JPL PUBLICATION 81-61

(NASA-CR-164697) REGIONAL CHARACTERISTICS RELEVANT TO ADVANCED TECHNOLOGY COGENERATION DEVELOPMENT (Jet Propulsion Lab.) 155 p HC A08/MF A01 CSCL 10B
N81-30559
Unclas
G3/44 27242

Regional Characteristics Relevant to Advanced Technology Cogeneration Development

Ram Manvi

July 1981

Prepared for
NASA Lewis Research Center
and
U.S. Department of Energy
Through an agreement with
National Aeronautics and Space Administration
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

JPL PUBLICATION 81-61

Regional Characteristics Relevant to Advanced Technology Cogeneration Development

Ram Manvi

July 1981

Prepared for
NASA Lewis Research Center
and
U.S. Department of Energy
Through an agreement with
National Aeronautics and Space Administration
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Prepared by the Jet Propulsion Laboratory, California Institute of Technology, for the U.S. Department of Energy through an agreement with the National Aeronautics and Space Administration.

ABSTRACT

The Cogeneration Technology Alternatives Study was performed by NASA Lewis Research Center (LeRC) for the U.S. Department of Energy (DOE). The study was aimed at providing a data base to assist DOE in establishing research and development funding priorities in the area of advanced energy conversion technology. As part of a LeRC in-house effort, the Jet Propulsion Laboratory studied those specific factors within various regions of the country that may influence cogeneration with advanced energy conversion systems. Regional characteristics of advanced technology cogeneration possibilities are discussed, with primary emphasis given to coal-derived fuels. Factors considered for the study were regional industry concentration, purchased fuel and electricity prices, environmental constraints, and other data of interest to industrial cogeneration.

ACKNOWLEDGMENT

This study was funded by the U.S. Department of Energy's Division of Fossil Fuel Utilization, through NASA's Lewis Research Center.

The author would like to acknowledge the technical support and direction provided by Gary Sagerman of Lewis Research Center, and Elliot P. Framan of the Jet Propulsion Laboratory (JPL). Thanks are also due to the following JPL participants of this study: A. Aghan, C. Marcus, V. Moretti, W. Scheafle, and M. Slonski.

CONTENTS

Figures

Tables

SECTION I

INTRODUCTION AND OBJECTIVES

The Cogeneration Technology Alternatives Study (CTAS) was initiated by the U.S. Department of Energy (DOE), Division of Fossil Fuels Utilization, to address the merits of advanced cogeneration systems for providing industrial power and process heat. The study was carried out by NASA for DOE utilizing two laboratories, the Lewis Research Center (LeRC) and the Jet Propulsion Laboratory (JPL). The dominant effort in the CTAS was performed by companies from private industry under contract to the government; specifically, General Electric Company and United Technology Corporation. Project management at LeRC was supported by JPL in industry/process data areas and by LeRC in energy conversion systems and subproject management areas.

Cogeneration can be defined as the "simultaneous generation of electricity and useful thermal energy." This study addresses only one type of cogeneration - industrial cogeneration. Industrial cogeneration is defined as:

(1) Generation of electricity at a plant site with the rejected energy from the energy conversion system used for process heating (front-end configuration).

(2) Use of heat rejected from an industrial process by an energy conversion system which then generates electricity at a plant site (back-end configuration).

As a part of the NASA in-house effort, the study objectives at JPL were to assemble industry concentration, energy price, and environmental regulations data to study those specific factors within various regions of the country that may influence industrial cogeneration with advanced energy conversion systems. The JPL study focused primarily on coal and coal-derived fuels as alternate energy systems with merits for cogeneration applications. This report presents the assembled regional data and discusses regional characteristics of advanced technology cogeneration.

To prevent arbitrary differences in basic assumptions among the CTAS contractors and to ensure that the CTAS results were based on assumptions consistent with study philosophies and objectives, NASA specified certain ground rules which include fuel characteristics, emission guidelines, and projected energy prices. The JPL study effort was also aimed at identifying those areas of the United States where the regional values may be substantially different from those established by these ground rules.

SECTION II

APPROACH

The approach adopted in this study is illustrated in Figure 2-1. The significance of each regional factor that was considered is explained below, along with key issues.

A. LOCATION OF INDUSTRY

Twenty-two industries were surveyed in the CTAS. The first study objective was to obtain data on the regional concentration, origin, and growth trends of these industries. This information was considered important toward identifying cogeneration markets. Various trade associations were contacted to obtain answers to questions such as:

(1) Why are the plants located where they are?

(2) How many plants are located in each state?

(3) Is the industry growing in terms of the number of plants or production?

(4) Are existing plants being modified or expanded; are new plants being constructed?

(5) If new plants are being constructed in new regions, why are they relocating to that area?

B. FUEL AND ELECTRICITY PRICES

Previous studies have shown that high fuel costs and low electric power rates are factors that reduce the cost-savings effectiveness of industrial cogenerators. In order to provide (at least qualitatively) the impact of differences between regional and national average values on the economic attractiveness of the various energy conversion systems, it was considered necessary to (1) obtain projected 1985 industrial energy prices for each state for coal, oil, gas and electricity, (2) identify those regions which have projected energy prices significantly different than those specified as baseline values.

C. ENVIRONMENTAL REGULATIONS

Strict air quality requirements in a region will affect cogeneration. Because the CTAS emphasized coal and coal-derived fuels, both federal and state-level air quality control regulations that may be promulgated for coal and coal-derived fuels were considered. Therefore, it was considered necessary to (1) determine regional air quality regulations which an advanced energy conversion system is required to meet, (2) locate nonattainment areas at the

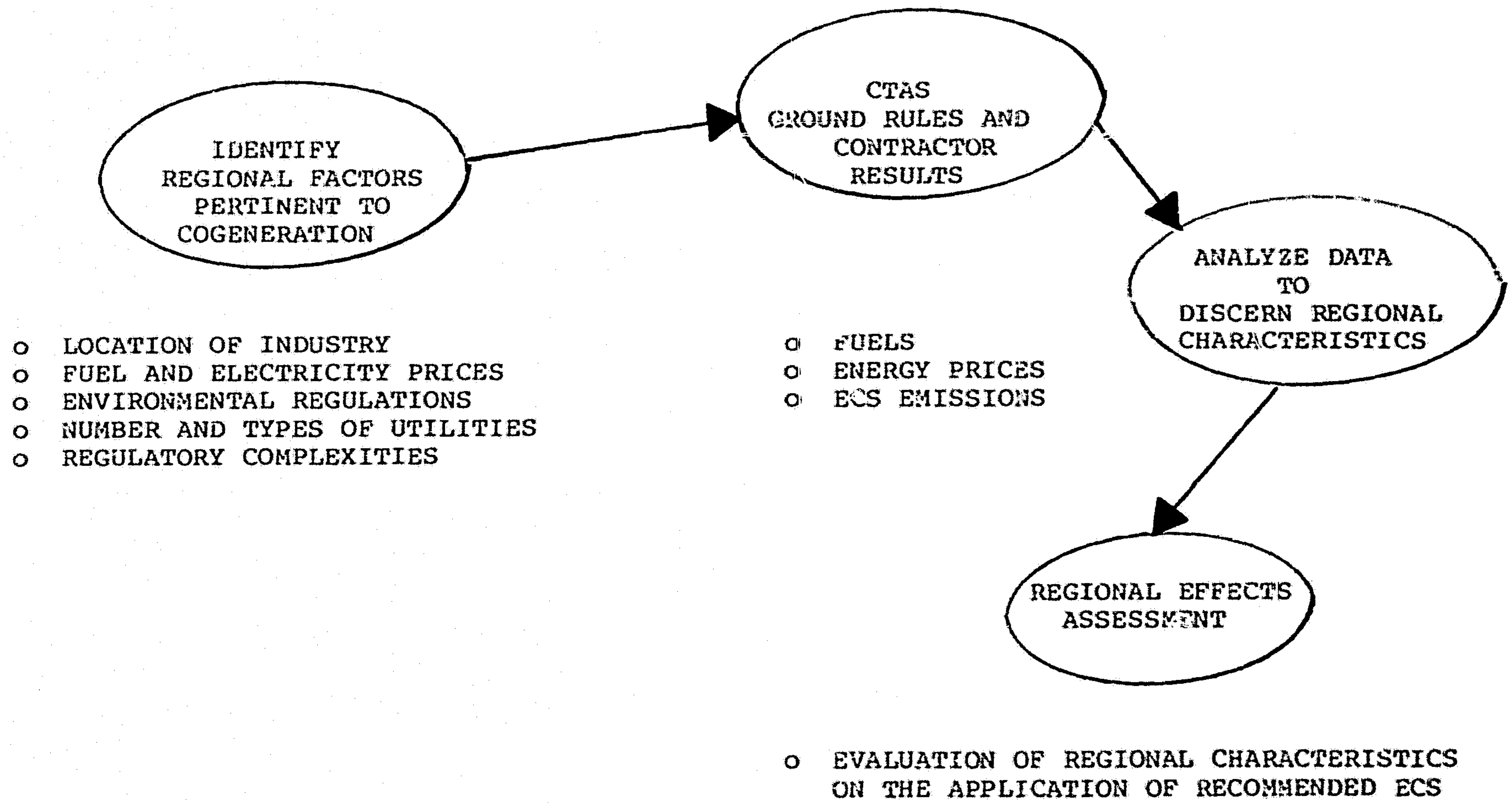


Figure 2-1. Approach for Regional Effects Assessment

county level for all the criteria pollutants (SO_2, NO_x, O_3, TSP, CO), (3) identify regions where local regulations are more stringent than the CTAS emission guidelines, and (4) identify regions where controlled emissions from advanced energy conversion systems considered in the CTAS may not be acceptable.

D. NUMBER AND TYPES OF UTILITIES

State laws and regulations governing the relationships between public and private utility companies and cogenerators are complex, largely because these problems have seldom been addressed by regulators. Issues of ownership, operating arrangements, rate structures, wheeling, and legal aspects of cogeneration are influenced by the number and types of utilities operating in a region. For example, municipal utilities in most states are prohibited from expending funds for "private benefit." Therefore, it was necessary to obtain regional data on the number and types of utilities.

E. REGULATORY COMPLEXITIES

The 1970's have seen an increased environmental awareness which has fostered the enactment of major federal and state legislation, significantly affecting the planning and economics of industrial development. Consistent with the legislative and regulatory initiatives taken at the federal level, states have aggressively enacted laws to regulate both existing and new developments. State activities can be categorized as (1) environmental policy acts, (2) facility siting laws, (3) land and water management acts, and (4) federally-delegated programs. It was necessary to identify requirements of regional regulations and to obtain information on special provisions (if recently enacted) for encouraging cogeneration.

SECTION III

U.S. MANUFACTURING INDUSTRIES SUMMARY DATA

The U.S. Federal Government classifies the entire field of U.S. economic endeavors in accordance with the Standard Industrial Classification Codes (SIC). The Cogeneration Technology Alternatives Study interest was only in the activities under Division D, manufacturing which includes the 20 groups in the two-digit classifications from SIC 20 through 39. The system classifies manufacturing and industrial plants and establishments in accordance with their products rather than by the processes employed or the fuels consumed. Not surprisingly, there is a wide variation in energy consumption from category to category because of the nature of products and because of the structure of the classification system. Table 3-1 shows the energy ranking by major two-digit industry groups.

The classification system extends to the four-digit level, but the product-oriented system does not provide a simple arrangement in terms of energy use classification. There are 451 SIC four-digit industries included in the manufacturing Division D. The CTAS emphasized the study of industrial processes in the top six SIC two-digit groups, but some processes outside this group have also been included. The top six SIC two-digit industry groups are described briefly below.

A. CHEMICALS AND ALLIED PRODUCTS

The chemicals and allied products industries (SIC 28) manufacture thousands of products, many of which are manufactured with totally different technologies. Approximately 71% of the energy consumption within the SIC 28 category occurs in the manufacturing processes of industrial chemicals (SIC 281). Within SIC 281, 84% of the energy is consumed by the manufacturing of only a handful of chemicals such as chlorine, ethylene, ammonia, industrial gases, phosphoric acid, styrene, methanol, alumina digestion, and phenol.

B. PRIMARY METALS

SIC 33 includes manufacturing establishments engaged in (1) the smelting and refining of ferrous and nonferrous metals from ore, pig iron, or scrap, (2) in the rolling, drawing, and alloying of ferrous and nonferrous metals, (3) in the manufacture of castings and other basic products of ferrous and nonferrous metals, and (4) in the manufacture of nails, spikes, and insulated wire and cable. The category also includes manufacturers of coke. Approximately 85% of the energy consumption within the primary metals category occurs in the manufacturing processes for steel, aluminum and copper. Except for the fact that all these components deal with the smelting, refining, casting, or some other treatment of metals, the technologies in the various components differ significantly. For example, the steel-making technology is much different than that of aluminum. The former is coal-intensive; the latter is electricity-intensive.

Table 3-1. Energy Ranking by Major Industry Group (Two-Digit SIC Code Categories Ranked by 1974 Consumption)

Rank	Consumption, 10^{12} kJ/Year	2-Digit SIC Code	Description	Cumulative Percentage
1	3090	28	Chemicals and allied products	80% (ranks 1–6)
2	2787	33	Primary metals	
3	1654	29	Petroleum and coal products	
4	1410	32	Stone, clay and glass products	
5	1404	26	Paper and allied products	
6	1009	20	Food and kindred products	
7	435	34	Fabricated metal products	20% (ranks 7–20)
8	396	37	Transportation equipment	
9	388	35	Machinery, except electrical	
10	341	22	Textile mill products	
11	287	24	Lumber and wood products	
12	269	30	Rubber and misc. plastic products	
13	265	36	Electrical and electronic equip. and supplies	
14	95	27	Printing and publishing	
15	75	38	Instruments and related products	
16	69	23	Apparel and other textile products	
17	62	25	Furniture and fixtures	
18	54	39	Miscellaneous manufacturing	
19	24	31	Leather and leather products	
20	21	21	Tobacco manufacturing	
Total	14137			

C. PETROLEUM REFINING

The petroleum industry (SIC 29) converts crude oil and natural gas liquids to a variety of fuels and other products such as chemical feedstocks and lubricants. Refineries may be classified as simple, complex, or fully integrated, depending upon the processes performed. There is a wide range of energy use in the petroleum refining industry, depending upon the type and relative complexity of the refinery.

D. CEMENT AND GLASS

Cement and glass manufacturers fall under SIC 32. There are two basic processes for producing cement - wet and dry. The only difference between these processes is that the wet process utilizes a slurry to feed the raw materials into the kiln or preheater; the dry process feeds the materials dry. There is an increase in the use of dry processes because of greater energy efficiency.

Four major glass industrial categories - SIC 3211 (flat glass), SIC 3221 (glass containers), SIC 3229 (pressed and blown glass), and SIC 3296 (fiber-glass wool insulation) - are large energy consumers because each category includes glass melting as part of the process. A dramatic fact is that the four glass melting segments use 60% to 85% of their energy in the melting, firing, and conditioning processes alone. Temperatures for these processes are in excess of 2000°F.

E. PULP AND PAPER INDUSTRY

Energy consumption within the paper industry (SIC 26) is concentrated in wood digestion (cooking), evaporation, furnace combustion, drying, and kiln operations. The paper and allied products industry includes pulp making, paper making, paper-board making, conversion of paper and paper-board into final products, and making of building paper and board. The data show that pulp making (SIC 261), paper making (SIC 262), and paper-board making (SIC 263) utilize about 86% of energy consumed by the SIC 26 category.

Four principal processes - ground wood and other mechanical, kraft, semichemical, and sulfite - are used to produce most of the industry's pulp. Use of the sulfite process has declined recently.

F. FOOD AND KINDRED PRODUCTS

SIC 20 accounts for a large and diverse food-processing industry which is subclassified into nine three-digit designations. There are 46 four-digit subclassifications and 187 subclassifications at the five-digit level. It is difficult to analyze each of these segments in detail. Because of time constraints, only meat packing (SIC 2011), prepared meats (SIC 2013), dehydrated fruits and vegetables (SIC 2034), wet corn milling (SIC 2046), beet sugar (SIC 2063), and malt beverages (SIC 2082) have been analyzed in detail and their energy requirements characterized.

SECTION IV

REGIONAL PURCHASED FUEL AND ELECTRICITY PRICES AND ENVIRONMENTAL REGULATIONS

A. REGIONAL FUEL AND ELECTRICITY PRICES

A major effort of the CTAS has been an examination of advanced energy conversion systems (ECS) in relation to high energy-consuming industrial processes. This investigation was conducted by General Electric Company (GE) and United Technology Corporation (UTC), and aided by experts in various advanced ECS technologies. These studies assumed constant nationwide fuel costs in 1985 dollars as shown in Table 4-1. For simplicity, the studies ignored variations in fuel prices and the effects of environmental regulations within the various regions of the country.

Table 4-1. CTAS Baseline 1985 Fuel Costs

Electricity	$\$9.67/10^6$ Btu
Coal	1.80
Distillate Oil	3.80
Residual Oil	3.10
Natural Gas	2.40

To validate the results of the GE and UTC studies and to evaluate regional effects, the JPL study participants examined the variation of purchased fuel and electricity prices in different regions of the country that may influence cogeneration using advanced ECS.

The CTAS chose the fixed fuel and electricity prices shown in Table 4-1 for the initial study baseline. The Sherman H. Clark Associates price forecasts* can be used to show the deviations from these baseline values graphically (Figures 4-1 through 4-4). (Note: The regional variations of distillate oil prices are so small, ie., within ±10% of CTAS rates, that a graphical presentation is not warranted.)

*"Solar Thermal Dispersed Power Program, Total Energy Systems Project, Final Technical Summary Report, Volume II: Energy Use and Price Forecasts," prepared for the Aerospace Corporation by Sherman H. Clark Associates, Menlo Park, Calif., March 31, 1978.

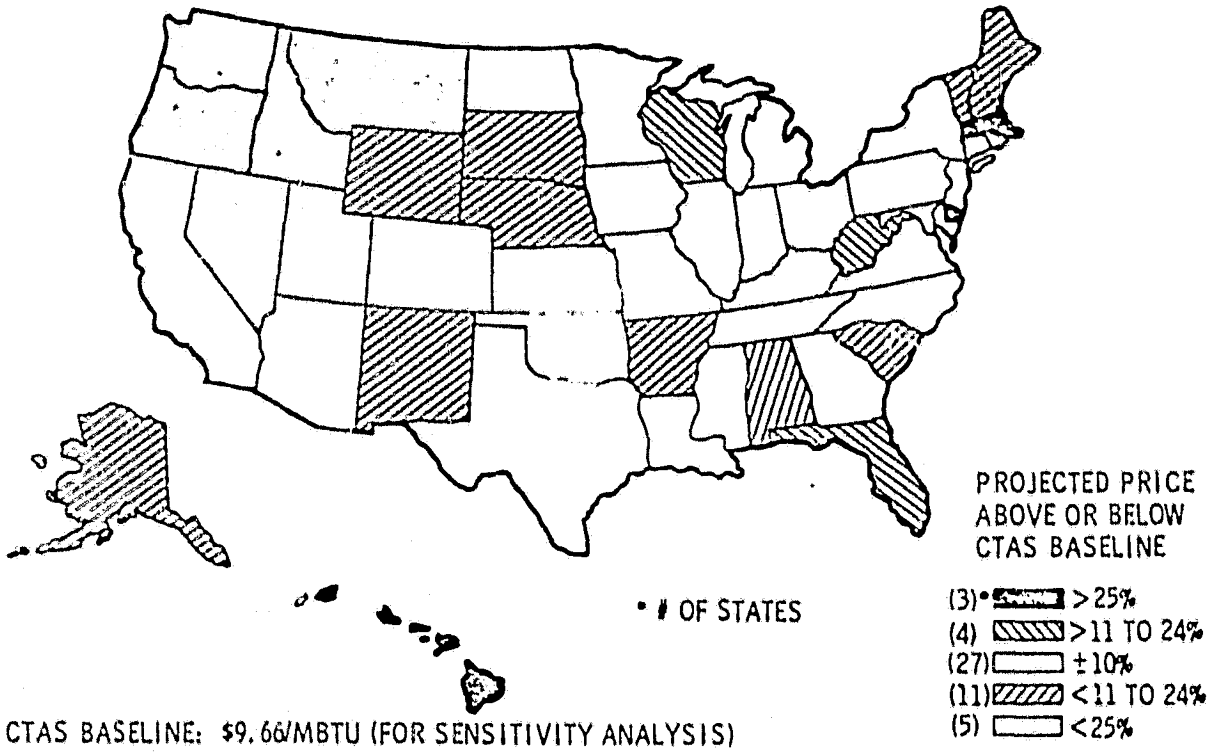


Figure 4-1. Regional Variation of Electricity Prices (1985)

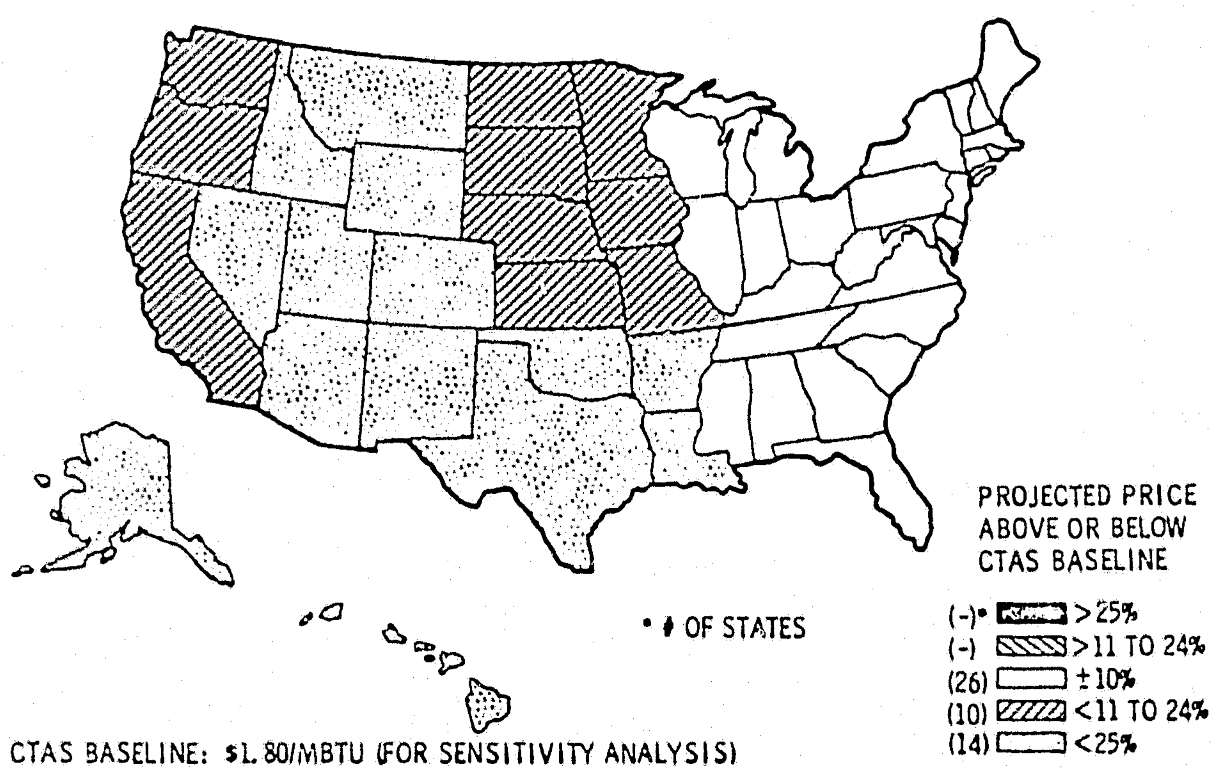


Figure 4-2. Regional Variation of Coal Prices (1985)

NOTE

No graph of the regional price variations of distillate oils is presented because all states have prices within ±10% of the CTAS rates.

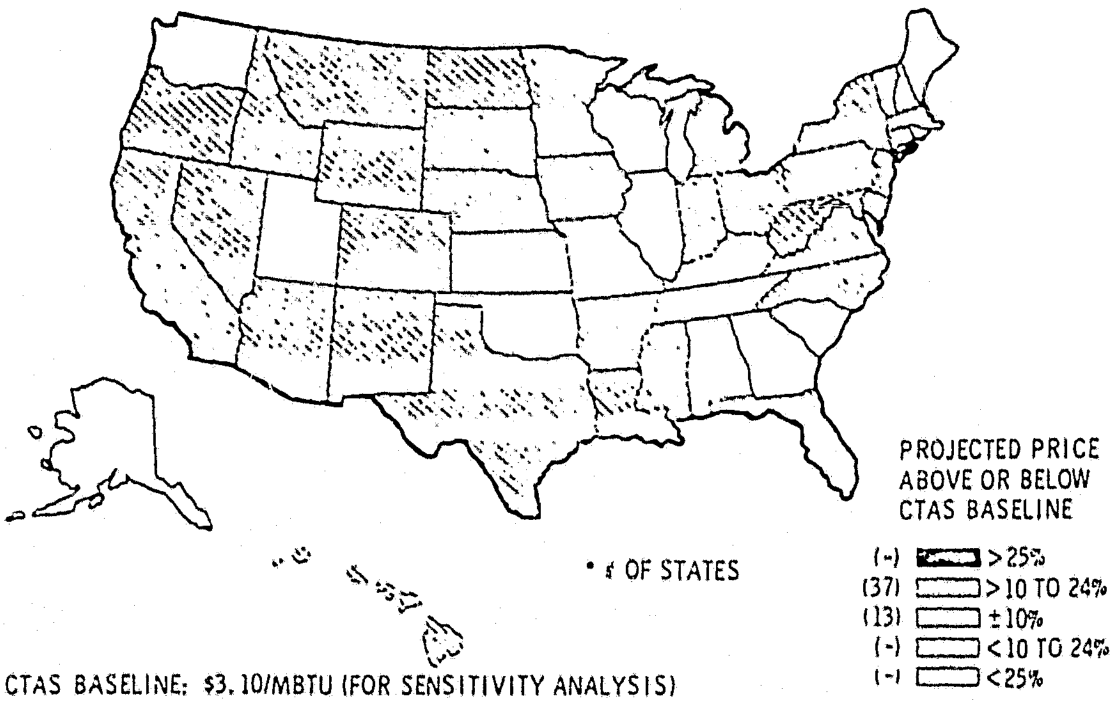


Figure 4-3. Regional Variation of Residual Oil Prices (1985)

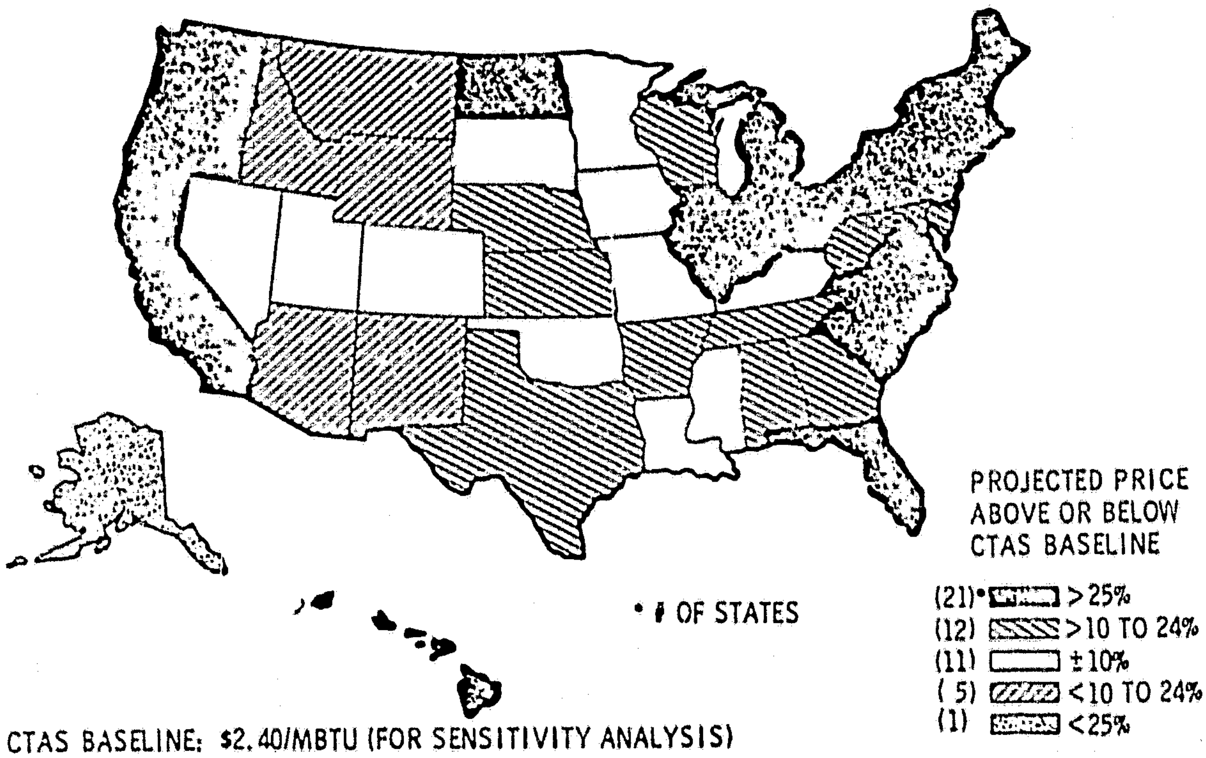


Figure 4-4. Regional Variation of Natural Gas Prices (1985)

On a region-by-region basis, the weighted average cost per region can be obtained by using the sum of the state price times consumption values divided by region-wide consumption. Data is shown in Table 4-2, along with the regional price ratio per unit of CTAS prices. Table 4-3 shows the Sherman H. Clark Associates costs for each state and the percentage above or below the CTAS baseline costs. This data was used to produce Figures 4-1 through 4-4.

In three states, electricity prices are more than 1.25 x CTAS rates: Hawaii, +62%; Massachusetts, +35.3%; and Delaware, +28.9%. Five states have prices lower than 0.75 x CTAS rates: Idaho, -56.0%; Washington, -52.8%; Montana, -40.2%; Oregon, -37.1%; and Nevada, -27.7%.

In no states do coal prices exceed CTAS rates by as much as 10%. All states west of the Mississippi have rates less than 0.9 x CTAS rates, and 14 of these have rates under 0.75 x CTAS rates.

Distillate oil prices in all states are within ±10% of the CTAS rates. Actually, all states are within ±5%, except Hawaii, at +6%.

No states have residual oil prices below CTAS rates. Thirty-seven states exceed CTAS rates by more than 10%, but no state is more than 17% above CTAS rates. Oklahoma has the lowest rate; 4.8% above CTAS rates.

Natural gas rates vary widely, from +239.1% above CTAS rates for Hawaii to -60.6% below for Alaska. Prices in eight states are below CTAS rates: Alaska, -60.6%; Wyoming, -16.5%; Arizona, -15.2%; Montana, -14.8%; New Mexico, -12.6%; Idaho, -10.9%; Colorado, -8.3%; and Nevada, -7.0%. Twenty-three states exceed CTAS rates by +25% or more.

Table 4-2. Comparison of Regional Fuel Price Estimates

	CTAS	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Weighted Average Fuel Cost in Dollars/Million Btu for 1985 (1978 Dollars)											
Electricity	9.67	10.89	10.23	9.76	9.30	9.90	10.04	10.27	8.98	10.00	4.99
Coal	1.80	1.98	1.91	1.88	1.72	1.68	1.41	1.27	0.87	1.50	NA
Distillate Oils	3.80	3.83	3.74	3.84	3.82	3.79	3.75	3.73	3.83	3.92	3.64
Residual Oils	3.10	3.45	3.45	3.50	3.42	3.53	3.47	3.48	3.38	3.50	3.41
Natural Gas	2.40	4.18	3.61	3.29	2.80	3.11	2.67	2.64	2.23	3.04	3.22
Region Definition											
		CT	NJ	DE	AL	IL	IA	AR	CO	AZ	AK
		ME	NY	DC	FL	IN	KS	LA	MT	CA	ID
		MA		MD	GA	MI	MO	MN	ND	HI	OR
		NH		PA	KY	MN	NE	OK	SD	NV	WA
		RI		VA	MS	OH		TX	UT		
		VT		WV	NC	WI			WY		
					SC						
					TN						
Regional Price Ratio Per Unit of CTAS Prices											
Electricity		1.126	1.058	1.009	0.962	1.024	1.038	1.062	0.929	1.034	0.516
Coal		1.100	1.061	1.044	0.956	0.933	0.783	0.706	0.483	0.833	NA
Distillate Oils		1.008	0.984	1.011	1.005	0.997	0.987	0.982	1.008	1.032	0.958
Residual Oils		1.113	1.113	1.129	1.103	1.139	1.119	1.123	1.090	1.129	1.100
Natural Gas		1.742	1.504	1.371	1.167	1.296	1.113	1.100	0.929	1.267	1.342

Table 4-3. Sherman H. Clark Associates Data

ELEC		%	COAL		%	DIST		%	RES		%	GAS		%	STATE
791.	LOW	-18.2	142.	LOW	-10.0	380.	LOW	-.0	336.	HIGH	9.2	267.	HIGH	11.2	AL
730.	LOW	-24.5	97.	LOW	-46.4	362.	LOW	-4.7	340.	HIGH	9.8	94.	LOW	-60.6	AK
974.	HIGH	.7	87.	LOW	-51.6	379.	LOW	-.3	356.	HIGH	14.8	207.	LOW	-15.2	AZ
851.	LOW	-12.0	127.	LOW	-29.6	379.	LOW	-.3	355.	HIGH	14.5	294.	HIGH	22.4	AR
1004.	HIGH	3.8	151.	LOW	-16.4	394.	HIGH	3.6	349.	HIGH	12.5	331.	HIGH	38.0	CA
912.	LOW	-5.6	87.	LOW	-51.6	386.	HIGH	1.6	346.	HIGH	11.5	220.	LOW	-8.3	CO
1034.	HIGH	6.9	158.	HIGH	10.1	390.	HIGH	2.7	357.	HIGH	15.2	405.	HIGH	68.7	CT
1247.	HIGH	28.9	186.	HIGH	3.2	376.	LOW	-1.1	360.	HIGH	16.2	299.	HIGH	24.6	DE
1125.	HIGH	16.4	186.	HIGH	3.2	379.	LOW	-.3	352.	HIGH	13.5	343.	HIGH	42.7	FL
882.	LOW	-8.8	186.	HIGH	3.2	381.	HIGH	.2	340.	HIGH	9.8	276.	HIGH	15.0	GA
1566.	HIGH	62.0	97.	LOW	-46.4	406.	HIGH	6.8	350.	HIGH	12.8	814.	HIGH	239.1	HI
426.	LOW	-56.0	87.	LOW	-51.6	379.	LOW	-.3	351.	HIGH	13.2	214.	LOW	-10.9	ID
974.	HIGH	.7	168.	LOW	-6.6	370.	LOW	-2.8	327.	HIGH	5.5	311.	HIGH	29.7	IL
1004.	HIGH	3.8	168.	LOW	-6.6	374.	LOW	-1.7	360.	HIGH	16.2	303.	HIGH	26.3	IN
1065.	HIGH	10.1	141.	LOW	-21.6	363.	LOW	-4.4	352.	HIGH	13.5	253.	HIGH	5.5	IA
1004.	HIGH	3.8	141.	LOW	-21.6	372.	LOW	-2.2	337.	HIGH	8.8	275.	HIGH	14.6	KS
974.	HIGH	.7	142.	LOW	-10.0	387.	HIGH	1.9	336.	HIGH	9.2	261.	HIGH	8.6	KY
1004.	HIGH	3.8	127.	LOW	-29.6	364.	LOW	-4.1	342.	HIGH	10.2	249.	HIGH	3.8	LA
851.	LOW	-12.0	158.	HIGH	10.1	383.	HIGH	.8	337.	HIGH	8.8	452.	HIGH	88.1	ME
943.	LOW	-2.5	186.	HIGH	3.2	368.	LOW	-3.0	352.	HIGH	13.5	299.	HIGH	24.6	MD&DC
1308.	HIGH	35.3	158.	HIGH	10.1	383.	HIGH	.8	349.	HIGH	12.5	442.	HIGH	84.2	MA
912.	LOW	-5.6	168.	LOW	-4.6	363.	LOW	-4.4	358.	HIGH	15.5	319.	HIGH	32.8	MI
1034.	HIGH	6.9	141.	LOW	-21.6	387.	HIGH	1.9	357.	HIGH	15.2	254.	HIGH	6.0	MN
1034.	HIGH	6.9	162.	LOW	-10.0	372.	LOW	-2.2	346.	HIGH	11.5	264.	HIGH	9.9	MS
1004.	HIGH	3.8	141.	LOW	-21.6	390.	HIGH	2.7	351.	HIGH	13.2	264.	HIGH	9.9	MO
578.	LOW	-40.2	87.	LOW	-51.6	379.	LOW	-.3	351.	HIGH	13.2	204.	LOW	-14.8	MT
851.	LOW	-12.0	141.	LOW	-21.6	361.	LOW	-4.5	349.	HIGH	12.5	292.	HIGH	21.5	NE
700.	LOW	-27.7	87.	LOW	-51.6	391.	HIGH	3.0	353.	HIGH	13.8	223.	LOW	-7.0	NV
730.	LOW	-24.5	158.	HIGH	10.1	380.	LOW	-.0	345.	HIGH	11.2	404.	HIGH	66.2	NH
1065.	HIGH	10.1	191.	HIGH	6.1	383.	HIGH	.8	345.	HIGH	12.2	356.	HIGH	48.3	NJ
851.	LOW	-12.0	87.	LOW	-51.6	379.	LOW	-.3	361.	HIGH	16.5	210.	LOW	-12.6	NM
1004.	HIGH	3.8	191.	HIGH	6.1	363.	LOW	-4.4	342.	HIGH	10.2	363.	HIGH	51.4	NY
1004.	HIGH	3.8	186.	HIGH	3.2	377.	LOW	-.8	344.	HIGH	10.8	326.	HIGH	35.6	NC
1004.	HIGH	3.8	141.	LOW	-21.6	376.	LOW	-1.1	342.	HIGH	10.2	339.	HIGH	41.4	ND
1004.	HIGH	3.8	170.	LOW	-5.4	390.	HIGH	2.7	360.	HIGH	16.2	328.	HIGH	36.7	OH
1034.	HIGH	6.9	127.	LOW	-29.6	361.	LOW	-4.9	325.	HIGH	4.8	263.	HIGH	9.4	OK
608.	LOW	-37.1	151.	LOW	-16.4	362.	LOW	-4.7	342.	HIGH	10.2	326.	HIGH	35.6	OR
943.	LOW	-2.5	191.	HIGH	6.1	388.	HIGH	2.2	349.	HIGH	12.5	343.	HIGH	42.7	PA
1095.	HIGH	13.2	158.	HIGH	10.1	363.	LOW	-4.4	342.	HIGH	10.2	365.	HIGH	52.2	RI
791.	LOW	-18.2	186.	HIGH	3.2	384.	HIGH	1.1	327.	HIGH	5.5	300.	HIGH	25.0	SC
760.	LOW	-21.4	141.	LOW	-21.6	392.	HIGH	3.3	357.	HIGH	15.2	243.	HIGH	1.2	SD
882.	LOW	-8.8	162.	LOW	-10.0	390.	HIGH	2.7	338.	HIGH	9.7	273.	HIGH	13.7	TN
1065.	HIGH	10.1	112.	LOW	-37.7	379.	LOW	-.3	355.	HIGH	14.5	269.	HIGH	12.0	TX
1004.	HIGH	3.8	87.	LOW	-51.6	384.	HIGH	1.1	334.	HIGH	7.8	243.	HIGH	1.2	UT
871.	LOW	-15.1	158.	HIGH	10.1	383.	HIGH	.8	345.	HIGH	11.7	391.	HIGH	63.1	VT
912.	LOW	-5.6	186.	HIGH	3.2	381.	HIGH	.2	352.	HIGH	13.5	315.	HIGH	31.0	VA
457.	LOW	-52.8	151.	LOW	-16.4	362.	LOW	-4.7	340.	HIGH	9.8	364.	HIGH	51.8	WA
1125.	HIGH	16.4	186.	HIGH	3.2	391.	HIGH	3.0	344.	HIGH	10.8	298.	HIGH	24.1	WV
1095.	HIGH	13.2	166.	LOW	-6.6	386.	HIGH	1.6	332.	HIGH	7.1	282.	HIGH	17.6	WI
760.	LOW	-21.4	87.	LOW	-51.6	397.	HIGH	4.3	351.	HIGH	13.2	200.	LOW	-16.5	WY

The wide variations in electricity and natural gas prices have important implications for cogeneration. It is believed that the adoption of cogeneration is sensitive to the ratio of electricity prices to coal prices in a given region. The above data indicates the driver to be electricity prices and areas such as Region 10 (Alaska, Idaho, Oregon, Washington), with low electric rates, tend to be less attractive for cogeneration. Because of the low electric rates, the region has a high concentration of aluminum plants.

In natural gas prices, Alaska is the outstanding exception and may become attractive to such industries as ethylene plants and related polyethylene and styrene plants. The mountain states, except for Utah, also have relatively low natural gas prices.

B. REGIONAL ENVIRONMENTAL REGULATIONS

CTAS emission guidelines were based on the Environmental Protection Agency's New Source Performance Standards (NSPS), and are shown below in Table 4-4. Strict air quality control requirements in a region will affect cogeneration. Because CTAS emphasizes coal and coal-derived fuels, both federal regulations and any air quality control regulations that may be promulgated for coal and coal-derived fuels at the state level need to be considered (see Table 4-5). Table 4-6 identifies the states that have laws governing power plant sites. Table 4-7 shows states that have more stringent standards than the guidelines for the CTAS project in the following respects; particulates, SO_2 from liquid fuels, SO_2 from coal, NO_x, residual oil sulfur content, coal sulfur content, and distillate oil sulfur content.

Table 4-4. CTAS Emission Guidelines Based on NSPS for Steam Power Plants and Proposed NSPS for Stationary Gas Turbines

	Fuel Type		
Pollutant	Solid	Liquid	Gaseous[a]
NO_x	0.7 lb/MBtu	0.5 lb/MBtu[b]	0.2 lb/MBtu
SO_x	1.2 lb/MBtu	0.8 lb/MBtu	0.2 lb/MBtu
Particulates	0.1 lb/MBtu	0.1 lb/MBtu	0.1 lb/MBtu
Smoke	20 SAE Number	20 SAE Number	20 SAE Number

[a]Solid fuel standards apply to systems using LBtu gas produced on-site from coal.
[b]NO_x guideline for petroleum distillate is 0.4 lb/10^6 Btu input.

Tables 4-8 through 4-11 outline state emission standards more stringent than CTAS guidelines and indicate by how much they exceed CTAS limits. The data indicate that only a few states have particulate and NO_x emission standards more stringent than the CTAS guidelines. The majority of western and southwestern states have SO_2 emission standards for coal burners more stringent than the CTAS guidelines. It should be recognized that these states have access to low-sulfur western coal. When this coal is used, it is possible for an advanced cogeneration system to meet these stricter standards with available SO_2 abatement technology.

The results also show that states with SO_2 emission standards stricter than the CTAS guidelines for oil burners are located in the West and Southwest, but again it should be noted that these states are located in the oil-rich part of the country, and it is possible in these regions to obtain lower-sulfur fuel oil but at higher cost. There are only a few states with fuel sulfur content requirements stricter than CTAS fuel specifications. Again, this does not create serious problems for advanced cogeneration facilities in these states, because states such as Oregon and Idaho have access to low sulfur western coal and the rest, Puerto Rico, the Virgin Islands, and Hawaii, rely mainly upon oil. Regional sulfur content requirements imposed on liquid fuels do not cause major problems, because those few states having stricter requirements can obtain their lower sulfur oil easily, although, of course, at a higher price.

Table 4-5. Statewide Allowable Emissions Data

ALLOWABLE LEVEL OF POLLUTANT IN EACH STATE (APOL) POUNDS/MBTU

NOTE: FOR STATES WHERE ALLOWABLE EMISSION STANDARDS DATA ARE NOT AVAILABLE THE NSPS STANDARDS WERE USED.
FOR STATES THAT HAVE DIFFERENT STANDARDS FOR DIFFERENT LOCALITIES OR FUELS THE LOWEST VALUE OF ALLOWABLE EMISSION WAS USED

	NOX				OZONE				SOX				PARTICULATES				
	10	100	250	1000	10	100	250	1000	10	100	250	1000	10	100	250	1000	HEAT 10E6 BTU/H
AL	.70	.70	.70	.70	.70	.70	.70	.70	1.80	1.80	.18	1.20	.50	.18	.12	.10	
AK	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.80	.80	.10	.10	.10	.10	
AZ	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.80	.80	.60	.35	.28	.10	
AR	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.80	.80	.10	.10	.10	.10	
CA	.70	.70	.70	.70	.70	.70	.70	.70	.40	.40	.40	.40	.10	.10	.10	.03	
CO	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.80	.20	.27	.15	.12	.10	
CT	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.80	.80	.10	.10	.10	.10	
DE	.70	.70	.70	.70	.70	.70	.70	.70	.80	.60	.80	.80	.30	.30	.30	.10	
FL	.70	.70	.70	.70	.70	.70	.70	.70	.60	.80	.80	.80	.10	.10	.10	.10	
GA	.70	.70	.70	.70	.70	.70	.70	.70	.60	.60	.60	.80	.50	.16	.10	.10	
HI	.70	.70	.70	.70	.70	.70	.70	.70	.60	.80	.60	.80	.10	.10	.10	.10	
ID	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.60	.80	.60	.33	.26	.10	
IL	.70	.70	.70	.70	.70	.70	.70	.70	.30	.30	.30	.30	.10	.10	.10	.10	
IN	.70	.70	.70	.70	.70	.70	.70	.70	6.00	3.60	2.60	.80	.60	.42	.36	.10	
IA	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.80	.80	.10	.10	.10	.10	
KS	.70	.70	.70	.70	.70	.70	.70	.70	3.00	3.00	3.00	.80	.60	.35	.28	.10	
KY	.70	.70	.70	.70	.70	.70	.70	.70	2.50	1.10	.80	.80	.56	.33	.26	.10	
LA	.70	.70	.70	.70	.70	.70	.70	.70	3.10	3.10	3.10	.80	.60	.60	.60	.10	
ME	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.80	.80	.60	.34	.30	.10	
MD	.70	.70	.70	.70	.70	.70	.70	.70	.60	.80	.80	.80	.10	.06	.05	.03	
MA	.70	.70	.70	.70	.70	.70	.70	.70	.34	.34	.34	.34	.10	.10	.10	.05	
MI	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.80	.80	.10	.10	.10	.10	
MN	.70	.70	.70	.70	.70	.70	.70	.70	1.75	1.75	1.75	.80	.40	.40	.40	.10	
MS	.70	.70	.70	.70	.70	.70	.70	.70	4.80	4.80	4.80	.80	.60	.41	.33	.10	
MO	.70	.70	.70	.70	.70	.70	.70	.70	2.30	2.30	2.30	.80	.60	.35	.28	.10	
MT	.70	.70	.70	.70	.70	.70	.70	.70	2.00	2.00	2.00	.80	.60	.35	.26	.10	
NB	.70	.70	.70	.70	.70	.70	.70	.70	2.50	2.50	2.50	.80	.60	.35	.28	.10	
NV	.70	.70	.70	.70	.70	.70	.70	.70	.15	.15	.11	.11	.60	.36	.28	.10	
NH	.70	.70	.70	.70	.70	.70	.70	.70	2.00	2.00	2.00	.80	.60	.35	.28	.10	
NJ	.70	.70	.70	.70	.70	.70	.70	.70	.60	.80	.30	.30	.60	.15	.10	.10	
NM	.70	.70	.45	.45	.70	.70	.45	.45	.34	.34	.34	.34	.02	.02	.01	.01	
NY	.70	.70	.70	.70	.70	.70	.70	.70	.40	.40	.40	.40	.10	.10	.10	.10	
NC	.70	.70	.70	.70	.70	.70	.70	.70	1.60	1.60	1.60	.80	.60	.33	.24	.10	
ND	.70	.70	.70	.70	.70	.70	.70	.70	3.00	3.00	3.00	.80	.60	.44	.39	.10	
OH	.70	.70	.70	.70	.70	.70	.70	.70	1.00	1.00	1.00	.80	.40	.20	.15	.10	
OK	.70	.70	.70	.70	.70	.70	.70	.70	2.00	2.00	2.00	.30	.60	.33	.26	.10	
OR	.70	.70	.70	.70	.70	.70	.70	.70	1.60	1.60	1.60	.80	.10	.10	.10	.10	
PA	.70	.70	.70	.70	.70	.70	.70	.70	1.00	.89	.78	.65	.40	.27	.16	.06	
RI	.70	.70	.70	.70	.70	.70	.70	.70	1.10	1.10	1.10	1.10	.20	.20	.20	.10	
SC	.70	.70	.70	.70	.70	.70	.70	.70	3.50	2.30	2.30	.80	.60	.60	.60	.10	
SD	.70	.70	.70	.70	.70	.70	.70	.70	3.00	3.00	3.00	.80	.30	.30	.30	.10	
TN	.70	.70	.70	.70	.70	.70	.70	.70	1.60	1.60	1.60	.80	.60	.17	.10	.10	
TX	.70	.70	.70	.70	.70	.70	.70	.70	.68	.68	.68	.30	.30	.30	.30	.10	
UT	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.80	.80	.60	.42	.36	.10	
VT	.70	.70	.30	.30	.70	.70	.30	.30	1.20	1.20	1.20	1.20	.50	.27	.11	.02	
VA	.70	.70	.70	.70	.70	.70	.70	.70	1.06	1.06	1.06	1.06	.40	.29	.23	.10	
WA	.70	.70	.70	.70	.70	.70	.70	.70	1.50	1.50	1.50	.80	.10	.10	.10	.10	
WV	.70	.70	.70	.70	.70	.70	.70	.70	1.60	1.60	1.60	1.20	.05	.05	.05	.05	
WI	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.60	.60	.10	.10	.10	.10	
WY	.70	.70	.70	.70	.70	.70	.70	.70	.80	.80	.80	.20	.10	.10	.10	.10	

Table 4-6. Power Plant Siting Laws

State	Power Siting Law: Yes	Power Siting Law: No
Alabama		X
Alaska		X
Arizona	X	
Arkansas	X	
California	X	
Colorado		X
Connecticut	X	
Delaware		X
Florida	X	
Georgia		X
Hawaii		X
Idaho		X
Illinois		X
Indiana		X
Iowa		X
Kansas		X
Kentucky	X	
Lousiana		X
Maine		X
Maryland	X	
Massachusetts	X	
Michigan		X
Minnesota	X	
Mississippi		X
Missouri		X
Montana	X	
Nebraska		X
Nevada	X	
New Hampshire	X	
New Jersey	X	
New Mexico	X	
New York	X	
North Carolina		X
North Dakota		X
Ohio	X	
Oklahoma		X
Oregon	X	
Pennsylvana		X
Rhode Island		X
South Carolina	X	
South Dakota		X
Tennessee		X
Texas		X
Utah		X
Vermont		X
Virginia		X
Washington	X	
West Virginia		X
Wisconsin		X
Wyoming	X	

Table 4-7. States Having More Stringent Emission Standards than the CTAS Guidelines

Category of Emission Standard	States Having More Stringent Standards than the CTAS Guidelines
Particulates	California (South Coast), District of Columbia, Maryland, Massachusetts, New Mexico, Pennsylvania (Allegheny County), West Virginia
SO_2 from Liquid Fuel Burners	California, Colorado, Illinois, Oklahoma, Massachusetts, Nevada, New Jersey, Texas
SO_2 from Coal Burners	Arizona, California, Colorado, Nevada, New Jersey, New Mexico, New York, Ohio, Pennsylvania (Allegheny County), Rhode Island, Texas, Virginia, Wyoming
NO_x	California, New Mexico, Vermont
Residual Oil Sulfur Content	Connecticut, Hawaii, Maryland, Puerto Rico, Virgin Islands
Coal Sulfur Content	Connecticut, Hawaii, Idaho, Oregon, Puerto Rico, Virgin Islands
Distillate Oil Sulfur Content	Delaware, Idaho, Maryland, Michigan, Oregon, Pennsylvania, Washington

Table 4-8. States Having Particulate Emission Standards More Stringent than the CTAS Guidelines

CTAS Particulate Emission Guideline = 0.1 lb/10^6 Btu		
State	Allowable Particulate Emission (lb/10^6 Btu)	Percent More Stringent than CTAS Guideline
Massachusetts	0.05	50
District of Columbia	0.03	70
Maryland	0.03 - 0.09	10 - 70
Pennsylvania Alleghany County	0.08	20
West Virginia	0.05	50
New Mexico	0.005 Oil	95
	0.02 - 0.05 Coal	50 - 80
California South Coast	0.03	70

Table 4-9. States Having SO_2 Emission Standards More Stringent than the CTAS Guidelines

CTAS SO_2 Emission Guidelines = 1.2 lb/10^6 Btu for Coal
0.8 lb/10^6 Btu for Oil

State	Allowable SO_2 Emission (lb/10^6 Btu)	Percent More Stringent than CTAS Guidelines
Massachusetts	D-Oil = 0.34	57
Metropolitan Boston	D-Oil and Coal = 0.56	30 - 53
New Jersey	0.3	62 - 75
New York		
New York City, Nassau County, Rockland County, Westchester County	0.4 Coal	67
Pennsylvania		
Allegheny County	0.65 Coal	46
City of Philadelphia	R-Oil = 0.3	63
Virginia		
National Capital	1.06 Coal	12
Rhode Island	1.1 Coal	8
Illinois	0.3 D-Oil	63
Ohio	1.0 Coal	17
New Mexico	0.34 Coal	72
Oklahoma	0.3 Oil	63
Texas	0.3 Coal	75
	0.5 to 0.68 Oil	15 - 37
Wyoming	0.2 Coal	75
Nevada	0.4	50 - 80
Clark County	0.15	81 - 87
Washoe County	0.105	87 - 91
California		
South Coast AQMD	0.56	30 - 53
Bay Area APCD	0.4	50 - 67
Ventura County	0.4	50 - 67
San Diego County	0.67	16 - 44
Guam	0.8 Coal	33
Arizona	0.8 Coal	33
Colorado	0.2	75 - 83

Note: D-oil = distillate oils.
R-oil = residual oils.

Table 4-10. States Having NO_x Emission Standards More Stringent than the CTAS Guidelines

CTAS NO_x Emission Guidelines = 0.7 lb/10^6 Btu for Coal; 0.4 lb/10^6 Btu for Liquid Fuels; 0.2 lb/10^6 Btu for Natural Gas

State	Allowable NO_x Emission, lb/10^6 Btu	Percent More Stringent than CTAS Guidelines
Vermont	0.3	25 - 57
New Mexico	0.45	36
California		
South Coast AQMD	0.28	30 - 60
Bay Area APCD	0.37	7 - 47
Ventura County	0.28	30 - 60
San Diego County	0.28	30 - 60
Monterey Bay United APCD	0.28	30 - 60
San Luis Obispo County	0.31	22 - 56

Table 4-11. States Having Fuel Sulfur Specifications More Stringent than the CTAS Specifications

CTAS Fuel Sulfur Specifications = { 3.9% wt. for Coal; 0.7% wt. for R-Oil; 0.5% wt. for D-Oil }

State	Allowable Fuel Sulfur Content (%)
Connecticut	R-Oil = 0.5 Coal = 0.5
Puerto Rico in Critical Areas	R-Oil = 0.5 Coal = 0.5
Virgin Islands	R-Oil = 0.5 Coal = 0.5
Delaware	D-Oil = 0.3
District of Columbia	R-Oil = 0.5 Coal = 0.5
Maryland	R-Oil = 0.5 D-Oil = 0.3
Pennsylvania	D-Oil = 0.2
Michigan Wayne County	D-Oil = 0.3 0.5 Coal and R-Oil
Idaho	Coal = 1 D-Oil = 0.3
Oregon Outside Portland	Coal = 1 #ID-Oil = 0.3
Washington	#ID-Oil = 0.3

Note: D-Oil = distillate oils.
R-Oil = residual oils.

SECTION V

INDUSTRY LOCATION AND CONCENTRATION

Table 5-1 lists the number of industrial plants for each of 22 industries in each of the 50 states. The percentage of industry plants is presented in Table 5-2 by DOE region rather than by individual state. Table 5-3 summarizes this data, listing DOE regions for each industry. The first DOE region listed has the highest percentage of plants for the industry and additional regions are listed in order of concentration down to 10% of the nationwide plants for each industry. Region 5 (Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin) contains the highest-percentage concentration for a total of nine industries, followed by Region 7 (Arkansas, Louisiana, New Mexico, Oklahoma, Texas) with eight industries. Region 4 (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee) has the highest concentration for three industries; Regions 6, 9, and 10 have the highest concentration for one industry. Regions 1, 2, 3, and 8 have a lower percentage of plants in all of the 22 industries. Figure 5-1 indicates by bar charts the regions with the highest-percentage concentration and regions with a concentration greater than 10%. Note that Regions 5 and 7 remain in first and second place but that when over 10% is considered, Region 4 is in second place. Region 8 (petroleum refining and copper) and Region 10 (aluminum and phosphoric acid) show the lowest plant concentrations.

Some industries show extremely high concentrations of plants. For instance, 87.5% of aluminum plants are located in Region 7, as well as 85.7% of styrene plants, 76.5% of ethylene plants, and 72.7% of the L.D. polyethylene plants. Region 4 contains 49.3% of the weaving mills and 43.5% of the phosphoric acid plants. Region 5 contains 46.5% of the motor vehicle plants, 45.5% of the integrated steel mills, and 42.9% of the wet corn milling plants.

A description of industry concentration by DOE region is given below.

<u>Region 1</u> (CT, ME, MA, NH, RI, VT)

1st

2nd Weaving mills, paper mills

3rd Boxboard mills

<u>Region 2</u> (NJ, NY)

1st

2nd

3rd Malt beverages, weaving mills, paper mills, glass containers

4th Boxboard mills

Table 5-1. Number of Plants by Industry in Each State

STATE	MEAT PACKING	FLUID MILK	WET CORN MILLING	BAKERY PRODUCTS	MALT BEVERAGES	WEAVING MILLS	PAPER MILLS	BOXBOARD MILL	CHLORINE CAUSTIC	ALUMINA	L.D.P. RESIN	STYRENE	ETHYLENE	AMMONIA	PHOSPHORIC ACID	PETROLEUM REFINING	GLASS CONTAINERS	CEMENT	INT. STEEL MILL	COPPER	ALUMINUM	MOTOR VEHICLES
AL	11	12	1	16		17	7	10	4	1				2	1	6	1	7	2		2	1
AK		1		2										1		4						
AZ	5	17		6	1		2							2		1		2		9		
AR	6	13		14		2	4	8		2				2		4	1	2			2	2
CA	51	217		68	6	14	30	10	1		1		2	8	6	40	16	12	1			11
CO	40	15		13	1		1									3	1	3	1			2
CT	11	11		9		10	10	4									1					1
DE	1	2		1			4	1	1				1			1						2
FL	1	36		27	4		3	10						2	16	1	4	6				
GA	23	23		18	1	50	8	14	3					3		2	3	3		1		3
HI	1	3		4	2											2		2				
ID	3	29		5			2							2	5			1				
IL	19	45	4	40	3	4	8	15	1		3		2	1	4	12	12	4	5	2		3
IN	25	41	4	18	2	1	8	8	1		1		1	1		7	10	5	4		1	7
IA	29	77	5	14	1	1	3				1			6	1			5				
KS	16	27		9			2		1					3		11		5				1
KY	50	45		8	2	3	4	1	2				2			4		1	2		2	2
LA	11	20		14	2		9	10	10	3	3	3	7	14	5	23	3	2			2	
ME	1	12		5		4	11	10	1									1				
MD	13	29		15	3	1	3	2								2	3	3	1	1	1	1
MA	2	11		23		16	30	18									2					1
MI	5	87		25	2	1	18	20	4			1				6	1	8	3	2		19
MN	49	172		18	3		6	6								3	2		1			1
MS	12	16		10			3	8	1					4	1	5	3	2				1
MO	103	54	1	21	2	1	3	3						2		1	1	7		1	1	7
MT	29	5		5			1									7		2		2	1	
NB	51	24		11	1									4		1		2				
NV	9	4		1					1							1		1		1		
NH	1	6		3	1	5	10	9								1						
NJ	15	10		28	5	15	16	14	1							4	13			2		3
NM	10	8		8			1									8		1		2		
NY	72	186	1	50	4	34	38	26	5					1		2	5	7	2	1	2	3
NC	14	30		22	1	70	10	8	2					1	2	1	4	1			1	
ND	29	17		5	1											3						1
OH	24	83	1	46	4	7	24	18	3					2		7	2	5	7		1	12
OK	18	20		8		3	5	2						4		12	7	3				1
OR	37	19		11	1	1	12	14	1					2		1	1	2			2	1
PA	158	22	1	55	6	31	30	19				1		2		10	16	18	9	1		3
RI		1		4	1	20	1										1					
SC	5	10		9		23	2	8									1	3	1			
SD	5	30		4														1				
TN	81	37	1	26	1	12	6	10	3					2		1	1	6		1	2	2
TX	60	61	2	54	6	5	7	11	13	2	13	9	19	9	3	53	5	21	3	3	4	1
UT	6	17		9					1					1	2	9		2	1	2		1
VT	12	38		2			7	2														
VA	10	35		18	2	3	8	6	1					1		1	1	2				2
WA	22	46		12	4		10	8	4					2		8	1	4		2	7	1
WV	2	6		8			2		3					3		3	6	1	1		1	
WI	10	383		70	5	1	32	20	2							1	1	3				5
WY	2	2												1		13		1				
TOTAL	1170	2115	21	826	78	355	401	333	70	8	22	14	34	88	46	285	129	167	44	33	32	101

Table 5-2. Regional Concentration of Industries (Percentages)

DOE Region	1. Meat Packing	2. Fluid Milk	3. Wet Corn Milling	4. Bakery Products	5. Malt Beverages	6. Weaving Mills	7. Paper Mills	8. Boxboard Mill	9. Chlorine Caustic	10. Alumina	11. L.D.P. Resin	12. Styrene	13. Ethylene	14. Ammonia	15. Phosphoric Acid	16. Petroleum Refining	17. Glass Containers	18. Cement	19. Int. Steel Mill	20. Copper	21. Aluminum	22. Motor Vehicles
1	2.3	3.7	0	5.6	2.6	15.5	17.2	12.9	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	3.1	0.6	0.0	0.0	0.0	2.0
2	7.4	9.3	4.8	9.5	11.5	13.8	13.5	12.0	8.6	0.0	0.0	0.0	0.0	1.1	0.0	2.1	14.0	4.2	4.5	9.1	6.3	5.9
3	15.7	4.4	4.8	11.8	14.1	9.9	11.7	8.4	7.1	0.0	0.0	7.1	2.9	6.8	0.0	6.0	20.2	14.4	25.0	6.1	6.3	7.9
4	16.8	9.9	9.5	16.5	11.5	49.3	10.7	20.7	21.4	12.5	0.0	0.0	5.9	15.9	43.5	7.0	13.2	17.4	11.4	6.1	21.9	8.9
5	11.3	38.3	42.9	20.3	24.4	3.9	23.9	26.1	15.7	0.0	18.2	7.1	8.8	4.5	8.7	12.6	21.7	15.0	45.5	12.1	6.3	46.5
6	17.0	8.6	28.6	6.7	5.1	0.6	2.0	0.9	1.4	0.0	4.5	0.0	0.0	17.0	2.2	4.6	0.8	11.4	0	3.0	3.1	7.9
7	9.0	5.8	9.5	11.9	7.7	2.8	6.5	9.3	32.9	87.5	72.7	85.7	76.5	33.0	17.4	35.1	12.4	7.4	6.8	15.2	25.0	4.0
8	9.5	4.1	0	4.4	5.1	0.0	0.5	0.0	1.4	0.0	0.0	0.0	0.0	2.3	4.3	12.3	0.8	5.4	4.5	12.1	3.1	4.0
9	5.6	11.4	0	9.6	11.5	3.9	8.0	3.0	2.9	0.0	4.5	0.0	5.9	13.4	13.0	15.4	12.4	10.2	2.3	30.3	0.0	10.9
10	5.3	4.5	0	3.6	6.4	0.3	6.0	6.6	7.1	0.0	0.0	0.0	0.0	8.0	10.9	4.6	1.6	4.2	0.0	6.1	28.1	2.0

Table 5-3. Industry Concentration and Growth

SIC Code	Industry	Number of Plants	DOE Regional Concentration (> 10%)	Industry Growth: New Plants	Industry Growth: Expansion (Modernization)	Relocation
2011	Meat packing	1170	6,4,3,5	X	X	No
2026	Fluid milk	2115	5,9		X	No
2046	Wet corn milling	21	5,6		X	No
2051	Bakery products	826	5,4,7,3		X	No
2082	Malt beverages	78	5,3,2 & 4 & 9	X (Few)	X	Yes (Minor)
2221	Weaving mills	355	4,1,2		?	No
2621	Paper mills	401	5,1,2,3,4	X (Few)	X	Yes (Minor)
2631	Boxboard mills	333	5,4,1,2	X (Few)	X	
2812	Alkalies and chlorine	70	7,4,5		X	No
2819	Alumina	8	7,4			No
2821	L.D. polyethylene	22	7,5		X	No
2865	Styrene	14	7		X	No
2869	Ethylene	34	7	X	X	No
2873	Ammonia	88	7,6,4,9		X	No
2874	Phosphoric acid	46	4,7,9,10		X	No
2911	Petroleum refining	285	7,9,5,8		X	No
3221	Glass container	129	5,3,2,4,7,9		X	No
3241	Cement	167	4 & 7,5,3,6,9		X	No
3312	Integrated steel mill	44	5,3,4	X (Few)	X	No
3331	Copper	33	9,7,5,8		X	No
3334	Aluminum	32	10,7,4		X	No
3711	Motor vehicles	101	5,9	X (Few)	X	Yes

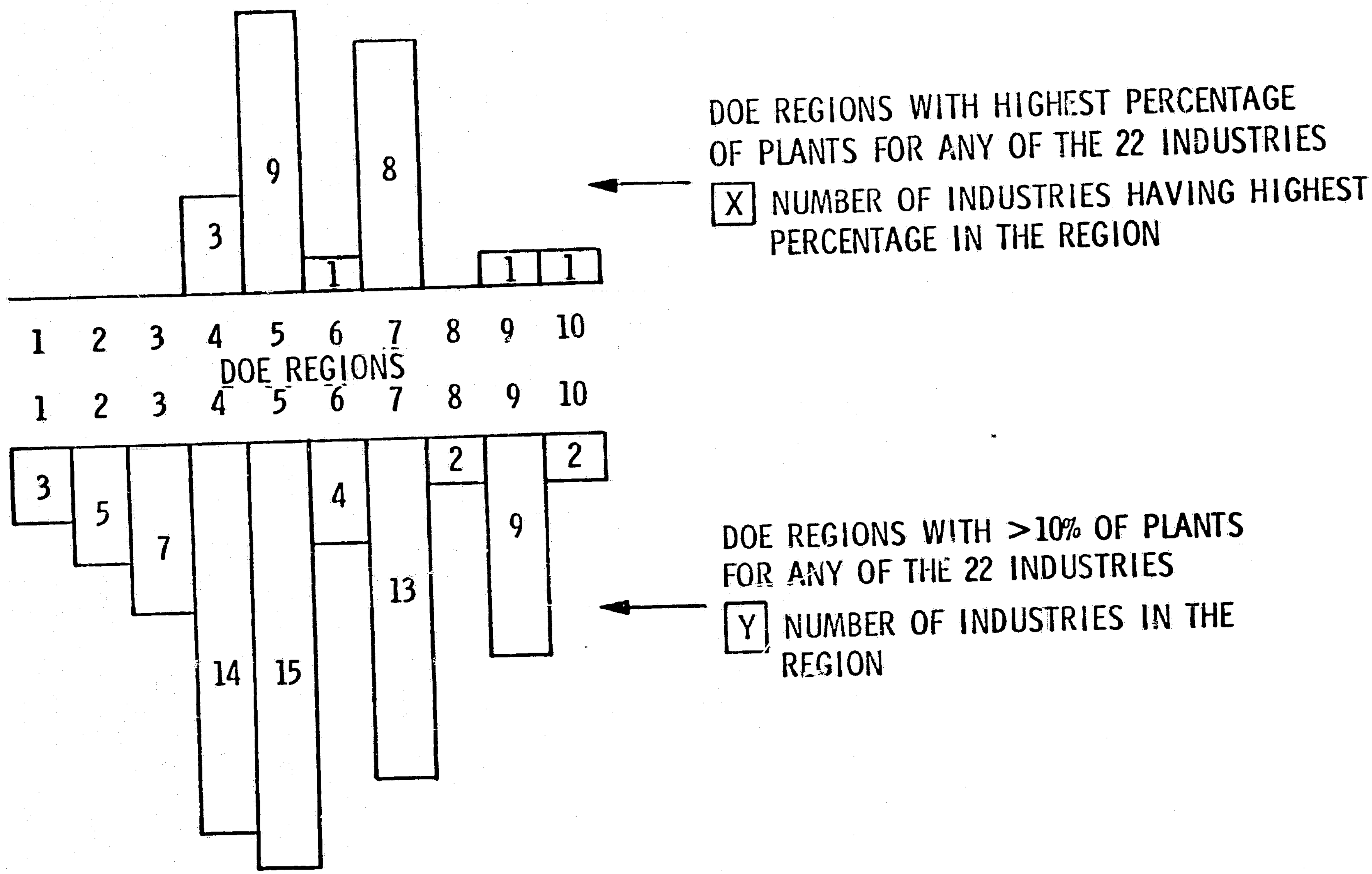


Figure 5-1. Regional Industry Concentration

Region 3 (DE, DC, MD, PA, VA, WV)

1st

2nd Malt beverages, integrated steel mills, cement, glass containers

3rd Meat packing

4th Bakery products, paper mills

Region 4 (AL, FL, GA, KY, MS, NC, SC, TN)

1st Weaving mills, phosphoric acid, cement

2nd Meat packing, bakeries, boxboard mills, alkali and chlorine, alumina

3rd Ammonia, aluminum, integrated steel mills

4th Glass containers

5th Paper mills

Region 5 (IL, IN, MI, MN, OH, WI)

1st Fluid milk, wet corn milling, bakeries, malt beverages, paper mills, boxboard mills, glass containers, integrated steel mills, motor vehicles

2nd Cement, L.D. polyethylene

3rd Copper, petroleum refining, alkali and chlorine

4th Meat packing

Region 6 (IA, KS, MO, NE)

1st Meat packing

2nd Wet corn milling, ammonia

3rd

4th Cement

Region 7 (AR, LA, NM, OK, TX)

1st Alkali and chlorine, alumina, L.D. polyethylene, styrene, ethylene, ammonia, petroleum refining, cement

2nd Phosphoric acid, copper, aluminum

3rd Bakeries

4th

5th Glass containers

Region 8 (CO, MT, ND, SD, UT, WY)

1st

2nd

3rd

4th Petroleum refining, copper

Region 9 (AZ, CA, HI, NV)

1st Copper

2nd Fluid milk, petroleum refining, motor vehicles

3rd Phosphoric acid

4th Malt beverages, ammonia

5th Cement

6th Glass containers

Region 10 (AK, ID, OR, WA)

1st Aluminum

2nd

3rd

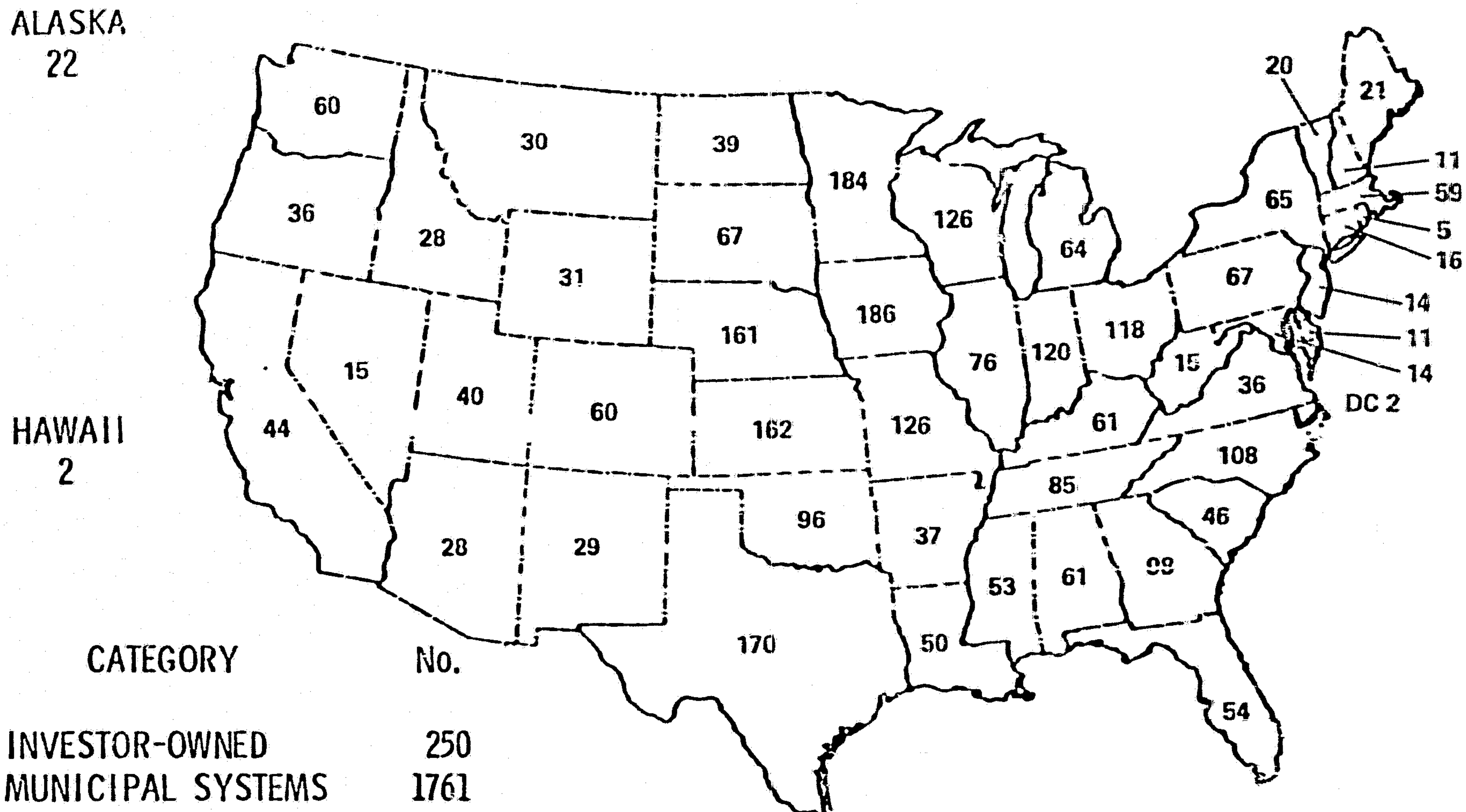
4th Phosphoric acid

SECTION VI

CONCLUSIONS

The Cogeneration Technology Alternatives Study (CTAS) was predicated on the need to match advanced energy conversion systems for industrial cogeneration via a transition from the use of natural gas and light oils to heavy oils, coal, and coal-derived fuels. Therefore, the use of coal and coal-derived fuels was emphasized. Some regional characteristics evident from the analyses of assembled data are discussed below; the results are summarized in Figures 6-1, 6-2, and 6-3.

REGION	CHARACTERISTICS
New England (CT, ME, MA, NH, RI, VT)	The smallest coal-consuming region. Industry relies primarily on gas and oil. The regulatory climate for coal utilization is not especially favorable. CT has coal ban with its systems implementation plan regulations. MA, RI, VT go beyond NSPS requirements. Substantial changes are required for coal to find increased use. The region does not have any industries with high thermal-to-electric energy consumption. The numbers of electric utilities and counties for the region are small, and are generally enthusiastic about cogeneration. The region does not show any meaningful coal-based industrial cogeneration opportunities.
Middle Atlantic (NJ, NY)	Consumes significant amount of high sulfur coal. Regulatory climate in this region mixed. NJ has an effective coal and residual oil use ban (0.3% S), NY and PA rely mostly on NSPS emission regulations. Industries switching to coal will face particulate and SO_2 air quality problems. NY and PA do show good opportunities for coal-based industrial cogeneration.
South Atlantic (DE, DC, MD, PA, VA, WV)	Second largest coal user in the nation. Five out of nine states rely on NSPS control. This region has the potential for increased coal use. No serious regulatory problems. However, because of the lack of a large number of industries with high thermal-to-electric energy consumption, the region does not offer significant opportunities for industrial cogeneration.



CATEGORY	No.
INVESTOR-OWNED	250
MUNICIPAL SYSTEMS	1761
RURAL COOPERATIVES	922
MISCELLANEOUS	196
TOTAL	3129

Figure 6-1. Location of Utility Companies

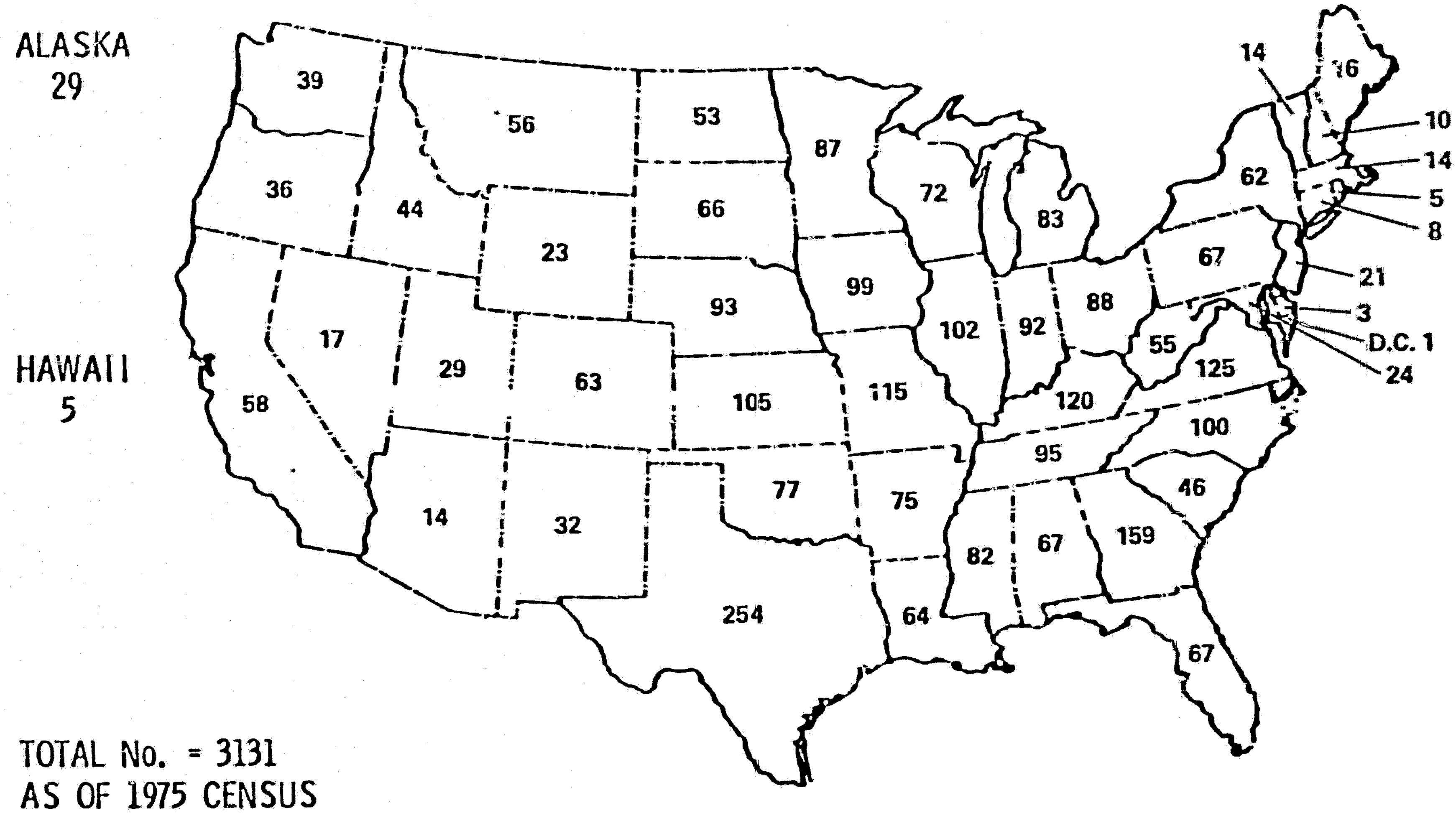


Figure 6-2. Number of Counties per State

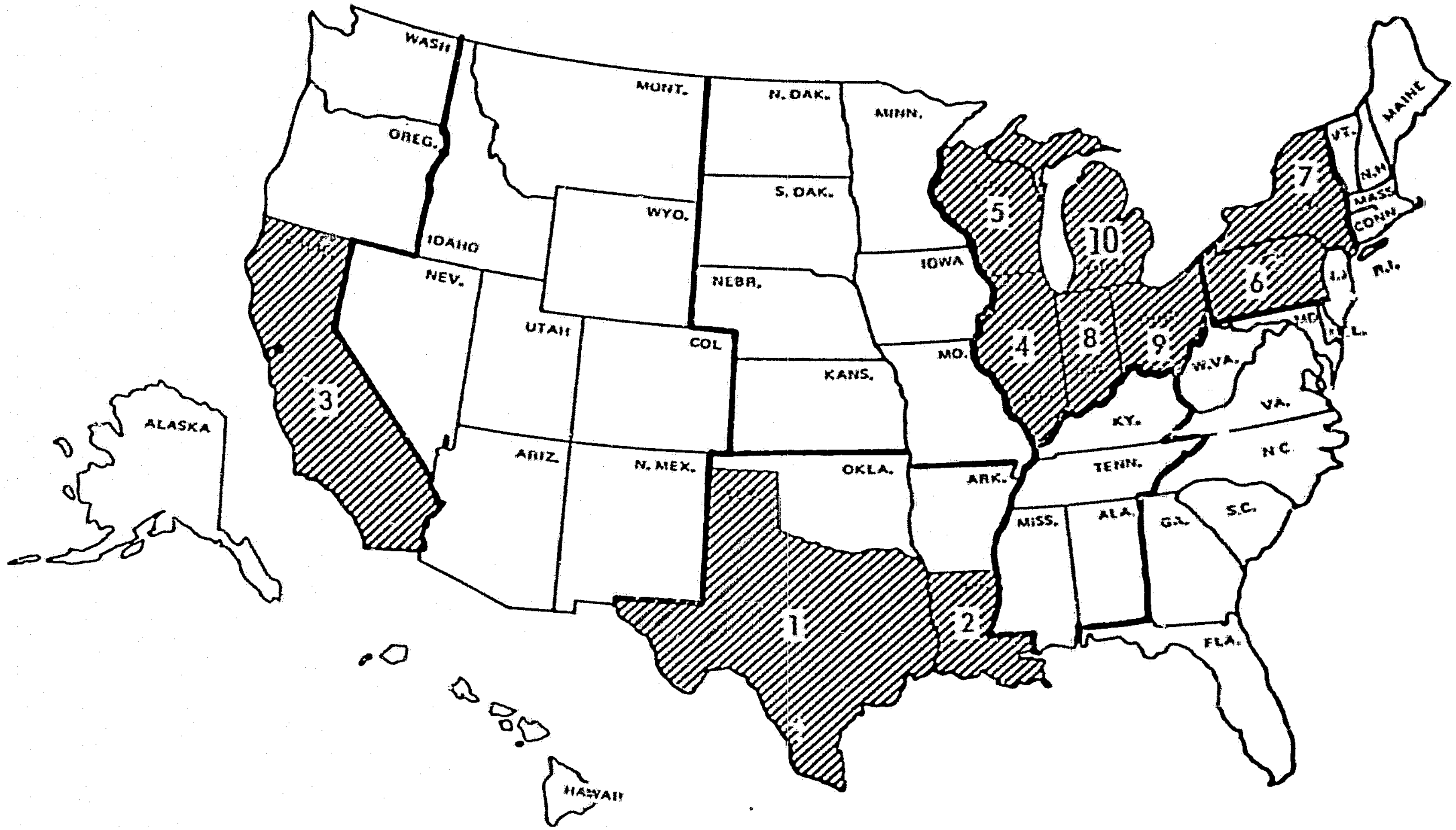


Figure 6-3. Top Ten States with Best Cogeneration Opportunities

East North Central: (IL, IN, MI, OH, WI)	Largest coal consumer and with widest choice of coal options. Regulatory climate does not pose any unusual hindrances. IL, IN, WI all use NSPS regulations for new plants. OH has siting regulations. Good cogeneration potential for the region.
East South Central: (AL, KY, MS, TN)	Moderate coal users. All states rely on NSPS regulations. No significant cogeneration opportunities.
West North Central: (KS, MN, MO, NB, ND, SD)	Close to abundant sources of low sulfur coal. All states except MN rely on NSPS regulations. The Environmental Protection Agency's Prevention of Significant Deterioration guidelines could affect large areas. No meaningful industrial cogeneration opportunities because the region is predominantly agricultural.
West South Central: (AK, LA, OK, TX)	Traditional reliance on local oil and gas. Little consumption of coal. AR has strict air quality standard. LA has concentration limit. OK and TX use NSPS regulations. Coal options attractive under gas deregulation conditions. This region has a large number of industries with high thermal-to-electric energy-consuming industries, offering very attractive coal-based industrial cogeneration opportunities.
Mountain: (AZ, CO, ID, NM, NV, UT, WY)	Have access to large quantities of low sulfur coal. Region has the lowest electricity cost. Five out of eight states have regulations that go beyond NSPS. AZ, CO, NV, NM, WY all have SO_2 emission limits. ID, UT have fuel 1% S limit. Lack of high-energy consuming industries in the region, therefore no meaningful cogeneration opportunities.
Pacific: (AK, CA, HI, OR, WA)	Very small coal consumers. Significant regulatory constraints on coal use. CA has fuel 0.5% S limit. CA offers significant coal-based industrial cogeneration opportunities.

The results of this study lead to the conclusions that:

(1) Cogeneration decisions with advanced technology will be based on a variety of parameters. Air quality is an important but not overriding constraining factor.

(2) Site certification is a complex effort requiring interface with a variety of federal, state, and local channels; it will require a significant amount of time and effort.

(3) The overall industry trend is to increase and modernize the total production capacity at existing sites rather than to relocate.

(4) CTAS baseline-projected energy price specifications are mostly within ±25% of regional price variations.

(5) CTAS emission ground rules are generally applicable across all regions. However, a small number of states have more stringent SO_2 standards than those specified.

APPENDIX

REGIONAL CONCENTRATION OF U.S. MANUFACTURING INDUSTRIES STUDIED IN CTAS

MEAT PACKING REPORT (SIC 2011)

In the survey conducted of the meat packing industry, the plants included were selected according to a certain set of criteria. First, only federally inspected plants were included; the non-federally inspected plants were found to be generally small and had no measurable impact on energy consumption. Second, only integrated plants were considered for this report; integrated being defined as having both slaughtering (S) and processing (P) operations. In some cases, these integrated plants also had boning (B), edible fats processing (E), and inedible fats processing (I) operations. Plants that did not have both slaughtering and processing operations were found to have a minor impact on the characteristics of a region and were therefore not considered. The breakdown of the federally inspected plants as obtained from the U.S.D.A. Directory is as follows:

	USDA Code			
	Minimum	Others Included	Number of Plants	Percent of Total
Processing plants w/o slaughter	P	B,E,I	4716	73.4
Slaughter plants w/ processing	S and P	B,E,I	1172	18.3
Slaughter plant w/o processing	S	---	534	8.3
TOTAL number of plants			6422	100.0

Table A-1 shows the distribution, by state, of the 1172 federally inspected integrated plants. Figures A-1 and A-2 depict the number and concentration of these plants.

The concentration of plants was obtained by considering only those states containing at least 2.5% of the total integrated plants (29 or more plants per state).

Although the five states of Pennsylvania, New York, Missouri, Tennessee and Kentucky show the greatest concentration of plants (40% of total), they do not account for the largest productivity (personal communication, Dr. Ewes Wilson, 1978). The plants in New York and Pennsylvania import livestock from other states and are mostly small and very old plants (some dating back to the 17th Century). The plants in Kentucky and Tennessee are small hog slaughtering plants that are usually family-run or independent operations. The high productivity plants are the larger, newer cattle and hog slaughtering operations in the Midwest and surrounding areas. These plants are located near the livestock feed areas, namely Iowa, Illinois, Indiana, Kansas, Missouri, Nebraska, Texas, Oklahoma, Colorado and Wyoming.

Production for the industry is expected to increase gradually over the long term, however, a downward trend is expected during the next two years. The cattle livestock industry produces most of the red meat consumed in the U.S. The following data indicates 1977 meat production and what types of livestock feed were used:

1977 Production				
Livestock	Product	Red Meat (Carcass Wt.) 10^9 lb.	Head Slaughtered 10^6	Feed
Cattle	Beef	25	42	Corn and Silage
Calves	Veal	0.79		
Hogs	Pork	13	77	Corn and Soybean
Sheep and Lamb	Mutton	0.34	—	Corn and Silage
TOTAL		39	119	

Although the number of hogs slaughtered far exceeds the number of cattle slaughtered, beef production is almost twice that of pork. This is in spite of the fact that the yield from pork (64% of live wt.) is greater than the yield from cattle (45% of live wt.). This is explained by the five times greater cattle live weight than hog live weight.

Due to the competitive and capital-intensive nature of the meat industry, monopolies by large companies do not exist. The giants of fifty years ago (Armour, Swift, Cudahay and Wilson) are hard pressed to remain competitive with large corporations that are building newer, more efficient plants. The need for outside capital to infuse new life into the old, established companies is seen in the salr of Armour to the Greyhound bus company.

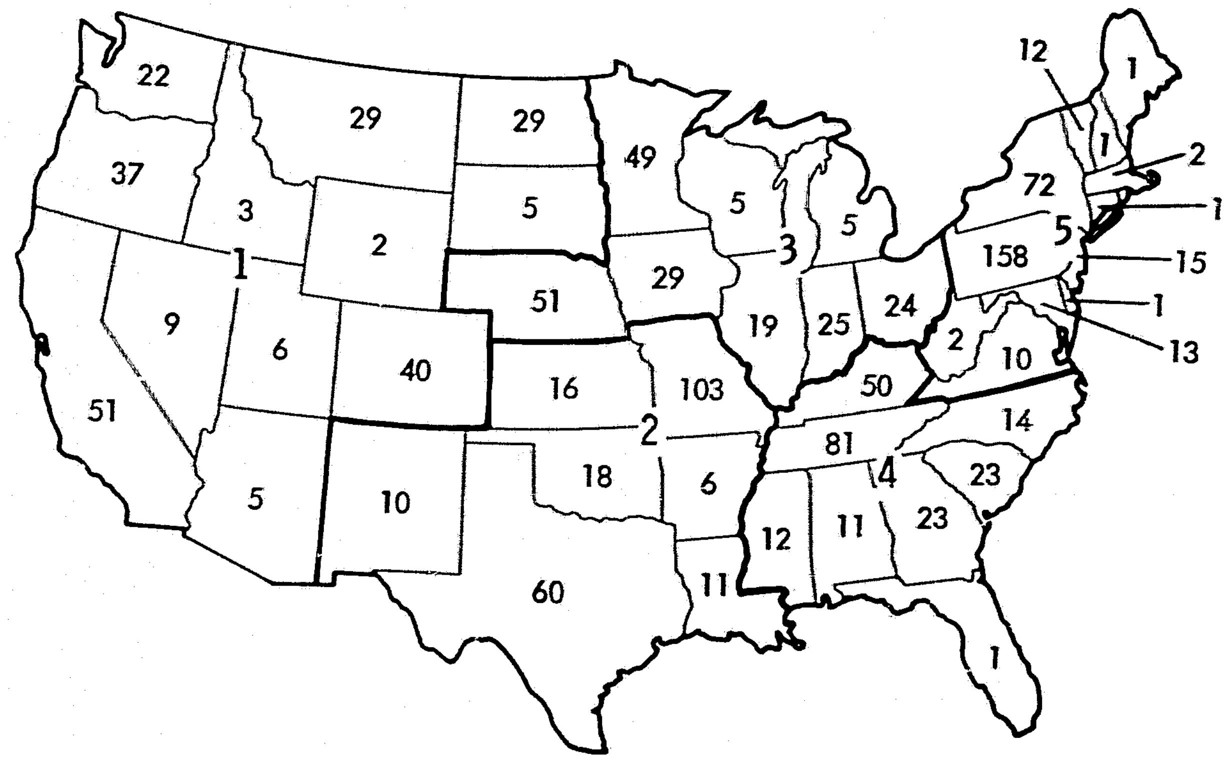
When the capital to build new plants is not available, existing plants are modified and expanded to increase productivity. This does not, however, offset the trend toward the merging of companies to increase available capital. The small, old plants of Pennsylvania, New York, Tennessee and Kentucky will not have an appreciable impact on energy consumption in the year 2000. The future concentration of the meat slaughtering and processing plants is in the Midwest and its fringe states.

Table A-1. Integrated Meat Packing Plants Location and Number

	No. of Plants	% of Total No. of Plants
ADMINISTRATIVE REGION 1		
Alaska	0	0
Arizona	5	0.43
California	51	4.35
Colorado	40	3.40
Hawaii	1	0.09
Idaho	3	0.26
Montana	29	2.47
Nevada	9	0.77
North Dakota	29	2.47
Oregon	37	3.16
South Dakota	5	0.43
Utah	6	0.51
Washington	22	1.88
Wyoming	2	0.17
	239	20.39
ADMINISTRATIVE REGION 2		
Arkansas	6	0.51
Kansas	16	1.37
Louisiana	11	0.94
Missouri	103	8.78
New Mexico	10	0.85
Oklahoma	18	1.54
Texas	60	5.12
	224	19.11
ADMINISTRATIVE REGION 3		
Illinois	19	1.62
Indiana	25	2.13
Iowa	29	2.47
Michigan	5	0.43
Minnesota	49	4.18
Nebraska	51	4.35
Ohio	24	2.05
Wisconsin	10	0.85
	212	18.09

Table A-1. (Cont'd)

	No. of Plants	% of Total No. of Plants
ADMINISTRATIVE REGION 4		
Alabama	11	0.94
Florida	1	0.09
Georgia	23	1.96
Kentucky	50	4.27
Mississippi	12	1.02
North Carolina	14	1.19
Puerto Rico	2	0.17
South Carolina	5	0.43
Tennesse	81	6.91
	199	16.98
ADMINISTRATIVE REGION 5		
Connecticut	11	0.94
Delaware	1	0.09
D.C.	0	0
Maine	1	0.09
Maryland	13	1.11
Massachusetts	2	0.17
New Hampshire	1	0.09
New Jersey	15	1.28
New York	72	6.14
Pennsylvania	158	13.48
Rhode Island	0	0
Vermont	12	1.02
Virginia	10	0.85
West Virginia	2	0.17
TOTALS	298	25.43

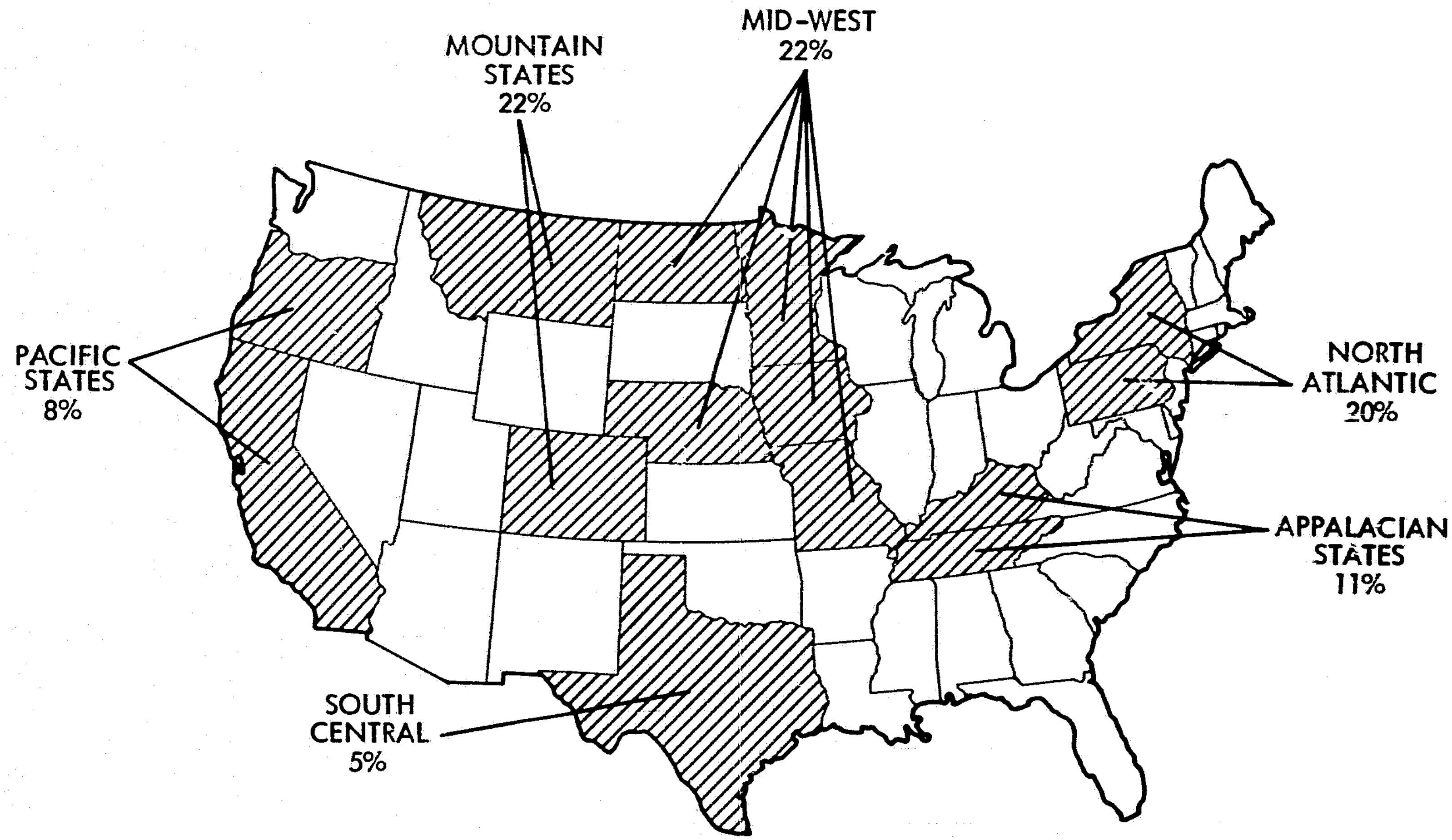


Hawaii
1

Puerto Rico
2

Total Number of
Integrated Plants, 1172.

Figure A-1. Number of Integrated Meat Packing Plants Per State



Notes:
(1) Percentages shown are for slaughter and process combination plants (1172 in number).
(2) States shown are for 29 or more integrated plants (2.5% of total per state).
(3) 72% of the total number of plants are represented or 839 plants.

Figure A-2. Concentration of Integrated Meat Packing Plants

FLUID MILK (SIC 2026)

The production and processing of milk occurs in every state of the union. In 1977, there were approximately 2114 fluid milk plants in the United States. The location of the plants is influenced to a large extent by climate (dairy cows prefer cool climates) and the proximity of large population centers. Tables A-1 and A-2 show the breakdown, by state, of milk production in the U.S. Wisconsin, California and New York are major milk producing states due to their favorable climates and large populations. On a regional basis, milk production is concentrated in the north central and northeastern areas of the U.S. (Figure A-3). The actual production of milk is commonly carried out in rural areas surrounding cities with distribution systems to the population centers.

Annual per capita milk consumption is approximately 292 pounds and is expected to increase in the future. The demand for milk increases along with the general population growth of an area.

The total number of processing plants has been decreasing, while production has increased. This is consistent with the trend toward larger, more centralized plants. The number of small processing plants has been decreasing at a faster rate than the large plants. Table A-3 depicts the plant trend for the years 1958-1972. Almost all of the small plants and nearly half of the medium-sized plants are over twenty years old. When these outdated plants are rebuilt, they are generally rebuilt on the same site. There seems to be no trend toward relocation of the milk industry.

Table A-2. Fluid Milk Production and Concentration - 1977
(Millions of Pounds)

State	Quantity	No. of Plants[a]	% of Plants
Alabama	684	12	0.56
Alaska	16	0	0.01
Arizona	914	17	0.74
Arkansas	740	13	0.60
California	11,960	217	9.73
Colorado	847	15	0.69
Connecticut	624	11	0.51
Delaware	137	2	0.11
Florida	1,963	36	1.60
Georgia	1,283	23	1.04
Hawaii	150	3	0.12
Idaho	1,600	29	1.30
Illinois	2,480	45	2.02
Indiana	2,270	41	1.85
Iowa	4,240	77	3.46
Kansas	1,461	27	1.19
Kentucky	2,466	45	2.01
Louisiana	1,090	20	0.89
Maine	638	12	0.52
Maryland	1,580	29	1.29
Massachusetts	600	11	0.49
Michigan	4,761	87	3.87
Minnesota	9,483	172	7.71
Mississippi	858	16	0.70
Missouri	2,958	54	2.41
Montana	295	5	0.24
Nebraska	1,344	24	1.09
Nevada	198	4	0.16
New Hampshire	339	6	0.28
New Jersey	550	10	0.45
New Mexico	426	8	0.35
New York	10,228	186	8.32
North Carolina	1,661	30	1.35
North Dakota	941	17	0.77
Ohio	4,548	83	3.70

[a]Assumed 55 x 10^6 lb as standard production per plant in order to calculate number of plants for each state.

Table A-2. (Cont'd)

State	Quantity	No. of Plants[a]	% of Plants
Oklahoma	1,120	20	0.91
Oregon	1,052	19	0.86
Pennsylvania	7,791	22	6.34
Rhode Island	57	1	0.05
South Carolina	531	10	0.43
South Dakota	1,670	30	1.36
Tennessee	2,021	37	1.64
Texas	3,365	61	2.74
Utah	936	17	0.76
Vermont	2,109	38	1.72
Virginia	1,920	35	1.56
Washington	2,555	46	2.08
West Virginia	333	6	0.27
Wisconsin	21,041	383	17.11
Wyoming	122	2	0.10
TOTAL:	122,957	2,114	100.06

[a]Assumed 55 x 10^6 lb. as standard production per plant in order to calculate number of plants for each state.

Table A-3. Fluid Milk - Plant Trend

Year	Plants		
	Total	Less Than 20 Employees	More Than 20 Employees
1958	5828	3589	2239
1963	4619	2671	1948
1967	3481	1845	1636
1972	2507	1220	1287
1977	2114	—	—

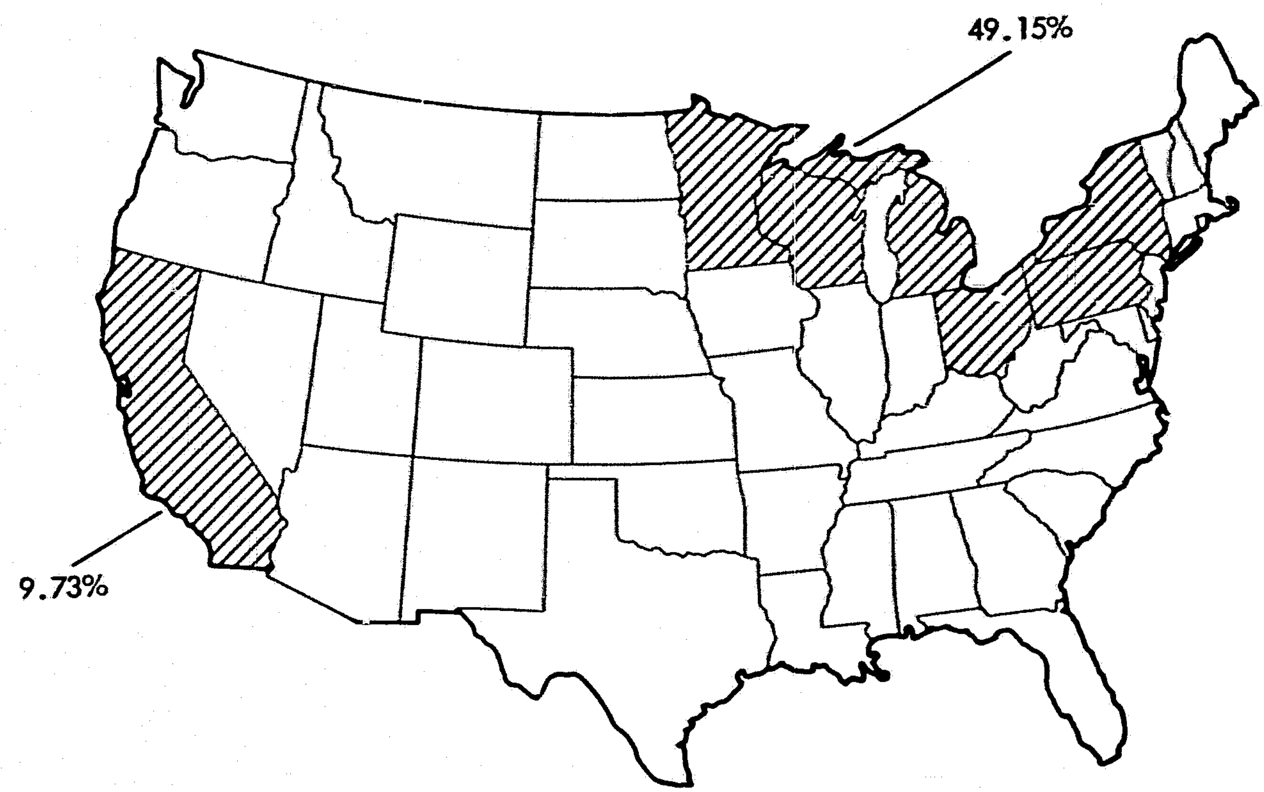


Figure A-3. Fluid Milk Production Concentration

WET CORN MILLING (SIC 2046)

The wet corn milling industry was first introduced to the United States in 1888. In 1978, there were 21 wet corn milling plants located in ten states. The number of plants in each state is listed in Table A-4, along with the percentage of the U.S. total. Most of the plants are located in the Midwest, close to the corn-growing areas (Figures A-4 and A-5).

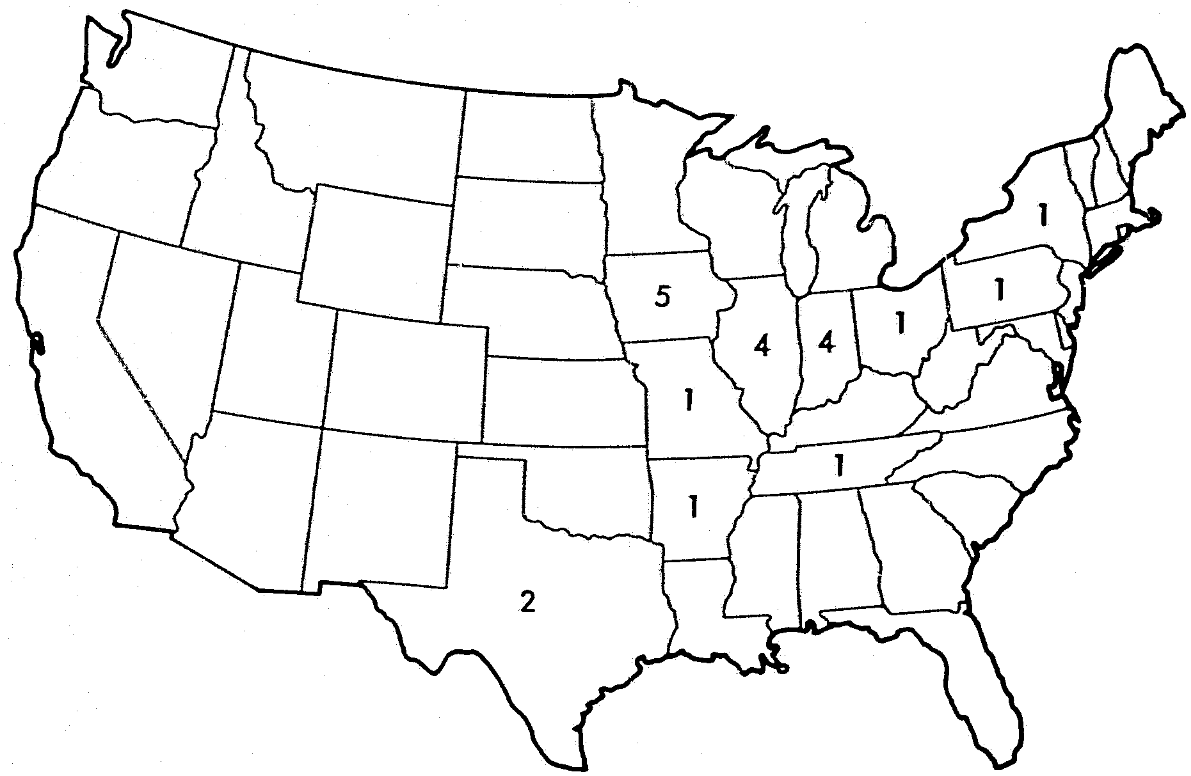
In 1975, the production capacity of the milling plants was 268.1 million bushels per year. Plant capacities vary from 15,000 bushels per day to 120,000 bushels per day (average: 50,000 bushels/day).

The average age of the milling plants is 15 years, although there are numerous plants over 60 years of age that are still producing. In general, the older plants have a larger capacity than the newer ones.

The industry is expected to grow at a rate of 3% to 4% per year due to an increasing demand for corn-sweetner products. Additional production capacity will be achieved through modification of existing plants rather than through new plant construction. The trend toward modification of existing plants precludes any shift toward relocation of the industry.

Table A-4. 1978 Wet Corn Milling Plant Locations and Concentrations

State	No. of Plants	% of Total
Alabama	1	4.8
Illinois	4	19.0
Indiana	4	19.0
Iowa	5	23.8
Missouri	1	4.8
New York	1	4.8
Ohio	1	4.8
Pennsylvania	1	4.8
Tennessee	1	4.8
Texas	2	9.4
TOTAL	21	100.0



Total Number of Plants: 21.

Figure A-4. Wet Corn Milling Plant Locations

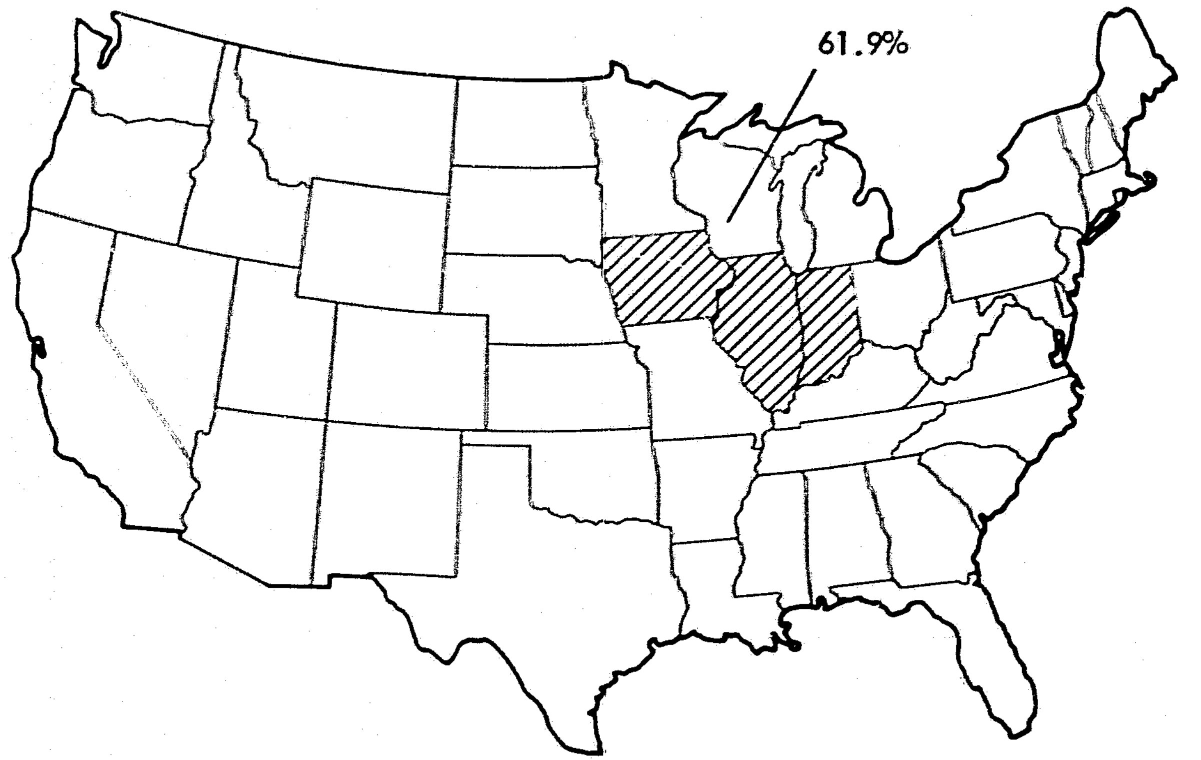


Figure A-5. Wet Corn Milling Plant Concentrations

BREAD, CAKE AND RELATED PRODUCTS (SIC 2051)

The bread, cake and related products industry was selected to represent the bakery products industry as a whole because it had the greatest number of plants. The breakdown of the bakery products industry is as follows:

SIC	Title	No. of Plants	% of Total
2051	Bread, Cake and related products	826	72.8
2052	Cookies and crackers	161	14.2
2041	Flour and other grain mill products	83	7.3
2045 and 2098	Blended and prepared flour Macaroni and spaghetti	65	5.7
		1135	100

The products of the industry generally referred to as bread, cake and related products are as follows:

- Bread and Specialty Bread (White Pan, Dark Wheat, Rye, White Hearth, Raisin, Sour Dough and others).
- Rolls (Hamburger/Weiner, Brown'n Serve, English Muffin and others).
- Sweet Goods (Sweet Yeast Goods, Cakes, Cake Donuts, Pies and Yeast Donuts).

The largest outlets for these products are the bakeries that have more than $1 million in sales per year. These facilities represent plants that have a high rate of energy consumption. The plants are divided into four types of manufacturers: wholesale, grocery-owned, private label and other. As the wholesale manufactures account for 88.7% of the total number of plants, they were chosen to represent the bread, cake and related products industry.

A breakdown of the number of wholesale bakeries in each state is given in Table A-5. The number of locations per state is shown in Figure A-6 and the areas of high concentration are shown in Figure A-7.

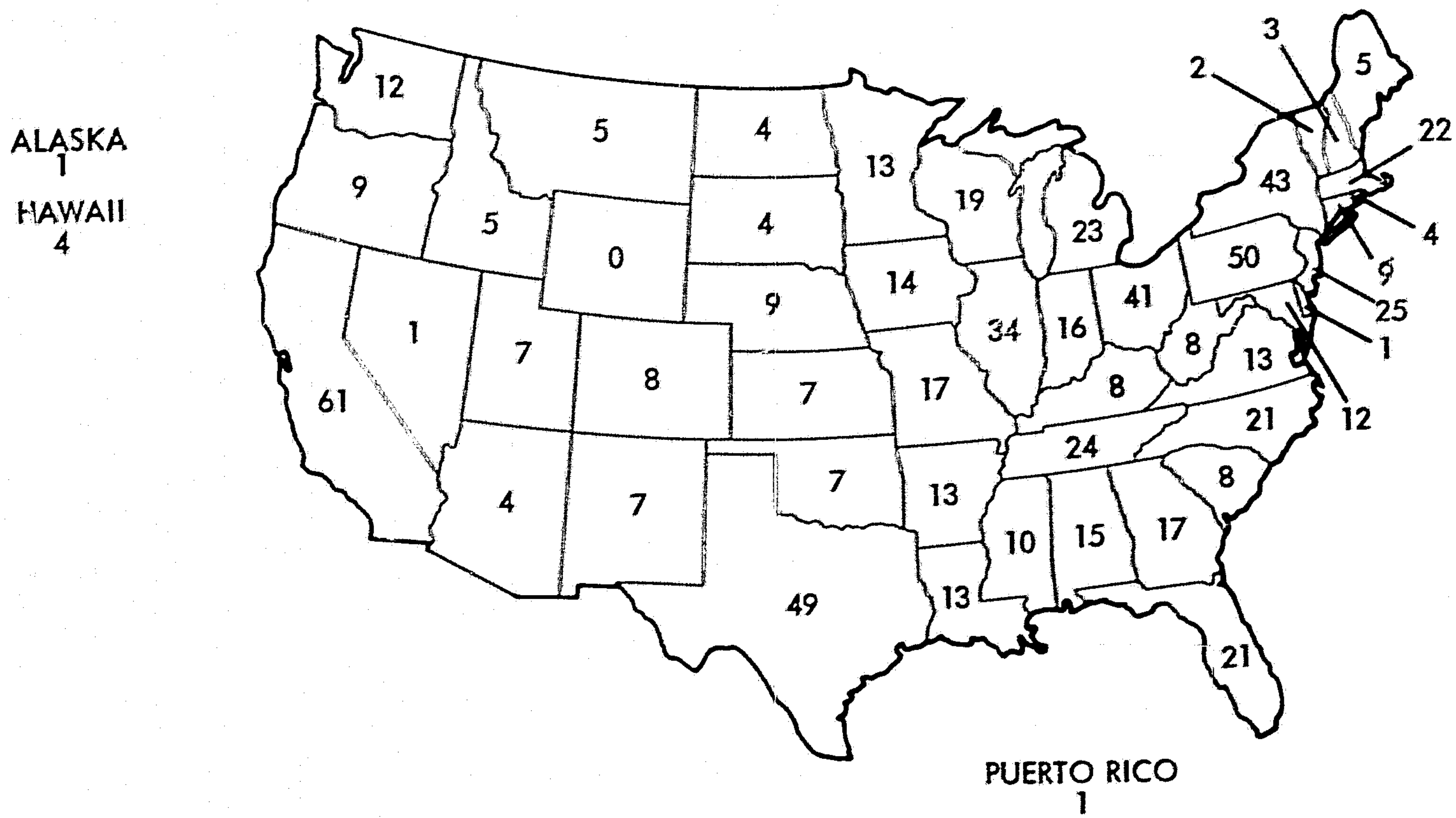
Most of the early plants were located on the east coast near highly populated areas. Although the baking industry dates back to the 1890's, most of today's large plants were built in the 1930's. These were all located near the population centers of that time.

Most of the large plants are located about 125 to 150 miles from major population areas. The products are delivered to the supermarkets daily by truck because of their limited shelf life. The trend toward freezing the products and then shipping to distribution centers has made interstate deliveries possible. Other than the product freezing concept, there are no new technology advancements anticipated.

In recent years, 75% of the new plants have been built in Florida and the "Sun Belt" states. Existing plants are modified rather than rebuilt whenever possible. Many of the companies are merging, causing the total number of bakeries to decrease although production does not. At the present time, the multiple plant companies account for 60%-65% of the production of all bakeries. The production of bakery products is expected to increase slightly over the next 20 years. Companies are attempting to expand variety bread production lives and other production efficiency programs.

Table A-5. Wholesale Bakeries Location and Number (Bread and Cake Manufacturers)

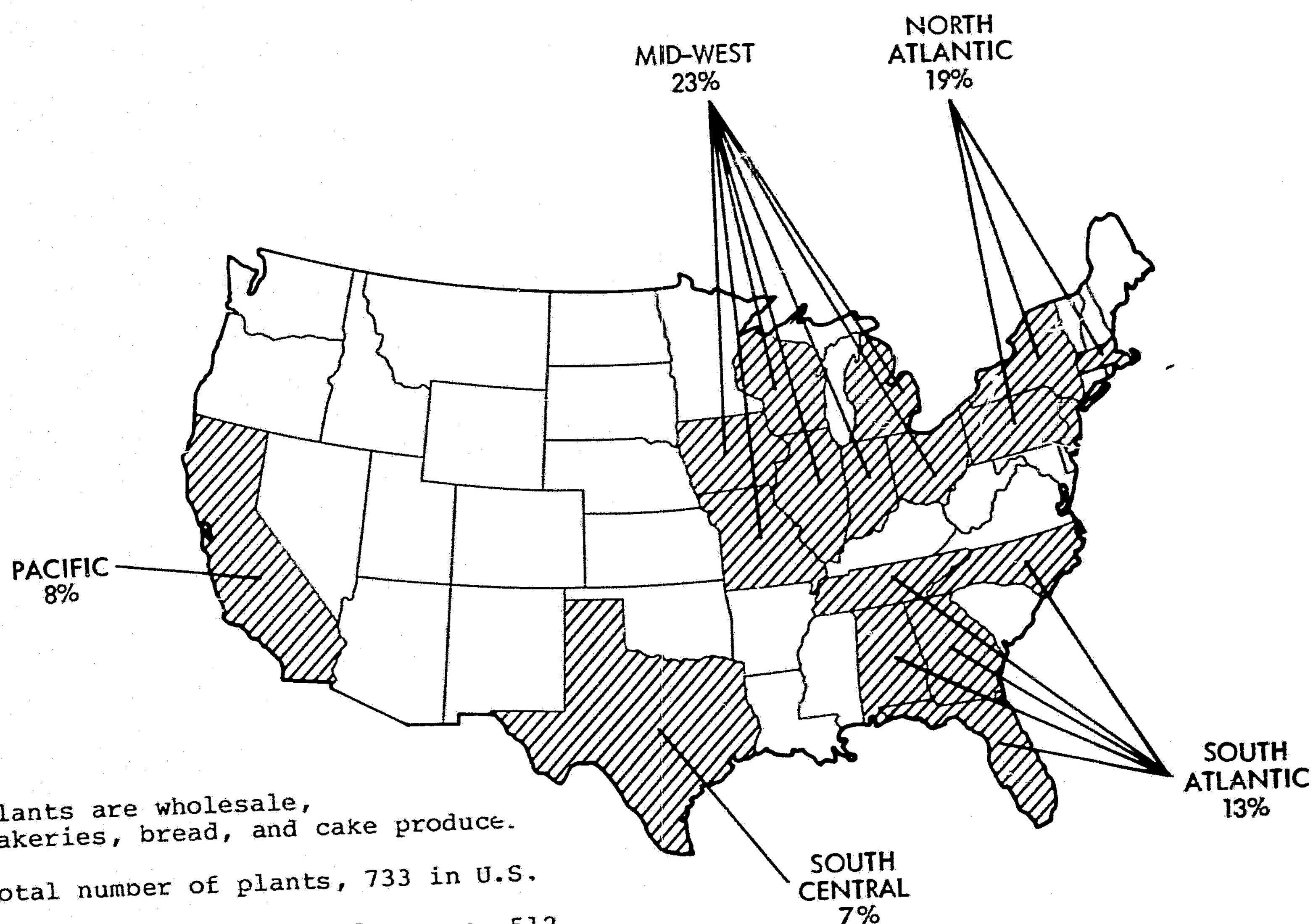
Location	No. of Plants	% of Total	Location	No. of Plants	% of Total
Alabama	15	2.05	Montana	5	0.68
Alaska	2	0.27	Nebraska	9	1.23
Arizona	4	0.55	Nevada	1	0.14
Arkansas	13	1.77	New Hampshire	3	0.41
California	61	8.32	New Jersey	25	3.41
Colorado	8	1.09	New Mexico	7	0.95
Connecticut	9	1.23	New York	43	5.87
Delaware	1	0.14	North Carolina	21	2.87
Washington, D.C.	3	0.41	North Dakota	4	0.55
Florida	21	2.87	Ohio	41	5.59
Georgia	17	2.32	Oklahoma	7	0.95
Hawaii	4	0.55	Oregon	9	1.23
Idaho	5	0.68	Pennsylvania	50	6.82
Illinois	34	4.64	Puerto Rico	1	0.14
Indiana	16	2.18	Rhode Island	4	0.55
Iowa	14	1.9	South Carolina	8	1.09
Kansas	7	0.95	South Dakota	4	0.55
Kentucky	8	1.09	Tennessee	24	3.27
Louisiana	13	1.77	Texas	49	6.69
Maine	5	0.68	Utah	7	0.95
Maryland	12	1.64	Vermont	2	0.27
Massachusetts	22	3.00	Virginia	13	1.77
Michigan	23	3.14	Washington	12	1.64
Minnesota	13	1.77	West Virginia	8	1.09
Mississippi	10	1.36	Wisconsin	19	2.59
Missouri	17	2.32	Wyoming	0	0
			TOTALS:	733	100



Total Number of Plants, 733.

Figure A-6. Bakery Products Location and Number

(Wholesale Bakeries - Bread and Cake Plants)



NOTES:

(1) Plants are wholesale, bakeries, bread, and cake produce.

(2) Total number of plants, 733 in U.S.

(3) Total number represented on map, 512, for 70% of the total.

Figure A-7. Bakery Products Concentrations

(14 or More Plants per State = 2% of Total)

MALT BEVERAGES (SIC 2082)

The first malt beverage plant in the United States was constructed in 1636. The breweries today vary in size from the very large breweries to small, experimental ones. The experimental breweries do not yet produce a marketable product, and along with the small breweries, they have a negligible impact on energy conservation efforts. Therefore, only large breweries were surveyed. There are 103 breweries in the United States, of which 78 are considered large. Table A-6 shows the location and breakdown by size of the 103 breweries.

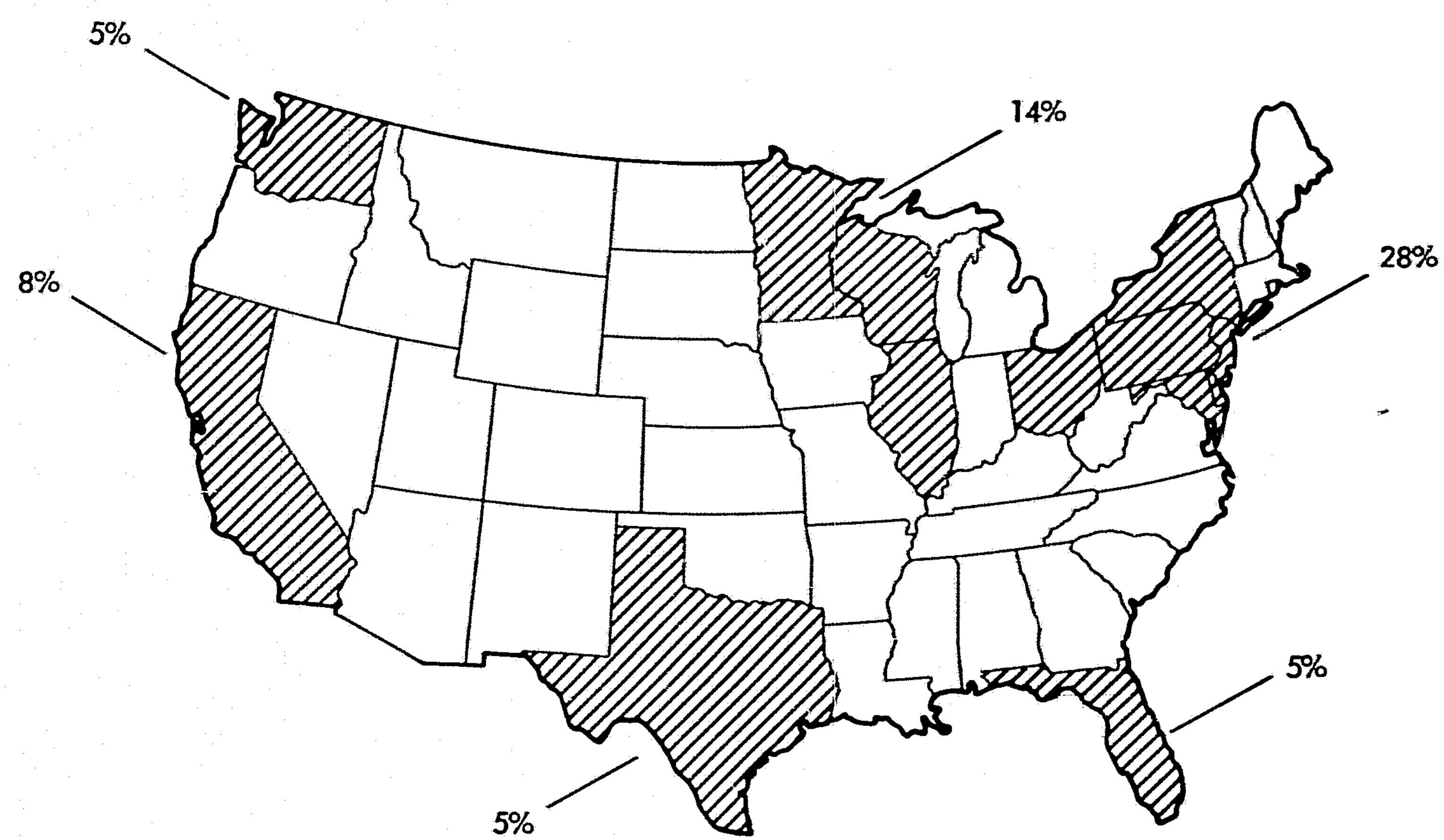
The regional concentration of the breweries was determined by selecting states that had three or more breweries. The breweries in these states account for 68% of the large breweries, the heaviest concentration being in the northeastern and north central states (Figure A-8).

There is no median age of breweries; plants are continuously upgraded or rebuilt. The plant location is dependent upon each company's individual marketing, transportation and supply needs.

The brewing industry is growing, although there is a decrease in the number of plants. This points to a trend towards consolidation of smaller breweries to compete with the large enterprises. Relocation of the industry does not occur, as each company is limited in site selection by its individual needs.

Table A-6. Breweries Location and Number

	Total	Large	Small	Experimental
Alaska	1		1	
Arizona	1	1		
California	8	6	2	
Colorado	1	1		
Florida	4	4		
Georgia	1	1		
Hawaii	2	2		
Illinois	5	3		2
Indiana	2	2		
Iowa	2	1		1
Kentucky	2	2		
Louisiana	2	2		
Maryland	3	3		
Michigan	3	2	1	
Minnesota	4	3	1	
Missouri	2	2		
Nebraska	1	1		
New Hampshire	1	1		
New Jersey	5	5		
New York	6	4	1	1
North Carolina	1	1		
North Dakota	1	1		
Ohio	4	4		
Oregon	1	1		
Pennsylvania	10	6	4	
Rhode Island	1	1		
Tennessee	1	1		
Texas	7	6	1	
Virginia	2	2		
Washington	4	4		
Wisconsin	15	5	3	7
TOTALS:	103	78	14	11



NOTES:

(1) Percentages shown are % of total large breweries (78 in number).

(2) States shown are with three or more breweries, 68% of total represented.

(3) 42% of the larger breweries are in the two cluster areas, north central (14%) and northeastern (28%).

Figure A-8. Breweries Concentration (Three or More Per State)

WEAVING MILLS, SYNTHETIC FIBERS (SIC 2221)

The weaving industry in the United States began in the early seventeenth century (1638) in New England. The industry continued to be based in New England until a series of historical and political events made it advantageous to relocate the industry in the southeastern part of the country. The southeastern states offered advantages such as non-unionized low-cost labor, favorable tax benefits, the availability of natural resources, and an abundance of water.

Traditionally, cotton was the predominant raw material used in the weaving industry. In the 1960's, synthetic fibers emerged as the chief competitor of cotton and eventually the production of synthetics surpassed that of cotton. Synthetics are continuing to dominate the market, with cotton being used in conjunction with synthetics to form blends.

There are 355 integrated synthetic fiber weaving mills out of a total of about 7080 plants in the United States. These integrated weaving plants also have dyeing and finishing equipment and are more complex and energy intensive than plants with only weaving equipment. Integrated synthetic fiber plants were chosen to represent the textile industry as they are the best candidates for cogeneration applications. Table A-7 and Figure A-9 list the number of these mills by state, as well as the percentage of the total number of integrated mills in each state. Table A-8 and Figure A-10 show the area concentration of integrated mills in the U.S.

The future growth of the textile industry is expected to be around 5% per year. This figure is highly dependent upon changes in style and the availability of land and natural resources. The need for land has been lessened by the introduction of synthetics to the textile industry. A single manufacturing plant located on 300 acres of land is able to produce as much weight of polyester fiber as can be produced from 600,000 acres planted with cotton. This would suggest a continuing shift to synthetics in the future.

Major uncertainties exist in the future of the textile industry. No new plants have been built in the past 5 years and little expansion is seen in the next 5 years. The modifications to the existing plants (median age = 60 - 70 yrs.) will be concerned mostly with process efficiency and meeting government regulations. The small amount of growth that is predicted is dependent on the industry successfully solving its current problems.

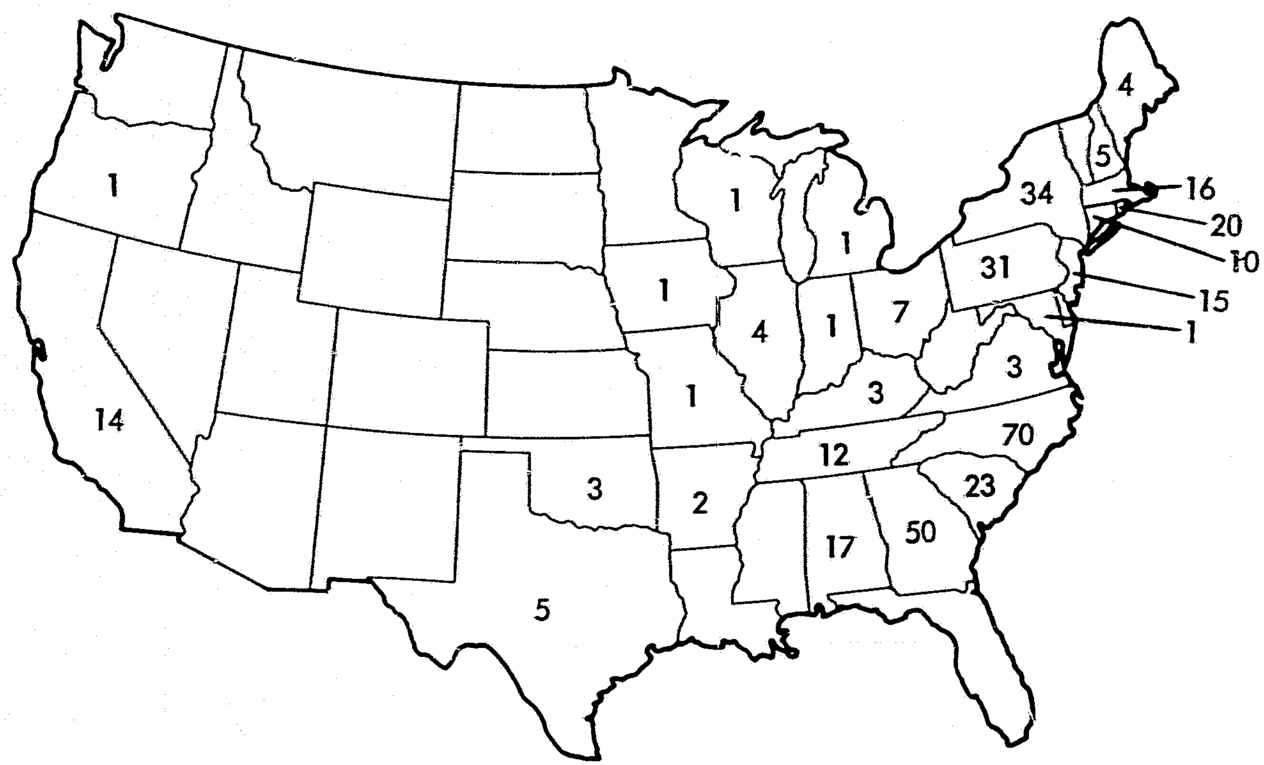
Recent trends in the industry suggest that the small mills will be forced to sell out to the larger companies that have the necessary resources to implement changes. It is probable that a conglomerate of large companies will dominate the industry in the future.

Table A-7. Weaving and Synthetic Fiber Mill Locations

	No. of Plants	% of Total		No. of Plants	% of Total
Alabama	17	4.8	New Hampshire	5	1.4
Arkansas	2	0.6	New Jersey	15	4.2
California	14	3.9	New York	34	9.6
Connecticut	10	2.8	North Carolina	70	19.7
Georgia	50	14.1	Ohio	7	2.1
Illinois	4	1.1	Oklahoma	3	0.8
Indiana	1	0.3	Oregon	1	0.3
Iowa	1	0.3	Pennsylvania	31	8.7
Kentucky	3	0.8	Rhode Island	20	5.6
Maine	4	1.1	South Carolina	23	6.5
Maryland	1	0.3	Tennessee	12	3.4
Massachusetts	16	4.5	Texas	5	1.4
Michigan	1	0.3	Virginia	3	0.8
Missouri	1	0.3	Wisconsin	1	0.3
			TOTALS:	355	100.0

Table A-8. Weaving Mill Concentrations (Fifteen or more per State or 4% of Total)

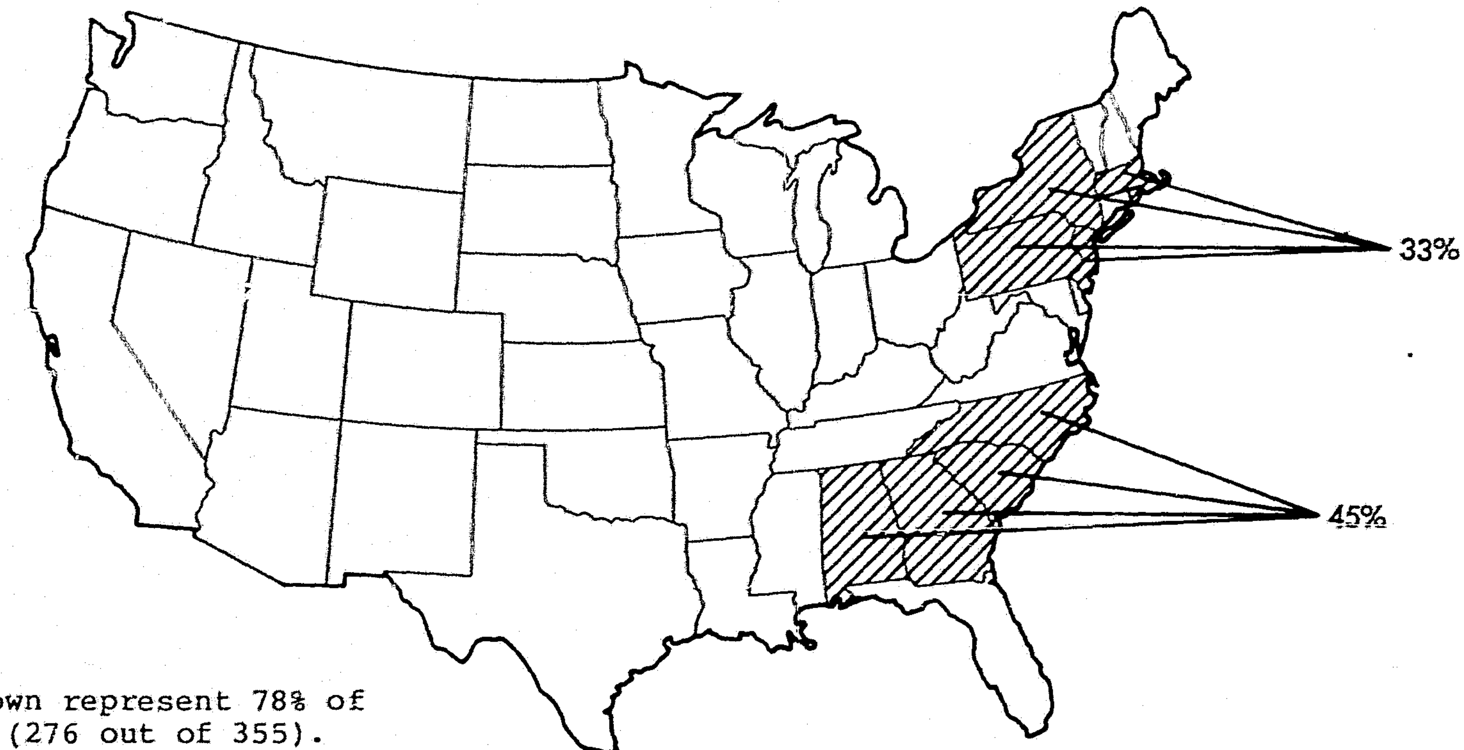
Location	No. of Plants Per State	Percentage of Total
Northeast		
New York	34	9.6
Pennsylvania	31	8.7
Rhode Island	20	5.6
Massachusetts	16	4.5
New Jersey	15	4.2
South		
North Carolina	70	19.7
Georgia	50	14.1
South Carolina	23	6.5
Alabama	17	4.8
Totals:	276	77.7
Clusters		
Northeast	116	32.6
South	160	45.1
TOTALS:	276	77.7



NOTES:

(1) Plants shown are for synthetic fiber weaving with dyeing and finishing equipment.
(2) Total number of plants, 355.

Figure A-9. Weaving Mill Locations (Synthetic Fibers)



NOTES:

(1) Plants shown represent 78% of the total (276 out of 355).
(2) Plants shown represent 15 or more plants per state or 4% of total.
(3) Plants are for synthetic fiber weaving with dyeing and finishing equipment.

Figure A-10. Weaving Mill Plant Concentrations (Synthetic Fibers)

PAPER AND PAPERBOARD MILLS (SIC 2621 and 2631)

The geographic dispesion of the modern paper industry has been shaped, to a large extent, by the industries' search for new fiber sources. The paper industry of the 1920's and 1930's consisted largely of companies that produced a single line of products. The companies have responded to changing supply and demand factors by introducing vertical integration.

This trend towards vertical integration began in the 1930's. It was brought about by the development of southern pine as a pulpable wood, which spurred the industry to integrate pulp production with paper and paperboard production. In the 1950's, producers of containerboard integrated production to include the manufacture of corrugated shipping containers. As a result, many of the containerboard companies have become fully integrated, from the forest to the finished product.

As the technology of pulp and paper-making led to larger machines, the investment in papermaking facilities increased with the result that company sales and assets increased significantly in size. The distinct nature of the various sectors of the industry, from both a supply and market standpoint, permited different companies to grow side by side, each along its own particular lines. As pulping processes improved, companies also tended to expand their grade structure, so that many of the largest companies now serve a wide range of markets - for example, both printing and packaging papers.

In the mid-1950's, two other trends became evident. Packaging was becoming more important as the changing distribution system moved further away from bulk sales toward modern marketing techniques of packaged consumer goods. As a result, some of the can and glass container manufacturers in the mid-fifties felt the need to offer a full line of packages and acquired or built paper and paperboard mills and converting plants. These companies are still major factors in the specific packaging markets in which they participate, but there were no new developments along this particular trend after that.

New technology that permitted the pulping of chips, slabs, edging and similar residues of other forest industries, brought some of the largest lumber companies into the paper industry. These companies were located in the Pacific Northwest and, in some instances, built new pulp and paper mills. Once in the industry, they also acquired existing mills and plants in order to diversify on a product and geographic basis. There was also a move in the late 1960's for some of the larger conglomerates to pick up companies in the paper industry, but this has largely subsided.

At present, the larger corporations in the industry are vertically integrated. This means they produce their own wood pulp, make their own paper and paperboard and, where the product is appropriate, as in the packaging and consumer product grades, they convert their primary production to final products. The study dealt with a selected portion of the total SIC 26 paper industry, specifically SIC 2621 - Newsprint and Writing Paper Mills, and SIC 2631 - Corrugated Paper and Boxboard Mills. Pulp mills are not included unless they are part of an integrated plant, one which produces paper products as well as pulp.

The paper and allied products industry is a very large industry, not only in total sales but also in the number of products and grades of paper produced. An industry profile shown in Table A-9 indicates the magnitude of this industry. The top 20 paper-producing companies are shown in Table A-10. These companies make 55% of the net paper and allied products sales. The top 10 companies are principally engaged in this industry. By comparing paper sales with total sales, it may be seen that about four of the other companies get more than half of their sales from non-paper businesses. The number and location of paper and paperboard mills in the United States are shown in Table A-11 and in Figure A-11. By considering only those states with 19 or more plants, or 2.6% of the total, the concentration of plants is determined as shown in Table A-12 and in Figure A-12. Table A-13 defines the regions into which the country is divided, to categorize concentrations of each industry. A breakdown of states into their respective regions is shown in this table. Most paper or paperboard mills that utilize wastepaper as their major furnish are in the northeast, from the Mississippi River east and from a parallel of the Mason-Dixon line north. Most of the large integrated pulp and and papermills are in the southern and Pacific regions, and these mills have larger power requirements.

Leading paper- and board-producing states are shown in Table A-14 and Figure A-13. Paper and paperboard production breakdown for all grades is shown in Table A-15. In the printing and writing paper category, it can be seen that in 1976 newsprint and writing paper accounted for 77 million tons or 45% of the total in this category. This number is 29% of the total paper production. Linerboard and corrugating medium accounted for 16.4 million tons or 58% of total board production. The combined production of the above products was 24.1 million tons or 40% of the total for all grades.

Paper mills tend to have very long lives, although they may make considerable changes in their grade structure over the years. The recession of 1970 had a major impact on the industry, in that it led to the closing of machines accounting for about a million and one-half or so tons of capacity. This capacity was largely in mills that were economically obsolete and unable to meet the existing pollution abatement standards; they had been able to stay in business because of the strong trend in demand during the 1960's and because of fewer restrictive regulations. Some of the mills shut down have since come back into business, but most of them have been dismantled and are no longer operating. A list of the number of idle or dismantled mills in each state is shown in Table A-16. Between 1975 and 1977, there was a low growth rate in paper and paperboard capacity of about 1.6% per year. Tables A-17 and A-18 give regional capacities for newsprint and writing paper and paperboard production for the year 1976 as well as the projected capacities for 1980. The number of mills with each specific capacity range is given in Table A-19 and the capacity in integrated and non-integrated mills is listed by product in Table A-20. Table A-21 gives machine capacity in millions of short tons. Continued average growth is expected to be about 4.1% per year.

Presently, mills are located near trees and water. It takes about 50,000 gallons of water to make a ton of paper. Thus, availability of water is an important element in the selection of a new mill site for pulp and paper operations. The Clean Air Act of 1972 called for mills to have the best practical technology currently available installed by 1977 and the best available installed by 1983. Installation of the best available technology will require some mills to restructure their internal processes rather than develop equipment to treat the effluent of existing processes. Table A-22 gives a history of the installation or rebuilding of machines and their capacity. Announced capacity expansions, including new mills and machines, are shown in Table A-23. Planned expansion projects listed in the table include new paper, paperboard and market woodpulp mills and new paper and paperboard machines in existing mills. Each project has been publicly announced by the management of the company concerned and is included in the confirmed capacity estimates reported in the survey. The capacity estimates also include new machines that have not been publicly announced, which, in keeping with the confidential nature of the survey, are not included in the listing. The list does not include publicly announced expansion projects that are under serious consideration but not yet confirmed.

Today there are approximately 500 x 10^6 acres of commercial timberland. This amount is adequate for present production levels. With present planting levels, new research, advanced harvesting techniques, and new technology, future timber supply is also adequate. However, for the year 2000, new sources will have to be developed. Of all mills operating, 22% are now recycling papermills, using wastepaper for production. Recycling mills are generally located near large metropolitan areas where wastepaper is available. A shift from wood to wastepaper is probably a realistic approach for the future. The technology to separate the recycled paper fibers into the necessary homogeneous fibers for quality paper is not presently available. Until this problem is solved, trees will continue to be used as the main source for pulp, and mills will remain near the forest areas.

In the future, the paper industry could be affected by the use of computers, microfilm and microfiche cathode ray tubes, and optical readers. So far, however, the net result of these trends has been a greater, rather than smaller demand for printing and writing paper. If new technology is generated for recycling wastepaper, it may then be possible for paper mills to relocate. Because it will no longer be necessary for mills to be near timberlands, papermill construction beyond 1985 may be near large cities. Thus, future mill concentrations may shift toward metropolitan areas.

Table A-9. Paper and Allied Products Industry

	1975	1976
Net Sales	32,044,000,000	39,270,000,000
Net Profit Before Taxes	2,901,000,000	3,643,000,000
Net Profit After Federal Taxes	1,801,000,000	2,270,000,000
Value of Shipments	43,484,000,000	50,234,000,000
Wholesale Price Index (1967=100)	170.4	179.4
Capital Expenditures	2,950,000,000	3,270,000,000
Employees, Total	643,000	676,000
Production Wokers	483,000	512,000
Av. Hourly Earnings, Pdctn. Wrkrs.	4.99	5.43
Exports (tons)	6,654,000	7,382,000
Exports ($)	2,432,791,000	2,621,000
Imports (tons)	9,945,000	11,144,000
Imports ($)	2,659,715,000	3,284,000
Per Capita Use, Paper & Boards (lbs)	524	598

Table A-10. Leading U.S. Paper Companies in 1976

Company	Paper and Allied Products Sales (millions of dollars)	Total Sales (millions of dollars)
International Paper Company	2,933	3,541
Crown Zellerbach Corporation	1,596	2,126
Mead Corporation	1,467	1,599
Kimberly-Clark Corporation	1,458	1,585
St. Regis Paper Company	1,401	1,661
Weyerhauser Company	1,195	1,868
Scott Paper Company	1,193	1,374
Champion Inernational Corporation	1,161	2,911
Boise Cascade Corporation	1,064	1,932
Container Corporation of America	995	995
Procter & Gamble	977	6,513
Westvaco Corporation	835	922
Great Northern Nekoosa Corporation	803	845
The Continental Group, Incorporated	771	3,458
Georgia-Pacific Corporation	763	3,038
Union Camp Corporation	676	1,003
Hammermill Paper Company	660	690
American Can Company	629	3,143
Hoerner Waldorf	480	511
Owens Illinois, Incorporated	463	2,572
TOTALS	21,520	43,187

Table A-11. Paper and Paperboard Mills Location and Number of Plants

State	No. of Plants	% of Total	State	No. of Plants	% of Total
Alabama	17	2.3	Mississippi	11	1.5
Arizona	2	0.3	Missouri	6	0.8
Arkansas	12	1.6	Montana	1	0.1
California	40	5.4	New Hampshire	19	2.6
Colorado	1	0.1	New Jersey	30	4.1
Connecticut	14	1.9	New Mexico	1	0.1
Delaware	5	0.7	New York	64	8.7
Florida	13	1.8	North Carolina	18	2.5
Georgia	22	3.0	Ohio	42	5.7
Idaho	2	0.3	Oklahoma	7	1.0
Illinois	23	3.1	Oregon	26	3.5
Indiana	16	2.2	Pennsylvania	49	6.7
Iowa	3	0.4	Rhode Island	1	0.1
Kansas	2	0.3	South Carolina	10	1.4
Kentucky	5	0.7	Tennessee	16	2.2
Louisiana	19	2.6	Texas	18	2.5
Maine	21	2.8	Vermont	9	1.2
Maryland	5	0.7	Virginia	14	1.9
Massachusetts	48	6.5	Washington	18	2.5
Michigan	38	5.2	West Virginia	2	0.3
Minnesota	12	1.6	Wisconsin	52	7.1
			TOTALS:	734	100.0

Table A-12. Paper and Paperboard Mills Concentration

(19 or More Plants per State or 2.6% of Total Number of Plants)

Location	No. of Plants	% of Total No. of Plants
PACIFIC STATES		
California	40	5.4
Oregon	26	3.5
MIDWEST		
Wisconsin	52	7.1
Ohio	42	5.7
Michigan	38	5.2
Illinois	23	3.1
NORTH ATLANTIC		
New York	64	8.7
Pennsylvania	49	6.7
Massachusetts	48	6.5
New Jersey	30	4.1
Maine	21	2.8
New Hampshire	19	2.6
SOUTH ATLANTIC		
Georgia	22	3.0
SOUTH CENTRAL		
Louisiana	19	2.6
TOTALS:	493	67.0
REGIONAL CLUSTERS		
Pacific States	66	8.9
Midwest	155	21.1
North Atlantic	231	31.4
South Atlantic	22	3.0
South Central	19	2.6
TOTALS:	493	67.0

Table A-13. Definitions of Regions

NEW ENGLAND

Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont

MID-ATLANTIC

New Jersey
New York
Pennsylania

EAST NORTH CENTRAL

Illinois
Indiana
Michigan
Ohio
Wisconsin

WEST NORTH CENTRAL

Iowa
Kansas
Minnesota
Missouri
Nebraska
North Dakota
South Dakota

SOUTH ATLANTIC

Delaware
Florida
Georgia
Maryland
North Carolina
South Carolina
Virginia
West Virginia

EAST SOUTH CENTRAL

Alambama
Kentucky
Mississippi
Tennessee

WEST SOUTH CENTRAL

Arkansas
Louisiana
Oklahoma
Texas

MOUNTAIN & PACIFIC

Arizona
California
Colorado
Idaho
Montana
Nevada
New Mexico
Oregon
Utah
Washington
Wyoming

Table A-14. Leading Paper and Board Producing States

State	1975 Production x 10^6 tons	% of USA Total Output
Georgia	4.158	8.0
Alabama	3.503	6.7
Louisiana	3.246	6.2
Wisconsin	3.102	6.0
Oregon	2.689	5.1
Maine	2.485	4.8
Washington	2.291	4.4
Pennsylvania	2.070	4.0
Virginia	2.045	3.9
South Carolina	2.018	3.9
	27.607	53.0

TOTAL 1975 Production = 52 x 10^6 tons

Table A-15. Paper and Paperboard Production Breakdown

Grade	1976 Production x 10^6 Tons
Printing and Writing Paper	
Newsprint	3.736
Groundwood Printing & Converting	1.279
Coated Printing & Converting	3.981
Book, Uncoated	2.973
Bristols, Bleached	0.997
Writing	3.920
TOTAL Printing & Writing	16.886
Packaging and Converting	
Wrapping	0.347
Shipping Sack	1.106
Bag	2.383
Glassine, Greaseproof & Vegetable Parchment	0.202
Other Packaging and Industry Converting	1.426
TOTAL Packaging & Converting	5.464
Tissue	
Toilet Tissue	1.609
Facial Tissue	0.335
Napkin	0.455
Towelling	1.323
Other Tissue	0.464
TOTAL Tissue	4.186
TOTAL Paper	26.536
Board	
Linerboard	11.376
Corrugating Medium	5.061
Container Chip & Filler	0.263
Folding	4.715
Set-Up	0.332
Milk Carton & Food Service	1.519
Gypsum Wallboard Facing	0.985
Tube, Can & Drum	1.017
Other (Incl. Exports)	3.172
TOTAL Board	28.440

(Table continued on next page)

Table A-15. (Cont'd)

	1976 Production x 10^6 Tons
Other	
Wet Machine Board	0.130
Construction Paper & Board	5.418
TOTAL Other	5.548
TOTAL All Grades	60.524

Table A-16. Paper Mills Idle or Dismantled

	Idle	Dismantled
Alabama	-	1
California	1	1
Connecticut	1	1
Florida	-	1
Illinois	1	-
Maine	2	-
Maryland	2	-
Massachusetts	1	-
Michigan	-	1
Missouri	-	1
New Hampshire	3	-
New Jersey	1	4
New York	5	1
North Carolina	1	-
Ohio	1	-
Oregon	-	2
Pennsylvania	6	-
Tennessee	-	1
Vermont	-	1
Virginia	-	1
Washington	-	1
West Virginia	1	-
TOTALS	26	17

Table A-17. Newsprint and Writing Paper

1976

Region /x 10^3 Short Tons	Newsprint	Printing Writing & Related[a]	Total
New England	412	2741	3153
Mid-Atlantic	214	2070	2284
East North Central	127	3776	3903
West North Central	–	779	779
South Atlantic	373	1729	2102
East South Central	963	1078	2041
West South Central	914	1400	2314
Mountain and Pacific	1029	1122	2151
TOTALS	4,032	14,695	18,727

1980

	Newsprint	Printing Writing & Related[a]	Total	% Increase (1976-80)
New England	412	3153	3565	13.1
Mid-Atlantic	214	2161	2375	4.0
East North Central	132	3870	4002	2.5
West North Central	–	779	779	0
South Atlantic	521	2085	2606	24.0
East South Central	1141	1242	2383	16.8
West South Central	1009	1454	2463	6.4
Mountain and Pacific	1260	1342	2602	21.0
TOTALS	4,689	16,086	20,775	
% Increase (1976-80)	16.3	9.5	10.9	

[a]Includes all envelope papers.

Table A-18. Paper Board

Region /x 10^3 Short Tons	Unbleached Kraft	Solid Bleached	Semi-Chemical	Recycled	Total	% Increase (1976-80)
1976						
New England	–	29	176	659	864	
Mid-Atlantic	–	–	–	2033	2033	
East North Central	–	3	1203	3065	4272	
West North Central	–	–	173	266	440	
South Atlantic	6768	1648	1335	994	10745	
East South Central	2678	714	568	323	4284	
West South Central	2771	1116	649	304	4839	
Mountain and Pacific	2463	547	643	1084	4737	
TOTALS	14,680	4,056	4,748	8,729	32,213	
1980						
New England	–	29	176	697	902	4.4
Mid-Atlantic	–	–	–	2097	2097	3.2
East North Central	–	–	1428	3269	4697	10.0
West North Central	–	–	173	268	441	0.2
South Atlantic	7193	1904	1465	1125	11687	8.8
East South Central	3366	726	624	344	5059	18.1
West South Central	3424	1442	756	322	5955	23.1
Mountain and Pacific	2526	547	707	1211	4990	5.3
TOTALS	16,508	4,648	5,331	9,342	35,830	
% Increase (1976-80)	12.5	14.6	12.3	7.0	11.2	

Table A-19. Mill Size[a]

Annual Capacity	Paper and Paperboard: Number of Mills	Paper and Paperboard: Annual Capacity[b]	Woodpulp: Number of Mills	Woodpulp: Annual Capacity[b]
Total	690	68,184	274	53,047
0 - 25	238	3,043	32	487
26 - 50	133	4,891	40	1,491
51 - 75	72	4,500	26	1,620
76 - 100	52	4,606	20	1,779
101 - 125	33	3,686	15	1,688
126 - 150	18	2,506	13	1,724
151 - 175	25	4,037	16	2,583
176 - 200	17	3,194	9	1,682
201 - 250	21	4,687	21	4,555
251 - 300	19	5,187	14	3,834
301 - 350	18	5,758	12	3,896
351 - 400	10	3,803	12	4,573
401 - 450	11	4,617	15	6,397
451 - 500	6	2,888	8	3,858
over 500	17	10,781	21	12,880

[a]Mill sizes reflect annual capacities in 1976 measured on a practical maximum basis.
[b]Thousands of short tons.

Table A-20. Integrated and Nonintegrated Mills

Paper and Paperboard			Thousands of Short Tons
	ANNUAL CAPACITY IN 1976		
Grades	Integrated To Woodpulp	Non-Integrated	Total
All Grades	50,482	17,702	68,184
Paper	21,360	7,851	29,210
Newsprint	3,589	425	4,014
Uncoated Groundwood	1,093	216	1,309
Coated Groundwood	2,218	81	2,299
Coated Free Sheet	1,359	544	1,903
Uncoated Free Sheet[a]	4,837	2,624	7,461
Thin Papers	57	301	358
Solid Bleached Bristols	1,092	73	1,155
Pkg. and Ind. Conv.	5,071	1,131	6,202
Tissue	2,043	2,457	4,500
Paperboard	23,836	8,261	32,097
Unbleached Kraft	14,568	-	14,568
Solid Bleached	3,998	-	3,998
Semi-Chemical	4,758	-	4,758
Recycled	513	8,261	8,774
Construction Paper and Board	5,286	1,590	6,876

[a]Includes cotton fiber.

Note: Integrated mills include all mills with active on site woodpulp capacity, whether or not this capacity provides a significant portion of total furnish.

Table A-21. Paper Machine Output

Grades[a]	Number of Machines	Machine Capacity
ALL GRADES	1,578	68.3
TOTAL Paper	981	29.4
Newsprint	38	4.0
Uncoated Groundwood	38	1.3
Coated Papers	81	4.1
Uncoated Free Sheet[b]	278	7.6
Thin Papers	62	0.4
Solid Bleached Bristols	16	1.3
Packaging & Industrial Conv.	228	6.2
Tissue	240	4.5
TOTAL Paperboard	395	32.3
Unbleached Kraft	69	14.4
Solid Bleached	31	4.1
Semi-Chemical	51	4.9
Recycled	244	8.8
TOTAL Other Paper and Board	202	6.7

[a]The total capacity of a machine which produces more than one grade of paper on paperboard is included under the grade category representing the major portion of its production.

[b]Includes cotton fiber.

Table A-22. History of Paper Machines

Year Installed or Rebuilt	Number of Machines	Percent of U. S. Capacity	
		Group	Cumulative
TOTAL	1,578		
No Data Available	625		
TOTAL Sample[a]	953		
1975	89	11.6	11.6
1974	48	5.7	17.3
1973	32	3.1	20.4
1972	28	3.0	23.4
1971	30	4.1	27.5
1966 - 1970	220	29.2	56.7
1961 - 1965	165	16.4	73.1
1956 - 1960	106	10.8	83.9
1951 - 1955	59	6.2	90.1
1946 - 1950	56	4.9	95.0
1941 - 1945	16	0.7	95.7
Prior to 1940	104	4.3	100.0

[a]Machines in sample represent 78% of annual capacity in 1975.

Note: Major rebuilds include only modifications which significantly extended the useful life or increased the capacity of a machine.

Table A-23. Announced Expansions, New Mills and Machines

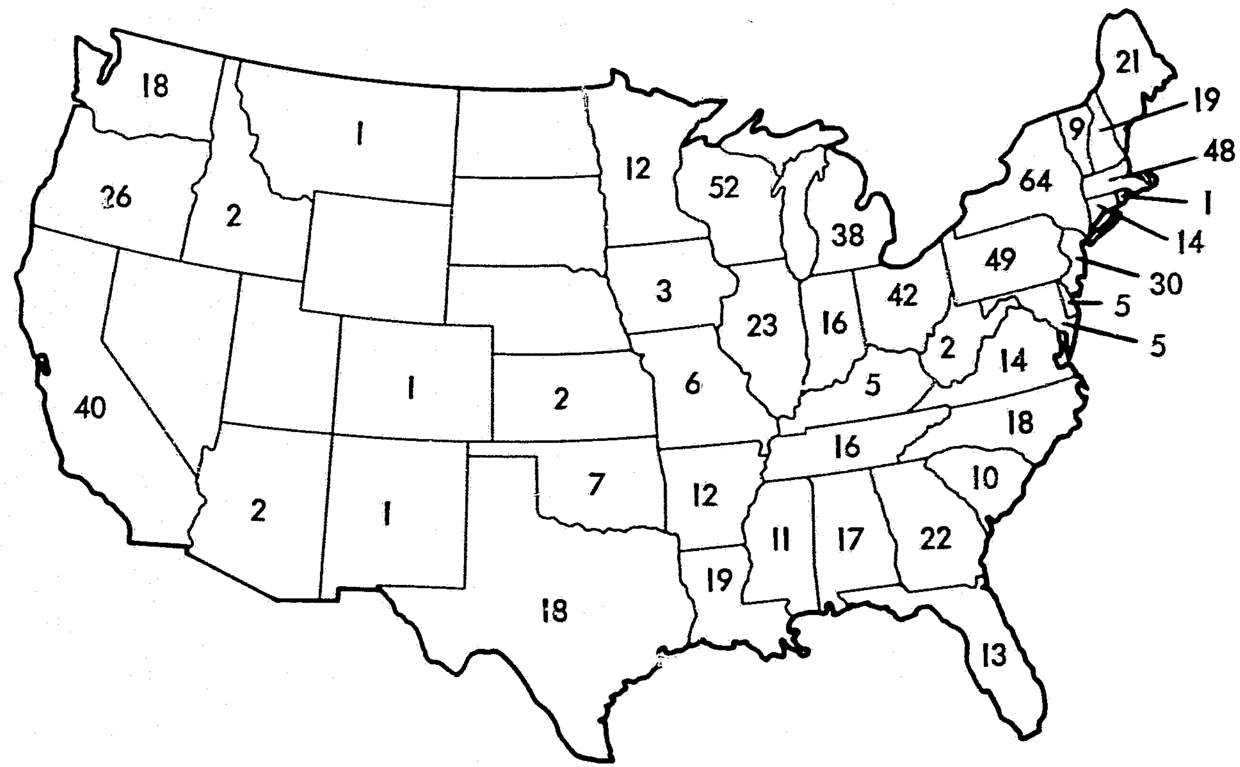
Company	Location	Grade	Approximate Annual Capacity[a]
1977			
Georgia-Pacific Corp.	Crossett, Ark.	Tissue	50
Hammermill Paper Co.	Kaukauna, Wisc.	Thin Papers	25
International Paper Co.	Jay, Me.	Uncoated Free Sheet	140
International Paper Co.	Jay, Me.	Thin Papers	35
Owens-Illinois, Inc.	Orange, Texas	Unbleached Kraftliner	110
Potlatch Corp.	McGehee, Ark.	Solid Bleached Board	160
St. Regis Paper Co.	Bucksport, Me.	Coated Groundwood	170
Scott Paper Co.	Marinette, Wisc.	Tissue	NA[b]
1978			
The Continental Group, Inc.	Augusta, Ga.	Solid Bleached Board	150
Fort Howard Paper Co.	Muskogee, Okla.	Tissue	NA[b]
Georgia-Pacific Corp.	Plattsburg, N.Y.	Tissue	30
International Paper Co.	Texarkana, Texas	Solid Bleached Board	NA[b]
Olinkraft, Inc.	West Monroe, La.	Unbl. Kraft Folding	190
Marcal Paper Mills	Elmwood Park, N.J.	Tissue	60
Proctor & Gamble Co.	Albany, Ga.	Tissue	NA[b]
1979			
Alabama River Pulp Co.	Clairborne, Ala.	Bleached Sulphate Pulp	350
Bowater, Inc.	Calhoun, Tenn.	Newsprint	140
Consolidated Papers, Inc.	Stevens Point, Wisc.	Coated Groundwood	110
Fort Howard Paper Co.	Muskogee, Okla.	Tissue	NA[b]
Green Bay Packaging, Inc.	Morrilton, Ark.	Unbleached Kraftliner	110
North Pacific Paper Co.	Longview, Wash.	Newsprint	220
Owens-Illinois, Inc.	Tomahawk, Wisc.	Semi-Chemical	245[c]

[a]Thousands of short tons
[b]NA - not available.
[c]140,000 tons net.

(Table continued on next page)

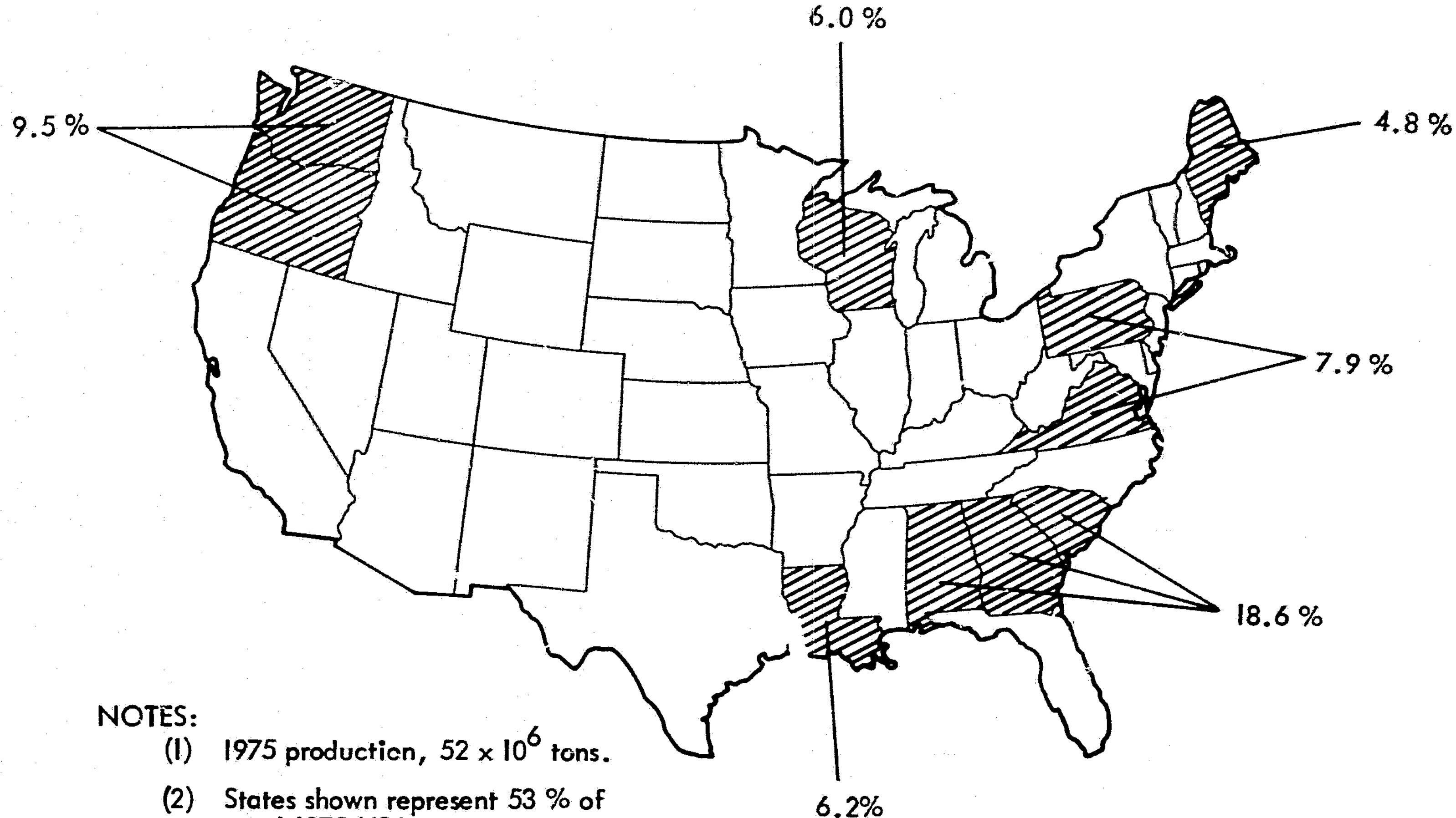
Table A-23. (Cont'd)

Company	Location	Grade	Approximate Annual Capacity
1980			
Boise Cascade Corp.	Wallula, Wash.	Uncoated Free Sheet	140
Champion International Corp.	Courtland, Ala.	Uncoated Free Sheet	NA[b]
Gulf States Paper Corp.	Tuscaloosa, Ala.	Unbl. Kraft Folding	180
Southeast Paper Co.	Dublin, Ga.	Newsprint	150
Union Camp Corp.	Montgomery, Ala.	Unbleached Kraftliner	350



Total No. of plants, 734.

Figure A-11. Paper and Paperboard Mills Locations

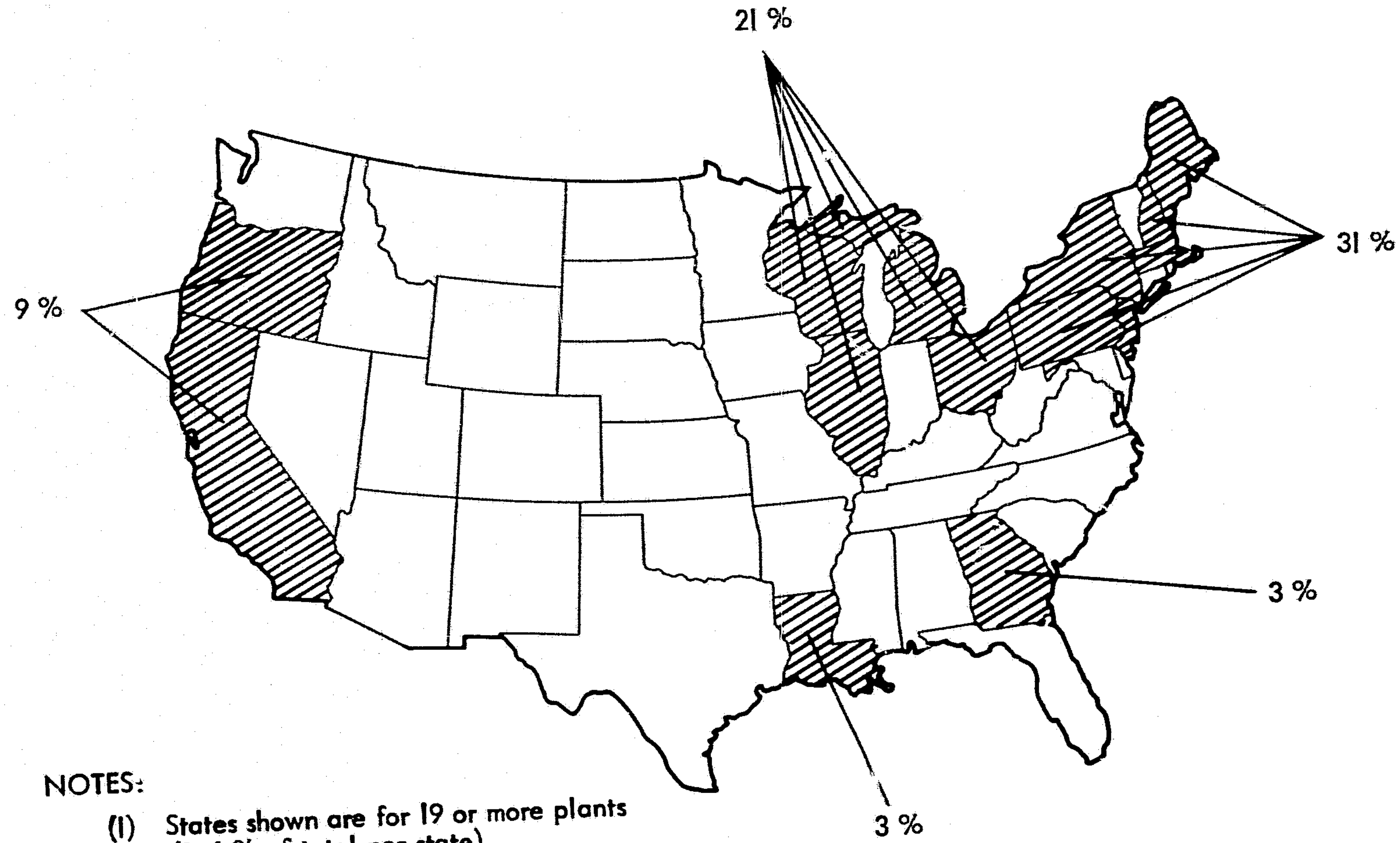


NOTES:

(1) 1975 production, 52×10^6 tons.

(2) States shown represent 53 % of total 1975 USA output.

Figure A-12. Paper and Paperboard Mills Concentrations



NOTES:

(1) States shown are for 19 or more plants (2.6 % of total per state).

(2) 493 plants represented for 67% of total 734 plants.

Figure A-13. Paper and Paperboard Production (Leading Top Ten States, % of Total US Output - 1975)

ALKALIES AND CHLORINE (SIC 2812)

The chlorine industry in the United States dates back to 1892. Today, there are 70 plants, most of them built since 1955. The location of the plants depends primarily upon accessibility to the marketplace and the cost of energy. A secondary factor is the availability of salt or brine.

The industry currently has plants in 23 states (Table A-24). The states containing the largest concentrations of plants are Texas and Louisiana. These states also have the highest amount of production (Table A-25, Figure A-14). The industry is dominated by Dow Chemical Company, which has the largest plant (Freeport, Texas) and produces 30% to 40% of the total United States production. The typical industry plant produces about 150,000 tons of chlorine per year. Existing plants produce from a low of 1800 tons per year to a high of 2,030,000 tons per year. The estimated cost of building a new plant in the Gulf Coast region that would be capable of producing 100,000 tons per year is $120 million. It is not considered economically feasible to build plants that would produce less than 100,000 tons per year. It is unlikely that there would be any relocation of the industry in the future as most obsolete plants are either modified or rebuilt at the same location.

The long-range outlook for the chlor/alkali industry is unfavorable. By 1980, the industry is expected to be underutilizing its plant capacity, therefore ruling out any new construction. The growth of the industry is expected to average between 3.5% to 5.5% per year through the year 2000. The growth potential is seriously affected by energy costs. As the costs of electricity and steam increase, the production efficiency decreases. Government regulations on various chlorinated compounds are upsetting the balance between chlorine and caustic soda production. As these two are co-products, a certain balance must be maintained to produce each one economically.

New technology is available to the industry, but its implementation is unlikely due to the underutilization of current capacity and the uncertain future of the industry as a whole.

Table A-24. Chlorine and Caustic Soda Plant Locations

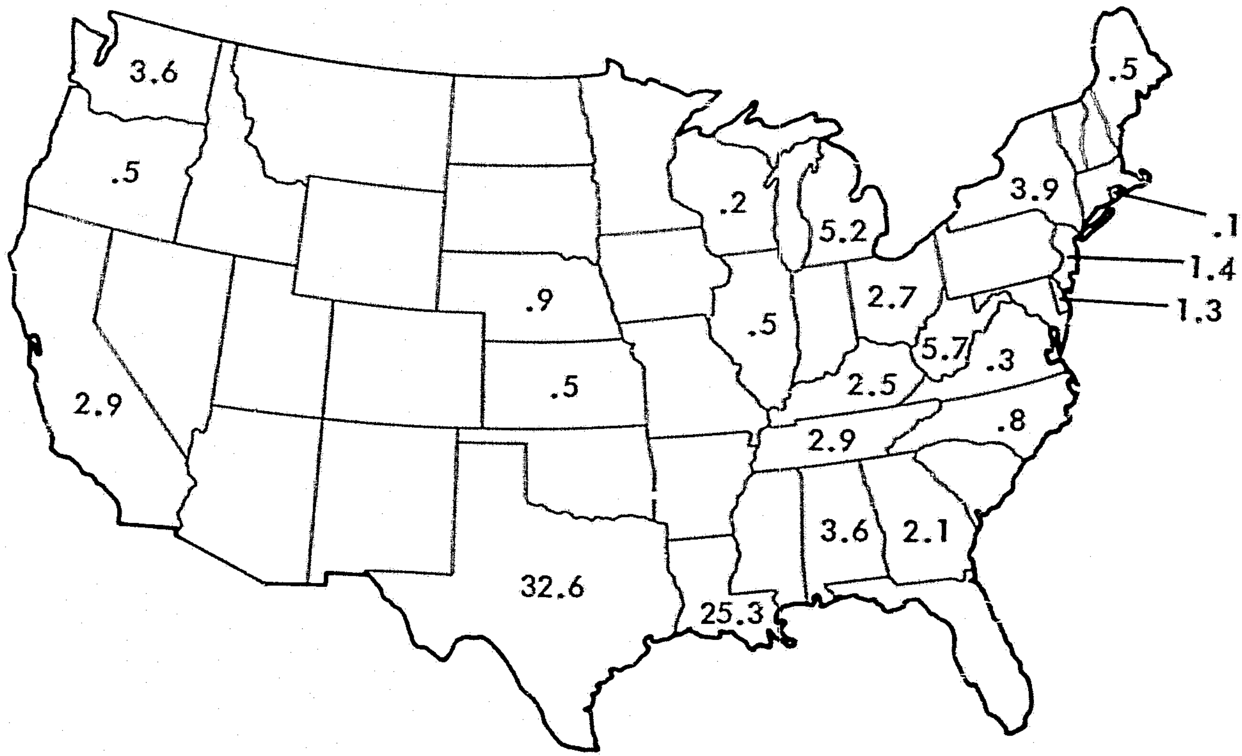
State	Chlorine[a]	Caustic Soda[b]	No. of Plants	% of Total
Alabama	--	4	4	5.7
California	--	1	1	1.4
Delaware	--	1	1	1.4
Georgia	--	3	3	4.3
Illinois	--	1	1	1.4
Indiana	--	1	1	1.4
Kansas	--	1	1	1.4
Kentucky	--	2	2	2.9
Louisiana	--	10	10	14.9
Maine	--	1	1	1.4
Michigan	--	4	4	5.7
Mississippi	1	--	1	1.4
Nevada	--	1	1	1.4
New Jersey	--	1	1	1.4
New York	--	5	5	7.1
North Carolina	--	2	2	2.9
Ohio	--	3	3	4.3
Oregon	--	1	1	1.4
Tennessee	1	2	3	4.3
Texas	4	9	13	18.6
Utah	--	1	1	1.4
Virginia	--	1	1	1.4
Washington	--	4	4	5.7
West Virginia	--	3	3	4.3
Wisconsin	--	2	2	2.9
TOTAL	6	64	70	99.8

[a]Includes chlorine only; chlorine and caustic Potash; chlorine and sodium; and chlorine and magnesium plants.

[b]Includes caustic soda only; chlorine and caustic soda; chlorine, caustic soda and soda ash; and chlorine, caustic soda and sodium plants.

Table A-25. 1974 Chlorine Production

State	Tons	% of Total
Alabama	384,680	3.6
California	307,596	2.9
Delaware	137,389	1.3
Georgia	232,272	2.1
Illinois	49,418	0.5
Kansas	56,195	0.5
Kentucky	263,336	2.5
Louisiana	2,715,725	25.3
Maine	58,371	0.5
Michigan	562,781	5.2
Nebraska	94,814	0.9
New Jersey	148,955	1.4
New York	420,029	3.9
North Carolina	84,356	0.8
Ohio	288,706	2.7
Oregon	47,182	0.5
Rhode Island	5,388	0.1
Tennessee	309,557	2.9
Texas	3,503,494	32.6
Virginia	27,912	0.3
Washington	380,989	3.6
West Virginia	615,232	5.7
Wisconsin	21,732	0.7
TOTAL	10,753,109	100.0



NOTES:

(1) Total 1974/Production, 10.75 x 10^6 tons.

Figure A-14. 1974 Cnlorine Production
(% of Total)

LOW-DENSITY POLYETHYLENE AND STYRENE (SIC 2821 and 2865)

Low-density polyethylene and styrene are both products of petrochemical feedstocks. Low-density polyethylene is an important product of the plastics industry; styrene is used in rubber, resin and plastics production. Polyethylene is produced from ethylene feedstock and styrene is produced from ethylene and benzene. Styrene production began in 1940 and although polyethylene production also began in the early 1940's, it did not develop to any great extent until after World War II.

Plant locations for both industries are determined by proximity to petrochemical feedstocks. Table A-26 lists the number of plants in each state for both low-density polyethylene and styrene. Figures A-15 and A-16 show the geographic concentration of plants for both industries. The Gulf states of Texas and Louisiana contain the largest number of plants for both industries.

The capacity data for both industries are available by produce rather than state (Tables A-27 and A-28). The production capacity of the styrene industry varies from 80 to 1500 million pounds per year (avg.= 600 million lbs/yr); low-density polyethylene production varies from 300 to 150 million pounds per year (avg.= 500 million lbs/yr).

The styrene industry recently expanded its capacity production from 500 million pounds in 1976 to one billion pounds in 1977. This gives the industry sufficient capacity for years to come. Although there is minimal new plant construction at this time, the rising operating costs may force older smaller plants to close, opening the way for new construction. Predicted growth rates for the styrene industry are at 5% to 6% per year. Although the use of synthetic rubber is slowing down, new areas of demand are opening up.

Table A-26. Plant Locations and Concentration Low-Density Polyethylene and Styrene

	LDPE		Styrene	
State	Number of Plants	% of Total	Number of Plants	% of Total
California	1	4.5	--	--
Illinois	3	13.6	--	--
Indiana	1	4.5	--	--
Iowa	1	4.5	--	--
Louisiana	3	13.6	3	21.4
Michigan	--	--	1	7.1
Pennsylvania	--	--	1	7.1
Texas	13	59.1	9	64.3
TOTALS	22	99.8	14	99.9

C-2

Table A-27. Low-Density Polyethylene Capacity - 1977
(Millions of Pounds per Year)

Manufacturer	Capacity
ARCO/Polymers	400
Chemplex	310
Cities Service	350
Rexene Polyolefins	400[a]
Dow Chemical USA	1020
DuPont	710
Eastman	350
Exxon	420[a]
Gulf	850[a]
Mobil	
National Distillers (U.S.I. Chemicals)	500
Northern Petrochemical	600
Union Carbide	1500
TOTAL	7410

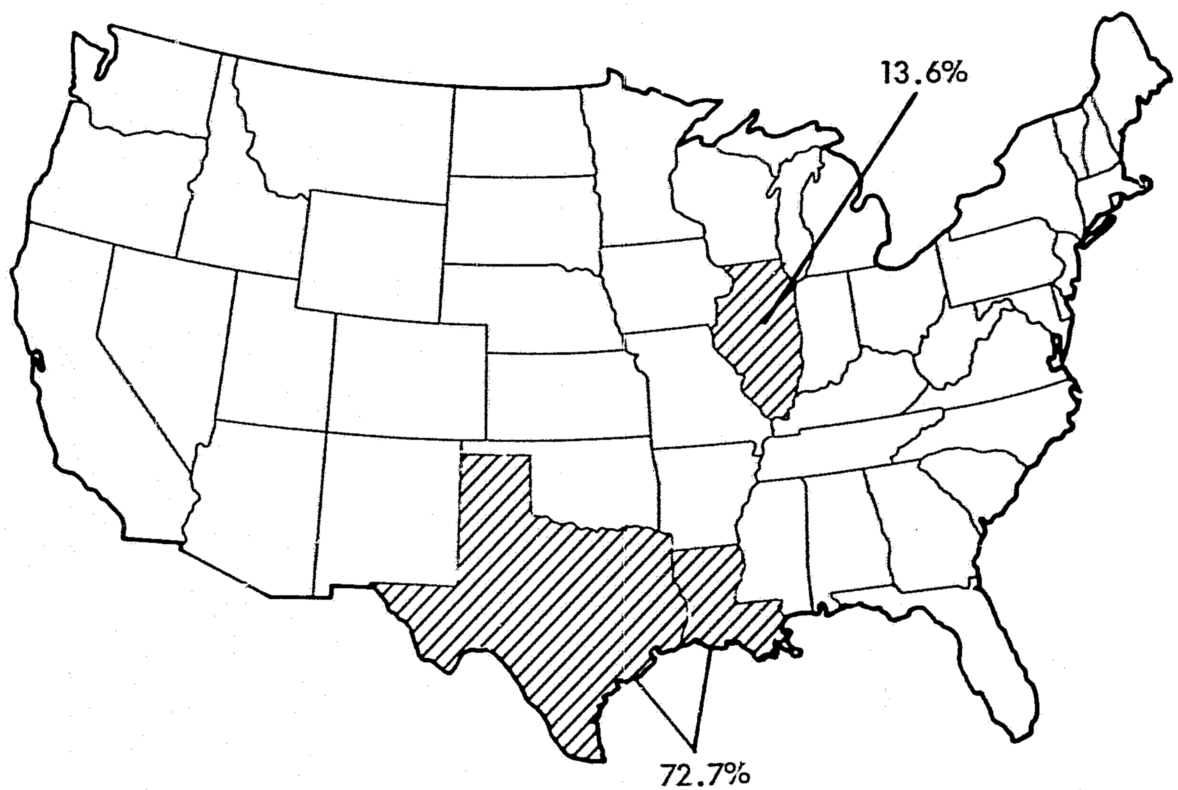
[a]In 1978 these are expected to be:

Rexene	550
Exxon	660
Mobile (new plant)	300

for a total capacity of 8100 million pounds per year.

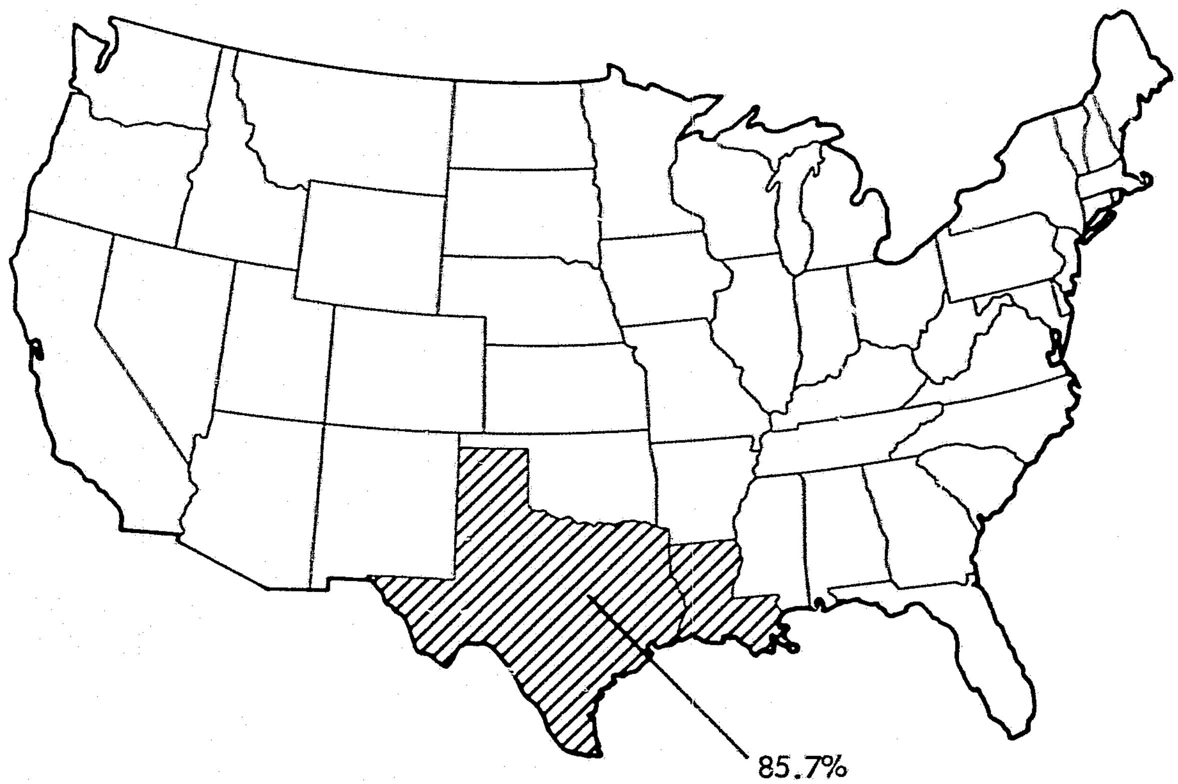
Table A-28. Styrene Capacity - 1977 (Millions of Pounds per Year)

Manufacturer	Capacity
American Hoechst (Foster Grant)	880
American Petrofina (Cosden)	110
Amoco Chemicals	840
ARCO/Polymers	560
Cos-Mar	1300
Dow Chemical USA	1850
El Paso Products	150
Gulf Oil Chemicals	600
Monsanto	1500
Oxirane	1000
Sun Co.	80
Union Carbide	300
TOTAL	9170



Total Number of Plants, 22.

Figure A-15. Low-Density Polyethylene Plant Concentration



Total Number of Plants, 14.

Figure A-16. Styrene Plant Concentration

ETHYLENE PLANTS (SIC 2869)

Ethylene plants in the United States are traditionally located near the natural gas sources of the gulf states. Liquid natural gas is used as the feedstock for ethylene plants. Table A-29 lists the 34 ethylene plants by state and shows the 1978 production capacity of each state. Texas and Louisiana contain the largest number of plants and have the greatest production capacity of the ethylene-producing states (Figure A-17).

The ethylene industry came of age during the late 1940's and early 1950's and has been rapidly growing ever since. The industry is expected to grow at a rate of one to two new plants per year (production capacity = 1 billion lb per year). Annual U.S. consumption is on the order of 25 X 10^9 lb. This amount is expected to increase by 4% per year through the year 2000.

There has been a slight shift in the location of ethylene plants to the Gulf states of Texas and Louisiana. When plants become obsolete they are generally rebuilt at the same location rather than relocated or renovated. More important than plant relocation is the increase in production capacity of the Gulf state region. This trend is expected to continue through the year 2000 barring any unforeseen circumstances.

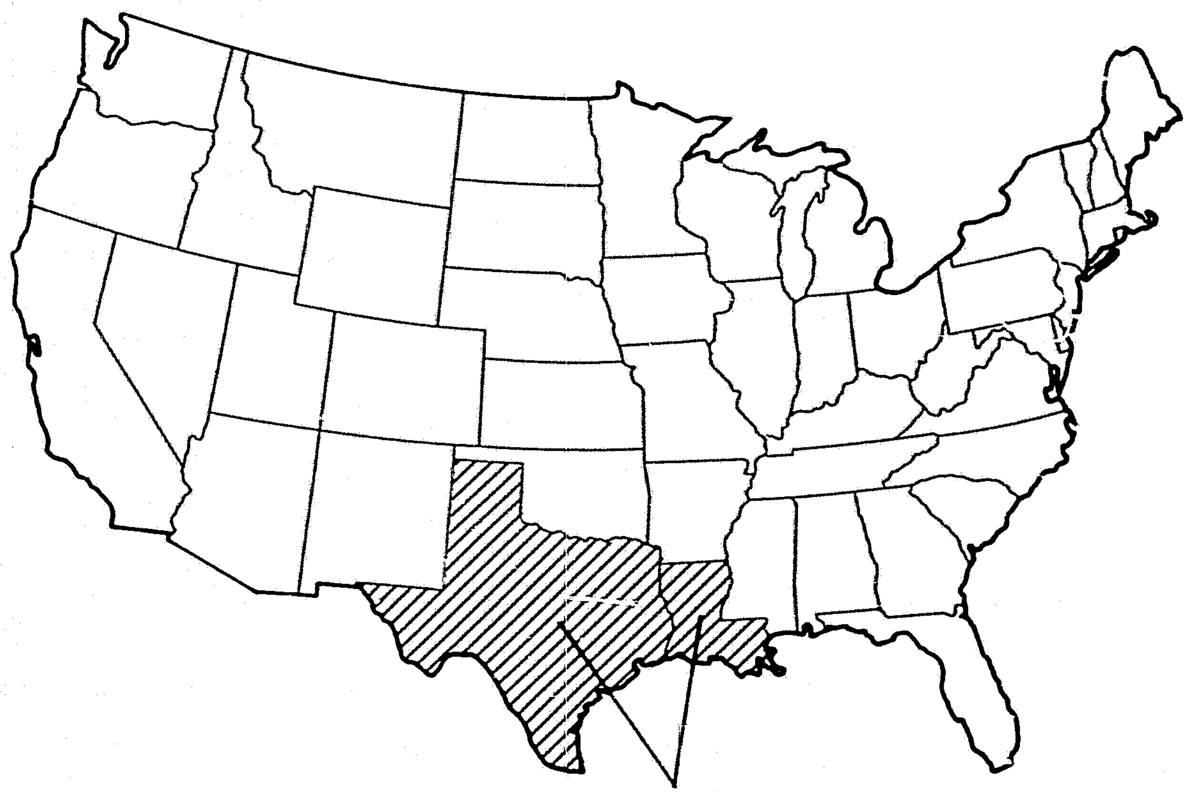
The ethylene industry is not monopolized by any one company; the 34 plants are owned by 25 different companies (Table A-30). The number of companies is expected to remain more or less constant through the year 2000.

Table A-29. Location of Ethylene Plants with 1978 Production Capacity

State	No. of Plants	% of Total	Production Capacity x 10^3 Metric Tons	% of Total
California	2	5.9	106	0.8
Delaware	1	2.9	109	0.8
Illinois	2	5.9	582	4.2
Iowa	1	2.9	227	1.7
Kentucky	2	5.9	181	1.3
Louisiana	7	20.6	3,224	23.6
Texas	19	55.9	9,252	67.6
TOTALS	34	100.0	13,681	100.0

Table A-30. Installed Ethylene Capacity in USA (as of September 4, 1978)

Company	Location	Annual Production x 10^3 Metric Tons	% Total Capacity per Company
UNITED STATES			
Allied Chemical Corp. (with Borg-Warner Chemicals and BASF-Wyandotte)	Geismar, La.	328	2.4
ARCO Chemical Co.	Watson, Calif.	33	8.9
	Channelview, Tex.	1,180	
ARCO Polymers	Houston, Tex.	227	1.7
ARCO Chemicals Corp.	Chocolate Bayou, Tex.	910	6.6
Chemplex Co.	Clinton, Iowa	227	1.7
Cities Service Co.	Lake Charles, La.	400	2.9
Conoco Chemicals	Lake Charles, La.	295	2.2
Cosden Oil & Chem	Groves, Tex.	9	0.1
Dow Chemical Co.	Freeport, Tex.	1,136	12.3
	Plaquemine, La.	545	
Du Pont	Orange, Tex.	375	2.7
Eastman Chemical Products	Longview, Tex.	580	4.2
El Paso Products Co.	Odessa, Tex.	235	1.7
Exxon Chemical U.S.A.	Baton Rouge, La.	800	6.0
	Baytown, Tex.	23	
B. F. Goodrich	Culvert City, Ky.	136	1.0
Gulf Oil Chemicals Co.	Port Arthur, Tex.	558	9.3
	Cedar Bayou, Tex.	719	
Jefferson Chemical Co.	Bellaire, Tex.	240	1.8
Mobil Chemical Co.	Beaumont, Tex.	410	3.0
Monsanto Chem. Int. Co.	Texas City, Tex.	45	2.4
	Alvin, Tex.	285	
Northern Petrochemical	Morris, Ill.	400	2.9
Olin Corp.	Brandenberg, Ky.	45	0.3
Phillips Petroleum	Sweeney, Tex.	515	3.8
Shell Oil Co.	Norco, La.	665	10.1
	Houston, Tex.	715	
Sun-Olin	Claymont, Del.	109	0.8
Union Carbide	Seadrift, Tex.	545	9.9
	Taft, La.	191	
	Texas City, Texas	545	
	Torrance, Calif.	73	
U.S.I.	Tuscola, Ill.	182	1.3
	U.S. TOTAL	13,681	100.0



NOTE:

(1) Total Plants = 33
Texas = 18
Louisiana = 6
24 or 72.8% of total.

Figure A-17. Ethylene Plants Concentration - 1977

ALUMINA (SIC 2819)

Alumina production in the United States is confined to the southeastern portion of the country (Table A-31, Figure A-18). The bauxite ore used in the production of alumina is almost entirely imported to the country. Close to 90% of the ore is imported from Jamaica, Guyana, Surinam, the Dominican Republic, Haiti, Huinea and Sierra Leone. The remaining 10% comes from bauxite deposits in Arkansas, Alabama and Georgia.

The nine aluminum refining plants in the U.S. are located near shipping lanes to the bauxite mining countries. Table A-32 shows the location of each plant, its start-up date and the 1976 alumina production.

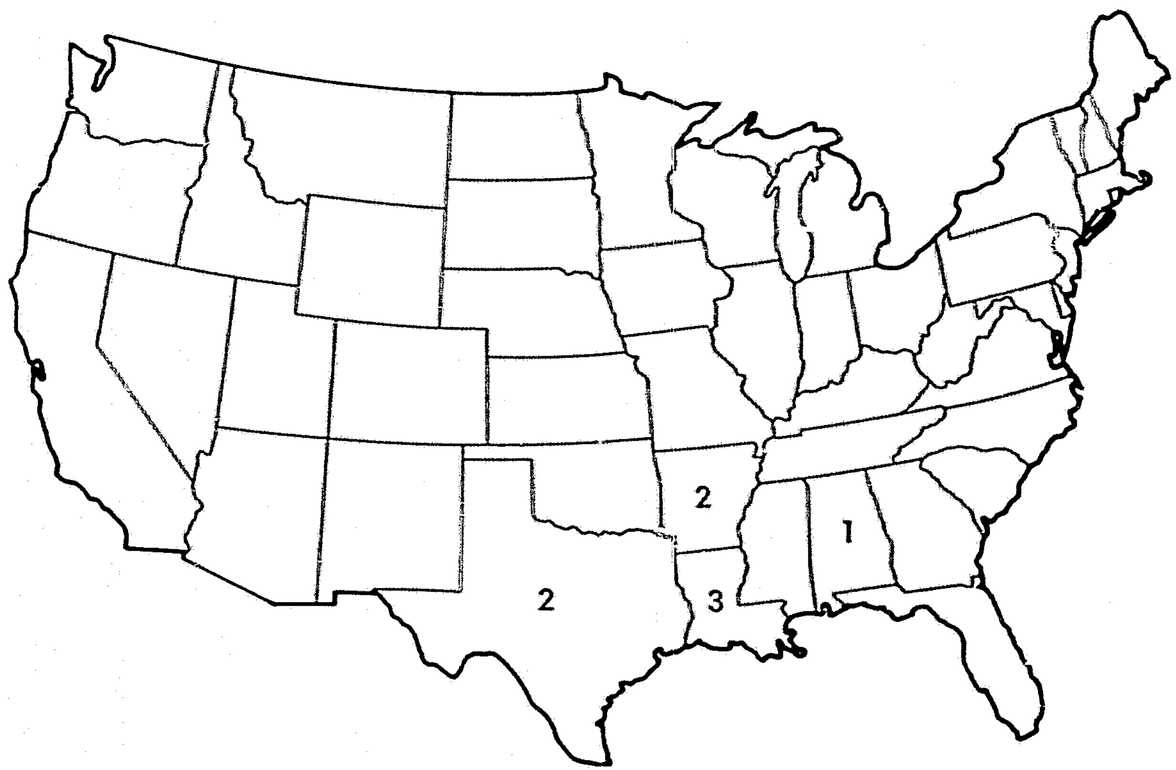
The potential exists for an expansion of the industry if the problem of limited availability of bauxite ore can be overcome. Experimental projects are being sponsored by leading aluminum companies and the Bureau of Mines to examine alternative processes for producing alumina from non-bauxite sources. Materials such as clays, alunite, anorthosite and lawsonite are being tested. If successful, these projects could spur new growth and a relocation of the industry; if not, the industry will most likely remain in its present state through the year 2000.

Table A-31. Alumina Plants, Capacity, and Company, 1976

State	No. of Plants	% of Total	10^3 Short Tons of Alumina	% of Total Capacity
Alabama	1	11.1	990	12.6
Arkansas	2	22.2	1230	15.7
Louisiana	3	33.4	2430	31.0
Texas	2	22.2	2730	34.8
Virgin Islands	1	11.1	460	5.9
TOTALS	9	100.0	7840	100.0
Company				
Alcoa	3	33.4	2710	34.6
Reynolds	2	22.2	2240	28.6
Kaiser	2	22.2	1830	23.3
Ormet	1	11.1	600	7.6
Martin-Marietta	1	11.1	460	5.9
TOTALS	9	100.0	7840	100.0

Table A-32. Alumina Plants History

Start-Up Date	Company	Location	1976 Capacity	% of Total
1938	Alcoa	Mobile, Alabama	990	12.6
1942	Kaiser	Baton Rouge, Louisiana	1030	13.1
1942	Reynolds	Hurricane Creek, Arkansas	850	10.8
1952	Alcoa	Bauxite, Arkansas	380	4.9
1953	Reynolds	Corpus Christi, Texas	1390	17.7
1958	Ormet	Burnside, Louisiana	600	7.7
1959	Alcoa	Point Comfort, Texas	1340	17.1
1960	Kaiser	Gramercy, Louisiana	800	10.2
1967	Martin-Marietta	St. Croix, Virgin Islands	460	5.9
	TOTALS		7840	100.0



Total Number of Plants, 9.

VIRGIN ISLANDS
1

Figure A-18. Alumina Plant Locations

AMMONIA (SIC 2873)

Ammonia production in the United States was developed during the 1920's and was first produced commercially in 1931 in New York. The ammonia industry grew during World War II, when ammonia was used in the production of ammunition. Following the war, the ammonia plants were converted to produce ammonia for fertilizers.

Almost all ammonia produced uses natural gas as a feedstock; therefore the location of the industry is tied to the availability of natural gas. The older plants are scattered around the country. As the availability of natural gas becomes more scarce, there is likely to be a shift in plant location to the remaining natural gas sources.

In 1978, there were 88 U.S. ammonia plants with a total production capacity of just over 18 million short tons per year. The average plant capacity is 185,000 short tons per year, although some of the larger plants are capable of producing 400,000 tons per year. Table A-33 shows the location by state of the plants and the percentage concentration. Table A-34 shows the production capacity of each state and Figure A-19 shows the major producing states.

The older plants that were built in the 1950's are closing down, primarily because of the decreasing availability and increasing price of natural gas. Production capacity is still adequate due to the major capacity expansion that occurred between 1975 and 1977 (about 30%). This expansion occurred primarily through new plant construction at new locations, and future expansion is expected to follow this trend.

New plants are being located near intrastate gas lines to ensure natural gas supplies. The industry is also researching the use of coal gasification as a substitute for natural gas. If this is successful, a shift to western coal states and Illinois is likely to occur. Illinois is a prime location, as it has both an ample coal supply and a large market for ammonia.

The outlook for the ammonia industry is for slow growth in the future; 3% a year is considered optimistic. Growth is slowed both by ample existing supplies of ammonia and less expensive foreign supplies.

Table A-33. 1978 Ammonia Plant Locations and Concentration

State	No. of Plants	% of Total
Alabama	2	2.3
Alaska	1	1.1
Arizona	2	2.3
Arkansas	2	2.3
California	8	9.1
Florida	2	2.3
Georgia	3	3.4
Idaho	2	2.3
Illinois	1	1.1
Indiana	1	1.1
Iowa	6	6.8
Kansas	3	3.4
Louisiana	14	15.9
Mississippi	4	4.5
Missouri	2	2.3
Nebraska	4	4.5
North Carolina	1	1.1
New York	1	1.1
Ohio	2	2.3
Oklahoma	4	4.5
Oregon	2	2.3
Pennsylvania	2	2.3
Tennessee	2	2.3
Texas	9	10.2
Utah	1	1.1
Virginia	1	1.1
Washington	2	2.3
West Virginia	3	3.4
Wyoming	1	1.1
TOTAL	88	100.0

Table A-34. 1978 Ammonia Plant Locations and Concentration

(1000 Short Tons Per Year)

State	Capacity	% of Total
Alabama	251	1.4
Alaska	510	2.7
Arizona	48	0.3
Arkansas	617	3.4
California	1,078	5.9
Florida	220	1.2
Georgia	306	1.7
Idaho	208	1.1
Illinois	230	1.3
Indiana	150	0.8
Iowa	1,063	5.8
Kansas	585	3.2
Louisiana	4,477	24.5
Mississippi	1,146	6.3
Missouri	206	1.1
Nebraska	598	3.3
North Carolina	210	1.1
New York	85	0.5
Ohio	610	3.3
Oklahoma	1,325	7.3
Oregon	98	0.5
Pennsylvania	360	2.0
Tennessee	510	2.7
Texas	2,212	12.7
Utah	70	0.4
Virginia	340	1.9
Washington	178	1.0
West Virginia	414	2.3
Wyoming	167	0.9
TOTAL	18,272	100.0

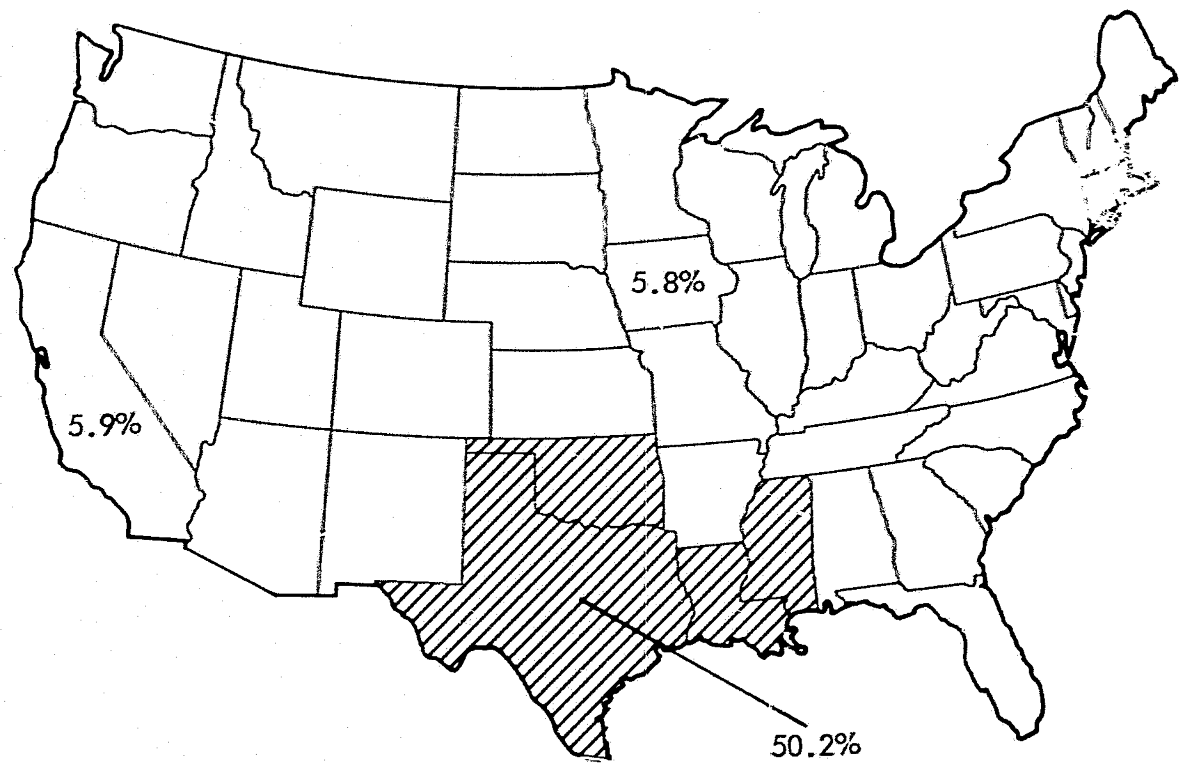


Figure A-19. Ammonia Production Capacity

PHOSPHORIC ACID (SIC 2874)

The phosphoric acid industry has undergone major process changes since its inception in the 1930's. The original plants used the furnace process, which has become too expensive to use today. The industry changed to the wet process, using sulfuric acid, in the early 1950's.

There are 46 phosphoric acid plants in the United States today. The majority of the plants are located near sources of phosphorus rock, with access to sulfur being a secondary location factor. Close access to seaports is another important consideration because of the high exportation market of phosphoric acid. The plant locations and percent of concentration are listed by state in Table A-35. The gulf states have the highest concentration of plants, due to accessibility to both phosphorus rock and seaports (Figure A-20).

The total production capacity of the industry is almost 10 million short tons per year. The average plant capacity is 215,000 short tons per year. Florida is by far the leading producer of phosphoric acid, with 53.9% of the total (Table A-36).

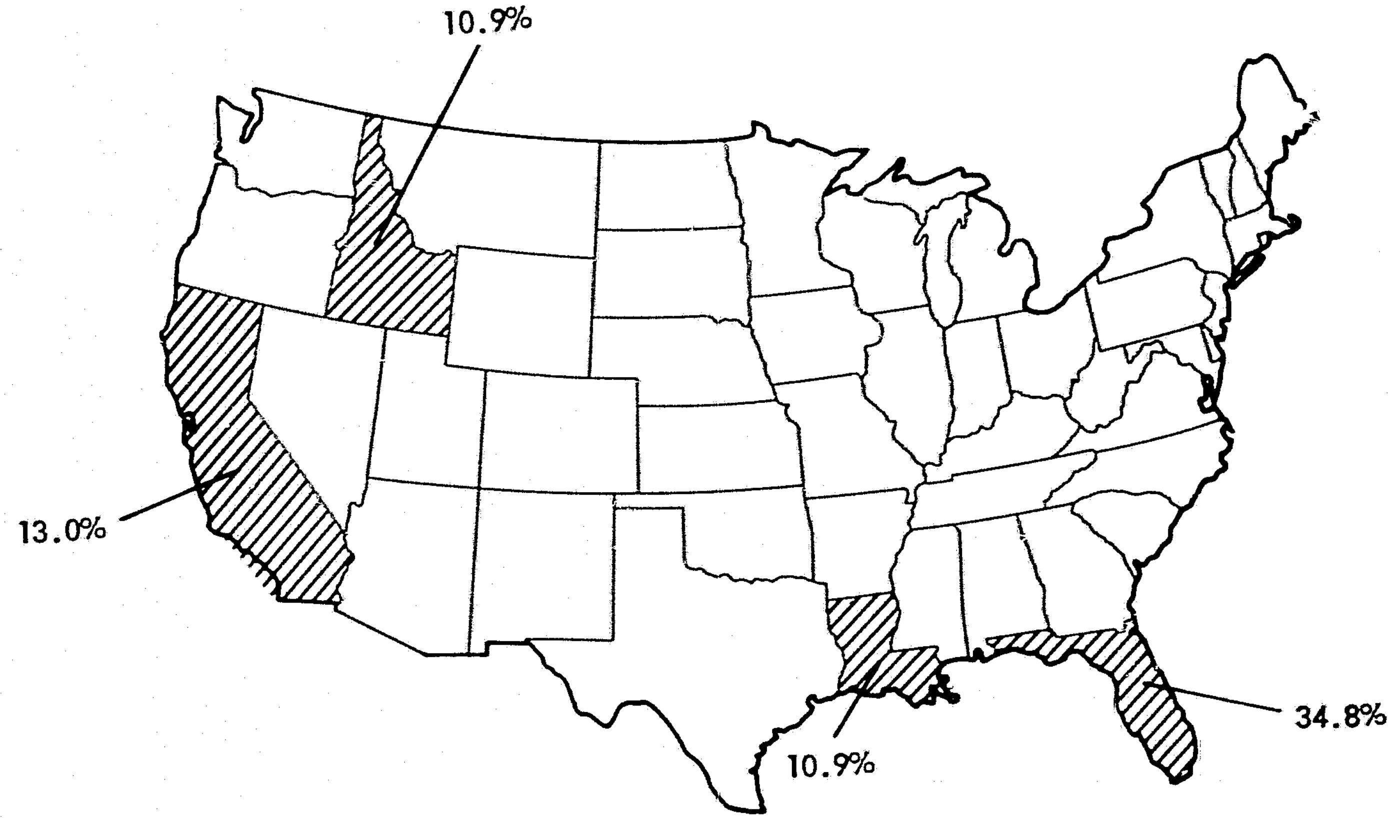
Growth of the industry is expected to be about 2% to 3%, mostly in exports. Domestic demand for phosphoric acid is expected to be slight to non-existent in the future, as phosphate levels in the soil are more than adequate. Environmental regulations, especially in Florida, are making it increasingly difficult to build new plants. The majority of the plants are 25 or more years old, with no new plants having been built since 1975. The industry tends to maintain and improve existng plants rather than build new ones. The newest plant was completed in 1975 and there are no plans for any others, therefore no industry relocation is foreseen. The only possibility of a relocation would be toward a sulfur source, although this is considered highly unlikely.

Table A-35. 1975 Phosphoric Acid Plant Locations and Concentration

State	No. of Plants	% of Total
Arkansas	1	2.2
California	6	13.0
Florida	16	34.8
Idaho	5	10.9
Illinois	4	8.7
Iowa	1	2.2
Louisiana	5	10.9
Mississippi	1	2.2
North Carolina	2	4.3
Texas	3	6.5
Utah	2	4.3
TOTAL	46	100.0

Table A-36. 1975 Phosphoric Acid Capacity
(1000 Short Tons Per Year)

State	Capacity	% of Total
Arkansas	50	0.5
California	171	1.7
Florida	5,392	53.9
Idaho	571	5.7
Illinois	375	3.8
Iowa	225	2.3
Louisiana	1,652	16.5
Mississippi	150	1.5
North Carolina	928	9.3
Texas	382	3.8
Utah	99	1.0
TOTAL	9,995	100.0



69.6% of total.

Figure A-20. Phosphoric Acid Plant Concentration

PETROLEUM REFINERIES (SIC 2911)

The history of the oil industry dates back to 1869, when oil was first discovered in Pennsylvania. Prior to 1915, the industry was monopolized by Rockefeller's Standard Oil trust. The trust was broken by the U.S. Government and 10 to 15 separate companies were formed, based on geographical location.

The refineries are based either where crude oil is available or close to the market for the finished product. Both locations are considered when a new refinery is built; the final decision is based on economic feasibility and the ease of obtaining construction permits. A special case exists in Alaska regarding North Shore oil. The most economical course is to ship the crude to the Continental U.S. and refine it there. Local politicians, calling for more home-based industry, may succeed in having the refineries built in Alaska.

As of 1978, there were 285 refineries located in 42 states (Table A-37). The majority of the refineries are located in the south-central and Gulf states (Figure A-21). The total number of oil companies remains fairly stable. The large companies are very strong financially and have international operations. The smaller companies are protected by the governmental entitlement program, a price control program for crude oil to be sold to smaller refineries.

Refinery growth in the United States is characterized primarily by the expansion and conversion of existing plants. New refinery construction is at a low level and no change is anticipated. The construction slowdown is due to the long length of time it takes to get construction permits approved (5 years), and the continuously changing environmental regulations.

The refinery output generally keeps up with demand. Prior to the oil embargo, demand was increasing at about 5% a year. After dropping to 3% for awhile, it has begun to climb upward to the 5% level again. As of January 1978, total crude capacity for the 285 refineries was 16.85 X 10^6 barrels per calendar day. This computes to an overall average of 59,100 barrels per day for each refinery. Table A-38 lists the crude capacity and the various refining operations performed for each state.

In conclusion, there is no trend toward a significant relocation of the refining industry. This is due both to the low level of new construction and the fact that when new refineries are built, they are usually located in the existing concentration areas.

Table A-37. Refineries, Location and Number

Location	No. of Plants	Percentage of Total
Alabama	6	2.11
Alaska	4	1.40
Arizona	1	0.35
Arkansas	4	1.40
California	40	14.04
Colorado	3	1.05
Delaware	1	0.35
Florida	1	0.35
Georgia	2	0.70
Hawaii	2	0.70
Illinois	12	4.21
Indiana	7	2.46
Kansas	11	3.86
Kentucky	4	1.40
Louisiana	23	8.07
Maryland	2	0.70
Michigan	65	2.11
Minnesota	3	1.05
Mississippi	5	1.75
Missouri	1	0.35
Montana	7	2.46
Nebraska	1	0.35
Nevada	1	0.35
New Hampshire	1	0.35
New Jersey	4	1.40
New Mexico	8	2.81
New York	2	0.70
North Carolina	1	0.35
North Dakota	3	1.05
Ohio	7	2.46
Oklahoma	12	4.21
Oregon	1	0.35
Pennsylvania	10	3.52
Tennessee	1	0.35
Texas	53	18.60
Utah	9	3.16
Virginia	1	0.35
Washington	8	2.81
West Virginia	3	1.05
Wisconsin	1	0.35
Wyoming	13	4.56
TOTAL	285	100.00

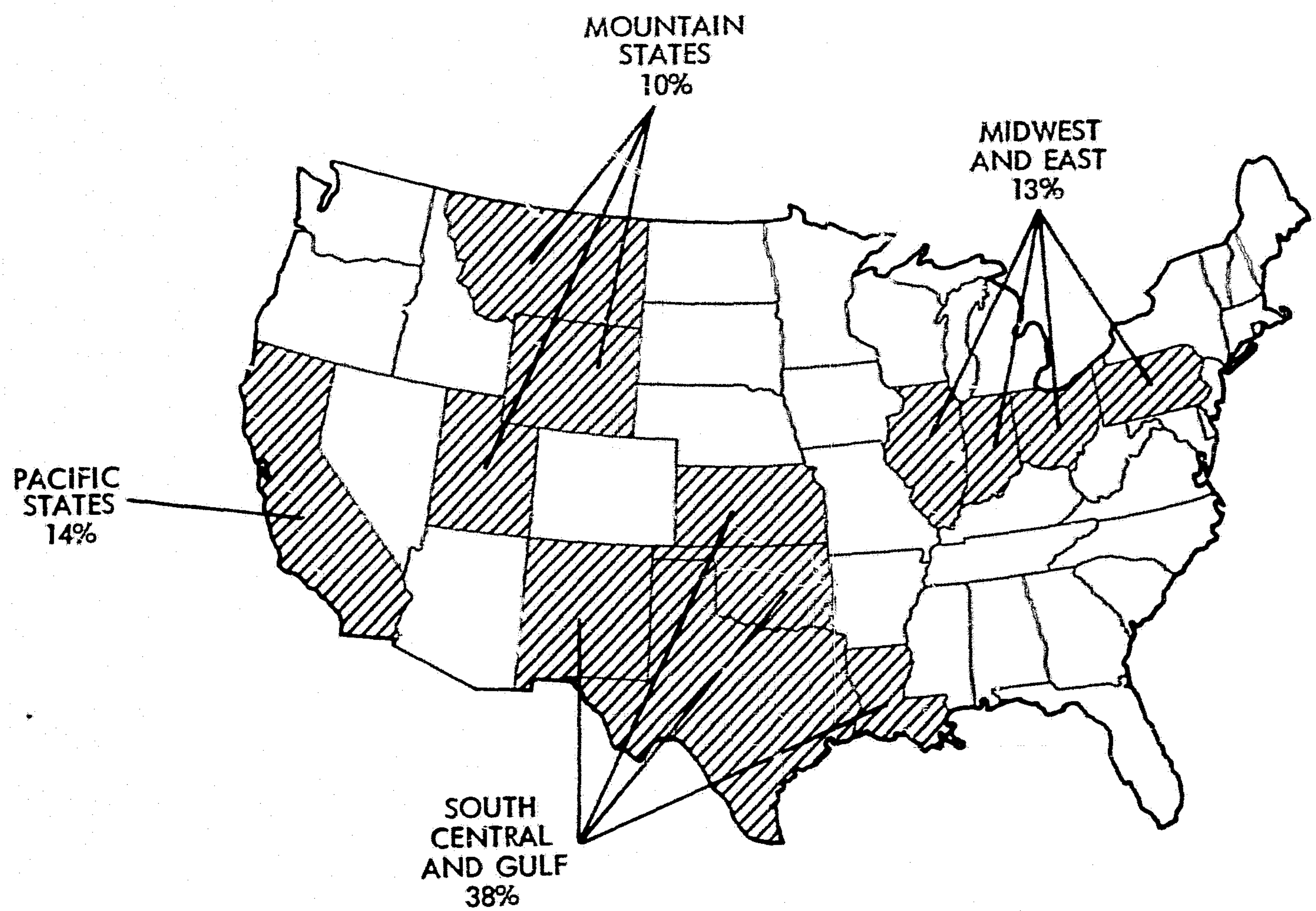
Table A-38. U.S. Refinery Size Distribution as of January 1, 1975

Capacity Range 10^3B/CD [a]	Number of Refineries		Total Capacity, B/CD [a]	Percent of Capacity	Average Capacity, B/CD [a]
≤5	49		146,592	0.99	2,992
5-10	31	124	230,688	1.55	7,442
10-15	19		234,780	1.58	12,357
15-25	25		517,520	3.49	20,701
25-50	50		1,910,592	12.87	38,712
50-75	21		1,309,385	8.82	62,352
75-100	21		1,878,950	12.66	89,474
100-200	28		4,002,900	26.96	142,961
>200	15		4,614,000	31.08	307,600
TOTAL	259		14,845,407	100.00	57,318

Median Capacity (128 refineries smaller, 128 refineries larger) = 28,500 B/CD

[a]B/CD = barrels per calendar day. 1 barrel = 42 gallons = 158.97 liters.

This table was extracted from Battelle Columbus Laboratories report entitled "Survey of the Applications of Solar Thermal Energy Systems to Industry Process Heat" - Volume 2, January, 1977.



NOTES:

(1) Total Number of refineries in U.S., 285.
(2) Total Number of indicated on this map, 212, for 75% of the total.
(3) Shaded states represent 7 or more refineries per state, for 2.5% of total per state.

Figure A-21. Petroleum Refinery Concentrations

GLASS CONTAINERS (SIC 3231)

The first production of glass containers was in Jamestown, Virginia in the early 1600's and used the old glass blowing method. It is considered America's first industry. Mass production of glass containers was made possible in the early 1900's with the development of the first bottle-making machine, and caused rapid expansion of the industry. The first commercial glass-making plants were located near the raw materials necessary to make the glass; silica (sand), limestone, and soda ash. For example, there are large sand deposits in Oklahoma and consequently there are a number of old plants located in the state. Plant location philosphy changed with the development of rail transportation in the country and plants were subsequently built close to their service accounts. This brought the industry nearer to the populated areas; mostly east of the Mississippi River.

Today, there are 129 glass container plants in the United States (Table A-39). Of the 129 plants, 76% are located east of the Mississippi River. In order to determine where the concentrations are, states with five or more plants (3.8% of the total per state) were selected. This amounts to 59.4% of the total plants, or 77 out of the 129 shown in Table A-40. Figure A-22 presents the regional concentrations. Most of the industry is located in the northeastern part of the United States. Five states, Pennsylvania, Illinois, Indiana, West Virginia and New York have 49 plants, 39% of the total.

Production in the glass-container industry is increasing every year, although not as rapidly as in the past. The following data shows production for the years 1950 to 1976 with rate increases:

Year	Shipments $\times 10^9$ lb	Increase Per Year $\times 10^9$ lb
1950	9.0	0.4
1960	12.9	1.0
1970	22.7	0.6
1976	26.0	

Although the rate of increase is declining, the industry is expected to grow over the long term. The number of plants is expected to increase with time. Most of the increased production is expected to come from these new plants. Older plants in urban areas are being modified but they are unable to expand because of a lack of available land. When new plants are built, they are normally located close to their prime customers (i.e., breweries).

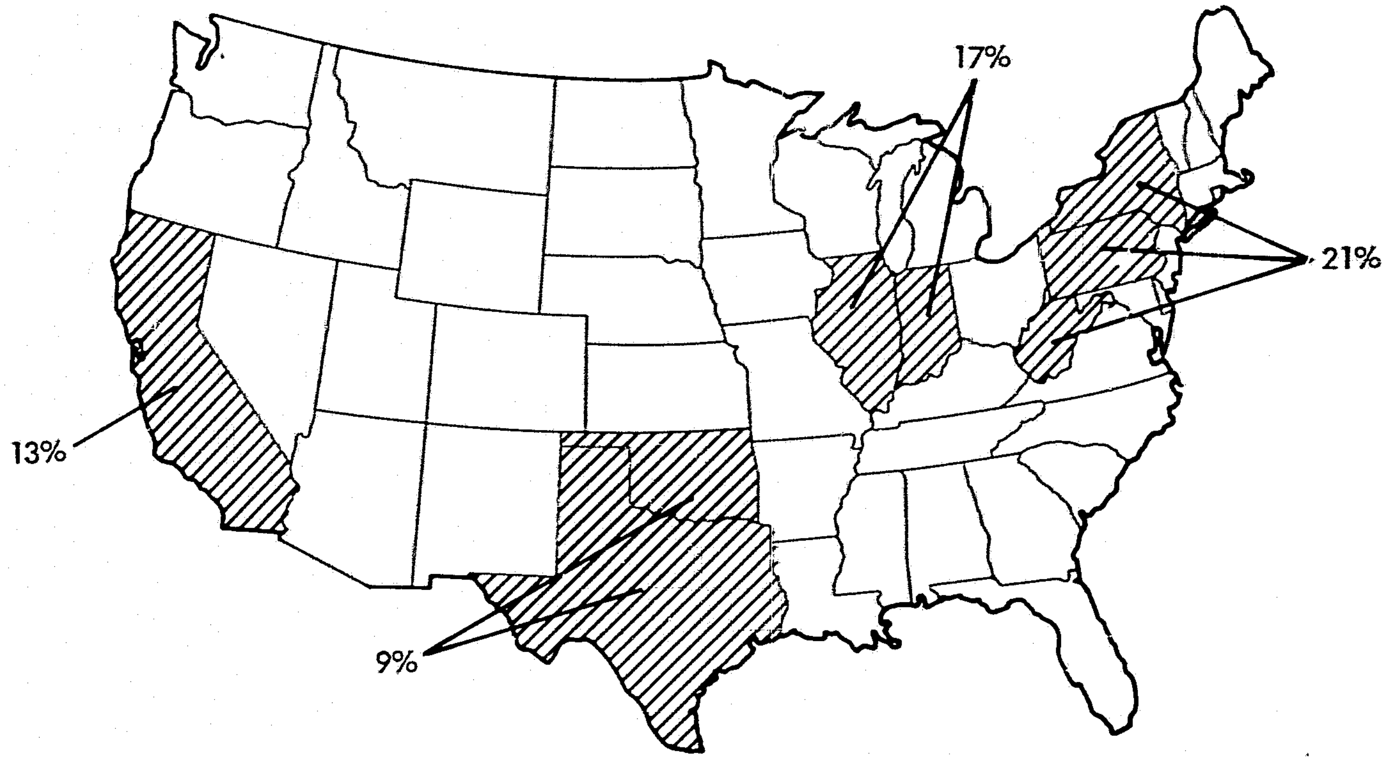
Companies within the industry are becoming less in number and are larger and more diversified. Many are now manufacturing containers other than glass, tin cans, plastics and paperboard containers, once the traditional competitors of the glass industry.

Table A-39. Glass Container Plants, Location and Number

Location	No. of Plants	% of Total
Alabama	1	0.8
Arkasas	1	0.8
California	16	12.4
Colorado	1	0.8
Connecticut	1	0.8
Florida	4	3.1
Georgia	3	2.3
Illinois	12	9.3
Indiana	10	7.7
Louisiana	3	2.3
Maryland	3	2.3
Massachusetts	2	1.6
Michigan	1	0.8
Minnesota	2	1.6
Mississippi	3	2.3
Missouri	1	0.8
New Jersey	13	10.0
New York	5	3.8
North Carolina	4	3.1
Ohio	2	1.6
Oklahoma	7	5.4
Oregon	1	0.8
Pennsylvania	16	12.4
Rhode Island	1	0.8
South Carolina	1	0.8
Tennessee	1	0.8
Texas	5	3.8
Virginia	1	0.8
Washington	1	0.8
West Virginia	6	4.6
Wisconsin	1	0.8
TOTALS	129	100.0

Table A-40. Glass Container Plants, Regional Concentrations

Region	No. of Plants in State	% of Total	No. of Plants in Region	% of Total
PACIFIC			16	12.4
California	16	12.4		
SOUTH CENTRAL			12	9.2
Oklahoma	7	5.4		
Texas	5	3.8		
MIDWEST			22	17.0
Illinois	12	9.3		
Indiana	10	7.7		
NORTH ATLANTIC			27	20.8
Pennsylvania	16	12.4		
West Virginia	6	4.6		
New York	5	3.8		
TOTALS	77	59.4	77	59.4



NOTES:

(1) Total number of plants in U.S., 129.
(2) Total shown on this map, 77, for 60% of total.
(3) States shown have 3.8% of total per state and 5 or more plants per state.

Figure A-22. Glass Container Plants Concentrations

CEMENT (SIC 3241)

The first cement plant was constructed in 1871 in Lehigh Valley, Pennsylvania (near Allentown) because of the availability of limestone in this area. Cement plants grew in number at locations where raw materials such as limestone were available and where the market created a demand for the product. Now, most cement plants tend to be located within 150 to 200 miles of their principal markets. Beyond that distance, overland transportation costs become excessive in relation to the value of the product. Because of the regional nature of cement markets, the optimum plant size tends to be that which combines maximum production efficiencies with expectations of product demand in the geographic area served by the plant. For this reason, extremely large plants (those of a million or more tons of annual capacity) are generally located on waterways. This permits transportation of cement by boat or barge to distant terminals in other market areas that are, in some cases, hundreds of miles from the plant.

In 1977, there were 167 cement plants in the United States, operated by fifty-two companies. Table A-41 lists these plants by state and the percentage of plants in each state. The highest concentration of plants now exists in the northeastern and south central states (Figure A-23).

At the present time, the ten leading cement-producing states account for 63% of the total cement production capacity in the United States and 47% of national cement consumption. Table A-42 lists the cement production capacity of each state and the predicted ranking of the top five states in the year 2000.

The average cement plant production has grown from 165,000 tons per year in 1950 to 563,000 tons per year at the present time. Today, the production ranges from 55,000 tons per year to 2.4 million tons per year.

At present, the dry-process technology accounts for 45% of the total industry. Nearly all new plant construction, plant expansions, and modernizations are incorporating preheater dry-process technology, as the dry process is more energy-efficient. It is expected that by the year 2000, 75% of the industry will be composed of dry-process plants.

It is difficult to predict the patterns in cement use, but one indicator is per capita cement consumption. Table A-43 lists consumption by state in the year 1976. The long-term trend line in the figure indicates that per capita use nationally has grown approximately 40% in the period 1947-1977. It is evident from the actual consumption curve that cement consumption is relatively sensitive on a short-term basis.

Although production has remained level for the past 5 to 6 years, with an average annual production of 97 x 10^6 tons, it is anticipated that cement production will increase 3% to 5% over the next 10 years. This rate of increase in production suggests that the construction of new plants will not be necessary. Recently, the trend has been toward making major modifications to existing plants and replacing old hardware with new technology equipment. The average lifetime of a cement plant is about 18 to 20 years. The oldest plant in existence has been operating over 50 years, but has been continuously modified and updated.

Because the major market for cement is now west of the Mississippi, it is expected that in the next 30 years existing plants in the West will modernize and expand. New plants with large capacities will also be built in the West, and the older plants in the East will shut down. Although the total production may not increase tremendously, it is anticipated that plants will be relocated to the western part of the country.

Table A-41. Cement Plants Location and Number (Wet and Dry Process Plants Included)

Location	No. of Plants	Percentage of Total	Location	No. of Plants	Percentage of Total
Alabama	7	4.2	Montana	2	1.2
Arizona	2	1.2	Nebraska	2	1.2
Arkansas	2	1.2	Nevada	1	0.6
California	12	7.2	New Mexico	1	0.6
Colorado	3	1.8	New York	7	4.2
Florida	6	3.6	North Carolina	1	0.6
Georgia	3	1.8	Ohio	5	3.0
Hawaii	2	1.2	Oklahoma	3	1.8
Idaho	1	0.6	Oregon	2	1.2
Illinois	4	2.4	Pennsylvania	18	10.7
Indiana	5	3.0	South Carolina	3	1.8
Iowa	5	3.0	South Dakota	1	0.6
Kansas	5	3.0	Tennessee	6	3.6
Kentucky	1	0.6	Texas	21	12.5
Louisiana	2	1.2	Utah	2	1.2
Maine	1	0.6	Virginia	2	1.2
Maryland	3	1.8	Washington	4	2.4
Michigan	8	4.8	West Virginia	1	0.6
Mississippi	2	1.2	Wisconsin	3	1.8
Missouri	7	4.2	Wyoming	1	0.6
			TOTALS	167	100.0

Table A-42. U.S. Cement Production Capacity by States (1976)

Location	Companies	No. of Plants[a]	Total Capacity 1000 Tons	Rank (Top 40)	Estimated Rank Yr 2000
Alabama	6	7	3902	8	
Arizona	2	2	1720	18	
Arkansas	2	2	1245	23	
California	8	12	10095	1	2
Colorado	2	3	1714	19	
Florida	5	6	3957	7	4
Georgia	3	3	1683	21	
Hawaii	2	2	770	27	
Idaho	1	1	210	39	
Illinois	4	4	2810	11	
Indiana	4	5	3496	9	
Iowa	5	5	3093	10	
Kansas	5	5	2386	14	
Kentucky	1	1	660	30	
Louisiana	2	2	1089	24	
Maine	1	1	472	35	
Maryland	3	3	1861	16	
Michigan	8	8	6442	4	5
Mississippi	2	2	664	29	
Missouri	6	7	4956	5	
Montana	2	2	650	31	
Nebraska	2	2	1025	25	
Nevada	1	1	400	37	
New Mexico	1	1	420	36	
New York	6	7	4684	6	
North Carolina	1	1	610	33	
Ohio	5	5	2451	13	
Oklahoma	3	3	1698	20	
Oregon	1	2	630	32	
Pennsylvania	12	18	9499	2	3
South Carolina	3	3	2539	12	
South Dakota	1	1	570	34	
Tennessee	4	6	2004	15	
Texas	13	21	8928	3	1
Utah	2	2	710	28	
Virginia	1	2	1530	22	
Washington	4	4	1789	17	
West Virginia	1	1	935	26	
Wisconsin	3	3	374	38	
Wyoming	1	1	200	40	
TOTALS	139	167	94,871		

[a]Includes grinding-only and white cement plants.

Table A-43. U.S. Cement Consumption by States (1976)

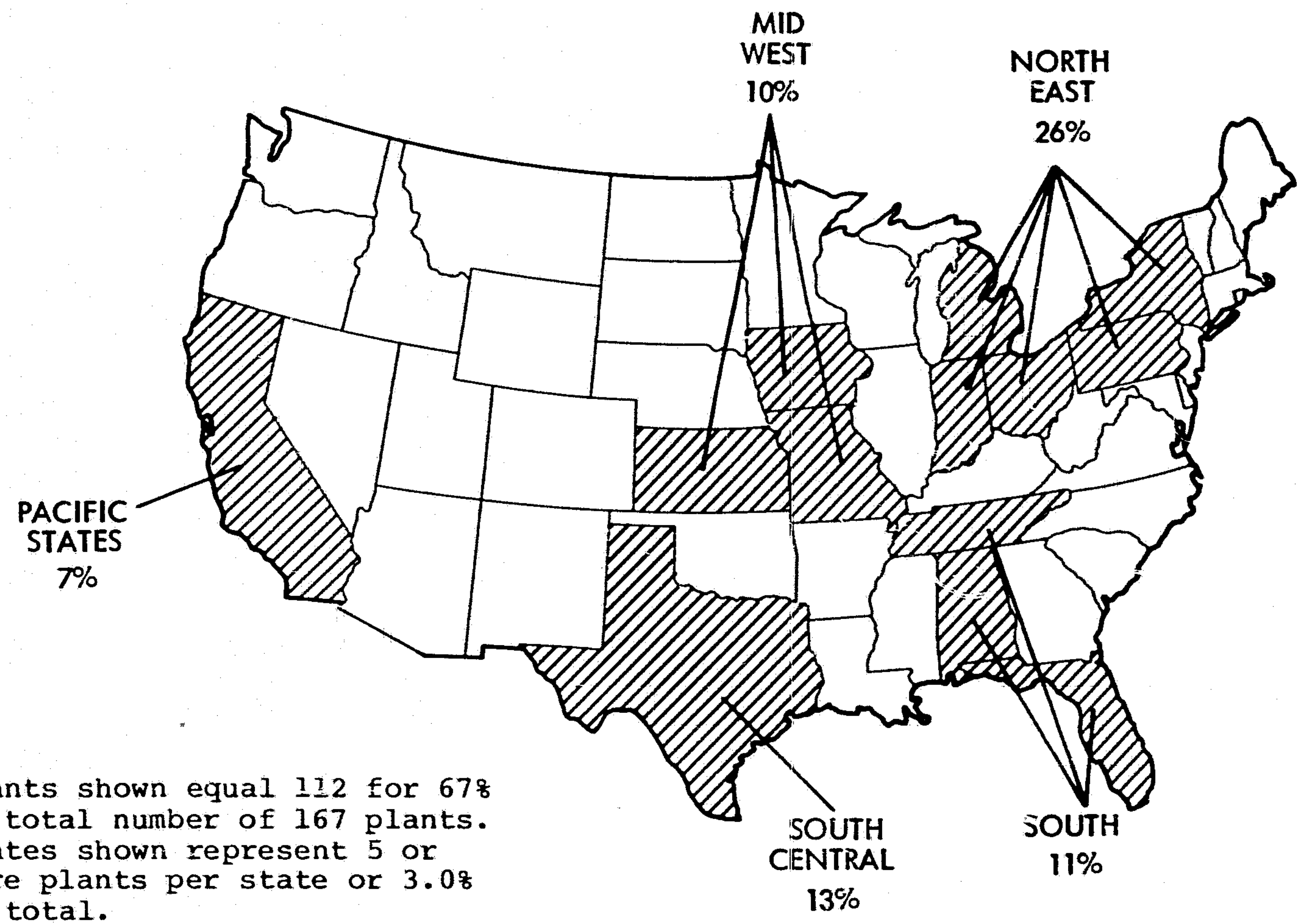
Location	Consumption, 1000 Tons	Rank[a]	Per Capita Consumption, lb	Rank[a]
Alabama	1361	18	743	21
Alaska	163	48	854	17
Arizona	1117	26	985	12
Arkansas	886	30	841	18
California	7316	1	680	27
Colorado	1197	23	927	14
Connecticut	563	36	362	48
Delaware	142	49	488	44
D.C.	196	47	559	40
Florida	3389	4	805	19
Georgia	1644	13	662	29
Hawaii	327	44	738	22
Idaho	512	38	1233	7
Illinois	3759	3	670	28
Indiana	1682	12	635	33
Iowa	1849	10	1289	5
Kansas	1228	22	1064	10
Kentucky	1046	27	611	35
Louisiana	2500	8	1302	4
Maine	308	45	576	36
Maryland	1188	24	574	38
Massachusetts	810	32	279	50
Michigan	2595	7	571	39
Minnesota	1551	16	783	20
Mississippi	831	31	707	24
Missouri	1723	11	722	23
Montana	336	43	893	16
Nebraska	1029	28	1326	3
Nevada	363	42	1191	8
New Hampshire	236	46	575	37
New Jersey	1351	19	369	47
New Mexico	543	37	930	13
New York	2088	9	231	51
North Carolina	1459	17	534	42
North Dakota	412	40	1282	6
Ohio	2770	6	519	43
Oklahoma	1262	21	913	15
Oregon	794	33	682	26
Pennsylvania	2850	5	481	45
Rhode Island	141	50	305	49

[a]Rank among 50 states and District of Columbia.

Table A-43 (Cont'd)

Location	Consumption, 1000 Tons	Rank[a]	Per Capita Consumption, lb	Rank[a]
South Carolina	782	34	550	41
South Dakota	376	41	1097	9
Tennessee	1310	20	622	34
Texas	6482	2	1039	11
Utah	919	29	1497	2
Vermont	109	51	458	46
Virginia	1598	15	636	32
Washington	[illegible]	25	647	30
West Washington	5[illegible]5	35	636	31
Wisconsin	1602	14	696	25
Wyoming	418	39	2144	1

[a]Rank among 50 states and District of Columbia



NOTES:

(1) Plants shown equal 112 for 67% of total number of 167 plants.
(2) States shown represent 5 or more plants per state or 3.0% of total.
(3) Wet and dry process included.

Figure A-23. Cement Plant Concentrations

INTEGRATED STEEL (SIC 3312)

The steel industry in the United States began shortly after the close of the Civil War. The location of plants depended on the proximity to the required raw materials, primarily high-grade ore and water. The discovery of high-grade ore was an important factor in the industrialization of the nation; new ore discoveries encouraged the development of transportation systems for hauling ore to the steel mills.

Integrated steel mills produce molten pig iron from raw materials which may then be combined with scrap and converted into steel, using either an open hearth furnace or a basic oxygen furnace. The open hearth process was the primary method of steel production for many years; more recently the basic oxygen method has become predominant due to economic and environmental factors.

In 1977, there were 44 integrated steel mills located throughout the United States. The majority of the plants (25) are located in Pennsylvania, Ohio, Indiana, and Illinois (Figure A-24). Table A-43 lists the location, by state, of the plants and the percentage concentration of plants in the states with major production.

Total integrated steel production for the United States in 1977 was 125.3 million tons. Most of the integrated steel mills produce more than three million tons of output per year; the greatest amount being five million tons per year. The states of Pennsylvania, Ohio, Indiana and Illinois produce 63.6% of the total capacity. Table A-44 indicates the production in each state, as well as the production concentration.

Industry expansion is usually accomplished through the modification of existing plants. Older plants are usually renovated rather than rebuilt due to capital requirements. Most of the new, integrated steel mills were built around 1955. A few of the older plants have been shut down due to costly pollution control requirements. When new plants are built, they are usually located in the traditional areas of high concentration, ruling out any relocation of the industry.

The industry is expected to continue growing at about 2.6% per year, as it has since the 1960's. This would make the industry capable of producing 200 million tons per year beginning in 1983. The additional capacity is expected to come from modification and expansion of existing plants rather than the construction of new plants.

Table A-43. Location and Concentration of Integrated Steel Mills

LOCATION

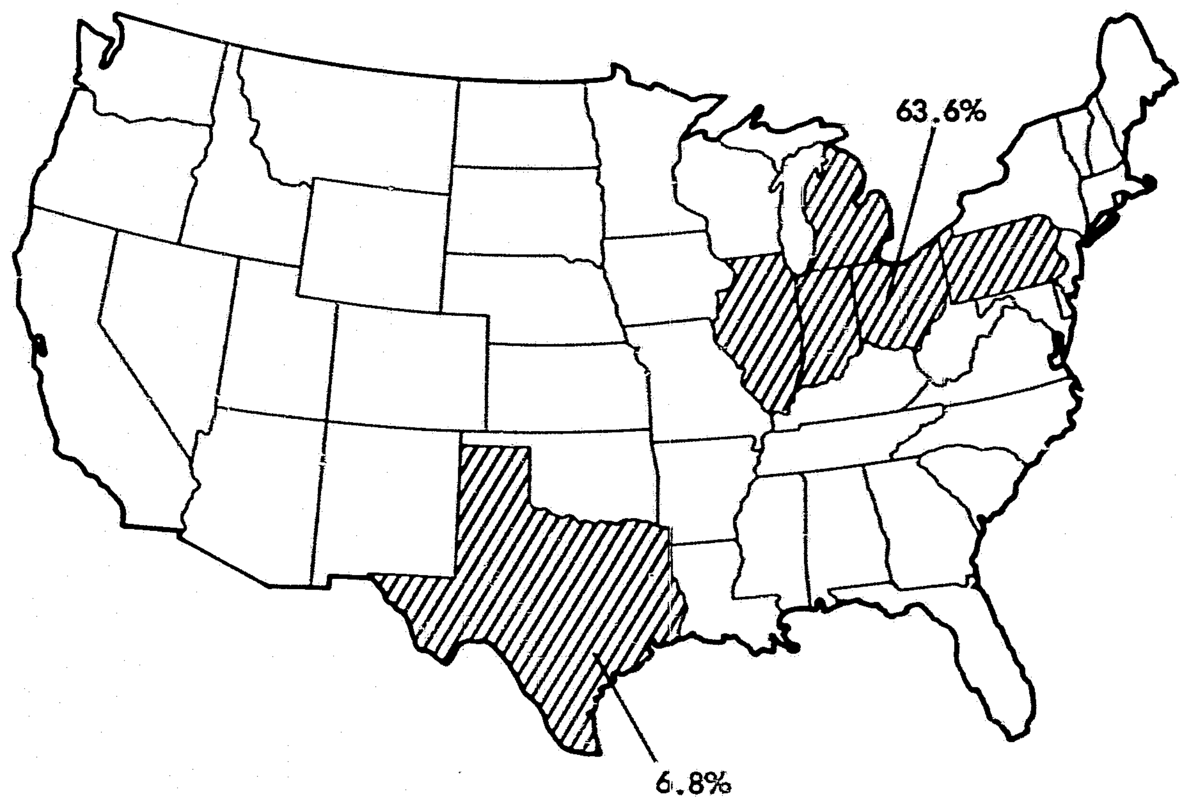
State	No. of Mills	% of Total
Alabama	2	4.5
California	1	2.3
Colorado	1	2.3
Illinois	5	11.4
Indiana	4	9.1
Kentucky	2	4.5
Maryland	1	2.3
Michigan	3	6.8
Minnesota	1	2.3
New York	2	4.5
Ohio	7	15.9
Pennsylvania	9	20.4
South Carolina	1	2.3
Texas	3	6.8
Utah	1	2.3
West Virginia	1	2.3
TOTALS	44	100.0

CONCENTRATIONS

State	No. of Mills	% of Total
Pennsylvania	9	20.4
Ohio	7	15.9
Illinois	5	11.4
Indiana	4	9.1
Michigan	3	6.8
Texas	3	6.8
TOTALS	31	70.4

Table A-44. U.S. Integrated Steel Mill Capacity (1977)

State	Capacity (Thousand of Net Tons)	% of Total
Alabama	3,963	3.2
California	3,224	2.6
Colorado & Utah	4,758	3.8
Illinois	10,872	8.7
Indiana	21,472	17.1
Kentucky	2,289	1.8
Maryland	5,306	4.2
Michigan	10,051	8.0
Minnesota & Texas	6,753	5.4
New York	3,958	3.2
Ohio	21,466	17.1
Pennsylvania	25,737	20.5
S. Carolina & W. Virginia	5,484	4.4
TOTALS	125,333	100.0



NOTE:

Shaded areas represent
70.4% of the total.

Figure A-24. Concentration of Integrated Steel Mills

Primary Copper (Smelting and Refining - SIC 3331)

Copper smelting and refining are each separate processes and both are different from the initial mining operation. The major copper producers in the United States are integrated companies that mine, smelt and refine their own copper ore. In addition, the larger producers often process copper mined by the smaller companies. This report is concerned only with the smelting and refining processes in producing copper.

Traditionally, the smelting of copper ore has been carried out near the copper mines, generally within the same state as the mines. The principal factor in this arrangement is the minimization of transportation costs. On the other hand, the processing of copper concentrates by electrolytic refineries has traditionally been located closer to the consumers and primarily on the East Coast.

In 1977, there were 19 primary smelters in the United States, 14 of them located in the western part of the country. Arizona is the leading state, with seven smelters. There were 14 refining plants in the U.S. in 1977 and the largest concentration of plants, 28.6%, was located in the eastern states of New York, Pennsylvania, New Jersey and Maryland.

In general, the smelting capacity concentration parallels the plant concentration and Arizona is again the leading state with 48.5% of the total U.S. smelting capacity. The refining capacity concentrations, however, present an entirely different picture from the plant concentrations. The leading state is Texas, with 34.7% of the total U.S. refining capacity. The four eastern states with the largest plant concentration comprise only 23.1% of the total refining capacity. The capacity concentrations for smelting and refining are illustrated in Figure A-25.

Because of the large capital investment required for a new plant, the copper industry has traditionally increased capacity through expansion and modification of existing plants rather than new construction. Recently, some new refineries have been built in the west nearer to the smelters (which explains the difference in plant and capacity concentrations discussed above) but it is unlikely that there will be more new construction in the future. The primary reasons for this unlikelihood are the large capital investment per dollar of revenue potential, the relatively low growth in demand, the cyclical nature of the demand, and environmental regulations. In general, production costs at existing facilities are less than costs from new facilities.

Copper production grew at a compound annual rate of 1.3% from 1967 to 1977. In 1977, the total smelting capacity was more than nine million short tons and the total refining capacity was about 2.5 million short tons. The major problems facing the industry that have affected investment are heavy debt burdens, primarily from large pollution abatement expenditures, inflation affecting capital costs, and the prolonged depression in copper prices. Although the industry has shown little growth in recent years, there are several positive factors that could contribute to an increased demand in the future. In particular, the telephone company has significantly increased its demand for communication wire and cable and the strong construction market will also be demanding more building wire and cable. In addition, it has been forecasted that the copper/aluminum price gap will close considerably because of widespread opposition to aluminum wiring for homes and a much stronger business climate. Thus, a 4% annual growth rate is expected over the next 5 years.

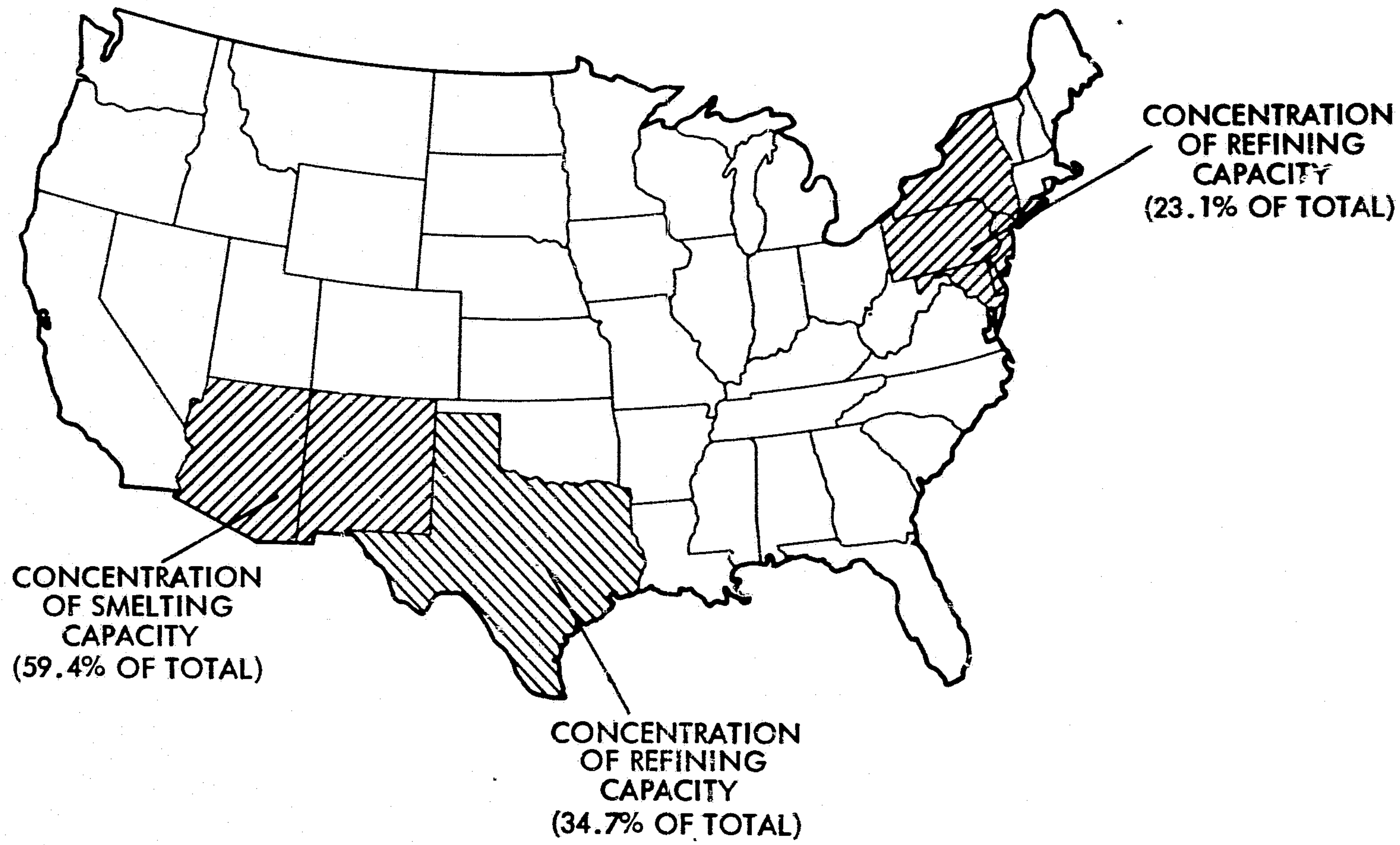


Figure A-25. Copper Industry Concentration

PRIMARY ALUMINUM (SIC 3334)

The primary aluminum smeltering process requires a tremendous amount of electrical power, which made it necessary for early plants to be located where low-cost energy was available. Early plants were built in the areas administered by the Bonneville Power Administration in the Pacific Northwest and the Tennessee Valley Authority in the Southeast. Texas was an advantageous location, due to its large quantities of lignite and natural gas; New York was also advantageous because of the availability of low-cost hydropower.

In 1977, there were 32 aluminum plants in the United States, located in 16 states (Table A-45). The aluminum production capacity for 1977 was 5.193×10^6 short tons (Figure A-26); the actual production (Figure A-27) was 4.539×10^6 short tons (87.4% output-to-capacity ratio). Table A-47 lists the capacity of each company and the number of plants per company. The areas of the Pacific Northwest, Southeast, Texas and New York are the largest producers. Table A-46 lists all of the plants, along with each plant's production capacity and start-up date.

Rising energy prices are cause for concern within the aluminum industry. The Bonneville Power Administration increased the price of electricity in 1978 by 150%. Two plants in Texas have been closed due to rising natural gas prices. As a result, U.S. aluminum producers have begun to build new plants in foreign countries rather than the United States. Brazil, the Middle East, Southeast Asia and Malaysia all have available, low-cost energy for new plants. The single new plant under construction in the U.S. is in Berkely, South Carolina. It is owned by Alumax and should go on line in 1981, producing 100,000 tons per year. Alumax also has preliminary plans for a new plant in Umatillo, Oregon. Due to the small amount of new construction in the United States, no relocation of the primary aluminum industry is expected.

Table A-45. Location of Aluminum Plants

State	No. of Plants	% of Total	1977 Production Capacity 10^3 Metric Tons	% of Total Capacity
Alabama	2	6.3	288	6.1
Arkansas	2	6.3	175	3.7
Indiana	1	3.1	263	5.6
Kentucky	2	6.3	272	5.8
Louisiana	2	6.3	269	5.7
Maryland	1	3.1	160	3.4
Missouri	1	3.1	127	2.7
Montana	1	3.1	163	3.5
New York	2	6.3	309	6.6
North Carolina	1	3.1	114	2.4
Ohio	1	3.1	236	5.0
Oregon	2	6.3	200	4.2
Tennessee	2	6.3	326	6.9
Texas	4	12.5	567	12.0
Washington	7	21.7	1099	23.3
West Virginia	1	3.1	148	3.1
TOTALS	32	100.0	4716	100.0

Table A-46. Aluminum Companies

Company	No. of Plants	1977 Production Capacity x 10^3 Metric Tons	% of Total Capacity
Alcoa	9	1521	32.3
Reynolds	7	884	18.7
Kaiser	4	657	13.9
Anaconda	2	272	5.8
Intalco	1	236	5.0
Ormet	1	236	5.0
Martin-Marietta	2	191	4.0
Consolidated	2	164	3.5
National-Southwire	1	163	3.5
Estalco	1	160	3.4
Noranda	1	127	2.7
Revere	1	105	2.2
TOTALS	32	4716	100.0

Table A-47. Primary Aluminum Smelters in the United States, Production Capacity and Start-up Date

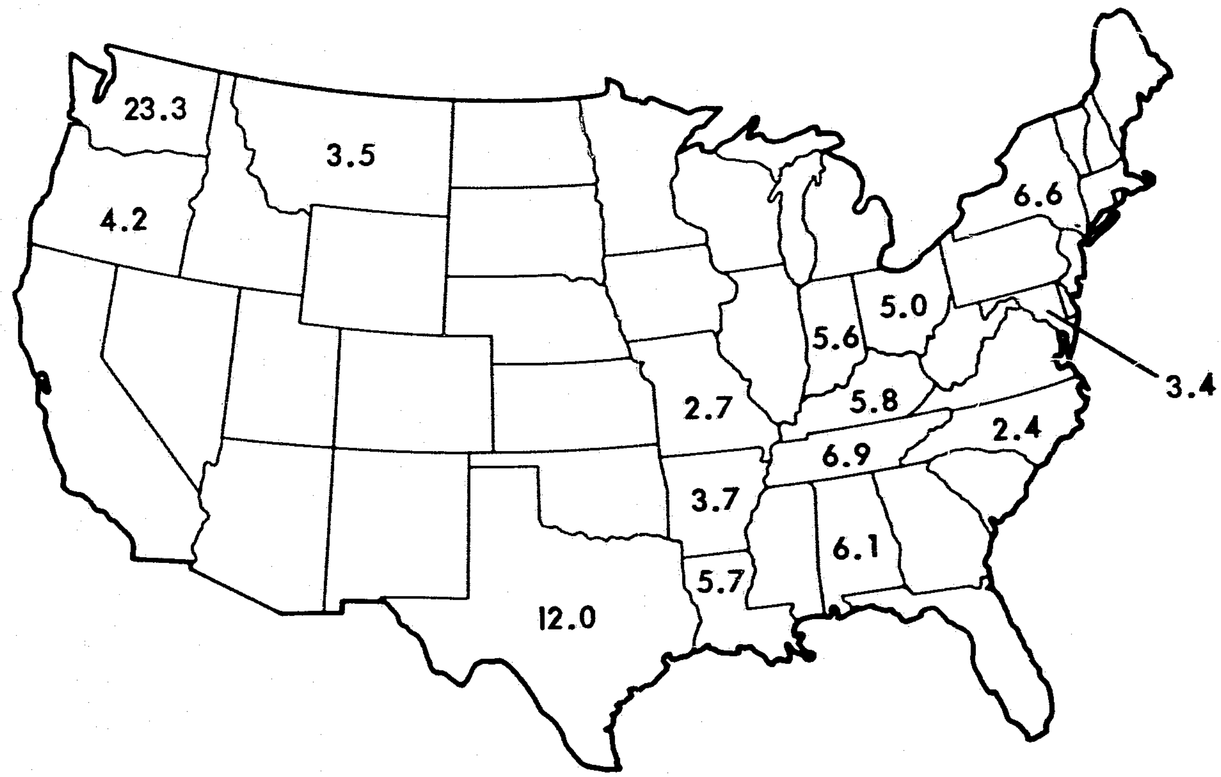
Company and Location	1977 Production Capacity, 1000 Metric Tons of Aluminum	Start-up Date
Aluminum Company of America		
Alcoa, Tennessee	195	1914
Badin, North Carolina	114	1916
Massena, New York	195	1903
Palistine, Texas	14	1976
Point Comfort, Texas	168	1949[a]
Rockdale, Texas		1952
Vancouver, Washington	104	1940
Evansville, Indiana	263	1960
Wenatchee, Washington	186	1952
Anaconda Aluminum Company		
Columbia Falls, Montana	163	1955
Sebree, Kentucky	109	1974
Consolidated Aluminum Corporation		
Lake Charles, Louisiana	33	1974
New Johnsonville, Tennessee	131	1963
Eastalco Aluminum Company		
Frederick, Maryland	160	1970
Martin-Marietta		
The Dalles, Oregon	82	1958
Goldendale, Washington	109	?
Intalco Aluminum Corporation		
Ferndale, Washington	236	1966
Kaiser Aluminum & Chemical Corp.		
Chalmette, Louisiana	236	1951
Mead, Washington	200	1942
Ravenswood, West Virginia	148	1957
Tacoma, Washington	73	1942
National-Southwire Aluminum Company		
Hawesville, Kentucky	163	1969
Noranda		
New Madrid, Missouri	127	1971

[a]Currently shut down.

Table A-47. (Cont'd)

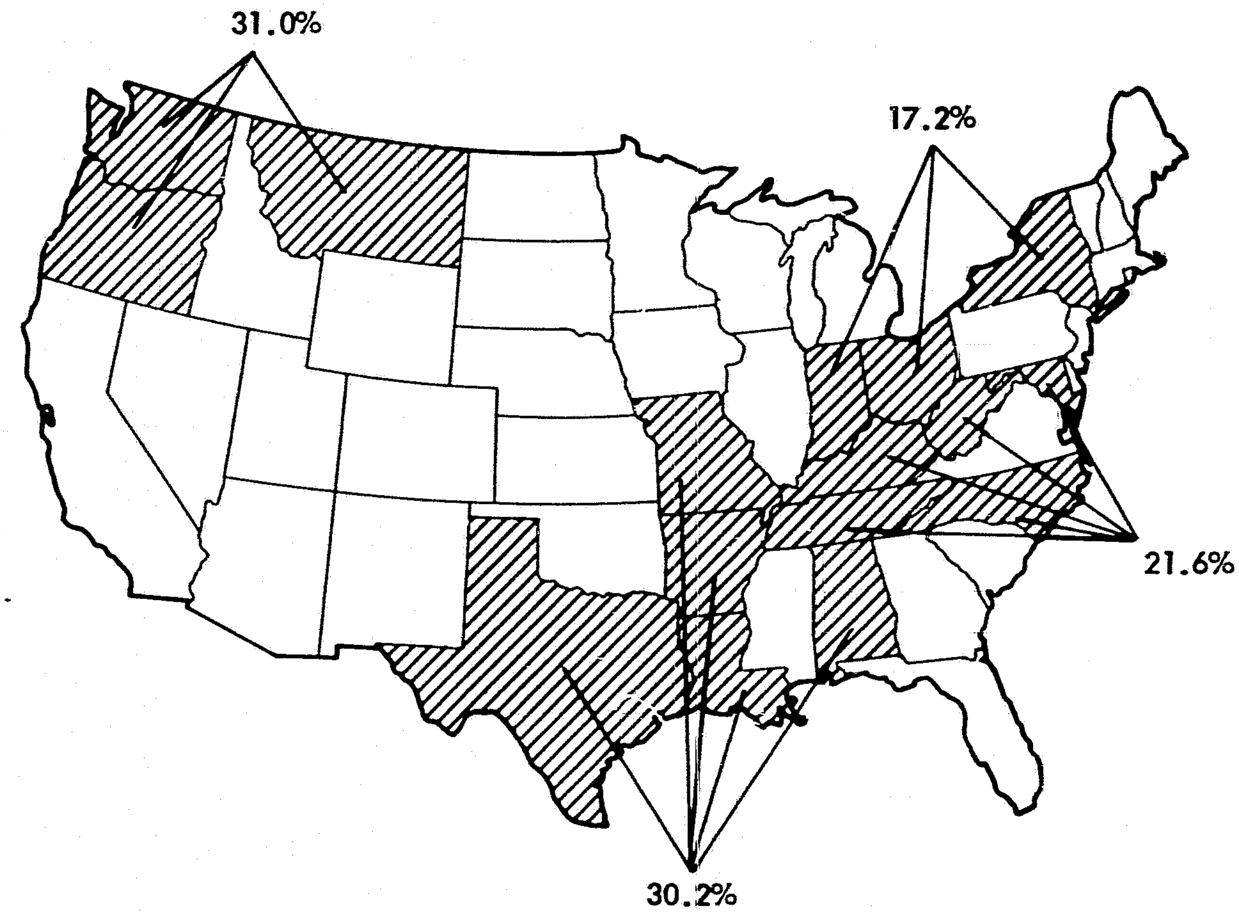
Company	1977 Production Capacity, 1000 Metric Tons of Aluminum	Start-up Date
Ormet Corporation		
Hannibal, Ohio	236	1958
Revere		
Scottsboro, Alabama	105	1971
Reynolds		
Arkadelphia, Arkansas	62	1954
Jones Mills, Arkansas	113	1942
Listerhill, Alabama	183	1940
Longview, Washington	191	1941
Massena, New York	114	1953
Corpus Christi, Texas	103	1952[a]
Troutdale, Oregon	118	1942
32 Misc. Plants	4716	Avg. 1952

[a]Currently shut down.



1977 TOTAL = 5.193×10^6 Short Tons.

Figure A-26. Aluminum Production Capacity (Shown as % of Total)



1977 TOTAL = 4,716,000 Metric Tons.

Figure A-27. Aluminum Industry Concentration

MOTOR VEHICLE ASSEMBLY PLANTS (SIC 3711)

The automobile era in the United States dates from September 21, 1893, when a motor carriage with a one-cylinder gasoline engine was developed in Springfield, Massachusetts. Although various types of vehicles were produced in the following years, it was not until 1897 that actual production for a sales market took place. The automobile industry has been located primarily in the mid-western states from its beginning. The hardwood forests of Michigan and Indiana had made the region the center of carriage and wagon manufacturing; the transition to motor vehicles was a natural one, as the machine shop facilities and skilled labor were already available in this region. In 1914, complete moving assembly-line production was begun by Ford Motor Company.

Because the motor vehicle industry is so complex and is composed of so many industries, only motor vehicle assembly plants have been selected for the primary contents of this report. The most recent statistics compiled in December 1977 by the Motor Vehicle Manufacturers Association indicate that there are 101 assembly plants located in 30 states. Table A-49 lists the number of motor vehicle assemmbly plants in each state and the percentage of the total number of plants. The geographical concentration of plants is shown in Figure A-28. As is shown in the figure, the present concentration of plants is much the same as it was at the inception of the industry, i.e., primarily in the mid-western states.

The motor vehicle industry is composed of five major automobile manufacturers and nine truck manufacturers. Production figures for automobile manufacturers and their various car models are shown in Table A-50 (1978), and the production figures for trucks are shown in Table A-51. A comparison between 1977 and 1978 production figures is also included. The production figures for the year 1974 are listed by state in Table A-52. In the following years, production increased, and in 1977 9.3 million cars were produced.

A number of factors affect the dynamics of the U.S. motor vehicle industry. Competition with foreign imports has been a major factor since the rising cost of fuel has brought about a larger demand for smaller cars. However, according to a study by Predicasts, a business information and market research firm, the United States will remain the world's largest producer of autos through 1990. Japan's production, however, is expected to be within 10% of U.S. output by then. In the study, Predicasts also noted that the Japanese code of lifetime employment "makes it unlikely that production plants will be built in major export markets such as the U.S." German vehicles, however, are already being manufactured in the United States. A new Volkswagen assembly plant is being constructed in New Stanton, Pennsylvania, and will have an annual rated capacity of 200,000. Volkswagen also bought a stamping plant from American Motors located in Charleston, West Virginia.

Despite the competition from foreign imports, the U.S. motor vehicle industry has been growing in production by 1% to 3% per year. Growth is expected to continue to be moderate and to fluctuate, due to the many factors affecting the industry. New plants are being built at various locations in the country but modification of existing plants will be the dominant trend in years to come. Beyond 1982, federal emissions, safety, and fuel economy standards will require extensive product changes with large capital expenditures. If the modification of manufacturing lines is possible, it will most likely be done, as modifications are more economical than building a new plant. However, if the vehicle design changes radically, it becomes necessary to redesign the plant floor plan. At present, the median age of an assembly plant is about 20 years. Because cars are changing so rapidly, assembly plants must be at the state-of-the-art. Plants are now being designed and constructed with as much built-in flexibility as possible.

In an effort to cope with the rising costs in other related industries such as steel, rubber, plastic, and aluminum, American car manufacturers have been working in the past few years toward the development of smaller cars which use less material. As the cost of fuel is also continuing to rise, smaller cars that use less fuel are becoming more attractive. Other methods to cope with the energy problem and reduce manufacturers' costs are being tried. For example, between 1971 and 1975, the Chrysler Corporation tried to uncomplicate the car-building process by eliminating 5500 detail parts. They also applied interchangeability techniques to new body designs and built parts which were usable on both the right and left sides of a car.

Research and development programs are being designed to explore the possibilities of alternate engines in order to achieve major fuel efficiency gains at acceptable emission levels. The engines which appear to have potential for high volume production between 1980 and 1985 are the stratified charge and the lightweight diesel. These engines are derivatives of the current spark-ignited, passenger car engine, and do not involve long lead times for R&D or the tooling required for more exotic engines. Candidates for the post-1985 engine include the gas turbine, Stirling-cycle engine, and electric drive and spark-ignition engines fueled with either a blend of gasoline and alcohol or pure alcohol. The gas turbine and Sterling-engines will require major technological breakthroughs for development of production designs. In addition, either type of engine would require complete rebuilding of engine production facilities. There are approximately 40 engine-producing assembly lines in the United States. Conversion of these production lines or installation of new lines to produce different engines would require 10 to 15 years and an estimated annual investment of between $400 and $500 million. A complete conversion to a new type of engine, such as the gas-turbine or Stirling-cycle, does not appear feasible until the middle 1990's.

Although the motor vehicle industry began near Detroit, it has grown to be a major industry all over the world. The demand for motor vehicles is now widespread throughout the United States and, instead of shipp' ıg the finished motor vehicle, it has become more economical to ship parts to assembly plants in other areas of the country. For this reason, new assebmly plants will continue to be built in other parts of the country as well as in the Mid-West. At this time, it is difficult to predict the exact location of new plants. Most likely, they will be built where the demand for motor vehicles is greatest and where labor, shipping, and material costs are most economical.

Table A-49. Location of Motor Vehicle Assembly Plants

	No. of Plants	% of Total		No of Plants	% of Total
Alabama	1	1.0	Mississippi	1	1.0
Arkansas	2	2.0	Missouri	7	6.9
California	11	11.0	New Jersey	3	2.9
Colorado	2	2.0	New York	3	2.9
Connecticut	1	1.0	North Dakota	1	1.0
Delaware	2	2.0	Ohio	12	11.9
Georgia	3	2.9	Oklahoma	1	1.0
Illinois	3	2.9	Oregon	1	1.0
Indiana	7	6.9	Pennsylvania	3	2.9
Kansas	1	1.0	Tennessee	2	2.0
Kentucky	2	2.0	Texas	1	1.0
Maryland	1	1.0	Utah	1	1.0
Massachusetts	1	1.0	Virginia	2	2.0
Michigan	19	18.8	Washington	1	1.0
Minnesota	1	1.0	Wisconsin	5	5.0
			TOTALS	101	100.0

Table A-50. U.S. Car Production

Company		Jan. 1 to July 29, 1978	% of Total
American Motors		78,758	1.4
Chrysler Corporation		695,770	12.6
Plymouth	292,033		
Chrysler	132,835		
Dodge	270,902		
Ford Motor		1,508,772	27.3
Ford Division	1,044,245		
Lincoln-Mercury Div.	464,527		
General Motors		3,232,918	58.5
Buick Division	500,013		
Cadillac Division	214,448		
Chevrolet Division	1,435,117		
Oldsmobile Division	548,975		
Pontiac Division	534,365		
Volkswagen		3,356	0.1
Checker		2,628	0.1
TOTAL Cars Produced in USA (from Jan. thru July '78)		5,522,202	100.00

Production Comparison

Jan. 1 to July 30, 1977	=	5,667,475
Jan. 1 to July 29, 1978	=	5,522,202
Decrease in Production	=	145,273

% Decrease '77 to '78 = -2.6%

Table A-51. U.S. Truck Production

Company	Jan. 1 to July 29, 1978	% of Total
Ford	697,621	33.3
Chevrolet	666,400	31.8
Dodge	281,585	13.5
GMC	222,498	10.6
Jeep[a]	102,583	4.9
International	65,087	3.1
Mack	20,383	1.0
White[b]	7,280	0.3
AM Corporation[c]	9,167	0.5
Miscellaneous	20,220	1.0
Total Trucks Produced in USA (from Jan. thru July '78)	2,092,824	100.0

Production Comparision

Jan. 1 to July 30, 1977	=	2,044,468
Jan. 1 to July 29, 1978	=	2,092,824
Increase in Products	=	88,356
% Increase '77 to '78	=	4.4%

[a]Jeep includes commercial vehicles only.

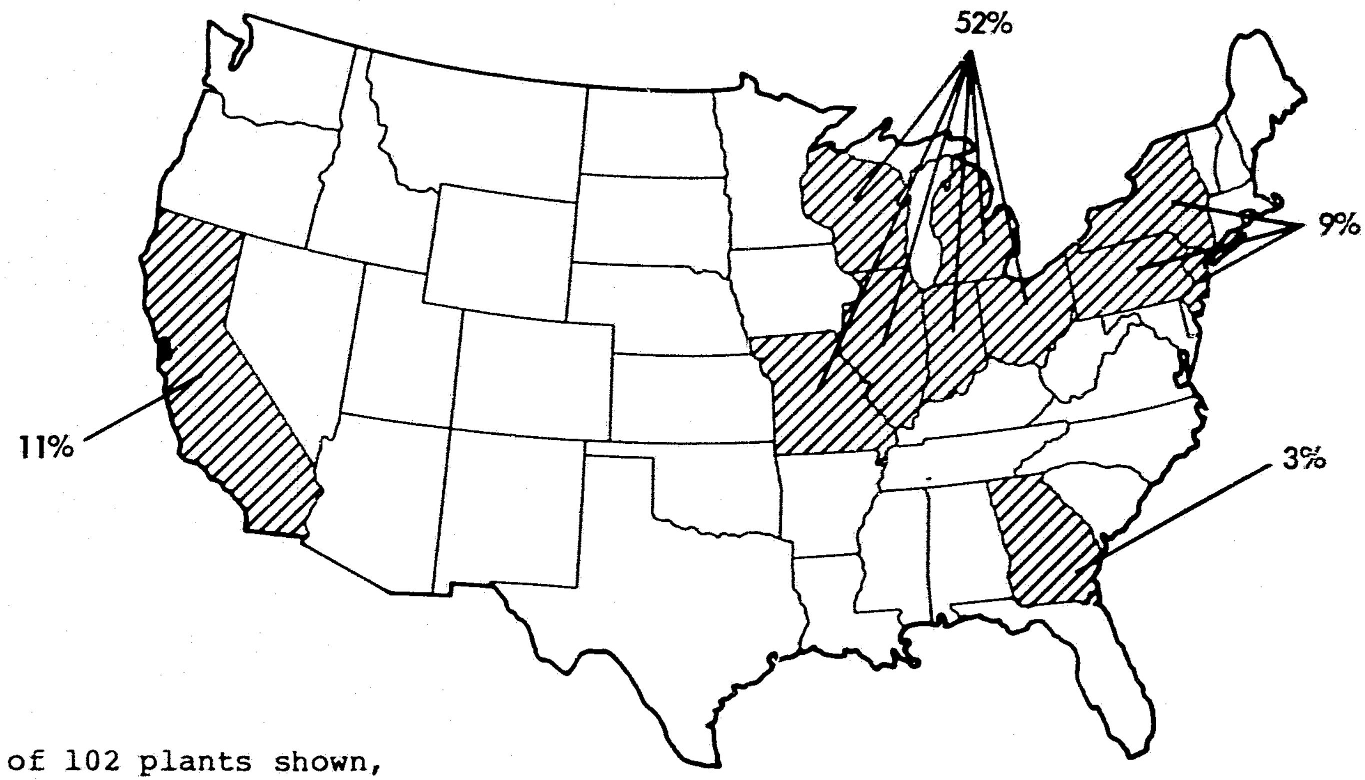
[b]White total includes Autocar, Western Star, and Freightliner (through 1977).

[c]AM General includes government-destined vehicles.

Table A-52. Car and Truck Assemblies (1974)

State	Cars[a] Units	%	Trucks[b] Units	%	Cars and Trucks Units	%
Michigan	2,534,420	31.2	899,624	33.9	3,434,044	31.8
Ohio	886,425	10.9	471,338	17.7	1,357,764	12.6
Missouri	916,964	11,3	279,256	10.5	1,196,220	11.1
California	620,542	7.6	223,867	8.4	844,409	7.8
Wisconsin	616,617	7.6	80,464	3.0	697,081	6.5
New Jersey	532,047	6.5	54,432	2.0	586,479	5.4
Georgia	436,113	5.4	114,731	4.3	550,844	5.1
Illinois	327,082	4.0			327,082	3.0
Delaware	309,173	3.8			309,173	2.9
Maryland	218,534	2.7	90,157	3.4	308,691	2.9
Kentucky	65,323	0.8	211,554	8.0	276,877	2.6
Texas	199,743	2.5	1,202	-	200,945	1.9
New York	154,304	1.9	3,129	0.1	157,433	1.5
Kansas	118,597	1.5	-	-	118,597	1.0
Indiana			103,925	3.9	103,925	1.0
Massachusetts	97,924	1.1			97,924	0.9
Minnesota	69,051	0.9	24,591	0.9	93,642	0.9
Virginia	26,614	0.3	60,393	2.3	87,007	0.8
Pennsylvania			25,229	0.9	25,229	0.2
Oregon			6,340	0.2	6,340	0.1
Tennessee			4,320	0.2	4,320	-
Washington			4,160	0.2	4,160	-
Connecticut			1,363	0.1	1,363	-
Utah			440	-	440	-
TOTALS	8,129,474	100.0	2,660,515	100.0	10,789,989	100.0

[a]Car production, 1974 model year.
[b]Truck assemblies, 1974.



NOTES:

(1) 76 of 102 plants shown, or 75% of the total.
(2) States with 3 or more plants (3% of total) are shown.

Figure A-28. Motor Vehicle Assembly Plants Concentration