drinks
21	Tobacco
2261	Finishing Plants, Cotton
2262	Finishing Plants, Synthetic
2411	Logging Camps
2421	Sawmills and Planning Mills
2435	Plywood
2436	Veneer
2511	Wooden Furniture
2512	Upholstered Furniture
2611	Pulp Mills
2621	Paper Mills
2631	Paperboard Mills
2661	Building Paper
2653	Paper Boxes

Page 1 of 2

TABLE 3

INDUSTRY SECTORS WHERE DIRECT USE OF OF GEOTHERMAL ENERGY IS FEASIBLE

SIC	Industry
2812	Alkalies and Chlorine
2865	Cyclic Intermediates
2819	Alumina
2816	Inorganic Pigments
2821	Plastic Materials and Resins
2822	Synthetic Rubber
2823	Cellulosic Manmade Fibers
2824	Noncellulosic Fibers
2834	Pharmaceutical Preparations
2841	Soaps and Detergents
2869	Organic Chemicals (N.E.C.)
2873	Urea
2892	Explosives
2911	Petroleum Refining
2951	Paving Mixtures
2952	Asphalt Felts and Coatings
3011	Tires and Inner Tubes
3079	Plastic Products
3111	Leather Tanning and Finishing
3211	Flat Glass
3221	Glass Containers
3241	Hydraulic Cement
3251	Brick and Structural Tile
3255	Clay Refractories
3271	Concrete Block
3273	Ready-Mix Concrete
3274	Lime
3275	Gypsum
3295	Treated Minerals
3312	Blast Furnace and Steel Mills
3321	Ferrous Castings
3331	Primary Copper
3333	Primary Zinc
3334	Primary Aluminum
3479	Galvanizing
3621	Motors and Generators
3711	Motor Vehicles

TABLE 4

DISTRIBUTION OF POTENTIAL DIRECT GEOTHERMAL ENERGY USES AMONG MANUFACTURING SECTORS

SIC	Title	Number of Sectors
SIC 20	Food and Kindred Products	18 sectors
SIC 21	Tobacco	2 sectors
SIC 22	Textiles	2 sectors
SIC 24	Lumber	3 sectors
SIC 25	Furniture	2 sectors
SIC 26	Paper	1 sector
SIC 28	Chemicals	11 sectors
SIC 31	Leather	1 sector
SIC 32	Concrete Products	4 sectors
SIC 33	Primary Metals	1 sector
SIC 34	Fabricated Metals	1 sector
SIC 36	Machinery	1 sector
SIC 37	Transportation Equipment	1 sector

Source: Sterling Hobe Corporation

well suited for direct use, i.e., resources within 70°F to 350°F range. The manufacturing processes which require energy within these temperature ranges are presented in Table 5. Data indicate a total of 113 manufacturing processes well suited for the direct use of geothermal energy. Seventy-three processes are in Food and Kindred Products sector, and 29 processes in Chemicals and Allied Products sector.

In summary, direct application of geothermal energy to various manufacturing operations has considerable technical potential. Whether the use of direct geothermal resources is initiated by the various manufacturing firms depends on numerous plant location determinants, the energy supply and/or cost and related factors. In the following chapter, these determinants and the role of direct geothermal resources are analyzed.

TABLE 5

SELECTED PROCESS HEAT REQUIREMENTS BY MANUFACTURING SECTORS AND BY PROCESS

Major SIC Code	Industry SIC Code	Description	Process	Application Temperature Requirement °F	°C
20 Food	2013	Sausages & prepared meats			
			Scalding, Carcass wash, cleanup	140	60
			Edible Rendering	200	93
			Smoking/Cooking	155	68
	2016	Poultry Dressing	Scalding	140	60
	2022	Natural Cheese Manufacturing			
			Pasteurization	170	77
			Starter Vat	135	57
			Make Vat	105	41
			Finish Vat	100	38
			Whey Condensing	160-200	71-93
			Process Cheese Blending	165	74
	2023	Condensed & Evaporated Milk			
			Stabilization	200-212	93-100
			Evaporation	160	71
			Sterilization	250	121
	2026	Fluid Milk	Pasteurization	162-170	72-77
	2032	Canned Specialties - Beans			
			Precook (Blanch)	180-212	82-100
			Simmer Blend	170-212	77-100
			Sauce Heating	190	88
			Processing	250	121
	2033	Canned Fruits and Vegetables			
			Blanching/Peeling	180-212	82-100
			Pasteurization	200	93
			Brine Syrup Heating	200	93
			Commercial Sterilization	212-250	100-121
			Sauce Concentration	212	100

Page 1 of 7

TABLE 5

SELECTED PROCESS HEAT REQUIREMENTS BY MANUFACTURING SECTORS AND BY PROCESS

Major SIC Code	Industry SIC Code	Description	Process	Application Temperature Requirement °F	°C
20 Food	2075	Soybean Oil Mills	Bean Drying	160	71
			Toaster Desolventizer	215	102
			Meal Dryer	350	177
			Evaporator	225	107
			Stripper	212	100
	2079	Shortening & Cooking Oil	Oil Heater	160-180	71-82
			Wash Water	160-180	71-82
			Dryer Preheat	200-270	93-132
			Cooking Oil Reheat	200	93
			Hydrogenation Preheat	300	149
	2082	Malt Beverages	Cooker	212	100
			Water Heater	180	82
			Mash Tub	170	77
			Brew Kettle	212	100
	2085	Distilled Liquor	Cooking (Whiskey)	212	100
			Cooking (Spirits)	320	160
			Evaporation	250-290	121-143
			Distillation	230-250	110-121
	2086	Soft Drinks	Bulk Container Washing	170	77
			Returnable Bottle Washing	170	77
			Nonreturnable Bottle Warming	75-85	24-29
			Can Warming	75-85	24-29

TABLE 5

SELECTED PROCESS HEAT REQUIREMENTS BY MANUFACTURING SECTORS AND BY PROCESS

Major SIC Code	Industry SIC Code	Description	Process	Application Temperature Requirement °F	°C
20 Food	2037	Frozen Fruits & Vegetables	Fruit & Veg. Drying	165-185	74-85
			Potatoes - Peeling	212	100
			Precook	160	71
			Cook	212	100
			Citrus Juice Concentration	190	88
			Juice Pasteurization	200	93
			Blanching	180-212	82-100
			Cooking	170-212	77-100
	2046	Wet Corn Milling	Starch Dryer	120	49
			Steepwater Heater	120	49
			Sugar Hydrolysis	270	132
			Sugar Evaporator	250	121
			Sugar Dryer	120	49
	2048	Prepared Feeds	Pellet Conditioning	180-190	82-88
	2051	Bread & Baked Goods	Proofing	100	38
	2062	Cane Sugar Refining	Mingler	125-165	52-74
			Melter	185-195	85-91
			Defecation	160-185	71-85
			Granulator	110-130	43-54
			Evaporator	265	129
	2063	Beet Sugar	Extraction	140-185	60-85
			Thin Juice Heating	185	85
			Thin Syrup Heating	212	100
			Evaporation	270-280	132-138
			Granulator	150-200	66-93
			Pulp Dryer	230-280	110-138

TABLE 5

SELECTED PROCESS HEAT REQUIREMENTS BY MANUFACTURING SECTORS AND BY PROCESS

Major SIC Code	Industry SIC Code	Description	Process	Application Temperature Requirement °F	°C
21 Tobacco	2111	Cigarettes	Drying	220	104
			Rehumidification	220	104
	2141	Tobacco Stemming & Redrying	Drying	220	104
22 Textiles	2261	Finishing Plants, Cotton	Washing	200	100
			Dyeing	200	100
			Drying	275	135
	2262	Finishing Plants, Synthetic	Washing	200	93
			Dyeing	212	100
			Drying & Heat Set	275	135
24 Lumber	2421	Sawmills & Planing Mills	Kiln Drying, Lumber	300	149
	2435	Plywood	Plywood Drying	250	121
	2436	Veneer	Veneer Drying	212	100
25 Furniture	2511	Wooden Furniture	Makeup Air & Ventilation	70	21
			Kiln Dryer & Drying Oven	150	66
	2512	Upholstered Furniture	Makeup Air & Ventilation	70	21
			Kiln Dryer & Drying Oven	150	66
26 Paper & Allied Prods	2661	Building Paper	Pulp Refining	150	66
			Black Liquor Treatment	280	138
			Pulp & Paper Drying	290	143
28 Plastics/ Chemicals	2816	Inorganic Pigments	Drying Chrome Yellow	200	93

Page 4 of 7

TABLE 5

SELECTED PROCESS HEAT REQUIREMENTS BY MANUFACTURING SECTORS AND BY PROCESS

Major SIC Code	Industry SIC Code	Description	Process	Application Temperature Requirement °F	°C
28 Plastics/ Chemical	2821	Plastic Materials & Resins	Polymerizer Preheat	200-215	93-102
			Heating Wash Water	190-200	88-93
	2822	Synthetic Rubber	Bulk Storage	80-100	27-38
			Emulsification	80-100	27-38
			Blowdown Vessels	130-145	54-63
			Monomer Recovery by Flashing/Stripping	120-140	49-60
			Dryer Air Temperature	150-200	66-93
			Oil Emulsion Holding Tank	80-100	27-38
	2823	Cellulosic Man-made Fibers	Acrylic	250	121
	2824	Noncellulosic Fibers	Rayon	212	100
			Acetate	212	100
	2834	Pharmaceutical Preparations	Autoclaving & Clean-up	250	121
			Tablet & Dry-capsule Drying	250	121
			Wet Capsule Formation	150	66
	2841	Soaps & Detergents	Soap - Various Processes, Manufacture	180	82
			Deterg. - Various Low Temperature Process	180	82
	2869	Organic Chemicals, NEC	Ethanol	200-250	93-121
			Isopropanol	200-350	93-177
			Cumene	250	121
	2873	Urea	High Pressure Steam-Heated Stripper	375	191

TABLE 5

SELECTED PROCESS HEAT REQUIREMENTS BY MANUFACTURING SECTORS AND BY PROCESS

Major SIC Code	Industry SIC Code	Description	Process	Application Temperature Requirement °F	°C
28 Plastics/ Chemicals	2873	Urea	Low Pressure Steam-Heated Stripper	290	143
	2892	Explosives	Inert Ingredients - Drying	300	149
			Wax Melting	200	93
			Nitric Acid Concentrator	250	121
			Sulfuric Acid Concentrator	200	93
			Nitric Acid Plant	200	93
			Blasting Cap Mfg.	200	93
31 Leather	3111	Leather Tanning & Finishing	Bating	90	32
			Chrome Tanning	85-130	29-54
			Retan, Dyeing, Fat Liquor	120-140	49-60
			Wash	120	49
			Drying	110	43
			Finishing Drying	110	43
32 Concrete	3271	Concrete Block	Low Pressure Curing	165	74
	3273	Ready Mix Concrete	Hot Water for Mixing	120-190	49-88
	3275	Gypsum	Wallboard Drying	300	149
	3295	Treated Minerals	Drying	230	110
		Expanded Perlite	Drying	160	71
		Barium	Drying	230	110
33 Primary Metals	3323	Ferrous Castings	Iron Foundries - Pickling	100-212	38-100

TABLE 5

SELECTED PROCESS HEAT REQUIREMENTS BY MANUFACTURING SECTORS
AND BY PROCESS

Major SIC Code	Industry SIC Code	Description	Process	Application Temperature Requirement	
				°F	°C
34 Fabricated Metals	3479	Galvanizing	Cleaning, Pickling	130-190	54-88
36 Machinery	3621	Motors & Generators	Drying & Preheat	150	66
37 Transportation	3711	Motor Vehicles	Baking-Prime & Paint Ovens	250-300	121-149
38 Professional Instruments					

Source: Based on various reports analyzed by Sterling Hobe Corporation.

CHAPTER 2

PLANT LOCATION DETERMINANTS

This chapter presents a comprehensive discussion on plant location determinants, especially those determinants and factors which impact specifically on the six industry sectors selected for study.

Initially a theoretical discussion of plant location determinants is presented, followed by presentation of available empirical data on the characteristics of plant location for the six sectors of industry.

In the final section of this chapter, results are presented of interviews with industry executives to determine what they consider are important plant location determinants. Throughout this discussion, the energy-related issues in general and the direct utilization of geothermal resources in particular are emphasized.

2.1 PLANT LOCATION DETERMINANTS IN THEORY

The theoretical development of plant location determinants has considerable history of research. Significant theoretical work on this subject has been undertaken in the United States1/

1/ See for example: B. H. Stevens and C. A. Brackett, Industrial Location; a Review and Annotated Bibliography of Theoretical, Empirical and Case Studies, University of Pennsylvania Press, Philadelphia, Pa. 1967.

as well as abroad.[1/]

Ever since E. M. Hoover's original work[2/] on the factors which determine plant location, it has become increasingly clear that the number of such factors are large and their interrelationship complex.[3/] It has also become clear that some plant location determinants can be modified by certain policies[4/], i.e., local tax structure, others are beyond change,[5/] i.e., availability of raw materials. Finally, plant location determinants change over time due to changes in products, raw materials, production technologies and transportation systems.[6/]

1/ F.E.I. Hamilton, "Models of Industrial Location" in R. J. Chorley and P. Haggett (eds) Models in Geography, Allen and Unwin Ltd. London 1967, pp. 361-424.

W. F. Luttrell, Factory Location and Industrial Movement, University Press, London 1962.

2/ E. M. Hoover, The Location of Economic Activity, Harvard University Press, Boston, 1948.

3/ See for example: L. N. Moses, "Location and the Theory of Production" Quarterly Journal of Economics, 72:259-72, 1958, and

G. M. Nentze, "Major Determinant of Location Patterns," Land Economics 43: 227-32, 1967.

4/ On this see: W. Isard and E. W. Schooler, "Industrial Complex Analysis, Agglomeration Economics and Regional Development" Journal of Regional Science, 1:19-33, 1959.

5/ See: M. L. Greenhut Plant Location in Theory and Practice: The Economics of Space, University of North Carolina Press, 1957.

6/ L. Cooper, "Location-Allocation Problems," Operations Research, 11, 331-43, 1963, and D. C. North, "Location Theory and Regional Economic Growth," Journal of Political Economy, 63:243-58, 1955.

Current theoretical considerations of plant location determinants appear to be based in part on decisions regarding:

- new branch plants;
- relocations; and
- new firms.

In the first two cases, an existing firm is faced with either an expansion issue or an economically inefficient location and needs to decide:

- whether to expand at its present location;
- find an alternate or new location (i.e., relocate);
- continue at its present location and expand in a newly located branch plant.

Regardless of the type of plant, various studies[1/] have indicated two common factors in almost all location decisions:

(1) Firm attempts to locate its plant where profits will be maximized;

(2) Location decisions are made by upper management of the firm.

This second factor has been so widely reported that the subject

---

1/ See, for example: L. T. Wallace, Factors Affecting Industrial Location in Southern Indiana, Lafayette, Indiana: Purdue University, Agricultural Experiment Station, Research Bulletin 1961. T. M. Carrol and R. D. Dean, "Plant Location Search Costs and the Economics of Information," paper presented at the Western Regional Science Association Meeting, San Diego, California, 1976; and P. M. Townroe, "Industrial Location Decisions: A Study of Management Behavior," Birmingham, England: University of Birmingham, Centre for Urban and Regional Studies, Occasional Paper No. 15, 1971.

has generated considerable literature of its own.[1/]

The most common methodology employed in this research has been relatively crude, and can be described as falling into two categories:

(1) The use of questionnaires;

(2) The use of interview case studies.

In the former, the questionnaire is usually mailed to selected firms that have located, asking the decisionmaker to identify, and rank/weight those factors central to his firm's location decision. In the latter, questionnaires can also be used, as a supplemental tool, but basically an interviewer consults with the decisionmaker and guides or explains any item not completely understood. In addition, other aspects including the firm's transportation costs, labor costs, and similar items are usually discussed in detail. The case study approach serves to establish a higher degree of accuracy to the answers of the decisionmaker.

The critical point in both methods is the use of various location determinants. While the listing of the determinants vary from one study to another, Table 6 presents a typical listing of plant location determinants. These determinants can be readily grouped into two types:

(1) Those for which quantitative answers can be provided; and

---

1/ For an exhaustive review of previous research, see B. H. Stevens and C. A. Brackett, Industrial Location, A Review and Annotated Bibliography of Theoretical, Empirical and Case Studies, Philadelphia, Pennsylvania, Regional Science Research Institute, 1967.

TABLE 6

TYPICAL LISTING OF PLANT LOCATION DETERMINANTS

Determinant
I. Geographic Preference:
(1) Central city of a metropolitan area
(2) Metropolitan suburban area
(3) Non-metropolitan area
II. Industrial Park Preference:
III. Community Size Preference
(1) Under 25,000 population
(2) 25,000-49,000
(3) 50,000-99,000
(4) 100,000-249,999
(5) 250,000-499,000
(6) 500,000-999,999
(7) 1,000,000 or more
IV. Plant Site Size Preference:
(1) Less than one acre
(2) 1-4 acres
(3) 5-20 acres
(4) 21-50 acres
(5) 51-100 acres
(6) Over 100 acres

Page 1 of 2

TABLE 6

Determinant

V. Community Attributes Considered in Plant Location

(1) Air passenger service
(2) Local industrial bonds
(3) Vocational training facilities
(4) Higher educational facilities
(5) Tax incentives or tax holidays
(6) Fire protection
(7) Contract trucking
(8) Public warehousing
(9) Public refrigerated warehousing
(10) Police protection
(11) Local industrial development group
(12) Pool of trained workers
(13) Pool of unskilled workers
(14) Lenient industrial zoning
(15) Strict industrial zoning

VI. Plant Site Features

(1) Highway access
(2) Scheduled air freight service
(3) Water transportation
(4) Scheduled rail service
(5) Piggy back facilities (rail)
(6) Industrial water supply (processed)
(7) Industrial water supply (raw)
(8) Natural gas service
(9) Industrial sewage processing
(10) Solid waste disposal
(11) Soil load-bearing capabilities
(12) Electricity

VII. Low Wage Rates

(2) Those for which it is impossible to obtain quantitative measures.

A good example of the former group is local wage rates. In the latter group, determinants as "cultural qualities of the town" or "a state administration that is neutral in labor-management relations" can be noted as examples.

Clearly these latter determinants are difficult to quantify and their usefulness in location determination is questionable. Nevertheless they do impact on location decisions in several excellent studies.[1/]

Three important questions arise from the above discussion: (1) what are the variables considered by entrepreneurs in making locational decisions? (2) to what extent does the distribution of industry correlate with factors that individual firms list as being important: that is, even if they know where they should locate, do firms have sufficient information and ability to find a correct location? (3) what are the distinguishable characteristics of those firms located at sites not in accord with the factors most firms claim to be important? With regard to the variables considered, some answers can be obtained from numerous empirical studies on plant locations completed in the United States in recent years.

Since the importance of the location determinants differs among industries, separate sets of determinants for each of the

---

1/ See for example: M. Greenhut, Plant Location in Theory and Practice, University of North Carolina Press, 1968.

six industries included in this study require analysis. Tables 7 through 12 present the results of several studies analyzing plant location determinants. As noted, the information presented in these tables has been derived from several sources that are not fully comparable. Further, not all location determinants included in these studies have been treated in a uniform manner. However, some significant general information on plant location preferences has been obtained for these six industries.

2.1.1 Food and Kindred Products

Table 6 indicates that the critical location determinants for this sector are:

(1) Location in metropolitan suburban area
(2) Population of 100,000 or more
(3) Availability of contract trucking
(4) Availability of public refrigerated warehousing
(5) Highway access
(6) Scheduled rail service
(7) Piggyback facilities
(8) Industrial water supply processed
(9) Natural gas service
(10) Industrial water processing
(11) Solid waste disposal; and
(12) Electricity

The importance of location in a metropolitan suburban area with a population of 100,000 and over represents the need for this

TABLE 7. VALUATION OF PLANT LOCATION DETERMINANTS
FOOD AND KINDRED PRODUCTS

Determinant	Determinants: Critical	Determinants: Important	Determinants: Not Important
I. Geographic Preference:			
(1) Central city of a metropolitan area			XXX
(2) Metropolitan suburban area	XXX		XXX
(3) Non-metropolitan area			XXX
II. Industrial Park Preference:			XXX
III. Community Size Preference			
(1) Under 25,000 population			XXX
(2) 25,000-49,000			XXX
(3) 50,000-99,000			
(4) 100,000-249,999	XXX		
(5) 250,000-499,000	XXX		
(6) 500,000-999,999	XXX		
(7) 1,000,000 or more	XXX		
IV. Plant Site Size Preference:			
(1) Less than one acre		XXX	
(2) 1-4 acres			XXX
(3) 5-20 acres			XXX
(4) 21-50 acres			XXX
(5) 51-100 acres			XXX
(6) Over 100 acres			XXX

Page 1 of 3

TABLE 7. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants		
	Critical	Important	Not Important
V. Community Attributes Considered in Plant Location			
(1) Air passenger service			XXX
(2) Local industrial bonds			XXX
(3) Vocational training facilities			XXX
(4) Higher educational facilities			XXX
(5) Tax incentives or tax holidays		XXX	
(6) Fire protection		XXX	
(7) Contract trucking	XXX		
(8) Public warehousing			XXX
(9) Public refrigerated warehousing	XXX		
(10) Police protection			XXX
(11) Local industrial development group		XXX	
(12) Pool of trained workers		XXX	
(13) Pool of unskilled workers			
(14) Lenient industrial zoning			XXX
(15) Strict industrial zoning			
VI. Plant Site Features			
(1) Highway access	XXX		
(2) Scheduled air freight service			XXX
(3) Water transportation			XXX
(4) Scheduled rail service	XXX		
(5) Piggy back facilities (rail)	XXX		
(6) Industrial water supply (processed)	XXX		

Page 2 of 3

TABLE 7. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants		
	Critical	Important	Not Important
VI (cont'd)			
(7) Industrial water supply (raw)		XXX	
(8) Natural gas service	XXX		
(9) Industrial sewage processing	XXX		
(10) Solid waste disposal	XXX		
(11) Soil load-bearing capabilities			XXX
(12) Electricity	XXX		
VII. Low Wage Rates		XXX	

Sources: Compiled from: B. H. Stevens and C. A. Brackett Industrial Location: A Review and Annotated Bibliography, Philadelphia, Pa. Regional Science Research Institute, 1967; R. E. Carrier and W. R. Schriver Plant Location Analysis, Memphis State University, Bureau of Business and Economic Research, 1969 and J. I. Griffin, Industrial Location in New York Area, N.Y. City College Press, 1956.

TABLE 8. VALUATION OF PLANT LOCATION DETERMINANTS
TOBACCO

Determinant	Determinants: Critical	Important	Not Important
I. Geographic Preference:			
(1) Central city of a metropolitan area			XXX
(2) Metropolitan suburban area			XXX
(3) Non-metropolitan area			XXX
II. Industrial Park Preference:			
III. Community Size Preference			XXX
(1) Under 25,000 population			XXX
(2) 25,000-49,000			XXX
(3) 50,000-99,000		XXX	
(4) 100,000-249,999			XXX
(5) 250,000-499,000			XXX
(6) 500,000-999,999			XXX
(7) 1,000,000 or more			XXX
IV. Plant Site Size Preference:			
(1) Less than one acre			XXX
(2) 1-4 acres	XXX		
(3) 5-20 acres			XXX
(4) 21-50 acres			XXX
(5) 51-100 acres			XXX
(6) Over 100 acres			XXX

Page 1 of 3

TABLE 8. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants		
	Critical	Important	Not Important
V. Community Attributes Considered in Plant Location			
(1) Air passenger service			XXX
(2) Local industrial bonds		XXX	
(3) Vocational training facilities			XXX
(4) Higher educational facilities			XXX
(5) Tax incentives or tax holidays		XXX	
(6) Fire protection		XXX	
(7) Contract trucking	XXX		
(8) Public warehousing		XXX	
(9) Public refrigerated warehousing			XXX
(10) Police protection			XXX
(11) Local industrial development group		XXX	
(12) Pool of trained workers			XXX
(13) Pool of unskilled workers			XXX
(14) Lenient industrial zoning		XXX	
(15) Strict industrial zoning			XXX
VI. Plant Site Features			
(1) Highway access	XXX		
(2) Scheduled air freight service			XXX
(3) Water transportation			XXX
(4) Scheduled rail service		XXX	
(5) Piggy back facilities (rail)		XXX	
(6) Industrial water supply (processed)			XXX

Page 2 of 3

TABLE 8 VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants: Critical	Important	Not Important
VI (cont'd)			
(7) Industrial water supply (raw)			XXX
(8) Natural gas service		XXX	
(9) Industrial sewage processing		XXX	
(10) Solid waste disposal		XXX	
(11) Soil load-bearing capabilities			XXX
(12) Electricity	XXX		
VII. Low Wage Rates	XXX		

Sources: Compiled from: B. H. Stevens and C. A. Brackett Industrial Location: A Review and Annotated Bibliography, Philadelphia, Pa. Regional Science Research Institute, 1967; R. E. Carrier and W. R. Schriver Plant Location Analysis, Memphis State University, Bureau of Business and Economic Research, 1969 and J. I. Griffin, Industrial Location in New York Area, N.Y. City College Press, 1956.

TABLE 9. VALUATION OF PLANT LOCATION DETERMINANTS
TEXTILES

Determinant	Determinants: Critical	Determinants: Important	Determinants: Not Important
I. Geographic Preference:			
(1) Central city of a metropolitan area			XXX
(2) Metropolitan suburban area			XXX
(3) Non-metropolitan area			XXX
II. Industrial Park Preference:			
III. Community Size Preference			
(1) Under 25,000 population			XXX
(2) 25,000-49,000		XXX	
(3) 50,000-99,000			XXX
(4) 100,000-249,999			XXX
(5) 250,000-499,000			XXX
(6) 500,000-999,999			XXX
(7) 1,000,000 or more		XXX	
IV. Plant Site Size Preference:			
(1) Less than one acre			XXX
(2) 1-4 acres		XXX	
(3) 5-20 acres			XXX
(4) 21-50 acres			XXX
(5) 51-100 acres			XXX
(6) Over 100 acres			XXX

TABLE 9. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants: Critical	Important	Not Important
V. Community Attributes Considered in Plant Location			
(1) Air passenger service	XXX		
(2) Local industrial bonds		XXX	
(3) Vocational training facilities		XXX	
(4) Higher educational facilities			XXX
(5) Tax incentives or tax holidays		XXX	
(6) Fire protection		XXX	
(7) Contract trucking	XXX		
(8) Public warehousing		XXX	
(9) Public refrigerated warehousing			XXX
(10) Police protection		XXX	
(11) Local industrial development group	XXX		
(12) Pool of trained workers	XXX		
(13) Pool of unskilled workers			XXX
(14) Lenient industrial zoning		XXX	
(15) Strict industrial zoning			XXX
VI. Plant Site Features			
(1) Highway access	XXX		
(2) Scheduled air freight service			XXX
(3) Water transportation			XXX
(4) Scheduled rail service	XXX		
(5) Piggy back facilities (rail)		XXX	
(6) Industrial water supply (processed)	XXX		

TABLE 9. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants		
	Critical	Important	Not Important
VI (cont'd)			
(7) Industrial water supply (raw)		XXX	
(8) Natural gas service		XXX	
(9) Industrial sewage processing		XXX	
(10) Solid waste disposal		XXX	
(11) Soil load-bearing capabilities			XXX
(12) Electricity	XXX		
VII. Low Wage Rates	XXX		

Sources: Compiled from: B. H. Stevens and C. A. Brackett Industrial Location: A Review and Annotated Bibliography, Philadelphia, Pa. Regional Science Research Institute, 1967; R. E. Carrier and W. R. Schriver Plant Location Analysis, Memphis State University, Bureau of Business and Economic Research, 1969 and J. I. Griffin, Industrial Location in New York Area, N.Y. City College Press, 1956.

TABLE 10. VALUATION OF PLANT LOCATION DETERMINANTS
LUMBER AND WOOD PRODUCTS

Determinant	Determinants		
	Critical	Important	Not Important
I. Geographic Preference:			
(1) Central city of a metropolitan area			XXX
(2) Metropolitan suburban area			XXX
(3) Non-metropolitan area	XXX		
II. Industrial Park Preference:			
III. Community Size Preference			
(1) Under 25,000 population		XXX	
(2) 25,000-49,000			XXX
(3) 50,000-99,000			XXX
(4) 100,000-249,999			XXX
(5) 250,000-499,000			XXX
(6) 500,000-999,999			XXX
(7) 1,000,000 or more			XXX
IV. Plant Site Size Preference:			
(1) Less than one acre			XXX
(2) 1-4 acres	XXX		
(3) 5-20 acres			XXX
(4) 21-50 acres			XXX
(5) 51-100 acres			XXX
(6) Over 100 acres			XXX

Page 1 of 3

TABLE 10. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants		
	Critical	Important	Not Important
V. Community Attributes Considered in Plant Location			
(1) Air passenger service			XXX
(2) Local industrial bonds		XXX	
(3) Vocational training facilities			XXX
(4) Higher educational facilities			XXX
(5) Tax incentives or tax holidays		XXX	
(6) Fire protection	XXX		
(7) Contract trucking	XXX		
(8) Public warehousing			XXX
(9) Public refrigerated warehousing			XXX
(10) Police protection		XXX	
(11) Local industrial development group	XXX		
(12) Pool of trained workers			XXX
(13) Pool of unskilled workers		XXX	
(14) Lenient industrial zoning		XXX	
(15) Strict industrial zoning			XXX
VI. Plant Site Features			
(1) Highway access	XXX		
(2) Scheduled air freight service			XXX
(3) Water transportation		XXX	
(4) Scheduled rail service	XXX		
(5) Piggy back facilities (rail)			XXX
(6) Industrial water supply (processed)			XXX

Page 2 of 3

TABLE 10. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants: Critical	Important	Not Important
VI (cont'd)			
(7) Industrial water supply (raw)			XXX
(8) Natural gas service		XXX	
(9) Industrial sewage processing			XXX
(10) Solid waste disposal		XXX	
(11) Soil load-bearing capabilities			XXX
(12) Electricity		XXX	
VII. Low Wage Rates	XXX		

Sources: Compiled from: B. H. Stevens and C. A. Brackett Industrial Location: A Review and Annotated Bibliography, Philadelphia, Pa. Regional Science Research Institute, 1967; R. E. Carrier and W. R. Schriver Plant Location Analysis, Memphis State University, Bureau of Business and Economic Research, 1969 and J. I. Griffin, Industrial Location in New York Area, N.Y. City College Press, 1956.

TABLE 11. VALUATION OF PLANT LOCATION DETERMINANTS

CHEMICALS AND ALLIED PRODUCTS

Determinant	Determinants: Critical	Important	Not Important
I. Geographic Preference:			
(1) Central city of a metropolitan area			XXX
(2) Metropolitan suburban area		XXX	
(3) Non-metropolitan area		XXX	
II. Industrial Park Preference:			
III. Community Size Preference			XXX
(1) Under 25,000 population			XXX
(2) 25,000-49,000			XXX
(3) 50,000-99,000			XXX
(4) 100,000-249,999			XXX
(5) 250,000-499,000		XXX	
(6) 500,000-999,999		XXX	
(7) 1,000,000 or more		XXX	
IV. Plant Site Size Preference:			
(1) Less than one acre			XXX
(2) 1-4 acres			XXX
(3) 5-20 acres	XXX		
(4) 21-50 acres	XXX		
(5) 51-100 acres			XXX
(6) Over 100 acres			XXX

Page 1 of 3

TABLE 11. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants: Critical	Important	Not Important
V. Community Attributes Considered in Plant Location			
(1) Air passenger service		XXX	
(2) Local industrial bonds			XXX
(3) Vocational training facilities		XXX	
(4) Higher educational facilities		XXX	
(5) Tax incentives or tax holidays		XXX	
(6) Fire protection	XXX		
(7) Contract trucking	XXX		
(8) Public warehousing			XXX
(9) Public refrigerated warehousing			XXX
(10) Police protection		XXX	
(11) Local industrial development group		XXX	
(12) Pool of trained workers		XXX	
(13) Pool of unskilled workers		XXX	
(14) Lenient industrial zoning		XXX	
(15) Strict industrial zoning			XXX
VI. Plant Site Features			
(1) Highway access	XXX		
(2) Scheduled air freight service		XXX	
(3) Water transportation		XXX	
(4) Scheduled rail service	XXX		
(5) Piggy back facilities (rail)		XXX	
(6) Industrial water supply (processed)		XXX	

TABLE 11. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants		
	Critical	Important	Not Important
VI (cont'd)			
(7) Industrial water supply (raw,			XXX
(8) Natural gas service		XXX	
(9) Industrial sewage processing		XXX	
(10) Solid waste disposal		XXX	
(11) Soil load-bearing capabilities			XXX
(12) Electricity		XXX	
VII. Low Wage Rates			XXX

Sources: Compiled from: B. H. Stevens and C. A. Brackett Industrial Location: A Review and Annotated Bibliography, Philadelphia, Pa. Regional Science Research Institute, 1967; R. E. Carrier and W. R. Schriver Plant Location Analysis, Memphis State University, Bureau of Business and Economic Research, 1969 and J. I. Griffin, Industrial Location in New York Area, N.Y. City College Press, 1956.

TABLE 12. VALUATION OF PLANT LOCATION DETERMINANTS

LEATHER AND LEATHER PRODUCTS

Determinant	Determinants: Critical	Important	Not Important
I. Geographic Preference:			
(1) Central city of a metropolitan area			XXX
(2) Metropolitan suburban area			XXX
(3) Non-metropolitan area	XXX		
II. Industrial Park Preference:			
III. Community Size Preference			
(1) Under 25,000 population			XXX
(2) 25,000-49,000			XXX
(3) 50,000-99,000		XXX	
(4) 100,000-249,999			XXX
(5) 250,000-499,000			XXX
(6) 500,000-999,999			XXX
(7) 1,000,000 or more			XXX
IV. Plant Site Size Preference:			
(1) Less than one acre		XXX	
(2) 1-4 acres			XXX
(3) 5-20 acres			XXX
(4) 21-50 acres			XXX
(5) 51-100 acres			XXX
(6) Over 100 acres			XXX

Page 1 of 3

TABLE 12. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants		
	Critical	Important	Not Important
V. Community Attributes Considered in Plant Location			
(1) Air passenger service			XXX
(2) Local industrial bonds		XXX	
(3) Vocational training facilities			XXX
(4) Higher educational facilities			XXX
(5) Tax incentives or tax holidays		XXX	
(6) Fire protection			XXX
(7) Contract trucking	XXX		
(8) Public warehousing			XXX
(9) Public refrigerated warehousing			XXX
(10) Police protection		XXX	
(11) Local industrial development group		XXX	
(12) Pool of trained workers			XXX
(13) Pool of unskilled workers		XXX	
(14) Lenient industrial zoning		XXX	
(15) Strict industrial zoning			XXX
VI. Plant Site Features			
(1) Highway access	XXX		
(2) Scheduled air freight service			XXX
(3) Water transportation			XXX
(4) Scheduled rail service	XXX		
(5) Piggy back facilities (rail)	XXX		
(6) Industrial water supply (processed)	XXX		

TABLE 12. VALUATION OF PLANT LOCATION DETERMINANTS

Determinant	Determinants: Critical	Important	Not Important
VI (cont'd)			
(7) Industrial water supply (raw)		XXX	
(8) Natural gas service		XXX	
(9) Industrial sewage processing		XXX	
(10) Solid waste disposal		XXX	
(11) Soil load-bearing capabilities			XXX
(12) Electricity		XXX	
VII. Low Wage Rates	XXX		

Sources: Compiled from: B. H. Stevens and C. A. Brackett Industrial Location: A Review and Annotated Bibliography, Philadelphia, Pa. Regional Science Research Institute, 1967; R. E. Carrier and W. R. Schriver Plant Location Analysis, Memphis State University, Bureau of Business and Economic Research, 1969 and J. I. Griffin, Industrial Location in New York Area, N.Y. City College Press, 1956.

industry to be in close proximity to its market area. This consideration is what M. I. Logan[1/] calls ..."accessibility to the consumer goods (population) markets." The importance of the accessibility to the large population by this industry sector can be seen from Logan's formula developed for this industry

$$iV = K^{n}_{j=1} \frac{mj}{(dij)^2}$$

which is a derivation of the gravity model: where iV is the market potential of county i; mj is the mass (number of plants or population) in county j; dij is the linear distance between i and j; and K is a constant.

The other critical location determinants for this sector underscore the need for general accessibility to population by this sector as well as reflect some of the unique production technologies by this sector. For example, the critical importance of availability of public refrigerated warehousing facilities reflect the perishable nature of products manufactured by this sector.

2.1.2 Tobacco

Tobacco manufacturing sector has only five critical location determinants:

(1) Plant size of 1-4 acres

(2) Contract trucking

(3) Highway

(4) Electricity; and

(5) Low wage rates.

1/ M. I. Logan, "Location Decisions in Industrial Plants in Wisconsin," Land Economics, August 1970, pp. 325-27.

This determination essentially indicates only the need for access by highway to and from the plant. Note, however, that Table 8 does not indicate the cardinal plant location determinant for this industry - that of close proximity to the tobacco growing regions of the nation.

2.1.3 Textiles

As the data in Table 9 indicate, Textile sector has the following nine critical plant location determinants:

(1) Air passenger service
(2) Contract trucking
(3) Local industrial development group
(4) Pool of trained workers
(5) Highway access
(6) Scheduled rail service
(7) Industrial water supply (processed)
(8) Electricity; and
(9) Low wage rates.

The need for air passenger service can be explained by the fact that it provides accessibility to plants located in rural areas of the South to the executives of this industry.

The importance of local industrial development groups also has its roots in this industry's move from New England to the Southern states, with each community and state facilitating and encouraging such moves through the provision of various services furnished through local industrial development groups.

The remaining critical determinants reflect the need for high accessibility by the firms in this sector to major markets for textile products.

The importance of low wage rates, of course, reflects the principal concern of the textile industry to utilize non-union labor and is one of the principal reasons for this industry's relocation in Southern states.

2.1.4 Lumber and Wood Products

As Table 10 indicates, this sector has the following seven critical plant location determinants:

(1) Non-metropolitan area location

(2) 1-4 acres of plant site size

(3) Fire protection

(4) Contract trucking

(5) Highway access

(6) Scheduled rail service; and

(7) Low wage rates.

All of these determinants reflect the production processes used in this sector as well as the need to have access to the industry's market areas.

2.1.5 Chemicals and Allied Products

Surprisingly, this very large and complex industry sector has only five critical plant determinants:

(1) Plant site size of at least 5 acres

(2) Fire protection

(3) Contract trucking

(4) Highway access; and

(5) Scheduled rail service.

One explanation for this relatively short list of critical plant location determinants is that the large scale of facilities usually associated with this industry allows it to furnish their own services.

2.1.6 Leather and Leather Products

Table 12 indicates a total of seven critical plant location determinants:

(1) Non-metropolitan area location

(2) Contract trucking services

(3) Highway access

(4) Scheduled rail service

(5) Piggyback facilities

(6) Industrial water supply (processed); and

(7) Low wage rates.

Leather and leather products industry in the United States has been undergoing steady decline in output and employment. The industry is now located primarily in rural areas with low wage rates. The seven critical plant location determinants listed in Table 12 reflect these characteristics of this sector and indicate the need for accessibility of this industry to its market areas.

Clearly the data presented in Tables 7 through 12 has shortcomings and is limited in coverage. Nevertheless, this information does provide some initial knowledge on plant location determinants. In summary, the data in the Tables 7 through 12 suggest that accessibility to market areas via highway, rail and piggyback facilities is an important consideration for all six industries.

In summary, low labor rates are equally important to Textiles and Leather and Leather Products sectors. In the case of Food and Kindred Products industry--surely as important a sector because of its size and growth potential proximity to large population concentration--market area is an important plant location determinant.

Finally, in the case of Chemicals and Allied Products, critical plant location determinants are relatively few, principally because the production economics of scale in this industry are large; therefore this industry can and does provide its own services as well as create, for most part, the economic environment in which it operates.

In conclusion, our analysis of location decision focuses upon those components of general, long-run entrepreneurial decision processes which have a direct or indirect bearing upon the selection of regions, localities, and sites for a firm's activities. The locational and non-locational decisionmaking components are highly interdependent and the process by which general internal and external location conditions are mutated into more or less influential location factors is complex and not fully understood.

The history of the firm, the level of production, number and location of already established plants belonging to the firm, availability of and access to capital funds, ownership structure of the firm, competence, roles and personalities of top managers, attitudes and behavior of competitors, contractors, labor unions, chambers of commerce and local development corporations, government policies, and general economic conditions supply examples for internal and external conditions. In any decision process connected with a location selection, many of these conditions remain unconsidered due to their actual or perceived relative insignificance, or due to sheer neglect or ignorance. Other conditions are indirectly, implicitly, or unconsciously introduced at various stages of the decision process, thus, imposing constraints upon the effectiveness of those conditions which are being explicitly and consciously considered. In a large corporation, hardly any individual will be in a position to state with ultimate authority which considerations have been responsible for specific directions and discriminating selections at specific junctions or in specific corporate departments during a usually lengthy location decision procedure. This complexity can be approached analytically by identifying stages within the decision process on the basis of crucial thresholds which are being reached in the evolution of spatial and non-spatial constraints for specific, locationally significant variables.

This approach can possibly be accomplished in personal interviews with key executives of the industry sector who have the responsibility and authority to make plant location decisions.

In addition to the crude but effective methodology to which used plant location determinants are described above, other more sophisticated techniques exist. However, their usefulness is limited in that as a rule they analyze and predict regional economic development rather than location potential of a single plant. Nevertheless, these techniques should be discussed, as well as brief summaries of recent empirical studies that have analyzed regional economic activity and plant locations.

2.2 EXISTING TECHNIQUES FOR REGIONAL FORECASTING OF PLANT LOCATIONS

Since adequate summaries of techniques of regional analysis are well publicized in the general literature, no attempt will be made to present an exhaustive treatment of all possible techniques.[1/] However, an outline of the principal techniques and the reasons for rejecting each will be presented.

2.2.1 Flow Analysis

An example of the data-describing technique is flow analysis, which merely presents data in a form that is easy to read. The objectives of this study attempt to go beyond descriptions of past industrial structure. Flow analysis usually involves drawing maps of the region to be analyzed (i.e., state or county) and indicating with the use of arrows or other pictorial technique the destination and origin or products leaving and entering the region. Such "analysis" has little analytical content. Another device used by flow analysis is the location quotient, which compares a region's percentage share of a particular activity with its percentage share of a basic aggregate, such as income, value added, population, and area. The location quotient also is nothing more than a descriptive device, and its use may give rise to more confusion than understanding of causal forces.

1/ A brief summary is presented in Robert G. Spiegelman, Review of Techniques of Regional Analysis with Particular Emphasis on Applicability of These Techniques to Regional Problems, Menlo Park, California: Stanford Research Institute, June 1962. A more comprehensive treatment is given in Walter Isard, Methods of Regional Analysis: An Introduction to Regional Science, Cambridge, Massachusetts: The M.I.T. Press, 1960.

2.2.2 Population and Industry Distribution Comparisons

Benjamin Chinitz and Raymond Vernon have published a technique which, although still in the descriptive realm, offers considerable insight into industrial location.1/ Chinitz and Vernon analyzed geographic shifts of industries using data from the Census of Manufactures for 1939 and 1954 and found a "marked convergence in the ratio of manufacturing employment to population among the different regions of the country toward some common national ratios."2/ This trend was discovered in 90 of the 119 industries studied by calculating an index of concentration described as follows:

> "For each year, we compared the industry's employment distribution with the distribution of population among the major areas of the country. Then we calculated how many workers in the industry would have to be shifted in order to achieve a proportionate distribution of employment among the country's areas identical to the proportionate distribution of population. Finally, we expressed the number that would have to be shifted in the industry as a proportion of total national employment in the industry."3/

The analysis of Chinitz and Vernon can be differentiated from the descriptive techniques in that they have attempted to find the causes of changes in their index. However, Chinitz and Vernon use a case study and anecdotal approach and their technique *per se* is consequently not applicable to our project. Furthermore, many of their statistical conclusions seem to be based on zero-

---

1/ *Ibid.*, p. 525.

2/ Benjamin Chinitz and Raymond Vernon, "Changing Forces in Industrial Location," *Harvard Business Review*, January-Feburary, 1960.

3/ *Ibid.*, p. 127.

order correlations--that is, the statistical correlations they compute do not take other simultaneous influences into account. However, the following findings are still useful as background material:

1) The industries which grew fastest also moved fastest to conformity with the distribution of population; in other words, faster growing industries tend to be more decentralized relative to population.

2) One of the principal explanations for decentralization is lower transport costs; insofar as freight-cost data were available, they were positively correlated with a decline in concentration of an industry;--that is, industries with higher freight costs relative to other industries tended to be the industries which had the highest rates of decline in the index of concentration used by Chinitz and Vernon.

3) Another factor favoring decentralization is the increasing tendency for plants to use already processed materials. Thus, availability of raw materials has become less important as a factor determining plant location.

4) The motor vehicle has decreased the cost of transport in a manner that promotes the decentralization of industry. For example, trucking has reduced the cost of shipping in small lots relative to the cost of shipping in large lots. Chinitz and Vernon, however, point out that three recent developments may have effects in the opposite direction: "the spread of coordinated services such as 'piggy-back' and 'fishy-back;' the growing use of air freight; and the prospective reorientation of the railroad rate structure."

5) Chinitz and Vernon argue that there is a growing availability of skills in rural areas, largely as a result of transportation innovations and greater industrial experience. The increased decentralization in availability of skills is thus another factor favoring decentralization of industries.

6) Another related factor is that rural areas now can and, according to Chinitz and Vernon, frequently do provide facilities to industry on a competitive basis, partly because of the wider market areas of existing facilities (such as trucking depots).

2.3 INDUSTRIAL LOCATION THEORY

The other class of techniques that can be rejected consists of theoretical studies of location which disregard quantification. Location theory may in the long run lead to important conclusions for empirical analysis, but at present it is inappropriate for projects such as the one described in this study. Location theory analyzes the location of firms by studying the comparative costs of different firms. Thus, location theory attempts to answer the following type of question: Given several sources of raw materials and several markets, where will a firm locate? The analysis can be complicated by varying the processing and transfer costs at various locations. A summary of the literature on location theory would be out of place in this study because location theory not only has little empirical content, but offers very ordinary theoretical conclusions. Location theory tends to be abstract and usually concerns itself with ideal worlds in which only a few variables are important in location decisions, whereas we must analyze industrial growth in the real world with all of its complications. Furthermore, even if location analysis offered a rigorous and complete analysis of industrial growth, it would be useless for our project since it requires information which is simply not available. To apply location theory, at a minimum a complete matrix of transport costs to and from every county for every different product, a matrix of processing costs of each county for every product, and a knowledge of the demand function for every product in every county would all be needed.

2.3.1 Base Theory

A technique that has found wide application is base theory, which is little more than a straightforward application of Keynesian multiplier theory. The latter theory states that for a simple, nonspatial, timeless economy with consumption of one good, imports of one good, unemployment of factors of production, and constant marginal propensities to consume and import, the following functional relationship holds:

$$Y = \frac{A}{1 - c = m}$$

where Y is income, c is the marginal propensity to consume domestic goods, m is the marginal propensity to import, and A is exogenous expenditure. Base theory accepts this crude model and postulates that total regional income is proportional to exports, which are in effect assumed to be the only exogenous expenditure. It is usually postulated that the basic to nonbasic ratio of a region will be constant, where "basic" refers to export industries and "nonbasic" refers to local service industries. The empirical procedure usually consists of calculating the base/service ratio, projecting exports, and multiplying this projection by the above ration.

Economic base theory, while apparently straightforward and simple is plagued with difficulties, both in theory and in practical application.

Many theoretical objections can be raised to base theory. The theory assumes that all relationships within the region's economy will remain constant over time, an obviously deficient assumption. Not only must the marginal propensity to consume and the marginal propensity to import remain constant for all goods, but input-output interrelationships among industries must be constant over time. Furthermore, the theory ignores investment and assumes that exports are the only autonomous activities in the economy. Even if the assumption of no exogenous investment were true, base theory has no place for such "invisible" incomes as interest payments from other regions. The most fundamental objection is that, far from assuming that the base/service ratio is constant, the purpose of regional economics should be to explain the magnitude of this ratio and to be able to project changes in the ratio.

Base analysis assumes that the only dynamic component of an economy is its exports, and that all activities within the economy are dependent on its exports. The validity of this assumption is not obvious--it obviously is not true of the world as a whole and it has little relevance for a largely self-sufficient economy like that of the United States. One may ask at what stage do exogenously determined exports become crucial, or if they ever become crucial. For example, changes in productivity of local nonexport industries may be just as important for growth as changes in demand for a region's exports.

Even if the theoretical objections to base theory are overcome, the application of the technique encounters formidable obstacles. One immediately encounters the problem of how to measure economic activity. The researcher encounters an even greater difficulty trying to distinguish basic activities from nonbasic activities. It is not clear how firms should be handled which produce both for export and for local consumption. A further problem presenting theoretical as well as practical difficulties arises when the interdependencies inherent in a modern economy are considered.

2.3.2 Regional Input-Output Analysis and Linear Programming Techniques

Two additional techniques have occasionally been attempted in regional economic analysis: input-output and linear programming. Both are considerably more sophisticated than the techniques we have already analyzed, but both unfortunately possess difficulties of their own for interregional forecasting.

2.3.3 Shift Analysis

We have attempted to show why the formal regional economic models are not applicable to the problem of projecting plant location. Less formal approaches are available, however, which may yield meaningful empirical projections, such as the "shift" method used by Fuchs, Ashby, Perloff, and others.1/

In the shift method, the industrial growth of states is computed after an adjustment for the effects of industrial structure. That is, for a given state, "comparative growth, adjusted for industrial structure, shows what the comparative gain or loss would have been if all the others states had an industrial structure comparable to the state in question. Comparative industrial strucure shows what the comparative gain or loss would have been if each industry in the state had grown at its national rate".2/

Of the variables studied, the following were found to be significantly related to plant location: the relative extent of unionization, climate (deviation of mean temperature from 65^{o}), and population density (population per square mile). Fuchs concludes that while for manufacturing as a whole the degree of unionization in a state is an important explanatory variable, interstate differences in the supply of unskilled labor are most important in low-wage, labor-intensive industries.

Fuchs also attempted to find which industry characteristics are related to industry differences in mobility. In Fuchs' analysis,

---

1/ Victor R. Fuchs, Changes in the Location of Manufacturing in the United States Since 1929, New Haven: Yale University Press, 1962; Lowell D. Ashby, "Regional Change in a National Setting," Staff Working Paper in Economics and Statistics, No. 7, U.S. Department of Commerce, April 1964; Harvey S. Perloff, "How a Region Grows," Supplementary Paper No. 17, Committee for Economic Development, March 1963.

2/ Fuchs, op. cit., p. 62.

". . . mobility is defined as the extent to which an industry is located differently in one year as compared with an earlier year. If every state, for example, had the same percentage of industry x in period two as it had in period one, our measure would show zero interstate mobility. At the other extreme, an industry would record an interstate mobility of 100 percent if it were located in entirely different states in period two compared with period one. The measure of mobility, or percentage "shift," is the sum of the gain (in percent) of all states that increased their percentage share of a given industry between two dates." 1/

It should be noted that this definition "is not a synonym for physical movement. . . .An industry's geographical distribution changes more often through differential growth than through physical movement of plants or firms. Mobility measures the extent of this change, regardless of how it occurred." 2/

Fuchs tested the significance of the following industry variables as determinants of mobility: rate of growth; horsepower per worker; the ratio of wages to value added; concentration of ownership; average wages per production worker man-hour; percent of total employment in multiunit establishments; percent of value added produced in small companies; geographical concentration (scatter) ; number of workers per establishment; rate of change of wages; industry size; and an industry specialization ratio. In a multiple regression analysis the following variables were found to be statistically signficant: rate of growth (positively correlated), with a peaking of mobility at the middle ranges of concentration. Somewhat surprisingly, Fuchs found that industries with high fixed costs were not less mobile, ceteris paribus, than industries with low fixed costs; furthermore, the market-oriented

1/ Fuchs, op. cit., p. 105.

2/ Ibid.

industries, taken individually, tended to be less mobile than other industries.

As the above brief summary of the more sophisticated plant location forecasting methods suggest, these are of limited value to the principal issue in this report, i.e., how to determine plant locations for several industry sectors which are protected candidates for direct application of geothermal energy. The principal difficulty, in addition to the problem already indicated, is that those methods do not differentiate between location of a single plant and growth of regional economic activity.

2.4 RECENT EMPIRICAL STUDIES

Various studies recently completed furnish an empirical basis for supposing that such factors as markets, climate, labor, and thresholds contribute to the plant location decision. These studies also provide several other locational hypotheses, for example, the resource and agglomeration hypotheses. They also provide insights and evidence with which the interpretations and conclusions of the present study can be checked and compared.[1/] A few lesser studies also merit brief attention.

2.4.1 The McLaughlin-Robock Study

The earliest of the major studies is that of Glenn E. McLaughlin and Stefan Robock.[2/] Their research was confined to a group of 13 southern states (Virginia through Oklahoma and Texas). The authors used the interview technique in examining

1/ Several of these studies were summarized from Leonard F. Wheat Regional Growth and Industry Location, Lexington Books, Lexington, Mass., 1973.

2/ Glenn E. McLaughlin and Stefan Robock, Why Industry Moves South, Washington, D.C. 1949.

88 plants established in the South after World War II. These plants represented all major industry groups except tobacco. Each company official was encouraged to relate his story in his own way. Then he was queried about any omitted items from a locational factor checklist.

The authors found that business almost always selects its locations in two steps. First it selects a general region; then it selects a location within the region. The general region is one that secures the most important advantage--a regional market, a source of raw materials, or a source of cheap labor. Other requirements are then met by finding a suitable location within the region. Depending on how the general region is selected, a plant is (1) market-oriented, (2) materials-oriented, or (3) labor-oriented.

Markets was easily the leading determinant of location; 45 percent of the plants surveyed were market-oriented. Moreover, about one-fourth of the market-oriented plants but less than one-sixth of the materials-oriented and none of the labor-oriented ones employed over 1,000 workers; thus if impact is measured by employment, markets accounted for over half of the new industry. The market-oriented firms were mostly existing firms seeking to tap an expanding southern market by establishing branch plants. Only two of the plants represented new firms. Sometimes growth in the southern market meant that, for the first time, a plant of economical scale could be established. The branch plants were placed near their markets in order to cut transport costs or because their products were perishable.

Raw materials ranked second: materials and energy resources attracted 30 percent of the plants. Plants were materials-oriented when (a) the raw materials were perishable or otherwise not freely transportable, or (b) freight was an important element of the final cost and raw materials were more costly to transport than the finished product. With over two-fifths of the South covered by forests, abundant pulpwood attracted several paper and paper products firms. Oil and natural gas deposits induced chemical plants to locate in the western part of the region. Agricultural products, hydroelectric power, sulphur, and phosphorus also served as magnets.

Labor ranked third, accounting for 25 percent of the new plants. The South has the lowest wages, the lowest degree of unionization, and the most surplus labor of any region. Firms seeking attractive labor conditions have therefore gravitated to this region. The South's abundant surplus labor should not be underrated as an attraction. An adequate supply of labor was often sought as a means of reducing turnover, weakening the competitive bidding-up of wages, and allowing marginal workers to be weeded out. For labor-oriented firms, transportation was usually a small part of the delivered cost of the product; the market attraction was weak. Textiles, apparel, shoes, and machinery were the principal labor-oriented industries. Labor-oriented textile plants went to the northern part of the South to be closer to northeastern markets. Natural gas supplies sometimes induced market-oriented companies to deviate from central points within their marketing regions. Market-oriented and materials-oriented firms were seldom concerned about wages, but they often checked the labor histories of various communities before selecting a specific site.

McLaughlin and Robock discuss several other factors, but most are community influences or have strong market overtones. Transportation, for example, is primarily a reason for locating close to markets (but can also involve raw materials). One additional factor, climate, deserves attention. Some firms locating in the South expected to save on construction and heating costs, avoid winter shipping delays, or otherwise capitalize on the South's warm climate. One company chose a southern location in preference to one in upper New York because it was feared that the second-choice location might have excessive absenteeism during the winter.

2.4.2 The Thompson-Mattila Study

The prior study most nearly resembling the present one in methodology was prepared by Wilbur Thompson and John Mattila.[1/] It is geared to predicting state manufacturing growth and develops multiple regression equations for this purpose. However, most of the study deals with statistical by-products, namely, correlations between manufacturing growth and predictive variables.

1/ Wilbur R. Thompson and John M. Mattila, An Econometric Model of Postwar State Industrial Development, Detroit, Wayne University Press, 1959.

Most of the significant findings point to the market influence. The strongest relationship is between manufacturing growth and prior growth in consumer demand. Absolute growth shows correlations of +.90 and +.86 with prior absolute increases in population and income; percentage growth has a +.62 correlation with prior percentage increase in income. Prior growth, of course, represents not only increased demand but a whole complex of forces that influenced growth in one period and carried over into the next. But two considerations suggest that prior growth in demand emphasizes markets. First, it has higher correlations than a modified prior growth variable that is clearly a better proxy for miscellaneous attractions but a poorer measure of demand: prior growth in manufacturing employment has a +.73 correlation with absolute growth, compared to the +.90 achieved by prior growth in population. Second, correlations for individual industries known to be attracted to labor and raw materials are relatively low, as they should be if prior growth in population and income describes markets.

A +.84 correlation between the number of college-trained people and absolute growth reiterates that strong consumer demand spurs growth. Intended as a proxy for skills and training, the college variable seems really to be a proxy for population and especially income. Similarly, a +.31 correlation between percent college-educated and percentage growth seems to describe the effect of high per capita income, or high relate demand.

Two labor variables, average hourly earnings in manufacturing and union membership as a percentage of nonagricultural employment, are examined. For all manufacturing combined, their correlations with absolute and percentage growth are generally positive (the wrong sign). But this is less a denial of labor influences than an affirmation that high incomes attract industry. Thus the correlations for particular industries recognized as labor-oriented (e.g., apparel, leather and leather products) still come out negative: high wages and strong unions = low growth.

The only other findings of interest concern two tax variables: state and local taxes as a percentage of personal income, and state and local nonagricultural business taxes per employee. Neither is significantly correlated with absolute or percentage growth in any industry or for all industries combined--provided we do not count some positive correlations (the wrong sign). Taxes do not seem to be a significant influence.

2.4.3 The New York Metropolitan Region Study

In 1956 the Harvard Graudate School of Public Administration was asked to undertake a three-year study of the New York metropolitan region. Raymond Vernon directed the study. In order to grasp the influences at work in the region, the study team investigated factors shaping the growth of the nation as a whole. The relevant findings are summarized in two places: (1) a *Harvard Business Review* article by Benjamin Chinitz and Vernon and (2) a book by Robert Lichtenberg. Using a historical-descriptive approach, the authors develop important insights and evidence bearing on industrial location.

2.4.4 The Chinitz-Vernon Article[1]

Chinitz and Vernon point to a move toward decentralization, fostered by the desire to cut transport costs by locating close to the market. Transport costs weigh heavily in the cost structures of the decentralizing industries. At the same time, the advent of highways and trucking has radically altered transport costs. Compared to rail transport, trucking offers low short-haul costs; truckers have lower terminal costs to spread over short hauls. Thus, whereas manufacturers had little to gain from decentralization in the pretrucking days, regional plants now yield substantial transport savings.

Meanwhile, the competing nonmarket attractions have weakened. The resource influence has been hurt by (a) the lengthening chain of production linking raw materials to end products and (b) depletion of the best forests and mines, which has resulted in a more even distribution of resources. Interregional wage gaps have also narrowed, lessening the attraction of low wages. And external economies once found only in certain areas are now more widely available.

2.4.5 The Lichtenberg Book[2]

Using information from economic histories, economic geographies, industry studies, observed locational patterns, and interviews, Lichtenberg classifies manufacturing according to five dominant

---

1/ Benjamin Chinitz and Raymond Vernon, "Changing Forces in Industrial Location," Harvard Business Review 38, No. 1, January-Feburayr, 1960, pp. 126-36.
2/ Robert M. Lichtenberg, One-Tenth of a Nation, Cambridge, Harvard University Press, 1960.

locational factors. He finds that 51 percent of the nation's industry is transport-sensitive, 15 percent seeks external economies, 14 percent is governed by inertia (historical factors), 8 percent emphasizes labor costs and supply, and 12 percent is unclassifiable. The transport-sensitive industry subdivides into 43 percent oriented to markets and 8 percent oriented to raw materials.

2.4.6 The Perloff Study

The broadest and most useful study to date dealing with manufacturing location is that of Harvey Perloff, and others.[1/] It is basically historical-descriptive in nature, but there is some hypothesis testing. Judgments about locational influences rest on historical trends, shift-share analysis coupled with investigation of the causes of shifts in particular industries (many specialized studies are brought to bear), and a few correlations.

Over the years industry has shifted steadily from resource to market orientation: industries selling to other industries now produce almost 40 percent of all output, and most consumer industries have only remote connections to raw materials. "Filling in" growth in the South and West has increased the importance of markets. California, the prime mover in the spectacular growth of the Far West, passed a "market threshold" beyond which internal

---

1/ H. Perloff, et.al., Regions, Resources and Economic Growth, Baltimore: Johns Hopkins Press, 1960.

and external scale economies become operative. Remoteness from the Manufacturing Belt aided this development. Westward shifts in final markets have pulled intermediate markets along.

As evidence of the market attraction, the authors present rank correlations between employment in specific industries and population (forty-eight states). Industries generally regarded as market-oriented show the highest correlations; for example, printing and publishing reads +.93. But industries regarded as labor-oriented or resource-oriented have relatively low correlations--+.58 for lumber, +.63 for textiles, +.66 for leather and leather products, +.69 for petroleum and coal products. Since a particular industry cannot easily exert a strong influence on population, causality would seem to run mainly from population (markets) to manufacturing employment.

The study's main thrust is in the direction of a Manufacturing Belt concept of agglomeration. The authors seek a balanced explanation of growth--balanced in giving "full attention" to both the rapid gains of the West and the "remarkably small loss in relative standing" of the northeastern Manufacturing Belt. Agglomeration thus becomes the offset to markets, which directs growth to the South and West.

Other influences are not ranked, but resources receive the most attention. In specific industries, resources still exert a strong locational pull. Examples are refining and petrochemicals in the Southwest; other chemicals in various places; lumber products in the Southwest and West; pulp and paper in the South; canning, preserving, and freezing in several areas; and tobacco in the Upper South. The pull of resources on these industries is reflected in relatively low correlations between population and industry employment.

Despite these examples, the resource attraction has become weak. This conclusion is supported by a comparison of two groups of industries: (a) first-stage resource users, which use resources for over 10 percent of their inputs, and (b) second-stage users, which use first-stage products for over 10 percent of their inputs.

Labor, climate, and industry mix are covered briefly. Analyses of individual industries credit labor with attracting textiles, apparel, and shoe manufacturing to the South.

2.4.7 The Fuchs Study

One major study challenges the other studies by holding that markets is not an important determinant of manufacturing location. This is Victor Fuchs' study.1/ Fuchs' general approach entails measuring interregional shifts in manufacturing, pinning these down to the industries primarily responsible, and then explaining what happened in these industries. Judgments about the relative importance of different influences rest on (a) the factors affecting the industries with the biggest shifts, as suggested by a review of available literature, (b) an industry-wide correlation analysis relating comparative growth to several explanatory variables, (c) other statistical analyses, and (d) theory.

The shifts studies indicate rapid growth in the South and West (especially the West), moderate growth in the North Central

---

1/ Victor R. Fuchs, Changes in the Location of Manufacturing in the United States since 1929. New Haven: Yale University Press, 1962.

region (above average in the western part, below average in the eastern part), and a comparative loss in the Northeast. "The most important factors influencing these changes in the location of industry appear to have been climate, labor, and the availability of raw materials." Fuchs estimates that one-third of all employment shifts between census regions were due to resources (including climate) and raw materials; that "almost" another one-third resulted from abundant, low-cost, nonunion labor in the South; and that the remaining one-third was variously caused by changes in demand or could not be assigned to identifiable influences. The one-third credited to resources depends "heavily" on treating climate as a resource; so if climate and raw materials are separated as in the above quotation, labor ranks first. "Heavily" implies that climate ranks second, ahead of raw materials, which is apparently third. Since markets is not even close enough to deserve mention in the summary quotation, one infers that Fuchs would assign markets less than one-sixth (raw materials) and probably closer to one-tenth of the credit.

Labor's first-place rank is supported by a finding that four labor-oriented industries--textiles, apparel, footwear, and furniture--contributed heavily to the South's gains and the Northeast's losses. Also, a special analysis shows that growth in low-wage and labor-intensive industries is better correlated with wages and unionization than is growth in other industries--which supports the idea that the first industries are attracted by favorable labor conditions.

Climate's importance is suggested by its great influence on the location of aircraft manufacturing, a leading growth industry and the most important contributor to upward shifts in California and the Southwest. Climate has also influenced migration and the location of military bases, thereby supporting the growth of market-oriented industries. The -.53 industry-wide correlation between temperature deviation from the "ideal" (65 degrees) and percentage shift is exceeded only the the -.57 for patents per capita (evidently acting as a proxy for per capita manufacturing). (Intercorrelations between growth measures are not counted.)

Raw materials gains its high ranking from findings that raw materials lay behind some important upward shifts--chemicals in the South, lumbering on the West Coast, pulp and paper in the South and West, and canned and frozen foods in the South. The industry-wide correlations omit raw materials because "it is not feasible to assign a simple measure of raw material availability to each state which would meaningfully describe the diverse products of forests, fields, and mines that form the basis of much manufacturing activity."

2.4.8 The Fantus Study

The last major study deserving attention was conducted for the Appalachian Regional Commission by the Fantus Company, a leading plant location consulting firm. In its report,[1/] Fantus drew on its own experience and expertise. Extensive use was made of information

---

1/ The Fantus Company, Inc. The Appalachian Location Research Studies Program: Summary Report and Recommendations, New York, 1966.

in Fantus' files, most of it obtained during the course of several thousand plant location searches. The study consists of twenty-five substudies examining industries believed to have significant growth potential in Appalachia.

A table in the summary report lists a number of locational factors, local and regional, found to be significant. We can ignore the local factors (except for one), the most important of which is an adequate local labor supply. The regional factors are (1) transportation, (2) proximity to customers, (3) state manpower training assistance, (4) labor cost advantage, (5) low-cost electric power, (6) urban orientation, and (7) proximity to raw materials. Transportation, as used in this context, is partly a local factor (facilities) but mainly regional (cost of distributing over a region); power is largely a regional matter; urban orientation is mostly a local factor but has a bearing on the attractiveness of sparsely developed regions. Each factor is judged, relative to each of the twenty-five industries, as being of (a) critical importance, (b) primary importance, (c) importance, or (d) minor or no importance. Table 13 presents the results of this study. The number of industries for which each factor was of critical importance appears next to the weighted score for each factor.

Markets are clearly the most important regional influence among the industries studies: transport services, transport costs, and proximity to customers--three aspects of the market attraction--rank one, two, and three. Transportation can also involve raw materials, of course, but the report indicates that outbound transportation is

TABLE 13

THE FANTUS STUDY: INDUSTRIAL LOCATION FACTOR SCORES

Location Factor	Weighted Score
Transportation:	
Services	53
Costs	41
Proximity to customers	46
State manpower training assistance	31
Labor cost advantage	24
Low cost electric power	24
Urban orientation	24
Proximity to raw materials	11

Source: Based on Fantus report, The Appalachian Location Research Studies Program: Summary Report and Recommendations, New York, December 1966, Table 3, pp. 12-13.

usually what matters: most firms wish to minimize the time and cost of shipping goods to market. According to Fantus, the high ranking for proximity to customers indicates the desire of many firms to establish deeper market penetration: regional branch plants offer greater market access than a central plant or regional warehouses.

Two labor factors, state manpower training assistance and labor cost advantage, come next. Note that, even taken individually, both rank well ahead of raw materials. The relevant labor costs include not just wages but fringe benefits, work rules (unions), turnover, and absenteeism. The two industries for which labor costs are rated "crucial" are textiles and apparel.

Electric power and raw materials can be combined under the heading of resources. Fantus states that energy is seldom a critical term. The two "crucial" industries are chlor-alkali (chlorine and caustic soda) and primary aluminum.

Urban orientation, primarily a local rather than a regional factor, is included in the table because of its relationship to two factors examined in the present study--thresholds and the urban attraction. The Fantus concept of urban orientation is nothing very specific but designates a desire of some industries to locate within, in the suburbs of, or close to a city of some minimal size. The "crucial" industry is office machinery; other urban-oriented industries are paper boxes and shipping containers, plastics for packaging, nonferrous metal operations, and instruments and controls--industries variously attracted to intermediate markets and urban amenities (e.g., trim neighborhoods, recreational facilities, and good schools).

2.4.9 Webber's Study

In this important and novel study Webber[1/] explores two additional factors that impact on a firm's decision to locate its manufacturing facilities in certain areas.

Firstly, probability models are being used to describe town patterns and other mass human interactions; secondly, locational analysis is shifting away from the traditional link with economics and is beginning to analyse the psychological bases of decision-making.

Thus, an attempt is made here to define some of the ways in which uncertainty about the effects of decisions modifies location patterns. In each of the major models of location theory assumes rational behavior. Some function (profits) is maximized under given stated conditions. In Webber's theory maximum profits are held to be identical to minimum costs; in the interdependence approach and in Losch's theory, maximum profits are effectively considered to be maximum sales. Once the profit function has been defined, the process of maximization is simple and subject to well-defined mathematical rules.

The normal situation in which several departments of the factory are in conflict about where to locate can be simulated electronically. The model contains several machines, each simulat-

---

1/ Michael J. Webber, Impact of Uncertainty on Location, The MIT Press, Cambridge, Massachusetts, 1972.

ing one department of the firm. The machines are linked. The decision process then consists of each machine proposing states (locations) to the others, which either accept the proposals or reject them and propose counter-states. Satisfactory limits are fed into each machine and when all machines satisfy these limits the location bargaining ceases: a location has been chosen. By setting the limits arbitrarily high, an optimal rather than a satisfactory state may be obtained. Thus no matter how complicated are the real world and decisions about it, an optimal *ex ante* plan of location may be evolved.

But the enlarged idea of optimal decisionmaking must take account of another factor. Part of the process of making an optimal *ex ante* decision involves collecting the data upon which to base this decision. The firm has to decide how much information to collect and where to collect it from. This imposes further novel elements on the theory of the optimal *ex ante* decision.

Webber's model considers the following problem. An entrepreneur, located at one end of a linear market, wishes to find his optimal location. He knows that the profitability of sites varies randomly along the line: the profitabilities are approximately normally distributed within the limits of =p. The cost of sampling is cd, where c is a constant and d is distance from the entrepreneur's home site. There being no trend in profitability, the firm's best first sample is its cheapest--i.e., at d = 0. From A second sample is taken at d = 1. From these the firm can estimate the mean profitability of sites and the standard deviation of profitabilities. The standard error of these estimates can be computed. These data tell the firm the expected profitability of the next site to be sampled (at d = 2). If this expected profitability is greater than the maximum profitability of the sites already sampled plus the discounted future value of the cost of sampling (2c), the firm takes this third sample. Otherwise the firm locates at the best of sites 1 and 2. The procedure continues until the expected gain from sampling is less than the cost of sampling.

The firm takes an (n + 1)th sample if

$$\frac{1}{\sqrt{2\pi\sigma^2}} \int_{x=-\rho}^{\rho} x. \exp\left[\frac{-(x-\bar{x})^2}{\sigma^2}\right]$$

dx - matrix($x_1, x_2, \ldots, x_n$) $\geq$ nc, where x is the profitability of sites, is the standard deviation of profitability, $x_1, x_2, \ldots, x_n$ the profitability of the 1st, 2nd, . . ., nth sites, and nc is the discounted cost of sampling the (n + 1)th site.

This study is broadly theoretical and presents data only from the studies reviewed. The literature and concepts which are integrated into location theory are extremely diverse and provide for a complex theory covering location of cities, households, and firms, but is of limited use because energy costs are not explicitly considered.

2.4.10 Charles Revelle et al Formulation Sector Location Models

In this comprehensive study by Charles Revelle and his colleagues,1/ recent models of location are drawn together and compared as to structure, criteria, and constraints. Private

---

1/ Charles Revelle, D. Marks and J. C. Liebman, "An Analysis of Private and Public Sector Location Models" Management Science Vol. 16, No. 11, July 1970, pp. 692-707.

sector models are distinguished as those in which the total cost of transport and facilities is isolated as the objective to be minimized. The solution techniques of six such models are discussed. Public sector models are characterized by a criterion function involving a surrogate for social utility and by a constraint on investment in facilities or on the number of facilities. Five models with this format are discussed and compared. The two types of problems, location in the private sector and location in the public sector, are seen to have the same conceptual foundation, but formats differ of necessity due to our inability to relate social utility to dollar value.

Problems in location analysis can be classified into two major structural categories. These categories are:

A. Location on a Plane

B. Location on a Network

A. Location on a plane is characterized by

(1) an infinite solution space. That is, central facilities may be located anywhere on the plane and are confined neither to nodes of the network nor to points on the links between those nodes.

(2) distance measurements according to a particular metric. One example is the Euclidian metric where

$$d_{ij}^2 = (x_i - x_j)^2 + (y_i - y_j)^2$$

dij = the distance between points i and j

x_i, y_i = the coordinates in a rectangular system of the ith point.

Another example is the metropolitan metric where

$$d_{ij} = |x_i - x_j| + |y_i - y_j| \text{ .}$$

B. Location on a network is characterized by

(1) a solution space consisting of points on the network (both nodes and points on the arcs which join the nodes),

(2) distance measurement or time measurement along the network.

d_{ij} = the length (time) of the shortest path from node i to node j.

Define

w_i = the weight attached to the ith point (goods demanded, resources sent, population, etc.);

x_i, y_i = the location of the ith point relative to some fixed carthesian coordinate system;

x_p, y_p = the unknown coordinates of the central point P;

n = the number of points which are served; and

d_{ip} = the Euclidean distance from point i to central point P.

The objective is

(1) Minimize $2 = \Sigma_{i=1}^{n} w_i [x_i - x_p)^2 + (y_i - y_p)^2]^{\frac{1}{2}}$

(2) where $d_{ip} = [(x_i - x_p)^2 + (y_i - y_p)^2]^{\frac{1}{2}}$

Again, the principal shortening of this study is that energy costs are not explicitly considered.

2.4.11 Toyne's Study

Peter Toyne's study[1/] presents an excellent discussion on organization location and behavior but this study is too theoretical to be of any value for policy decisions.

1/ Peter Toyne, Organization Location and Behavior, John Wiley and Sons, New York, 1974.

Toyne regards nodal region as a system whose elements comprise the visual objects of human landscape occupance: the various residential, industrial, commercial, agricultural, transportational and recreational features which give every region its unique character of physical infrastructure. However, the recognition of elements in the landscape is dependent on the resolution level of the system. Hence, the residential elements may be considered variously as the individual dwelling units in their successive groupings into streets, neighborhoods and districts within hamlets, villages, towns or cities.

In the human landscape system, all the inputs and outputs emanate from the various decisions that individuals and groups make about the organization and location of all forms of economic activity. The decision-making process thus constitutes the control system which gives the morphological structure of human landscape organization its peformance.

Considerations of scale are fundamentally important because they may condition not only the profitability of any enterprise but also its locational requirements. Similarly, the cost, availability and allocation of the factors of production-land, labor and capital-affect the possibilities of the organization, location and profitability of human activity. Moreover, since distance separates all locations in geographical space, considerations of transfer inevitably enter into the locational decision; and the conditions of demand and supply are perhaps the major economic determinant of production and consumption levels within the system.

Decision makers may therefore find it necessary to introduce a series of constraints and incentives to their own decision-making process in order to counteract the mechanisms of the control system that they themselves have created. The evaluation of each of these elements is conditioned by an equally wide range of elements relating to the information, preferences and motivation of different decision makers.

The report presents an extensive review of government locational and development policies and programs. However, energy policies are omitted.

2.4.12 Summer's Report

This study undertaken by Gene F. Summers and his collaborators[1/] contains considerable empirical material which unfortunately is dated and does not cover energy considerations.

This report attempts to assess the validity of the view that the location of industry in small cities, towns, and rural areas is an important tool for solving the dual problems of rural poverty and urban crisis. The authors draw upon case study documents for research results about the impact of industrial development upon (1) the population dynamics, (2) the private sector, (3) the public sector, and (4) the quality of individual well-being in the host communities. Data, from 1945 on, was collected from 186 case studies on plant location in nonmetropolitan communities (primarily focusing on the Midwest and the South). The empirical

---

1/ Gene F. Summers et al, Industrial Invasion of Nonmetropolitan America: A Quarter Century of Experience, Praeger Publisher, New York, 1976.

generalizations drawn from the findings are then considered in light of publicly stated policy goals. Because most of the studies were done prior to public concern over energy this aspect is not covered in the report.

2.4.13 Nentze's Study

This study by G. M. Nentze[1/] describes the four major influences on location patterns: natural features, costs of transport and communication, production technology and demand patterns. These influences determine the location and spacing of the first towns to appear in a region which is important because of the immobility of industries and towns. By examining the process of town formation in a context of regional economic growth it has been possible to paint a picture of the original process. As long as inertia is not underrated, changes in the above factors can help to explain many of the changes that occur in patterns of location. Again, energy costs are not considered in this report.

2.4.14 McMillan's Report

This report[2/] discusses the results of surveys administered to area manufacturers to determine why they chose a particular area. Raw materials and market generally ranked first or second in the survey results. One survey conducted by Industrial Econ-

---

1/ G. M. Nentze "Major Determinants of Location Patterns," Land Economics, Vol. XLIII, No. 2, May 1967

2/ T. E. McMillan, Jr., "Why Manufacturers Choose Plant Location vs. Determinants of Plant Locations," Land Economics, Vol. XII, No. 3, September 1975, pp. 239-244.

omics Research Division, Texas Engineering Experiment Station, Texas A&M University in October 1954, included laws and regulations in its categories of determinants. Results from 350 weighted returns indicated that one firm considered it first, 2-second; 5-third; 6-fourth; and 14-fifth. The other respondents did not consider regulations to be crucial to industrial siting. Results are summarized in the Table 14 below.

As the data presented in Table 14 show, energy costs are relatively unimportant as location factors. This, however, can be readily explained by the fact that these factors represent conditions as of 1954.

2.4.15 Harris' Model

This model[1/] presents an interregional, multi-industry model designed to explain industrial location. The model considers two groups of stimuli to industry location-regional factor prices and regional agglomeration effects. Multivariate regression analysis is used to examine the importance of various explanatory variables on location as measured by the change in output. The model accounts for interregional and interindustry relationships. The major data source is the County Business Patterns for 1965 and 1966. Other data sources include Waterborne Commerce of the Corps of Engineers, Highlights of U.S. Export and Import Trade, 1963 Census of Transportation. As in most previous studies reviewed in this report, this model is dated and does not reflect the current energy costs and energy supply considerations.

1/ Curtis C. Harris and F. E. Hopkins, Location Analysis, D. C. Heath and Company, 1972.

TABLE 14

POSITIONS OF LOCATION FACTORS
(from 350 weighted returns)

Factor	1st	2nd	3rd	4th	5th	Total Points	Percent Weight
Market	118	44	35	24	13	928	18.9
Labor	33	78	45	34	31	711	14.5
Raw Materials	73	36	18	17	8	605	12.3
Building	26	28	29	15	9	368	7.5
Site	18	30	22	14	25	329	6.7
Transportation	14	32	32	31	22	378	7.7
Distribution	10	25	37	31	20	343	7.0
Living Conditions	14	11	29	35	35	306	6.2
Climate	11	8	11	22	25	189	3.9
Industrial Fuel	3	12	20	14	14	165	3.4
Water	3	7	12	10	8	107	2.2
Industrial Power	0	3	14	15	11	95	1.9
Financial Help	8	7	7	7	5	108	2.2
Taxes	5	5	3	14	22	104	2.1
Laws and Regulations	1	2	5	6	14	54	1.1
Miscellaneous	15	5	2	1	4	107	2.2

Source: Survey by Industrial Economics Research Division, Texas Engineering Station, Texas A & M University, October 1954.

2.5 SUMMARY AND CONCLUSIONS

The studies reviewed above, while dated, and at times contradictory, provide useful information regarding the plant location determinants in general. Table 15 presents the major plant location determinants found in the seven studies summarized. The information contained in this table clearly suggests that proximity to market (and availability), low transportation services costs, and low labor costs are the three principal plant location determinants. The fourth determinant is the supply of raw materials.

In terms of the six industries covered in this report, this means that for textiles, council and allied products and for leather sectors, all of which have nationwide markets, location in any geothermal resource area could be a very attractive proposition assuming that other plant location requirements can be satisfied. In the case of the Food and Kindred Products sector, plant location must be close to population concentrations which serve as market areas for the food products produced. Location for plants in tobacco and lumber and wood products sectors is governed by raw material availability.

TABLE 15

PLANT LOCATION DETERMINANTS FROM SELECTED STUDIES

Study	Plant Location Determinants	
Glen E. McLaughlin and S. Robock	1. Market Orientation (45%). 2. Raw Material Availability (30%). 3. Low labor costs (25%).	
Wilbur R. Thompson and I. Mattila	1. Consumer Demand and Market Orientation. 2. Low labor cost. Note that Thompson and Mattila indicate that local taxes has no significant impact on industry location.	
Benjamin Chinitz and R. Vernon	1. Market Orientation	
Robert Lichtenberg	1. Low transportation cost and market orientation (51%). 2. External economics (15%). 3. Historical factors (14%). 4. Low labor costs (81%).	
Harvey Perloff, <u>et al</u>	1. Market Orientation. 2. Agglomeration. 3. Labor. 4. Climate.	
Victor Fuchs	1. Raw material availability (including climate). 2. Low labor cost.	
The Fantus Company, Inc.		Weighted Score
	Transportation:	
	Services	53
	Costs	41
	Proximity to customers	46
	State manpower training assistance	31
	Labor cost advantage	24
	Low cost electric power	24
	Urban orientation	24
	Proximity to raw materials	11

CHAPTER 3

PLANT LOCATION DETERMINANTS: RESULTS OF INTERVIEWS WITH INDUSTRY EXECUTIVES

3.0 INTRODUCTION

This chapter presents the views of over 30 industry executives (see Appendix A) interviewed in the course of this study, regarding the issues that determine location of industrial plants in general and the impact of geothermal energy availability on plant location in particular.

All of the executives interviewed comprise senior personnel in 30 companies which represent the six sectors of economy analyzed in this study, i.e., Food and Kindred Products, Tobacco, Textiles, Lumber and Wood Products, Chemicals and Allied Products, and Leather and Leather Products.

3.1 GENERAL COMMENTS

The interviews reinforced the findings regarding plant location determinants presented in previous chapters of this report. However, several general issues also contribute to the information that impacts on the Department of Energy marketing effort for direct utilization of geothermal energy.

The first issue pertains to the question regarding who within an industrial/manufacturing firm determines the location of a new plant and/or chooses to utilize geothermal resources as a source of energy for the plant. Our interviews indicate that such decisions are made at a very high level in the corporate structure of the firm. While typically such decisions are the result of a committee meeting, the principal member of such a committee is usually a senior Vice President of a firm responsible for corporate planning. The committee itself, in addition to the Vice President for Corporate Planning, typically includes the Chief Executive Officer of the firm, the senior representative for engineering, i.e., Vice President for Engineering or Chief Scientists, the Treasurer and the senior representative of the firm for operations, i.e., Vice President for Operations. While at times such a committee may request formal plant location study (either from the internal staff of the firm or from outside consultant), more often the location decision is made without benefit of formal study.

The implication of this method of decisionmaking to the direct geothermal energy marketing effort by the Department of Energy is clear--any and all marketing efforts should be directed at the senior executive level of all firms considered candidates for direct use of geothermal energy.

The second issue resulting from our interviews is that of the familiarity of the senior executives with DOE programs to encourage utilization of the nation's geothermal resources in general and with the geothermal loan guaranty program (GLBP) in particular.

Our interviews with the senior executives in the six sectors of economy indicate beyond any doubt that the industry is almost completely unaware of DOE's efforts to promote direct use of geothermal resources. To be quite specific, among the senior executives interviewed, only 13 were aware of the existence of the Federal Nonnuclear Energy Research and Development Act of 1974 (PL 93-577), only 3 out of 30 were aware of the activities of Interagency Geothermal Coordinating Council, and none were familiar with the existing Geothermal Loan Guaranty Program (GLGP).

While it cannot be claimed that the 30 senior executives interviewed are representative of typical senior executives in the industry, the absence of familiarity on their part with the Department of Energy's programs for geothermal energy utilization is alarming. In this light, our recommendation is that the Department of Energy prepare a document which clearly outlines the Department's program for direct utilization of geothermal resources as well as the procedures for geothermal loan guaranty programs.

The final general issue is that of technical knowledge of direct utilization of geothermal resources (as opposed to institutional/government related issues of this) by the interviewed senior executives.

In this regard, our interviews indicate that most of the senior executives are very familiar with the technical feasibility of utilizing geothermal resources as a source of energy in the operation of their plants. In fact, 11 of the 30 senior executives interviewed indicated that their firms have undertaken investigations of geothermal energy use on their own.

This action suggests that the Department of Energy in its geothermal marketing program should concentrate on issues related to financial and institutional assistance which the Department can offer to the firms rather than on the technological feasibility of the direct use of geothermal resources.

The remainder of this chapter presents the results of our interviews with the 30 senior executives in the six sectors of industry selected for this report.

3.2 FOOD AND KINDRED PRODUCTS

The principal plant location determinant in the Food and Kindred Products sector is close proximity to the consumer markets. According to J. D. Forbes, Vice President, Technical Development of the Kellog Company, all of the Kellog Company's existing plants are located within the large metropolitan areas of the nation and such location is a prerequisite for all new facilities. Further, according to our interview with Mr. Forbes, the specific site for a new facility must have immediate access to a major highway which serves a market area.

Energy supply and cost considerations are indeed important to Kellog Company and this firm has an engineering task force evaluating all energy supply options including geothermal resources; however, these energy issues remain secondary with regard to a location of new facilities. Provided that an appropriate location can be determined which has geothermal resource, Kellog Comapny would certainly investigate the feasibility of direct geothermal resource application.

The principal current factors which militate against use of direct geothermal energy according to Mr. Forbes are as follows:

- Lack of engineering experience with geothermal energy sources by Kellog engineers;

- Considerable initial capital requirements for the development of geothermal resources as compared to conventional energy sources;
- Potential impacts on environmental from geothermal resource use and the need for various permits from Federal and state environmental offices.
- Absence of interest by Federal government to encourage geothermal resource use.

Mr. Forbes' comments regarding high initial capital costs of geothermal resource development were fully supported by Gerard Coiley, Purchasing Director, American Brands, Inc. According to Mr. Coiley, the absence of any major prototype full scale direct geothermal resource utilization plants creates a risk factor which the management of American Brands Inc., prefers not to face until the geothermal resource development costs are firmly established.

In Mr. Coiley's opinion, the current Geothermal Loan Guaranty Program (GLGP) does not offer sufficient inducement for a firm to develop geothermal resources for a new production facility.

The same opinion was held by Mr. George King, Manager of Planning of R. J. Reynolds Industries, Inc., by Mr. Jay Lind, President, Sebastian Stuart Fish Company, and by almost all other executives we interviewed.

A closely related concern expressed by almost all of those interviewed in the Food and Kindred Products sector, was that the in-house engineering staffs of food manufacturing firms as a rule are relatively ill equipped to undertake the necessary design and construction of geothermal energy facilities.

An example of this factor's importance in the utilization of geothermal resources by a firm can be readily seen in the case of Del Monte Corporation, a major food processor and a subsidiary of R. J. Reynolds Industries. Del Monte Corporation's numerous food processing facilities are located directly within several geothermal resource areas in California. Further, another subsidiary of R. J. Reynolds Industries, Aminoil USA, Inc. is one of the principal developers of the Geysers geothermal steam-powered electric generating facility.

In spite of the obvious expertise in geothermal resource development by Aminoil USA, Inc., Del Monte Corporation's engineers, according to George King, have not considered the use of geothermal resources in their California facilities because of their unfamiliarity in this area.

All of the factors related to potential use of geothermal resources by the Food and Kindred Products sector discussed above have been supported by Dr. Lee Harrow, the Principal Scientist of H. J. Heinz Company. According to Dr. Harrow, the principal plant location determinant for Food and Kindred Products sector is immediate accessibility to the market. If this criteria is satisfied and geothermal resources exist on the site, food processing firms would be interested in utilizing these resources provided that:

- Federal government undertakes additional engineering effort to establish feasibility of the direct geothermal energy use;
- Initial capital costs of geothermal resource development are well established and reasonable;
- A pool of engineering knowledge exists which can render technical assistance in the design and development of direct geothermal utilization facilities.

Since a large number of seafood processing plants in the Northwest states are located in geothermal resource regions, a special effort was made to determine the potential of geothermal resource application to seafood processing facilities.

The principal plant location determinants for seafood processing firms are accessibility to the rail, truck and waterborne transportation facilities rather than the supply and cost of energy for operations.

According to Jay Lind, President of Sebastian Stuart Fish Company, all seafood processing plants must be located in close proximity to the ports and harbors where raw material is unloaded from the fishing boats. The reason for this is, of course, the perishable nature of the seafood.

Further, as stated by Dr. William Jensen, President of West Coast Fisheries Development Foundation, most of the processed seafood is transported to the markets by rail and truck and therefore, access to these transportation services is of cardinal importance. Note that in the case of seafood processing operations located in Alaska, all of these companies transport their processed products to markets by seaborne commerce and therefore all of the Alaskan seafood processing plants are located close to harbors.

Furthermore, as stated by Mr. Lind, Dr. Jensen and by Anthony V. Mizetich, the Director of Government Relations, Starkist Foods, Inc., energy requirements in seafood processing are not an important consideration. In summary, seafood processing operations represent a marginal candidate for direct use of geothermal energy resources.

In summary, our interviews with the senior executives in Food and Kindred Products firms, as well as the information and empirical data contained in various reports, indicate that the principal plant location determinant for this sector is close proximity to large population concentrations, i.e., immediate proximity to the market area of the firm's output.

Provided that this location requirement can be satisfied, considerable interest exists in the Food and Kindred Products industry to use geothermal resources as a source of energy in their operations.

However, it is clear from our interviews that in order to successfully assure direct utilization of geothermal energy by this sector, the Department of Energy must provide additional technical and administrative information to the industry.

3.2.1 Tobacco

The cardinal plant location determinant for tobacco sector is close proximity to the tobacco growing areas, according to Gerard Coiley, Purchasing Manager, American Brands, Inc. and George King, Manager of Corporate Planning, R. J. Reynolds Industries, Incorporated.

However, the utilization of geothermal resources by a tobacco processing firm faces several other obstacles, including:

- Absence of experience regarding geothermal resource development by the in-house engineering staff of tobacco processing firms;
- Unknown initial capital costs of geothermal resource development;
- Potential environmental issues resulting from geothermal resource use.

In summary, the obstacles to introduce direct use of geothermal energy in Tobacco Manufacturing sector are almost identical to those in Food and Kindred Products sector. However, the fact must be stressed again that neither of the two executives interviewed in this sector of economy, and indeed both Mr. George King and Mr. Gerard Coiley are senior executives in their respective firms, had information on Department of Energy Geothermal Resource Programs.

3.2.2 Textile Mills Products

All of the senior executives interviewed in the textile mill product sector clearly identified low labor rates and/or nonunion labor as the principal plant location determinant.

As stated by Gordon T. Washington, Vice President for Engineering of Blue Bell Incorporated and Irhy Wright, Energy Coordinator, also with Blue Bell Incorporated, the low labor rates factor dominates all other considerations in plant site selection.

The third top determinant according to O'Jay Niles, Director of Government Relations, American Textile Manufacturers Institute, Inc., is accessibility by truck to major markets. Energy is an important consideration but according to Mr. Niles the Federal government has done little if anything to prove information concerning the technical feasibility of the direct use of geothermal energy. Further, the textile industry has experienced several major technical difficulties in their solar applications, and before any major textile firm will undertake planning for direct use of geothermal energy it will require considerably more technical information from the Department of Energy.

An identical view was also strongly advocated by Mr. John Morgan, Director of Energy of Burlington Industries. However, Mr. Morgan did indicate that the potential of direct utilization of geothermal energy in textile industry is significant provided that the Department of Energy undertakes necessary R&D efforts to clearly establish the feasibility of geothermal resource use as well as capital and operating costs.

3.2.3 Lumber and Wood Products

Lumber and Wood Products sector offers good opportunities for direct utilization of geothermal resources in kiln drying and related applications.

The principal determinant of whether or not firms in this industry will use geothermal resources in their operations, according to Alex M. Fisken, Senior Vice President for Facilities, Planning and Technology of Weyerhaeuser Corporation, is the location of such resources. As stated by Mr. Fisken, all of the Weyerhaeuser saw mill operations (and this is true for the other firms in this sector) are located on sites carefully selected to minimize transportation costs of raw logs to the saw mill.

If geothermal resources are available at the selected sites, utilization of geothermal resources will be given considerable consideration. Weyerhaeuser Corporation, for example, has in the last two years undertaken several feasibility studies on this issue. However, in the event that geothermal resources are not readily available at the site selected for mill operations, it is not likely that a mill site will be moved to a location simply to access geothermal resources.

The principal reason for not moving is the ability of most well-designed lumber mills to be self sufficient in their energy demands by utilizing tree bark and wood scrap for their heat requirements. According to B. Taggart Edwards, Vice President, Lumber and Plywood Division, St. Regis Company, most mills constructed or planned for construction after the mid-1970's have been designed to be energy self sufficient.

Two types of mills are an exception to this rule: mills designed after 1960 but before 1975; and mills with log input of less than 30 million board feet per annum.

The former type is an exception because these mills were designed during a time when oil was relatively inexpensive and no provisions were made in the design of these facilities to utilize bark and wood scrap.

The number of such facilities, however, are limited, according to Carval T. Tolar, Vice President, Engineering, Georgia Pacific Corporation. Further, even in this case, the economics of design and construction may favor redesign of these facilities for use of bark and wood scrap as a source of fuel rather than to use direct geothermal energy. However, since bark and wood scrap can be readily used by the firm in production of plywood and related products, or sell these by-products to pulp and paper mills, utilization of direct geothermal resources appears to be a very attractive proposition.

Thus, the smaller lumber mills which comprise part of the market are more likely targets for direct use of geothermal resources.

In summary, the Lumber and Wood Products sector offers good opportunities for the direct utilization of geothermal resources. The principal obstacle to increased use of geothermal resources by firms in this sector is their supply of bark and wooden scrap which can be used to meet the firm's energy requirements. However, as noted above, these byproducts can also serve in the manufacture of plywood, wallboard and other products.

According to Mr. C. T. Toler, the technology trends in this industry favor utilization of these byproducts. If it can be shown that direct utilization of geothermal energy is feasible in this sector, firms will utilize this energy source.

However, all of those interviewed expressed significant doubts about the current state-of-art in the direct utilization of geothermal resources. All of those interviewed suggested that additional Federal government-supported demonstration programs should be undertaken to clearly establish feasibility of direct geothermal resources use as well as to establish firm capital requirements.

3.2.4 Chemicals and Allied Products

Chemicals and Allied Products sector presents an excellent potential for direct use of geothermal resources in their plants. Energy supply and/or cost is not, however, the principal plant location determinant.

According to our interviews, the principal plant location determinants in this sector, in order of importance, are:

(1) Accessibility to the markets by both rail and truck and access to waterborne transport (both ocean and inland waterways);

(2) Nearby availability of raw materials and/or access to suppliers of raw materials;

(3) Availability of skilled labor force or labor pool that can be trained in the necessary skills;

(4) Location in relatively close proximity to the markets (in practical terms this means East Coast, the Midwest, center in the Chicago area, and California.)

The accessibility to various modes of transportation is clearly the dominant location determinant and its importance was stressed by almost all of those interviewed.

The importance of proximity to raw material supply as a location determinant was emphasized by those firms which produced bulk chemicals such as Mr. Hal Rozier, Vice President, Royster Company; W. H. Glick, Vice President, Engineering and Administration, BASF Wyandotte Corporation; P. L. Maisto, Director of Energy and Feedstocks BASF Wyandotte Corporation, and Chester Knowles, Director Environment and Energy, Olin Corporation.

On the other hand, those chemical and allied product firms which principally manufacture industrial and consumer end-products stressed the importance of proximity to markets as the plant location determinant. For example, this factor was emphasized by J. Lawrence Wilson, Group Vice President, Chief

Financial Officer and Treasurer of Rohm and Haas Company, Roy Djuvik, Director of Operations, North America, Rohm and Haas Company, Robert L. Harness, Manager Regulatory Affairs, Monsanto Corporation and Robert B. Murray, Vice President, Director Corporate Planning, Eastman Kodak Company.

Several factors adversely affect the adoption of direct geothermal resource utilization by the Chemical and Allied Products sector. The first of these is the fact that most of the expansion in this industry during the past decade has taken place by additions to the existing plants rather than construction of "greenfield" facilities. This, according to Mr. Carl O. Skoggard, Senior Vice President, Westvaco Corporation, is the direct result of various environmental regulations which effectively prohibit construction of new plants.

Another factor that militates against use of direct geothermal energy is the presence of technological risks that such undertaking may present, as emphasized by William B. Hayes, Vice President for Operations of Kerr McGee.

These risks are especially high because of the limited large-scale operations with direct utilization of geothermal resources. Most of those interviewed had very limited knowledge of the location of geothrmal resource regions, and of the technologies employed in direct geothermal energy application. However, unlike the case of Food and Kindred Products sector, or Tobacco sector, all of those interviewed maintained that their in-house engineering staffs could successfully design and operate direct geothermal resource utilization facilities.

Finally, several of those interviewed expressed the need for an explicit understanding (i.e., a formal agreement) between a firm and the Federal government that in the event a firm undertakes a direct geothermal utilization project, interference of any kind by the Federal government should be avoided, and that the Federal government should not treat the facility as a test demonstration project.

In summary, location of Chemical and Allied Products plants are determined by factors such as access to transportation facilities of all modes and accessibility to raw materials and markets. Energy supply and/or cost is not the principal plant location determinant. Nevertheless, our interviews suggest that this sector offers good opportunity for direct geothermal resource application, provided the industry is made aware of these opportunities for geothermal resource utilization.

3.2.5 Leather and Leather Products

Leather and Leather Products sector offers only marginal opportunity for direct use of geothermal resources. A number of factors contribute to this observation.

First, according to Robert Stix, Group Vice President, Manufacturing Operations, U.S. Shoe Corporation, cost of energy in leather tanning, processing and shoe manufacture is not an important consideration. Rather, according to Mr. Stix, and he is supported in this by Mr. Robert Feitler, President of the Wegenberg Shoe Manufacturing Company, the concentration of the leather tanning and shoe manufacturing operations in Chicago region and New England has been determined historically. Both regions are void of geothermal resources.

While there is a concentration of leather and leather products firms in Tennessee, interviews with Mr. Dan Gregory, Deputy General Manager, Footwear Sector, Mr. George Langstaff, Manager of Operations, and Mr. R. E. McLendon, Facilities, all of Genesco, Incorporated, clearly established the very depressed status of this industry, with essentially no capital spending for new facilities or rennovation of existing plants.

3.3 CONCLUSIONS

Our conclusions, based on interviews, suggest that in the case of Chemicals and Allied Products, Textiles and Food and Kindred Products sectors, good opportunities exist for the application of direct geothermal energy in their production processes.

Tobacco sector offers more limited opportunity, and in the Leather and Leather Products sector, such opportunities are marginal at best.

However, in our interviews we have also determined that a number of changes in the Department of Energy Geothermal Programs must be made in order to assure industries' interest in direct use of geothermal resources.

The following chapter contains our recommendations for such changes.

CHAPTER 4

PROBABLE PLANT LOCATIONS IN GEOTHERMAL RESOURCE REGIONS

The objective of this chapter is to indicate the probable number of new facilities of the six industry sectors covered in this report that can be reasonably expected to be located in the 1980 to 1990 period in geothermal resource regions. Because of the complexity of the plant location factors already discussed it should be clear that any indications of the future plant locations are highly putative and tenative. Nevertheless on the basis of our interviews some indication of probable facility location in geothermal resource regions is possible.

4.1 FOOD AND KINDRED PRODUCTS

Our interviews suggest that in the 1980 to 1990 decade about 15 to 20 new major facilities of this industry will be located in the Southeastern geothermal resource region with an additional 10 to 15 new facilities located in California, and not more than five in the Gulf States.

4.2 TOBACCO

Our interviews suggest that not more than two or three new major tobacco processing/manufacturing facilities will be established in the 1980 to 1990 period. All of these will be located within tobacco growing areas in Virginia and the Carolinas.

4.3 TEXTILE MILLS PRODUCTS

On the basis of our interviews we estimate that about six to eight new textile mills will be located in the South-Eastern Geothermal resource region in the 1980 to 1990 period.

4.4 LEATHER AND LEATHER PRODUCTS

Our interviews indicate that it is reasonable to expect about two to four new facilities of this sector to be established in the Southeastern geothermal resource region; with an additional three to six such facilities in the Gulf states and two to three new facilities in California.

4.5 LUMBER AND LUMBER PRODUCTS

Our interviews indicate that there will be a major geographic shift of the lumber and lumber products sector activities from the Pacific Northwest to the Southeastern United States. Such a geographic relocation of this sector will result in establishment of new processing facilities in the Southeastern geothermal resource region. Our estimates, based on interviews, suggest that it is reasonable to expect approximately six to ten such new facilities to be established in the 1980 to 1990 period.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Our interviews with the 30 senior industry executives, subsequent discussions with these executives and surveys of pertinent documents, unmistakably indicate a general and pervasive absence of knowledge of the Department of Energy Geothermal Energy Program by industry executives.

This absence of knowledge of the various program elements that comprise the Department's Geothermal Energy Policy and activities is unfortunate because it stymies the success of the Department's marketing effort.

Fortunately, this lack of knowledge can be readily overcome by the Department of Energy if certain programs and activities are undertaken. The remaining portion of this chapter will present, in a summary manner, our principal findings and our recommendations.

5.1 FINDINGS AND RECOMMENDATIONS: LOCATION OF GEOTHERMAL RESOURCE REGIONS

Almost all of the senior executives interviewed had at best only limited knowledge regarding the spatial boundaries and locations of geothermal resource regions in the United States. Most of those interviewed pointed to the California and Nevada area as the only regions which contain geothermal resources of sufficient quality and quantity to be used by industry.

Our recommendation is that Department of Energy prepare a comprehensive document which clearly delineates the geothermal resource regions in the United States with appropriate additional information related to this resource. We further recommend that this document be mailed to appropriate senior executives (such as Vice Presidents for Corporate Planning) of the major industrial firms in the nation.

5.2 FEASIBILITY OF DIRECT USE OF GEOTHERMAL RESOURCES

As noted, most of the executives we interviewed professed lack of knowledge of the feasibility of direct use of geothermal resources.

Our recommendation is for the Department of Energy to prepare a concise statement on this issue supported by appropriate bibliography and contact person for further information in the Department. We also recommend that this statement be distributed as above.

5.3 POLICIES AND ACTIVITIES OF DEPARTMENT OF ENERGY REGARDING GEOTHERMAL ENERGY UTILIZATION

None of the executives we interviewed had a clear understanding of the Department of Energy's policies and activities with regard to the geothermal energy development. None were aware of the Geothermal Loan Guaranty Program (GLGP); none were familiar with the Geothermal Steam Act of 1970 (PL 91-581) or Geothermal Energy Research, Development and Demonstration Act of 1974 (PL 93-410) or the activities of the Interagency Geothermal Coordinating Council.

Such knowledge on the part of executives is mandatory in order to prepare these executives for marketing efforts.

Our recommendation is that the Department of Energy prepare a document which presents this information in a concise and clear manner and distributes this document to the appropriate executives. At the minimum, a fact sheet on these issues with appropriate references for the more detailed and comprehensive information, should be prepared and distributed. We also recommend that the Department of Energy appoint a person on its staff with industry liaison responsibility and that the existence of this person (resource) is made known to the industry.

5.4 FURTHER MARKETING ACTIVITIES

In this report the following five industry sectors were identified as potential candidates for direct use of geothermal resources:

(1) Food and Kindred Products;

(2) Tobacco;

(3) Textile Mills;

(4) Lumber and Wood Products; and

(5) Chemicals and Allied Products.

In order to carry this marketing activity forward, our recommendations are:

That the Department of Energy prepare a document summarizing its geothermal energy program and assistance it can render to the industry, and distribute this document to the senior executives of the major firms in the five sectors of industry. Concurrently the Department of Energy personnel should seek personal meetings with selected executives of the firms in these five sectors to present before them the Department's policies with regard to the geothermal energy development. The Department of Energy should also, on the basis of this report, identify site-specific locations within geothermal resource areas and prepare and distribute fact sheets on such locations to the industry. An alternate approach to the above would be for the Department to engage for this task a professional organization with expertise in industrial site location.

Finally, we recommend that the Department of Energy organize a conference for industry executives with the objective of explaining Department of Energy geothermal utilization policies and activities. Judging from the awareness level of those interviewed, the Department of Energy might address several areas of concern with potential industry users of geothermal energy. These areas concern seed money for various successful prototype operations and subsequent distribution of capital costs requirements information. Industry needs assurances that geothermal energy usage will be profitable. Details on full-scale financing must be available upon which industry executives can base their decisions. Included with these financial data should be a basic plan to alleviate fears that industry could not cope with environmental requirements from other sectors of government. Environmental controls must be explained in terms of simplicity, and assurances given that industry will be able to meet these requirements economically and relatively quickly. Also assurances that government would serve in an advisory capacity would lend credibility to the Department of Energy's marketing efforts.

APPENDIX A

INDUSTRY LOCATION FACTORS FROM ECONOMIC DEVELOPMENT ADMINISTRATIONS FILES

Excellent although dated empirical data pertaining to industry location factors exist in EDA files. These data are contained in computer printouts maintained by Economic Development Administration (EDA) of the Department of Commerce.[1/] The data pertain to the year 1970 and according to EDA is the result of a carefully conducted survey of a total of 2,950 companies.

The following is a pertinent description of this survey as stated by EDA:

1/ For brief description of this data base see: Economic Development Administration, Manufacturing Plant Characteristics, 1970, June 1973.

Manufacturing industries which had demonstrated reasonable growth between 1958 and 1967, or which appeared to have good growth prospects in 1970, were selected for inclusion in this survey. These industries were identified by their Standard Industrial Classification (SIC) and the Bureau of the Census 5-digit product class code number. Within these industries and product classes, only plants with the following characteristics were included: (1) were primarily engaged in the production of the growth product classes (represented by 50 percent or more of the total value of shipments of the plant); and (2) had 100 or more employees. It should be noted that manufacturing activities which are not eligible to receive assistance from EDA to locate in designated areas (e.g., apparel manufacturing) were excluded from the scope of this survey.

The mailing panel consisted of selected individual manufacturing establishments in 254 product classes taken from the 1967 Census of Manufacturers name and address file. This list was then matched against the 1970 Annual Survey of Manufacturers to update plant identification records for such items as name and address.

The panel selected, mail canvass, and processing of returns were conducted by the Bureau of the Census as collecting and compiling agent for EDA.

A total of 2,950 companies in 254 product classes was selected as the mailing panel for this survey. They received 5,500 Form ED-707A's and 3,800 Form ED-707B's. Of these, 66 and 70 percent, respectively, were filed and are included in the tabulations. Respondents occasionally omitted responses to one or more of the specific inquiries on the forms. No followup attempt was made to secure a 100 percent response rate for all questions. 1/

From the computer printouts maintained by EDA, a total of 24 four-digit SIC industry sectors have been selected which correspond to the six major industry sectors selected for this study. Table 13 enumerates the sectors selected.

As the information contained in Table 1A suggests, the industry sectors for which plant characteristics are available do not fully correspond to the six major industry sectors

---

1/ *Ibid.*, pp. 3-4.

TABLE 1A

INDUSTRY SECTORS SELECTED FOR MANUFACTURING PLANT CHARACTERISTICS

SIC Code	Sector
2086	Bottled and Canned Soft Drinks
2256	Warp Knit Fabrics
2256	Circular Knit Fabrics
2272	Tufted Carpets and rugs
2295	Vinyl Coated Fabrics
2432	Softwood Plywood
2432	Nonwood-face Plywood
2432	Softwood Veneer
2815	Cyclic (coal tar) intermediates
2815	Synthetic Organic Dyes
2818	Miscellaneous Acyclic Chemicals
2819	Synthetic Ammonia
2821	Thermoplastic Resins
2824	Noncellulosic Synthetic Fibers
2833	Synthetic Organic Medicinal Chemicals
2834	Pharmaceutical Preparations
2834	Vitamins, Nutrients
2842	Specialty Cleaning Products
2844	Perfumes, etc.
2844	Miscellaneous Cosmetics
2879	Agricultural Insecticidal Preparations
2899	Miscellaneous Chemicals

selected for this study.

Data for only one sector of the Food and Kindred Products industry is available; there is no information for Tobacco and Leather and Leather Products sectors. Nevertheless, the data for the 27 industry sectors which are available provide some indication whether the plant location determinants which industry asserts to be of critical importance are indeed important.

Tables 2A through 25A present the EDA data for the 27 sectors of industry. These data clearly support our principal findings reported previously. In general terms, the data clearly indicate that accessibility by truck rather than railroad, water or air transport is of critical importance to all industry sectors. Conversely, in the other sectors accessibility per se and not the distance or time spent in delivering goods to the market areas is important, except in the case of Food and Kindred Products sector.

The implication of this finding is that except for Food and Kindred Products sector, the location of a firm can be distant from the market areas, provided the location has outstanding accessibility. Among the modes of transport, trucking is dominant followed by rail.

Location in industrial parks is apparently of marginal importance to most industry sectors. Except for Food and Kindred Products sector, availability of public water systems is also relatively unimportant.

The single important plant location characteristic that should be additionally emphasized is the large size of plant site used by Chemicals and Allied Products sector. For example, for industrial chemicals (i.e., SIC 2818), 75 percent of plants were located on plant sites 51 acres or larger, and 50 percent were located on sites 100 acres or larger.

Thus, availability of large parcels of appropriate industrial land is of critical importance for the Chemical and Allied Product sector; to a somewhat lesser extent, this is also true for Textiles and Lumber and Wood Products sectors.

TABLE 2A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2086

		Percent of Plants
I.	Population of City or Place in Which Plant is Located	
	(1) 50,000 or more	88
	(2) Less than 50,000	12
II.	Distance of Plant From City	
	(1) Less than 50 miles	83
	(2) 50 miles or more	17
III.	A. Is Plant Located in an Industrial Park	
	(1) Yes	8
	(2) No	92
	B. Approximate Size of Plant Site	
	(1) Less than one acre	2
	(2) 1-4 acres	37
	(3) 5-20 acres	56
	(4) 21-50 acres	3
	(5) 51-100 acres	2
	(6) Over 100 acres	0
IV.	Products and Material Delivery Schedules	
	A. Products Shipped by Plant	
	(1) Same day delivery	73
	(2) Overnight delivery	5
	(3) Next day delivery	13
	(4) Two-days delivery	5
	(5) More than two-days delivery	5
	B. Materials Received at Plant	
	(1) Same day delivery	22
	(2) Overnight delivery	16
	(3) Next day delivery	29
	(4) Two-days delivery	10
	(5) More than two-days delivery	24

TABLE 2A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIC 2086

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	8
(4) Truck	92
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	3
(4) Truck	97
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	91
(2) No	9

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 3A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIC 2256

		Percent of Plants
I.	Population of City or Place in Which Plant is Located	
	(1) 50,000 or more	
	(2) Less than 50,000	
II.	Distance of Plant From City	
	(1) Less than 50 miles	7
	(2) 50 miles or more	93
III.	A. Is Plant Located in an Industrial Park	
	(1) Yes	79
	(2) No	21
	B. Approximate Size of Plant Site	
	(1) Less than one acre	0
	(2) 1-4 acres	20
	(3) 5-20 acres	67
	(4) 21-50 acres	0
	(5) 51-100 acres	13
	(6) Over 100 acres	0
IV.	Products and Material Delivery Schedules	
	A. Products Shipped by Plant	
	(1) Same day delivery	7
	(2) Overnight delivery	20
	(3) Next day delivery	20
	(4) Two-days delivery	33
	(5) More than two-days delivery	20
	B. Materials Received at Plant	
	(1) Same day delivery	0
	(2) Overnight delivery	13
	(3) Next day delivery	20
	(4) Two-days delivery	20
	(5) More than two-days delivery	47

TABLE 3A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIC 2256

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	20
(4) Truck	80
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	67
(2) No	33

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 4A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2256

		Percent of Plants
I.	Population of City or Place in Which Plant is Located	
	(1) 50,000 or more	25
	(2) Less than 50,000	75
II.	Distance of Plant From City	
	(1) Less than 50 miles	73
	(2) 50 miles or more	27
III.	A. Is Plant Located in an Industrial Park	
	(1) Yes	0
	(2) No	100
	B. Approximate Size of Plant Site	
	(1) Less than one acre	5
	(2) 1-4 acres	25
	(3) 5-20 acres	40
	(4) 21-50 acres	25
	(5) 51-100 acres	5
	(6) Over 100 acres	0
IV.	Products and Material Delivery Schedules	
	A. Products Shipped by Plant	
	(1) Same day delivery	10
	(2) Overnight delivery	0
	(3) Next day delivery	15
	(4) Two-days delivery	25
	(5) More than two-days delivery	50
	B. Materials Received at Plant	
	(1) Same day delivery	10
	(2) Overnight delivery	10
	(3) Next day delivery	10
	(4) Two-days delivery	20
	(5) More than two-days delivery	50

TABLE 4A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2256

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	10
(4) Truck	90
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	75
(2) No	25

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 5A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2272

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	18
(2) Less than 50,000	72
II. Distance of Plant From City	
(1) Less than 50 miles	67
(2) 50 miles or more	34
III. A. Is Plant Located in an Industrial Park	
(1) Yes	29
(2) No	71
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	21
(3) 5-20 acres	45
(4) 21-50 acres	8
(5) 51-100 acres	11
(6) Over 100 acres	16
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	0
(2) Overnight delivery	3
(3) Next day delivery	18
(4) Two-days delivery	8
(5) More than two-days delivery	71
B. Materials Received at Plant	
(1) Same day delivery	13
(2) Overnight delivery	3
(3) Next day delivery	13
(4) Two-days delivery	11
(5) More than two-days delivery	58

TABLE 5A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2272

		Percent of Plants
V.	Delivery Methods for Products and Materials	
	A. Products Shipped by Plant	
	(1) Air	0
	(2) Water	0
	(3) Rail	5
	(4) Truck	95
	B. Materials Received at Plant	
	(1) Air	0
	(2) Water	0
	(3) Rail	3
	(4) Truck	97
VI.	Water Supply	
	A. Does This Plant Use a Public Water System	
	(1) Yes	87
	(2) No	13

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 6A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY SIC 2295

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	44
(2) Less than 50,000	56
II. Distance of Plant From City	
(1) Less than 50 miles	80
(2) 50 miles or more	20
III. A. Is Plant Located in an Industrial Park	
(1) Yes	0
(2) No	100
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	22
(3) 5-20 acres	56
(4) 21-50 acres	0
(5) 51-100 acres	22
(6) Over 100 acres	0
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	11
(2) Overnight delivery	33
(3) Next day delivery	11
(4) Two-days delivery	0
(5) More than two-days delivery	44
B. Materials Received at Plant	
(1) Same day delivery	0
(2) Overnight delivery	22
(3) Next day delivery	0
(4) Two-days delivery	33
(5) More than two-days delivery	44
	0

TABLE 6A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2295

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	67
(2) No	33

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 7A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2432

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	14
(2) Less than 50,000	86
II. Distance of Plant From City	
(1) Less than 50 miles	32
(2) 50 miles or more	68
III. A. Is Plant Located in an Industrial Park	
(1) Yes	17
(2) No	83
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	0
(3) 5-20 acres	28
(4) 21-50 acres	28
(5) 51-100 acres	17
(6) Over 100 acres	28
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	0
(4) Two-days delivery	100
(5) More than two-days delivery	0
B. Materials Received at Plant	
(1) Same day delivery	50
(2) Overnight delivery	3
(3) Next day delivery	6
(4) Two-days delivery	11
(5) More than two-days delivery	28
	3

TABLE 7A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2432

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	100
(4) Truck	0
B. Materials Received at Plant	
(1) Air	0
(2) Water	3
(3) Rail	17
(4) Truck	75
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	53
(2) No	47

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 8A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2432

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	25
(2) Less than 50,000	75
II. Distance of Plant From City	
1 (1) Less than 50 miles	67
(2) 50 miles or more	33
III. A. Is Plant Located in an Industrial Park	
(1) Yes	38
(2) No	62
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	25
(3) 5-20 acres	25
(4) 21-50 acres	25
(5) 51-100 acres	0
(6) Over 100 acres	25
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	13
(4) Two-days delivery	13
(5) More than two-days delivery	74
B. Materials Received at Plant	
(1) Same day delivery	13
(2) Overnight delivery	0
(3) Next day delivery	13
(4) Two-days delivery	0
(5) More than two-days delivery	74

TABLE 8A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2432

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	50
(4) Truck	50
B. Materials Received at Plant	
(1) Air	0
(2) Water	25
(3) Rail	12
(4) Truck	63
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	88
(2) No	12

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 9A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2432

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	0
(2) Less than 50,000	100
II. Distance of Plant From City	
(1) Less than 50 miles	50
(2) 50 miles or more	50
III. A. Is Plant Located in an Industrial Park	
(1) Yes	17
(2) No	83
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	0
(3) 5-20 acres	50
(4) 21-50 acres	33
(5) 51-100 acres	17
(6) Over 100 acres	0
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	33
(2) Overnight delivery	0
(3) Next day delivery	17
(4) Two-days delivery	0
(5) More than two-days delivery	50
B. Materials Received at Plant	
(1) Same day delivery	67
(2) Overnight delivery	0
(3) Next day delivery	0
(4) Two-days delivery	0
(5) More than two-days delivery	33

TABLE 9A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2432

		Percent of Plants
V.	Delivery Methods for Products and Materials	
	A. Products Shipped by Plant	
	(1) Air	0
	(2) Water	0
	(3) Rail	50
	(4) Truck	50
	B. Materials Received at Plant	
	(1) Air	0
	(2) Water	0
	(3) Rail	0
	(4) Truck	100
VI.	Water Supply	
	A. Does This Plant Use a Public Water System	
	(1) Yes	33
	(2) No	67

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 10A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIC 2815

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	36
(2) Less than 50,000	64
II. Distance of Plant From City	
(1) Less than 50 miles	100
(2) 50 miles or more	0
III. A. Is Plant Located in an Industrial Park	
(1) Yes	0
(2) No	100
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	0
(3) 5-20 acres	0
(4) 21-50 acres	18
(5) 51-100 acres	18
(6) Over 100 acres	64
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	0
(2) Overnight delivery	9
(3) Next day delivery	0
(4) Two-days delivery	9
(5) More than two-days delivery	82
B. Materials Received at Plant	
(1) Same day delivery	27
(2) Overnight delivery	0
(3) Next day delivery	0
(4) Two-days delivery	0
(5) More than two-days delivery	73

TABLE 10A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY SIC 2815

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	10
(3) Rail	45
(4) Truck	45
B. Materials Received at Plant	
(1) Air	0
(2) Water	36
(3) Rail	36
(4) Truck	28
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	36
(2) No	64

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 11A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2815

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	71
(2) Less than 50,000	29
II. Distance of Plant From City	
(1) Less than 50 miles	100
(2) 50 miles or more	0
III. A. Is Plant Located in an Industrial Park	
(1) Yes	0
(2) No	100
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	29
(3) 5-20 acres	14
(4) 21-50 acres	0
(5) 51-100 acres	29
(6) Over 100 acres	29
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	0
(2) Overnight delivery	14
(3) Next day delivery	43
(4) Two-days delivery	0
(5) More than two-days delivery	43
B. Materials Received at Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	0
(4) Two-days delivery	14
(5) More than two-days delivery	86

TABLE 11A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIG-2815

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	14
(4) Truck	86
B. Materials Received at Plant	
(1) Air	0
(2) Water	14
(3) Rail	28
(4) Truck	58
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	43
(2) No	57

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 12A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2818

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	47
(2) Less than 50,000	53
II. Distance of Plant From City	
(1) Less than 50 miles	88
(2) 50 miles or more	12
III. A. Is Plant Located in an Industrial Park	
(1) Yes	6
(2) No	94
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	0
(3) 5-20 acres	9
(4) 21-50 acres	16
(5) 51-100 acres	25
(6) Over 100 acres	50
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	9
(2) Overnight delivery	0
(3) Next day delivery	6
(4) Two-days delivery	6
(5) More than two-days delivery	78
B. Materials Received at Plant	
(1) Same day delivery	19
(2) Overnight delivery	0
(3) Next day delivery	3
(4) Two-days delivery	3
(5) More than two-days delivery	75

TABLE 12A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIC 2818

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	34
(3) Rail	44
(4) Truck	22
B. Materials Received at Plant	
(1) Air	0
(2) Water	47
(3) Rail	41
(4) Truck	13
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	28
(2) No	72

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 13A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2819

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	19
(2) Less than 50,000	81
II. Distance of Plant From City	
(1) Less than 50 miles	77
(2) 50 miles or more	23
III. A. Is Plant Located in an Industrial Park	
(1) Yes	6
(2) No	94
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	0
(3) 5-20 acres	0
(4) 21-50 acres	0
(5) 51-100 acres	25
(6) Over 100 acres	75
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	19
(2) Overnight delivery	0
(3) Next day delivery	1
(4) Two-days delivery	6
(5) More than two-days delivery	69
B. Materials Received at Plant	
(1) Same day delivery	13
(2) Overnight delivery	0
(3) Next day delivery	0
(4) Two-days delivery	0
(5) More than two-days delivery	87

TABLE 13A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIC 2819

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	6
(3) Rail	63
(4) Truck	31
B. Materials Received at Plant	
(1) Air	0
(2) Water	6
(3) Rail	44
(4) Truck	50
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	31
(2) No	69

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 14A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIC 2821

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	33
(2) Less than 50,000	67
II. Distance of Plant From City	
(1) Less than 50 miles	92
(2) 50 miles or more	8
III. A. Is Plant Located in an Industrial Park	
(1) Yes	0
(2) No	100
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	0
(3) 5-20 acres	17
(4) 21-50 acres	6
(5) 51-100 acres	33
(6) Over 100 acres	44
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	6
(2) Overnight delivery	0
(3) Next day delivery	6
(4) Two-days delivery	11
(5) More than two-days delivery	78
B. Materials Received at Plant	
(1) Same day delivery	6
(2) Overnight delivery	0
(3) Next day delivery	6
(4) Two-days delivery	6
(5) More than two-days delivery	82

TABLE 14A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2821

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	6
(3) Rail	61
(4) Truck	33
B. Materials Received at Plant	
(1) Air	0
(2) Water	28
(3) Rail	44
(4) Truck	28
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	28
(2) No	72

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 15A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2824

		Percent of Plants
I.	Population of City or Place in Which Plant is Located	
	(1) 50,000 or more	0
	(2) Less than 50,000	100
II.	Distance of Plant From City	
	(1) Less than 50 miles	50
	(2) 50 miles or more	50
III.	A. Is Plant Located in an Industrial Park	
	(1) Yes	0
	(2) No	100
	B. Approximate Size of Plant Site	
	(1) Less than one acre	0
	(2) 1-4 acres	0
	(3) 5-20 acres	0
	(4) 21-50 acres	0
	(5) 51-100 acres	0
	(6) Over 100 acres	100
IV.	Products and Material Delivery Schedules	
	A. Products Shipped by Plant	
	(1) Same day delivery	0
	(2) Overnight delivery	0
	(3) Next day delivery	0
	(4) Two-days delivery	100
	(5) More than two-days delivery	0
	B. Materials Received at Plant	
	(1) Same day delivery	0
	(2) Overnight delivery	0
	(3) Next day delivery	0
	(4) Two-days delivery	100
	(5) More than two-days delivery	0

TABLE 15A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2824

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
B. Materials Received at Plant	
(1) Air	0
(2) Water	50
(3) Rail	50
(4) Truck	0
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	0
(2) No	100

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 16A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2833

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	14
(2) Less than 50,000	86
II. Distance of Plant From City	
(1) Less than 50 miles	67
(2) 50 miles or more	33
III. A. Is Plant Located in an Industrial Park	
(1) Yes	0
(2) No	100
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	0
(3) 5-20 acres	14
(4) 21-50 acres	0
(5) 51-100 acres	0
(6) Over 100 acres	86
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	0
(2) Overnight delivery	14
(3) Next day delivery	0
(4) Two-days delivery	43
(5) More than two-days delivery	43
B. Materials Received at Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	0
(4) Two-days delivery	0
(5) More than two-days delivery	100

TABLE 16A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2833

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	29
(4) Truck	71
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	86
(4) Truck	14
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	29
(2) No	71

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 17A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2834

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	40
(2) Less than 50,000	60
II. Distance of Plant From City	
(1) Less than 50 miles	100
(2) 50 miles or more	0
III. A. Is Plant Located in an Industrial Park	
(1) Yes	0
(2) No	100
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	0
(3) 5-20 acres	50
(4) 21-50 acres	0
(5) 51-100 acres	10
(6) Over 100 acres	40
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	20
(2) Overnight delivery	0
(3) Next day delivery	20
(4) Two-days delivery	0
(5) More than two-days delivery	60
B. Materials Received at Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	10
(4) Two-days delivery	10
(5) More than two-days delivery	80

TABLE 17A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2834

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	20
(4) Truck	80
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	20
(4) Truck	80
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	70
(2) No	30

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 18A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2834

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	71
(2) Less than 50,000	29
II. Distance of Plant From City	
(1) Less than 50 miles	100
(2) 50 miles or more	0
III. A. Is Plant Located in an Industrial Park	
(1) Yes	14
(2) No	86
B. Approximate Size of Plant Site	
(1) Less than one acre	14
(2) 1-4 acres	29
(3) 5-20 acres	29
(4) 21-50 acres	14
(5) 51-100 acres	0
(6) Over 100 acres	14
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	29
(4) Two-days delivery	0
(5) More than two-days delivery	71
B. Materials Received at Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	0
(4) Two-days delivery	29
(5) More than two-days delivery	71

TABLE 18A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2834

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	100
(2) No	0

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 19A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY SIC 2834

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	100
(2) Less than 50,000	0
II. Distance of Plant From City	
(1) Less than 50 miles	100
(2) 50 miles or more	0
III. A. Is Plant Located in an Industrial Park	
(1) Yes	0
(2) No	100
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	0
(3) 5-20 acres	50
(4) 21-50 acres	0
(5) 51-100 acres	0
(6) Over 100 acres	50
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	0
(4) Two-days delivery	50
(5) More than two-days delivery	50
B. Materials Received at Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	0
(4) Two-days delivery	0
(5) More than two-days delivery	100

TABLE 19A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2834

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	50
(2) No	50

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 20A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIC 2834

		Percent of Plants
I.	Population of City or Place in Which Plant is Located	
	(1) 50,000 or more	50
	(2) Less than 50,000	50
II.	Distance of Plant From City	
	(1) Less than 50 miles	50
	(2) 50 miles or more	50
III.	A. Is Plant Located in an Industrial Park	
	(1) Yes	0
	(2) No	100
	B. Approximate Size of Plant Site	
	(1) Less than one acre	0
	(2) 1-4 acres	25
	(3) 5-20 acres	25
	(4) 21-50 acres	0
	(5) 51-100 acres	0
	(6) Over 100 acres	50
IV.	Products and Material Delivery Schedules	
	A. Products Shipped by Plant	
	(1) Same day delivery	0
	(2) Overnight delivery	0
	(3) Next day delivery	0
	(4) Two-days delivery	25
	(5) More than two-days delivery	75
	B. Materials Received at Plant	
	(1) Same day delivery	0
	(2) Overnight delivery	0
	(3) Next day delivery	0
	(4) Two-days delivery	0
	(5) More than two-days delivery	100

TABLE 20A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY SIC 2834

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	50
(4) Truck	50
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	25
(4) Truck	75
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	50
(2) No	50

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 21A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2842

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	50
(2) Less than 50,000	50
II. Distance of Plant From City	
(1) Less than 50 miles	100
(2) 50 miles or more	0
III. A. Is Plant Located in an Industrial Park	
(1) Yes	50
(2) No	50
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	50
(3) 5-20 acres	25
(4) 21-50 acres	0
(5) 51-100 acres	25
(6) Over 100 acres	0
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	25
(4) Two-days delivery	25
(5) More than two-days delivery	50
B. Materials Received at Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	25
(4) Two-days delivery	25
(5) More than two-days delivery	50

TABLE 21A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2842

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	100
(2) No	0

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 22A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIC 2844

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	25
(2) Less than 50,000	75
II. Distance of Plant From City	
(1) Less than 50 miles	100
(2) 50 miles or more	0
III. A. Is Plant Located in an Industrial Park	
(1) Yes	50
(2) No	50
B. Approximate Size of Plant Site	
(1) Less than one acre	25
(2) 1-4 acres	0
(3) 5-20 acres	25
(4) 21-50 acres	25
(5) 51-100 acres	25
(6) Over 100 acres	0
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	25
(2) Overnight delivery	0
(3) Next day delivery	25
(4) Two-days delivery	25
(5) More than two-days delivery	25
B. Materials Received at Plant	
(1) Same day delivery	25
(2) Overnight delivery	25
(3) Next day delivery	50
(4) Two-days delivery	0
(5) More than two-days delivery	0

TABLE 22A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2844

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	0
(4) Truck	100
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	25
(4) Truck	75
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	75
(2) No	25

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 23A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY

SIC 2844

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	69
(2) Less than 50,000	31
II. Distance of Plant From City	
(1) Less than 50 miles	75
(2) 50 miles or more	25
III. A. Is Plant Located in an Industrial Park	
(1) Yes	15
(2) No	85
B. Approximate Size of Plant Site	
(1) Less than one acre	8
(2) 1-4 acres	15
(3) 5-20 acres	31
(4) 21-50 acres	31
(5) 51-100 acres	15
(6) Over 100 acres	0
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	15
(4) Two-days delivery	77
(5) More than two-days delivery	8
B. Materials Received at Plant	
(1) Same day delivery	0
(2) Overnight delivery	0
(3) Next day delivery	16
(4) Two-days delivery	15
(5) More than two-days delivery	69

TABLE 23A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2844

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	8
(4) Truck	92
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	23
(4) Truck	77
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	85
(2) No	15

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 24A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2879

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	62
(2) Less than 50,000	38
II. Distance of Plant From City	
(1) Less than 50 miles	83
(2) 50 miles or more	17
III. A. Is Plant Located in an Industrial Park	
(1) Yes	19
(2) No	81
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	6
(3) 5-20 acres	31
(4) 21-50 acres	31
(5) 51-100 acres	19
(6) Over 100 acres	13
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	6
(2) Overnight delivery	19
(3) Next day delivery	25
(4) Two-days delivery	13
(5) More than two-days delivery	38
B. Materials Received at Plant	
(1) Same day delivery	6
(2) Overnight delivery	13
(3) Next day delivery	0
(4) Two-days delivery	13
(5) More than two-days delivery	69

TABLE 24A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2879

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	6
(3) Rail	19
(4) Truck	76
B. Materials Received at Plant	
(1) Air	0
(2) Water	13
(3) Rail	69
(4) Truck	19
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	50
(2) No	50

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

TABLE 25A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2899

	Percent of Plants
I. Population of City or Place in Which Plant is Located	
(1) 50,000 or more	58
(2) Less than 50,000	42
II. Distance of Plant From City	
(1) Less than 50 miles	88
(2) 50 miles or more	12
III. A. Is Plant Located in an Industrial Park	
(1) Yes	16
(2) No	84
B. Approximate Size of Plant Site	
(1) Less than one acre	0
(2) 1-4 acres	11
(3) 5-20 acres	63
(4) 21-50 acres	21
(5) 51-100 acres	0
(6) Over 100 acres	5
IV. Products and Material Delivery Schedules	
A. Products Shipped by Plant	
(1) Same day delivery	5
(2) Overnight delivery	0
(3) Next day delivery	16
(4) Two-days delivery	16
(5) More than two-days delivery	63
B. Materials Received at Plant	
(1) Same day delivery	11
(2) Overnight delivery	0
(3) Next day delivery	0
(4) Two-days delivery	11
(5) More than two-days delivery	79

TABLE 25A

SURVEY OF MANUFACTURING PLANT CHARACTERISTICS, INDUSTRY
SIC 2899

	Percent of Plants
V. Delivery Methods for Products and Materials	
A. Products Shipped by Plant	
(1) Air	0
(2) Water	0
(3) Rail	10
(4) Truck	90
B. Materials Received at Plant	
(1) Air	0
(2) Water	0
(3) Rail	26
(4) Truck	74
VI. Water Supply	
A. Does This Plant Use a Public Water System	
(1) Yes	89
(2) No	11

Source: Economic Development Administration, Manufacturing Plant Characteristics, 1973.

APPENDIX B

INDUSTRY EXECUTIVES INTERVIEWED DURING THE COURSE OF THIS STUDY

Chemicals

Fred Hoerger, Ph.D., Director
Regulatory and Legislative Issues
Health & Environmental Sciences
Dow Chemical Company
2030 Dow Center
Midland, Michigan 48640

Robert L. Harness
Manager, Regulatory Affairs
Monsanto
1101 17th Street, N.W.
Washington, D.C.

J. Lawrence Wilson, Group V.P.
Chief Financial Officer, Treasurer
Rohm and Haas Company
Independence Mall West
Philadelphia, Pennsylvania 19105

Hal Rozier
Vice President, Production
Royster Company
P.O. Drawer 1940
Norfolk, Virginia 23501

Roy Djuvik, Director of Operations
North America
Rohm and Haas Company
Independence Mall West
Philadelphia, Pennsylvania 19105

P. L. Maisot, Director of Energy
and Feedstocks
BASF Wyandotte Corporation
100 Cherry Hill Road
Parsippany, New Jersey 07054

John Ianos, Vice President, Finance
Reichhold Chemicals, Inc.
525 North Boradway
White Plains, New York 10603

W. H. Glick, Vice President
Engineering & Administration
BASF Wyandotte Corporation
100 Cherry Hill Road
Parsippany, New Jersey 07054

Carl O. Skoggard, Senior Vice President
Westvaco Corporation
299 Park Avenue
New York, New York 10017

Chemicals (continued)

Robert B. Murray
Vice President, Director Corporate Planning
Eastman Kodak Company
343 State Street
Rochester, New York 14650

Chester Knowles
Director, Environmental Energy
Olin Corporation
120 Long Ridge Road
Stamford, Connecticut 06904

Food

Dr. Lee Harrow
Senior Scientist
H. J. Heinz Company
P.O. Box 57
Pittsburgh, Pennsylvania 15230

G. E. Costley, Senior Vice President
Corporate Development

J. D. Forbes, Vice President
Technical Development
Kellog Company
235 Porter Street
Battle Creek, Michigan 49016

Robert Fasick
Vice President, Administration
Liggett Group, INc.
100 Paragon Drive
Montvale, New Jersey 07645

Anthony V. Nizetich, Director
Government Relations
Starkist Foods, Inc.
Terminal Island, California 90731

William B. Hayes
Vice President Operations
Kerr McGee Corporation
Oklahoma City, Oklahoma 73125

George Langstaff
General Manager
Genesco Inc.
Genesco Park
Nashville, Tennessee 37202

Food (continued)

R. E. McLandow, Manager of OPerations
Genesco Inc.
Genesco Park
Nashville, Tenn. 37202

George King
Manager of Planning
R. J. Reynolds Industries, Inc.
Winston-Salem, N.C. 27102

Gerard Coiley
Purchasing Director
American Brands, Inc.
245 Park Avenue
New York, N.Y. 10017

Dr. William Jensen
President West Coast Fisheries Development Foundation
720 S. Washington
Portland, Oregon 97205

Jay Lind
President
Sebastian Stuart Fish Company
P.O. Box 70548
Seattle, Wash. 98107

Lumber

B. Taggart Edwards
Vice President, Lumber and Plywood Div.
St. Regis
150 East 42nd St.
New York, N.Y. 10017

Carroll T. Tolar
V.P., Engineering
Georgia-Pacific
900 Southwest Fifth Avenue
Portland, Oregon 97204

Alec M. Fiskew
Senior Vice President
Facilities, Planning Technology
Weyerhaeuser
Tacoma, Wash. 98477

Textiles

Gordon T. Washington
Vice President, Engineering
Blue Bell, Inc.
Greensboro, North Carolina 27420

John Morgan
Director of Energy
Burlington Industries
3330 West Friendly Avenue
Greensboro, North Carolina 27420

O'Jay Niles, Director
Government Relations/Regulatory
American Textile Manufacturers Institute, Inc.
1101 Connecticut Avenue, N.W.
Suite 300
Washington, D.C. 20036

Leather

George Langstaff
R. E. McLendon
Dan W. Gregory, Deputy General
Manager Footwear Sector
Genesco, Inc.
Genesco Park
Nashville, Tennessee 37202

Robert Stix
Group Vice President
Manufacturing & Operations
U.S. Shoe Corporation
1658 Herald Avenue
Cincinnati, Ohio 45212

Robert Feitler, President
Weyenberg Shoe Manufacturing Company
234 E. Reservoir Avenue
Milwaukee, Wisconsin 53201

★U.S. GOVERNMENT PRINTING OFFICE: 1980-740-145/1067