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STRATEGIES IMPLEMENTED BY THE TEXTILE INDUSTRY IN RESPONSE TO NATURAL GAS CURTAILMENTS

Final Report

By
Robert L. Schreibeis

January 1980

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Division of Industrial Energy Conservation

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STRATEGIES IMPLEMENTED BY THE TEXTILE INDUSTRY IN RESPONSE TO NATURAL GAS CURTAILMENTS

FINAL REPORT

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U.S. DEPARTMENT OF ENERGY
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PREFACE

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Executive Summary

Natural gas supply interruptions resulted in production losses and plant closings during the winter of 1976-77. Among the industries most severely affected was the textile mill products group located primarily in the Southeastern U.S. The objective of this research was to identify and evaluate trends in the selection of short and long-term curtailment strategies implemented by textile firms in response to natural gas curtailments.

Towards that end, the energy intensive sectors of the industry were identified and sampled. Specific strategies were inventoried and evaluated in terms of plant size, type, and location. The level of expenditures for particular strategies and the regional distributions of curtailment impacts were documented. A cursory evaluation of the industry's capitalization problems was performed.

The industry sample was comprised of 34 firms located in the Carolinas and Georgia. An official from each firm responded to questions posed in a personal interview. These responses were coded and statistically evaluated by means of the Factor Analysis procedure of the Statistical Analysis System (SAS).

Cause and effect relationships were identified for several groups of variables as a product of the factor analysis. The most significant findings were expressed in terms of plant size, type, location, and severity of curtailment impacts.

- Plant size greatly influenced the level of curtailment spending and therefore, the strategies which were implemented over both the short and long term.

A sales volume criterion of $10 million was used to differentiate between large and small textile firms. Small firms generally suffered less severe impacts, possibly as a result of their higher curtailment priority classifications. The majority of small firms (65%) spent less than $10,000 for short-term curtailment relief with a maximum observed short-term expenditure of $112,000. Small firms with alternate fuel capabilities typically reported short-term expenditures of 10% more than their normal fuel bill for the period of curtailment impacts. In contrast, only 12% of the large firms reported spending less than $10,000 for short-term curtailment relief. Short-term expenditures for the large firms exceeded $500,000 in at least one instance.

In either case, short-term strategies were aimed primarily at the acquisition and storage of additional fuel supplies. More than 55 percent of the sample spent (on the average) 0.10 percent of their annual sales volume for short-term curtailment relief in the form of alternate fuel and/or fuel systems. Small firms favored an increase in the storage capacity of existing alternate fuel systems (primarily fuel oil). Larger firms more frequently added a complete alternate fuel system, usually propane. Special fuel purchases were made by nearly twice as many large firms as small. Large firms benefited from financial and administrative economies of scale as well, which enabled them to implement the more elaborate fuel acquisition schemes. These included gas purchases at the well-head and the bulk transport of propane in tanker trucks. Short-term remedial strategies implemented by the small firms tended to be less elaborate and were often temporary in nature.

Long-term curtailment strategies reflected a similar pattern. The purchase of altogether new energy saving technologies (e.g., jet dyeing) was reported exclusively by the larger firms. Other major additions such as boiler economizers or load management systems were similarly restricted to the larger firms. Smaller firms favored the low-cost measures that could be tailored to their individual requirements. Both automating the control of valves and traps, and switching to lower temperature dyestuffs were more popular with the smaller firms. Large and small plants utilized waste-water heat recovery and environmental controls with the same frequency. In addition, the motivation behind long-term curtailment related spending differed greatly between large and small plants. Smaller firms claimed that the curtailments accelerated changes that would have been postponed otherwise. Larger firms recognized the need to compete more efficiently and developed plans for modernization.

- Geographic location accounted for differences in the severity of and therefore, the reactions to curtailment impacts.

Natural gas pipeline service in the study area was provided by two interstate and five intrastate carriers. The two interstate pipelines owned by Southern Natural Gas Co., and Transcontinential Gas Pipe Line Corporation, both experienced demand surges and supply curtailments. Customers served by Southern however, underwent the most severe curtailments. Over 55 percent of our sample claimed to have suffered some form of impacts as a result of natural gas curtailments in the winter of 1976-77. Firms served by Transco experienced less hardship and spent less for curtailment remedies than those served by Southern.

The state of North Carolina is served exclusively by Transco and therefore, suffered the mildest curtailment impacts. Textile firms in South Carolina and Georgia (approximately 80 and 90 percent dependent on Southern for their natural gas supplies, respectively) were subjected to longer and more severe curtailments. The Georgia sample was least prepared to deal with the curtailments because of a lack of adequate alternate fuel capabilities.

- o Plants performing similar operations in close geographic proximity reacted consistently to natural gas curtailment impacts.

The majority of the sample did not adopt a consistent approach in handling their individual curtailment circumstances. Firms in the floor covering industry in Georgia however, were the exception. Due to a uniform operating environment, the floor covering industry appeared to have reacted as a distinct unit within SIC 22. The Georgia sample accounted for 80 percent of the total of new standby fuel installations reported. All of the firms that did not have an alternate fuel capability installed one; a large mill with an existing standby system purchased another. None of the other plant types included in the industry sample exhibited identifiable trends in the selection and implementation of curtailment strategies.

The concept of "total fuel flexibility" was suggested by several respondents as the optimal strategy for the future. A total fuel flexibility strategy would enable the firm to use gas, oil, coal, renewable resources, or plant waste at any given time. The main barriers to the adoption of such a strategy are the industry's resistance to change and the difficulty associated with financing the requisite capital additions.

I. Introduction

The incidence of interruptions in natural gas service by interstate pipeline companies has increased steadily since the Federal Energy Regulatory Commission (FERC) began monitoring deliveries and curtailments in 1970.[1)] The winter of 1976-77 was a period during which weather related gas curtailments led to adverse economic and social impacts in many states. Among the areas most severely affected was the South Atlantic region, which for the purposes of this study includes the states of Georgia, North Carolina, and South Carolina.

In efforts to assess the regional economic and social impacts resulting from natural gas curtailments, the textile industry was chosen as a case study. The textile industry is concentrated in the South Atlantic region and depends heavily on natural gas for process heat. As such, the industry was particularly vulnerable to supply interruptions and the resultant economic losses from production discontinuities. Two interstate pipelines service the region. Both experienced supply curtailments which elicited varying responses from individual firms in the textile industry. The purpose of this study is to examine the specific activities undertaken by these firms in the South Atlantic region, to insulate themselves against production losses resulting from natural gas curtailments.

This study is one of three tasks commissioned by the U.S. Department of Energy. The first task examines the effects of production shutdowns on the various economic and social measures of community well-being. The second phase

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[1)] Personal Communication, Mr. John Harlan, Federal Energy Regulatory Commission, January 9, 1979.

which is the subject of this document, focuses on patterns or trends of precautionary activities undertaken by textile firms in response to fuel supply interruptions. The third phase aims to assess the potential for forecasting supply interruptions by means of long-range weather projections.

The reports covering the first and third tasks are being submitted separately. Each report will provide industry and government decision-makers with a different perspective on the complexity of planning problems associated with fuel supply uncertainties.

Results of the research effort on the second task are reported in this document. Chapter II delineates the scope of the project, research design, and nature of the textile industry. Supporting documentation for Chapter II is included in Appendices A and B.

One hundred candidate firms for detailed study were identified by means of an industry directory which provided operational profiles of the firms. Selection of these firms was made primarily on the basis of size and relative intensity of natural gas use. Of these 100 candidates, 34 agreed to discuss their alternate fuel strategies with us. A list of questions was developed to characterize the industrial firms with whom discussions were held.

Information obtained from the firms was analyzed by means of two statistical analysis techniques. A discussion of the methods employed and the results obtained is presented in Chapter III. Relationships between specific variables were identified and interpreted in terms of their ability to explain industrial strategies implemented to avert natural gas curtailments. Summary data generated by the computer analyses are included in Appendices A and C, as well as Exhibits in the body of the report.

The overall results of the study are summarized in Chapter IV, along with a discussion of their significance as applied to the prospective future use of solar industrial process heat systems. In this context, an overview of the industry's financial structure is presented to highlight the investment dilemma facing corporate planners.

The conclusions presented in the report resulted from our interpretation of the statistical analysis performed on the data obtained from the thirty-four interviews with textile industry officials. These data supported the contention that certain precautionary strategies were implemented by firms having common characteristics. Variations in the strategies implemented by various concerns were accounted for in terms of geographic location, plant size, plant type, and the duration and extent of curtailment impacts. Ranges of expenditures for short and long term strategies were also identified.

II. Scope of the Project

2.1 Objective of the Research

The study described in this document was aimed at evaluating the reactions of textile industry establishments in Georgia and the Carolinas, to the adverse impacts resulting from a natural gas curtailment during the winter of 1976-77. The specific objectives of the research were:

- To examine current and planned precautionary strategies undertaken by textile firms in the Southeastern U.S., in order to avoid interruptions in production from natural gas curtailments.
- To isolate trends in the selection of such strategies and to discern the rationale behind their selection.
- To estimate the net costs of strategies implemented and planned, for a range of plant sizes.

In addition, the research results were intended to illuminate the prevailing attitude of textile industry officials in terms of fuel supply availability and investment planning. This insight could enable the advantages of solar process heat systems to be presented in a meaningful way to corporate planners. The methods employed in the realization of these objectives are discussed below.

2.2 Research Design

An overview of the research approach is presented in Exhibit 1. In efforts to define the dimensions of the study, available information sources were explored. Trade organizations, their publications, expert consultants, and a literature search provided insight into the structure of the textile industry. A survey of these sources enabled us to define the overall framework within which specific curtailment related activities would be identified.

Personal interviews with an appropriate sample of industrial concerns was found to hold the greatest potential for providing accurate results. Towards that end, an assessment of the energy intensive segments of the textile industry was conducted. The intention was to narrow the scope of the study to those firms which employed natural gas intensive operations. Knowledge of where and how natural gas was consumed facilitated the selection of a representative sample of textile firms for consideration. Exhibit 2 shows locations in the Southeast where interviews were conducted with textile industry representatives.

The schedule-structured method of interviewing was selected for use in the study. The order in which the questions were asked and their wording were identical for all of the interviews. This approach helped to insure that variations in response would be attributed to actual differences between respondents, and not to the conduct of the interview. Thus, a reliable data base was obtained and subjected to statistical analysis.

With the overall research objectives in mind, an evaluation of the information requirements of the study led to the development of a series of interview questions listed in Appendix A. The questions were intended to measure the:

EXHIBIT 1

RESEARCH DESIGN FLOW DIAGRAM

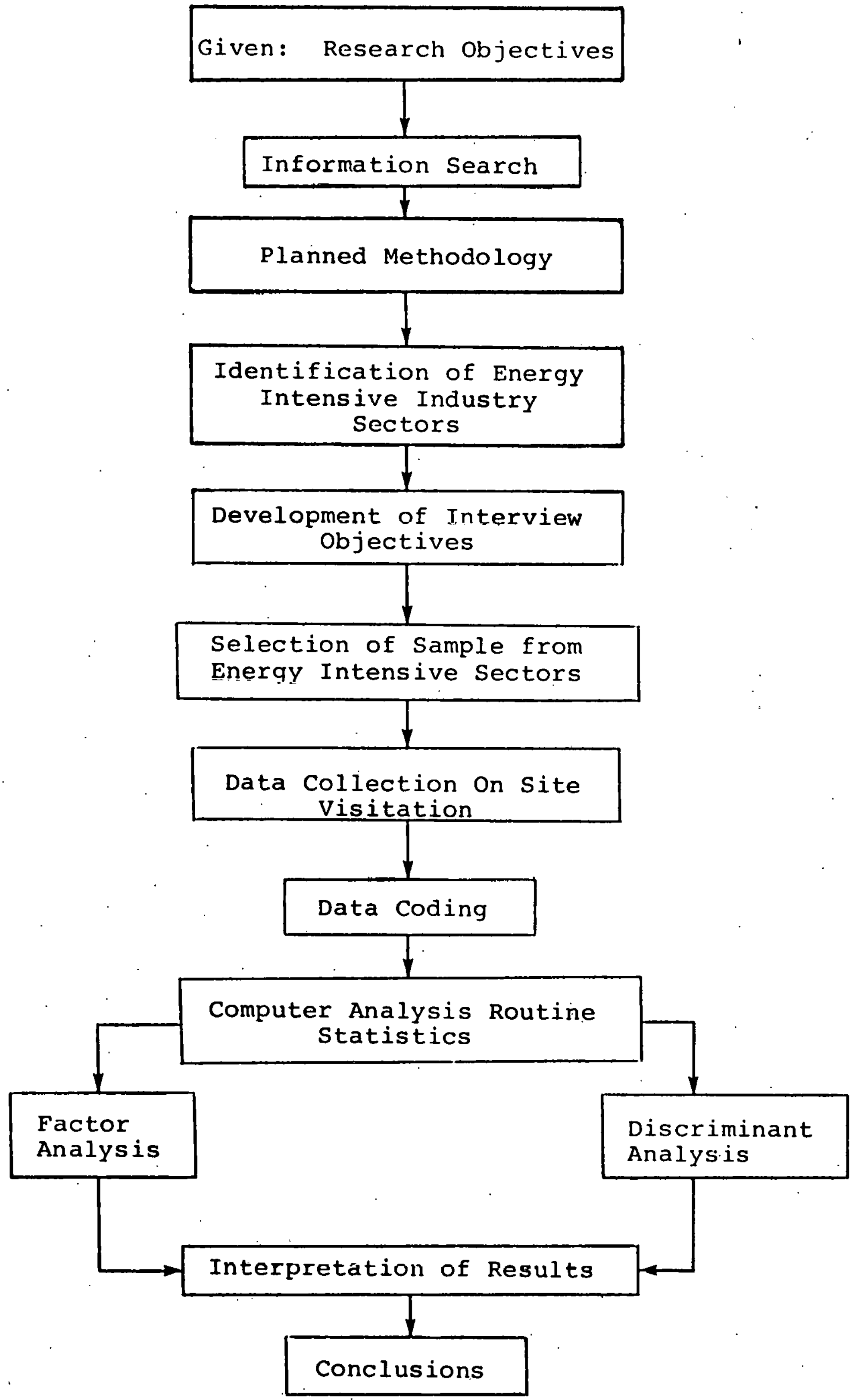
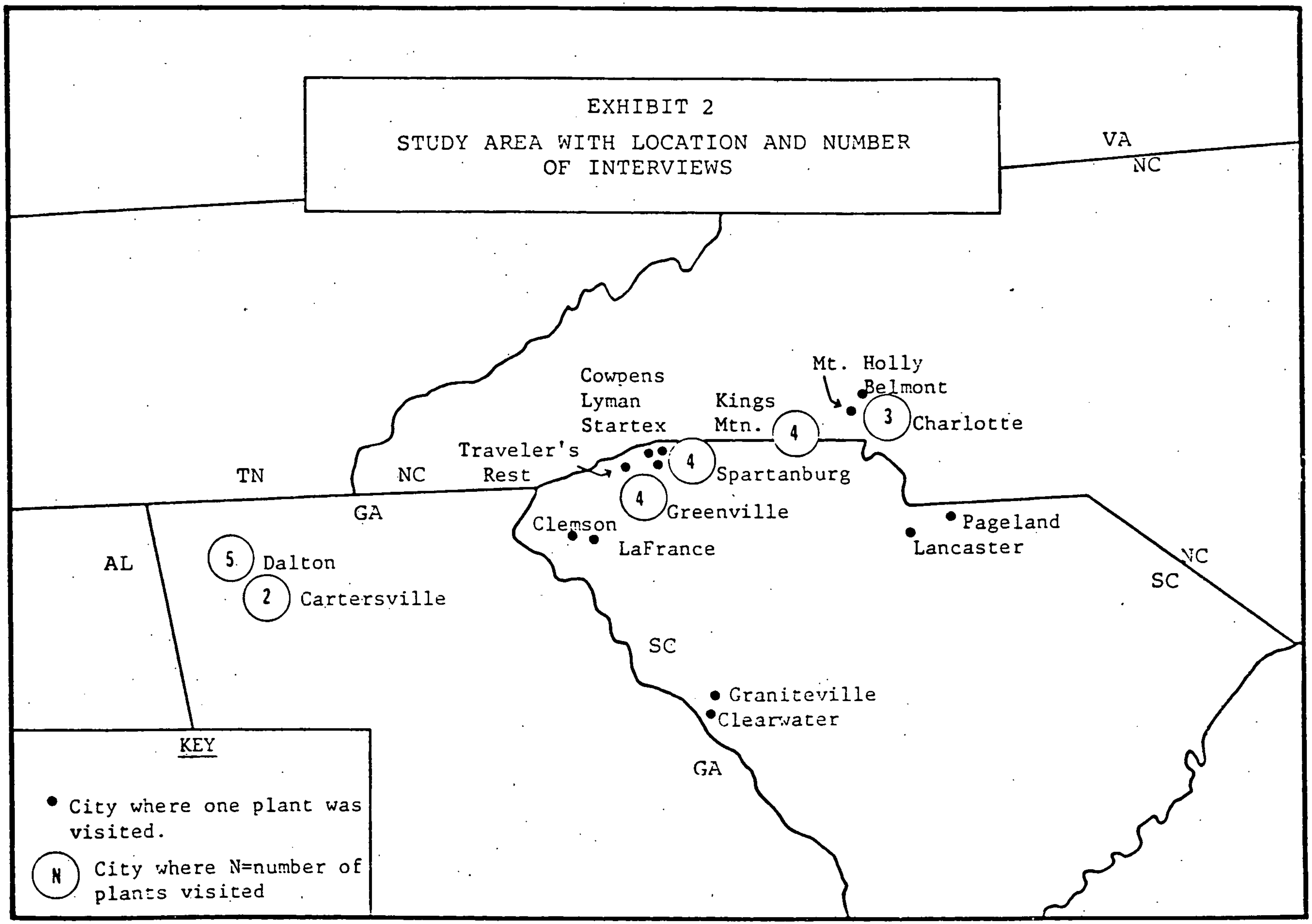


EXHIBIT 2

STUDY AREA WITH LOCATION AND NUMBER OF INTERVIEWS



- o demographic composition of the sample;
- o extent and duration of curtailment impacts;
- o strategies implemented and costs incurred as a result of curtailments; and
- o motivation behind the selection of particular strategies.

The process of compiling a list of candidate firms was carried out using an industry directory[2)] as the data base. One hundred natural gas intensive firms were selected as candidates. Thirty-four of these agreed to participate in the interviews and were contacted by one of our two experienced interviewers. A list of the positions held by the interviewees is included in Exhibit 3.

The purpose of the study was explained to respondents in advance, as was the possibility that direct quotes might be included in the final report. Assurances were given however, that these quotes would not be attributed to specific individuals or organizations. Appointments for the interviews were made with individuals who had been both with the company during the study period and directly involved in energy operations. The actual interviews were conducted during a three week period in October and November, 1978.

Responses to the interview questions were compiled and organized so as to highlight the most distinct differences encountered over the course of the thirty-four interviews. Numerical coding of the responses preceded the statistical analyses upon which the conclusions of this report are based.

[2)] Davison Publishing Co., Davison's Textile Blue Book, 112th edition, Ridgewood, NJ: 1978.

EXHIBIT 3

POSITIONS HELD BY INTERVIEWEES AND
FREQUENCY OF RESPONSE (N=34)

President of the Company	2
Vice President for Energy Conservation	6
Director of Engineering	2
Director of Purchasing	2
Corporate Engineer	5
Coordinator of Energy Conservation	1
General Manager	7
Plant Engineer	7
Master Mechanic	2
	34

The statistical analyses employed in this study were selected from two pre-programmed statistical packages which were designed to handle data of this type. The Statistical Analysis System (SAS)[3], and the Statistical Package for the Social Sciences (SPSS)[4], were used to generalize the interview data and, verify the accuracy of sample classification parameters, respectively.

2.3 Characterization of the Industry

In 1976, the Federal Energy Administration identified the ten most energy-consumptive industries in the United States.[5] The textile mill products group, SIC 22, ranked tenth in the country. The industry as a whole accounts for approximately 3% of our total annual industrial energy consumption.

Approximately 75% of the textile industry establishments are concentrated in North Carolina, South Carolina, and Georgia.[6] These states are served by either one or two interstate gas pipelines, both of which experienced supply curtailments in the winter of 1976-77. Where energy intensive industries are concentrated, particularly with a limited set of supply options, the effects

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[3] Barr, Anthony J., J.H. Goodnight, et al., A User's Guide to SAS '76, Raleigh, NC: Sparks Press, 1976.

[4] Nie, Norman H., C. Hadlai Hull, et al., Statistical Package for the Social Sciences, SPSS, Second Edition, New York: McGraw-Hill, 1975.

[5] 41 Federal Register, 12766, March 26, 1976.

[6] Hester, J. Charles, et al., Feasibility Evaluation: Solar Heated Textile Process Water, Volume 1, Clemson University, Clemson, South Carolina: 1977.

of a supply curtailment can be significant. A map of pipeline service in the study area is presented in Exhibit 4.

The textile industry in general is characterized by a diversity of technologies, operating procedures, product mixes, raw materials, energy requirements, and economies of scale. Firms within SIC 22 perform the operations necessary to process natural and man-made fibers into yarns, fabrics, or floor covering. Yarns are generally: woven or knit into fabric; manufactured into thread, twine, or cordage; or, tufted or woven into carpets. Fabrics are usually dyed, printed, treated, or otherwise finished to supply the apparel industry (SIC 23) and other commercial, industrial, and household markets. Specialized segments of the industry produce felts, lace, padding, nonwoven fabrics and a variety of other textile products.

There are two generic types of organizations which operate in the textile industry: the "integrated" mill and the "contract" mill. Integrated mills purchase raw materials, produce textiles within the organization, and sell a finished product. Contract or commission mills process materials owned by others.

The industry is highly fragmented and competitive. There are approximately 5,000 companies which operate some 7,000 plants whose primary activity is classified under SIC 22. Eighty-five percent of the companies employ less than 100 workers. The top 100 companies in dollar sales accounted for roughly half of the $35 billion industry volume in 1977.

The selection of the sample used in this analysis was made with regard to these characteristics and other operational considerations. A detailed description of the selection process is included in Appendix B. Site-specific

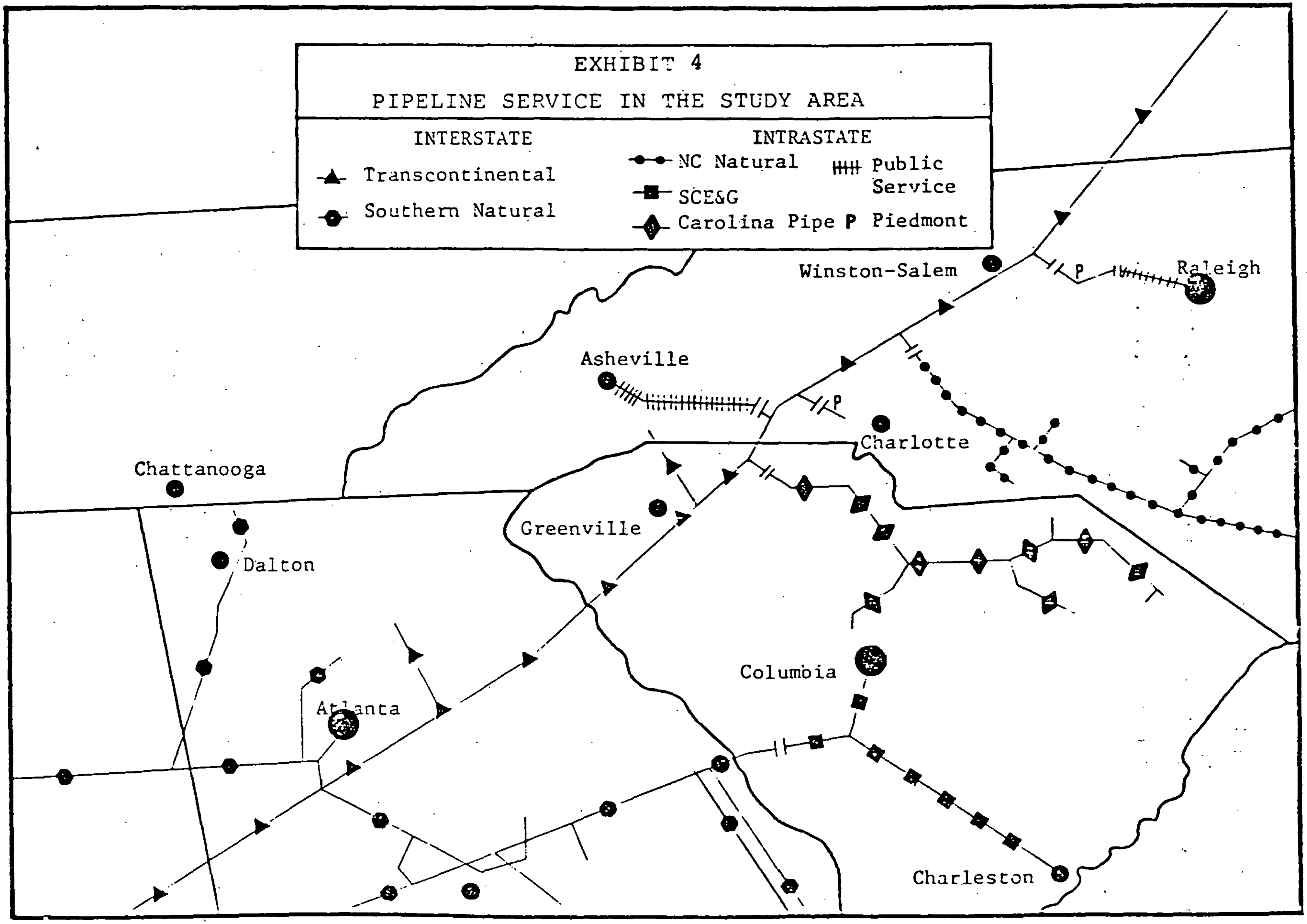
EXHIBIT 4
PIPELINE SERVICE IN THE STUDY AREA
INTERSTATE
Transcontinental
Southern Natural
INTRASTATE
NC Natural
SCE&G
Carolina Pipe
Public Service
P Piedmont
Winston-Salem
Raleigh
Asheville
Charlotte
Chattanooga
Greenville
Dalton
Columbia
Atlanta
Charleston

aspects of the industry, such as: plant type; boiler capabilities; standby fuels; pipeline service; and, the actual curtailment impacts and reactions, are discussed in the Analysis and Results section which follows.

III. Analysis and Results

The purpose of this chapter is to familiarize the reader with the analytical approach employed in the evaluation of interview responses. Both the method and results of the analysis are presented with a minimum of statistical detail. This will set the stage for the interpretation and conclusions which are discussed in Chapter 4. Appendix C has been included to supplement the material presented in this chapter. In Appendix C, the progression of events leading to the application of the analytical approach are detailed.

3.1 Analytical Approach

In efforts to determine the cause and effect relationships underlying the various industry reactions to natural gas curtailments, a set of questions was developed to characterize the sample. The questions (Appendix A) were structured to facilitate their use in establishing the independent variables for the analysis. Their purpose was to identify the major causative factors which were assumed to have interacted to produce the various textile plant responses to natural gas curtailments.

The major technique used in the evaluation of the independent variables was the Factor Analysis procedure of the SAS package. Several characteristics of the Factor Analysis technique led to its inclusion in the research design, i.e.:

- the ability to generalize large amounts of empirical data into statistically valid, composite factors;
- the capacity of these factors to explain correlations among the independent variables;

- the amenability of the results to interpretation as program generated hypotheses;

- the ability to generate these hypotheses without benefit of any prior assumptions or knowledge of the results; and,

- the cost-effectiveness and ready availability of the techniques in pre-programmed packages such as SAS.

There were three main procedures employed by the Factor Analysis, two of which yielded meaningful results. Statistical details of all three procedures are included in Appendix C. The results of the correlation matrix and final factor solution are presented below.

3.2 Correlation Matrix Results

A correlation matrix desplays a measure of association for every possible pair of independent variables. This measure is termed a correlation coefficient and represents the amount of variation in one variable of each pair that may be attributed to its relationship with the other variable in the pair. In a factor analysis, it is desirable to exclude those variables that are highly correlated. Highly correlated variables do not measure the sample independently and may identify spurious factors in the final factor solution. As a result, the importance of highly correlated variables would be inherently overstated.

In this analysis, two correlation matrices were established. The first correlation matrix, comprised of sixteen presumably independent variables, identified four variables that were too highly correlated with other variables to be included in further analyses. These variables highlight some important relationships bearing on the individual firm's reactions to the natural gas curtailments of winter 1976-77, and are discussed below. The second correlation matrix, comprised of the remaining twelve variables, was used to calculate the final factor solution which provided the major results of the study. The final factor solution is discussed in section 3.3.

The four highly correlated variables identified in the first correlation matrix were:

- o Number of Employees
- o Length of Impact
- o Cost of Short Term Strategies
- o Total Cost of Short and Long Term Strategies

The "number of employees" variable was observed to be highly correlated with the measure of "annual sales volume." It follows intuitively that the manufacturing industries would require more people to produce the goods needed for increased sales. "Number of employees" was also found to account for variations in "short-term" and "total" expenditures in response to the natural gas curtailments during the time period in question. In light of the relationship between "number of employees" and "annual sales volume" (as per Appendix B), it appears that the level of curtailment-related expenditures was directly related to the size of the firm, i.e. larger firms spent more than smaller firms.

The "length of impact" variable was also highly correlated with the magnitude of spending in the "short-term," "fiscal year 1978," and in "total." This suggests that the duration of curtailment impacts determined the level of spending in the three time periods mentioned. The "length of impact" variable was highly correlated with the "how impacted" variable which implies that the more severely impacted firms regardless of size, spent more overall than their lesser impacted counterparts. As would be expected, the motivation for long term spending was also found to be correlated with the "length of impact" variable. Firms that experienced lengthy production slowdowns, or plant closings were forced to deal with curtailment impacts over a longer period of time, which necessitated a greater commitment of funds. These firms were in the majority as evidenced by the frequencies of response to Variable Number X in Appendix A.

The "cost of short-term strategies" and "total cost of short and long term strategies" variables were highly correlated to: each other: "fiscal year 1978" spending; "length of impact"; and, the measures of relative size. This redundancy tends to substantiate the earlier findings that spending patterns are affected by size and severity of impacts.

The "pipeline service" variable provided the first indication of regional spending differences. Short-term spending was observed to be highly correlated with "pipeline service" and "length of impacts." It was considered likely that at least one region in the study area experienced pipeline service curtailments of the same duration that resulted in similar short term spending patterns. The carpet and rug industry in Georgia was identified as a result of the final factor solution as the area which exhibited this spending pattern.

In summary, the four highly correlated variables identified in the first correlation matrix indicate that:

- o the level of spending for short and long term remedial strategies was a function of plant size; and,
- o the extent and duration of curtailment impacts determined the magnitude of expenditures for the various plant sizes.

These results serve as indicators of general trends within the sample. When viewed in the context of the final factor solution, they take on added significance. We now direct our attention to the findings of the final factor solution.

3.3 Final Factor Solution

The primary objective of the Factor Analysis procedure was to identify those factors which accounted for the plant to plant variations in response to the natural gas curtailments of the winter of 1976-77. Our data indicated that five factors accounted for about 75% of the plant to plant variations found. Each of these factors was comprised of one or more variable(s) that indicated a cause and effect relationship between the variable(s) and the plant's reactions.

The five factors were named for the dominant variable to facilitate discussion. The factors and their component variables were:

Factor Name	Component Variable
o Process Fuel	-Percent of process fuel supplied by natural gas
o Size	-Annual sales volume -Conservation program
o Region	-Location -Pipeline service -Boiler capability
o Motivation	-Motivation behind long term engineering changes -Spending in fiscal year 1978 -Extent of curtailment impacts
o Preparedness	-Standby fuel availability -Plant type.

The first two factors identified by the program tend to be general in nature. They define major groupings of the data in the broadest terms. The questions pertaining to natural gas consumption and the existence of a conservation program surfaced in the first two factors for this reason. More than 74% of the respondents answered consistently in each case. Since the sample was chosen to represent the natural gas intensive segments of the industry, the emergence of the "Process Fuel" factor was anticipated.

The "Size" factor also indicates, in general terms, the underlying ability of differences in "annual sales volume" (and therefore, "number of employees" as per Appendix B), to affect the spending and purchasing patterns of the sample. This relationship will be explored in detail in Chapter 4.

The emergence of the "Region" factor is perhaps the single most important product of the Factor Analysis. Implicit in this factor is the relationship between plant location and the operational characteristics of the firm, as measured by "boiler capabilities." The significance of this relationship was manifested in the analysis of spending and purchasing patterns in Section 4.1.

The fourth factor, dealing with the "motivation" behind curtailment related spending, has far-reaching implications. Firms in the textile industry apparently measured their need for curtailment protection in terms of the severity of the winter curtailments in 1976-77. There can be no expressed or implied assurance as to the adequacy of the protective strategies implemented as a result. This furthers the possibility that the industry as a whole remains vulnerable to natural gas curtailments.

The "Preparedness" factor facilitated the identification of specific plant types that were more or less vulnerable to natural gas curtailments. This led to the identification of an inequitable distribution of curtailment impacts in the study area.

In summary, the final factor solution identified several underlying causative agents that explained the specific activities undertaken by textile firms in response to the natural gas curtailments of winter 1976-77. The most significant factors indicated that:

- o plant size determined the ability and need to implement specific precautionary strategies;
- o the severity of curtailment impacts strongly influenced the firms level of spending for precautionary strategies;
- o plant location determined the severity of curtailment impacts; and,
- o preparedness of the individual plant types varied according to location.

These findings, along with the findings of the first correlation matrix, directed our attention to an analysis of the specific activities undertaken by firms in the sample in response to the natural gas curtailments during the winter of 1976-77.

The interpretation of these results with regard to plant size, type, and location, and spending and purchasing patterns is presented in the following chapter.

IV. Interpretation of Findings

The findings of the Factor Analysis procedure were used as guidelines in the examination of specific activities initiated by textile firms as a result of natural gas curtailments during the Winter of 1976-77. An evaluation of the interview results in light of the Factor Analysis findings enabled us to identify trends in the selection of particular strategies, and a range of cost for the various plant sizes and types. Spending and purchasing patterns in the sample data were characterized by plant size and, type and location, with regard to the severity of impacts.

4.1 Plant Size

The relationship between plant size and the level of spending for both short and long term strategy mixes is examined in this section. It was anticipated that the linear relationship exhibited by the "annual sales volume" and "number of employees" variables (Appendix B) would hold true for the measures of curtailment related spending as well. The level of spending was observed to be a function of plant size for both the short and long terms.

Firms in the sample were categorized as either small or large based on an annual sales volume of $10 million dollars. An assessment of the expenditures for specific short and long term measures was performed for each group. The results of these comparisons are presented in Exhibit 5.

Industry spending was channeled towards the strategies that were thought to return optimal benefits. The short term strategies selected by the smaller firms indicated that a "make do" attitude prevailed. Limited

EXHIBIT 5

FREQUENCIES OF SHORT TERM STRATEGIES IMPLEMENTED, COSTS INCURRED, AND TOTAL EXPENDITURES, BY PLANT SIZE

Number of Firms	Small (% of Total)	Large (% of Total)
Firms Per Category	17 (50)	17 (50)
Switching to Existing alternate Fuel Capability	13 (38)	11 (32)
Adding an Alternate Fuel Capability	1 (3)	4 (12)
Increasing Storage Capacity of Existing Alternate	4 (12)	3 (9)
Making Special Fuel Purchases	5 (15)	9 (26)
Spending Less Than $100 Thousand for Short Term Measures	15 (45)*	9 (27)*
Spending More Than $100 Thousand for Short Term Measures	2 (6)*	7 (21)*
Spending Less Than $100 Thousand For Total of Short and Long Term Measures	15 (45)*	5 (15)*
Spending More Than $100 Thousand For Total of Short and Long Term Measures	2 (6)*	11 (33)

* = % based on 33 firms.

See Appendix B for discussion of plant size.

resources narrowed their available options considerably. Larger firms benefited from financial and administrative economies of scale.

This point is best illustrated in the efforts undertaken to procure alternate fuel supplies. The larger firms were able to lease or buy tanker trucks to haul propane from sources they had located in the Gulf states. These supplies were either consumed directly, or traded to a gas utility in exchange for additional pipeline gas. Smaller firms were "priced out" of this option but were able to purchase intermittent allotments of pipeline gas more frequently due to their higher curtailment priority classification.

The intrastate purchase of natural gas (at the well-head) for interstate delivery, was only implemented in cases where the firm had the administrative capability to do so. Contractual arrangements for this so-called "533" gas (after FPC Order No. 533, August 28, 1975) were not reported by any of the small firms in the sample. This option was viewed as too risky and too complicated by the smaller firms because delivery could not be guaranteed and the paperwork was voluminous.

Standby fuel systems were more prevalent among the smaller firms, but only slightly. Two of the smaller companies reported switching to kerosene which larger companies avoided due to its adverse effect on product quality. The larger companies were observed to have procured totally new alternate fuel systems (primarily propane) much more frequently than the smaller firms, who appeared to favor fuel oil. The cost of mixing and storage facilities for the propane alternative was prohibitive to all but one of the smaller firms in the sample. An increase in the storage capacity for an existing alternate fuel was more popular with the smaller firms for this reason.

Four typical short-term fuel strategies are presented in Exhibit 6. The actual expenditures for short term fuel strategies were observed to range from 0.06 to 0.15 percent of the annual sales volume for those firms that were unable to rely solely on existing stockpiles of alternate fuels. More than 55 percent of the sample was forced to spend (on the average) 0.10% of their annual sales volume for short-term curtailment relief in the form of alternate fuels and/or fuel systems. While these costs (provided by the respondents) were only estimates, their consistency as a percentage of annual sales volume is noteworthy.

Plant size was observed to have also accounted for variations in the selection of long-term engineering changes. Strategies which were implemented to afford some protection against future gas curtailments were aimed primarily at reducing energy consumption and utilizing waste heat. Small firms, in general, opted for the strategies which were less expensive and applicable to a variety of energy consumptive processes. Large firms favored major technologies which are by nature, capital intensive. Exhibit 7 illustrates the frequencies of response for specific long-term engineering changes selected by large and small firms in the sample.

The greatest disparities in Exhibit 7, are between automating controls, process modifications, and boiler economizers. Automating controls were favored by the small firms and included commercially available systems like the IBM 7, in addition to the localized controls that govern only one valve or trap. Boiler economizers and process modifications require a higher level of technical assistance and funding than the automating controls. Their

EXHIBIT 6

TYPICAL SHORT-TERM CURTAILMENT STRATEGY SCENARIOS FOR TWO LARGE AND TWO SMALL TEXTILE PLANTS

Plant Description	Impact	Alternate Fuels Used	Delivered Cost	Other Short-term Purchases	Other Short Term Costs	Total Short-term Expenditures (% of Annual Sales
Large, integrated carpet mill (GA)	slow-down four weeks	Propane #2 fuel oil	$165,000 $ 40,000[a]	none	none	$190,000 (.10)
Large, sewing and finishing complex (SC)	shut-down one week, slow-down two weeks	Propane 533 gas	$415,500 $ 50,000	3 tanker trucks	$60,000	$525,500 (.08)
Small, yarn dyeing (NC)	slow-down four weeks	#2 fuel oil	$ 2,500	fuel oil storage tank	$ 9,000	$ 11,500 (.13)
Small, knit fabric finishing (NC)	slow-down three weeks	#6 fuel oil Propane[b]	$ 8,000 $ 11,000	none	none	$ 19,000 (.10)

[a] includes storage facility

[b] supplied by municipal utility

Note: These figures do not include overtime wages, insurance, installation, tax, and other associated costs that varied according to the strategies selected.

EXHIBIT 7

FREQUENCIES OF LONG TERM ENGINEERING MEASURES CHOSEN BY LARGE AND SMALL FIRMS

Number of Firms	Small (% of Total)	Large (% of Total)
Number of Firms in Category	17 (50)	17 (50)
Waste Water and/or Condensate Heat Recovery	12 (35)	12 (35)
Automating Controls	9 (26)	5 (15)
Process Modifications	5 (15)	11 (32)
Boiler Economizers	1 (3)	5 (15)
Other Engineering Controls	5 (15)	5 (15)
Heating and Air Conditioning Modification	4 (12)	5 (15)
Other Housekeeping Measures	3 (9)	2 (6)
No Action	1 (3)	0 (0)
Other	0 (0)	2 (6)

See Appendix B for discussion of plant size.

potential for energy savings is proportionally greater as well. Only one small firm claimed to have installed a boiler economizer, but several reported rebuilding and adjusting the boiler already in operation. Process modifications for the small firms tended to be simpler and less expensive than those implemented by the large firms. It was common for the small firms for example to switch to lower temperature dyestuffs and resins. Large firms often purchased altogether new equipment (eg. jet dyeing) as part of their modernization program. Planning for acquisition of new equipment was lacking in the smaller firms who instead, tended to purchase used equipment from the industry leaders.

Wastewater heat recovery and other engineering controls were equally popular among all firms. These measures were implemented to capture waste heat from flue gases, dye liquor and/or drying ovens, to be used primarily for the pre-heating of boiler feed water.

4.2 Location and Plant Type

The relationships between geographic location and plant type are discussed in this section. Responses to the natural gas curtailments of the winter of 1976-77 were observed to vary from region to region within the study area. This implies that curtailment impacts were not uniformly distributed throughout the study area and that particular plant types were more susceptible than others. An analysis of the pipeline service, plant type, standby fuels, and location variables suggested that plant type, location, and therefore, pipeline service, did affect the severity of curtailment impacts. In addition to plant size, the major determinants of curtailment strategy implementation were concluded to be pipeline service and, to a lesser extent, plant type.

Firms in the sample that were served by Transcontinental were observed to have suffered less adverse impacts for shorter periods of time than those served by Southern. The following frequencies of response (Variable x, Appendix A), are illustrative of this disparity:

Laid off Majority (N=9)	Production Slow-Down (N=9)	No Effect (N=15)
6 Southern	6 Transco	14 Transco
3 Transco	3 Southern	1 Southern

Specific plant types that were most heavily impacted exhibited a geographic distribution similar to that of the pipeline companies. None of the firms sampled in North Carolina claimed to have laid-off the majority of workers. North Carolina is served exclusively by Transco. Two-thirds of the Fully Integrated Knit Fabric Mills and half of the Fiber or Yarn Dyers were located in North Carolina. Less than 25 percent had no standby fuels, and none of the North Carolina sample claimed to have made special fuel purchases.

In contrast, firms in the Georgia sample were served exclusively by Southern, which provides nearly all (89%) of the gas consumed in the state. All of the Floor Covering firms and related Yarn Dyeing operations were located in Georgia. The Floor Covering industry reported the highest incidence of worker displacements in the sample. Nearly 45 percent of the Georgia sample claimed to have laid-off the majority of workers for more than two weeks. Alternate fuel systems were least prevalent in Georgia which undoubtedly prolonged the displacement of production workers. Special fuel purchases were reported by 86 percent of the Georgia sample.

Southerns market share in South Carolina approaches 80 percent. Customers served by Southern in that state accounted for 66 percent of the firms which reported laying-off the majority of workers for more than one week. The South Carolina sample was better equipped with standby fuel systems than North Carolina yet experienced much more severe impacts.

On balance, firms served by Southern experienced the most severe impacts for two reasons:

- o firms in Georgia and South Carolina were subjected to longer and more severe curtailments, and,
- o firms in Georgia were poorly prepared to deal with the curtailments due to their lack of alternate fuel capabilities.

The greatest consistency in response to the natural gas curtailments was exhibited by firms in the floor covering industry in Georgia. The Georgia sample accounted for eighty percent of the total new standby fuel installations. All of the firms that did not have an alternate fuel capability installed one. A large mill with an existing standby system purchased another. Special fuel purchases were made by nearly every firm in the Georgia sample which included one of the two "533" gas purchases reported by the sample.

The special circumstances surrounding the floor covering industry are noteworthy because of the uniformity with which the firms reacted. The "Region" and "Preparedness" factors were generated as a result of this uniformity. No other segment of the industry as a whole, exhibited the same degree of consistency in efforts to mitigate the adverse impacts of gas curtailments.

The floor covering industry is a distinct entity within SIC 22. It is represented by its own trade organization, the Carpet and Rug Institute. Along with the majority of its membership, the Institute is located in Dalton, Georgia. The majority of the floor covering industry is served by the City of Dalton Utilities. The uniformity of industry response to gas curtailments was, to a great extent, the result of a common operating environment. In the absence of a similar set of circumstances, the remainder of the industry was observed to have reacted randomly in the selection and implementation of curtailment strategies.

Short and long-term spending patterns as a function of plant type are presented in Exhibit 8. The extent of curtailment impacts is expressed in terms of the percentage of firms in each plant type category that spent more or less than $100 thousand for short and long-term curtailment strategies. Exhibit 8 also suggests a geographic distribution of curtailment impacts which precipatated the observed spending patterns.

The real significance of curtailment spending patterns lies in their ability to signal trends in the selection of fuel strategies for the future. The following section is included to assess the trends which were identified from our sample and current industry sources.

4.3 Future Directions

Firms in the textile industry still have access to relatively plentiful supplies of fuel oil and natural gas. In spite of recent curtailment experiences, there is a great deal of resistance to change. The tenacity with which the

EXHIBIT 8

Short and Long-term Spending Patterns by Location and Plant Type

State	Plant Type	% of Sample[a]	Short-term Expenditures (%)		Long-term Expenditures (%)	
			$100 thousand	$100 thousand	$100 thousand	$100 thousand
NC	Fiber or Yarn Dyeing	12%	100	0	75	25
	Fully Integrated Knit Fabric	12%	100	0	100	0
	Fully Integrated Woven Fabric	3%	100	0	100	0
SC	Fiber or Yarn Dyeing	6%	100	0	50	50
	Fully Integrated Woven Fabric	15%	60	40	50	50
	Woven Fabric Finishing	21%	43	57	57	43
	Fully Integrated Knit Fabric	6%	100	0	50	50
	Knit Fabric Finishing	6%	100	0	100	0
GA	Fully Integrated Floor Covering	6%	0	100	0	100
	Fiber or Yarn Dyeing	6%	50	50	50	50
	Floor Covering Finishing	9%	33	66	66	33

[a] column does not add due to rounding

industry clings to traditional methods will bear directly on its ability to cope with future fuel supply interruptions. The ability to absorb the erratic supply fluctuations which precipitate fuel curtailments can be accomplished in a variety of ways. Industry sources suggest "total fuel flexibility" as the most promising of these.

At present, many plants have multiple boiler fuel capabilities. Our sample indicated that 76 percent have combination boilers which are capable of utilizing two or more fuels. The fuels of choice were overwhelmingly natural gas or oil, both of which remain susceptible to supply interruptions. A total fuel flexibility strategy would enable the firm to use gas, oil, coal, renewable resources, or plant waste at any given time.

The advantages of total fuel flexibility are numerous. A strategy of this kind would insulate the firm from curtailment impacts. The most economical fuel for the firm would be consumed while currently underutilized resources would be converted to energy. Funds would be channeled into local economies for renewable resources. The extent to which the concept of total fuel flexibility is adopted may well determine the industry's competitive viability in the future. Firms that ignore the realities of energy supply and demand will, at the very least, continue to be burdened with curtailment impacts.

Solar power can play a vital role in the overall strategy of fuel flexibility. Boiler fuel requirements can be augmented by solar power thereby reducing the firms overall demand for scarce fuels. Specific process applications of solar power are technologically feasible as well. Industry acceptance of solar process heat technology will hinge on the nature of the application, and, the performance and cost competitiveness of the system.

The widespread use of hot water and steam in a variety of textile manufacturing processes suggests a large potential market for solar pre-heating and high temperature applications. Given that energy intensive textile processes can be fueled by state-of-the-art solar technologies, the remaining barriers to implementation are economic. In the context of a total fuel flexibility strategy, solar power has the potential to be an attractive alternative.

The textile industry's ability to underwrite capital additions has however, been strained in recent years. Voluntary acceptance of solar energy technologies may be hindered as a result. For this reason, a cursory examination of the traditional means for selecting and financing investment alternatives in the textile industry was undertaken. The following analysis was based on information obtained from our sample and from twenty-nine annual reports of the industry's sales leaders.

4.4 Industry Capitalization

The textile industry operates in a highly competitive environment resulting in relatively low profitability. This makes the industry as a whole unattractive to outside investors. There has been a sharp downward trend in capital investment in the textile industry since the double-digit growth of the late 1960s. Rates of return on investment have suffered due to inflation and the aggressive marketing of low priced imports.

Given the inability to attract outside investors, most manufacturing firms would turn to the equity market to finance expansion. The common stocks of textile companies traditionally sell under book value, however. Annual reports of twenty-nine of the industry sales leaders indicated an average of less than one percent of the total funds available was provided by new equity.

When the equity market is unresponsive, long term debt is the next most suitable alternative. Textile bonds are frequently rated BAA or BBB, which makes them equally unattractive to investors.[7)] The main source of long term funds was found to be private placements with institutional investors such as insurance companies. Long-term financing is often used to retire debt.

Most firms, especially the smaller ones, must finance expansion and working capital internally. Bank loans do provide some short-term capital but the main sources are:

- depreciating plant and equipment;
- deferring federal and state income taxes; and
- selling tangible assets.

The majority of the industry is weakly capitalized and in a poor position to underwrite innovative strategies that provide only marginal economic gains.

[7)] Statement by the American Textile Manufacturers Institute, Inc., before the House Committee on Ways and Means, Tax Reform Act Hearings, March, 1976.

Virtually every textile firm employs some sort of Return on Investment (ROI) analysis of significant capital expenditures. The simplest of these is the payback period which is estimated to be 5.6 years for the industry as a whole.[8)] Intermediate and advanced life cycle costing techniques are also used. These methods consider a broad range of factors in addition to initial cost and annual savings that are the basis of a payback period. For example, an advanced life cycle cost analysis would include:

- o Initial cost;
- o Operating and maintenance costs;
- o Labor costs;
- o Startup costs;
- o Interest rates;
- o Taxes;
- o Depreciation;
- o Salvage Value; and,
- o Product mix.

The decision to invest in new equipment, whether it is energy related or not, is made with regard to these factors and the source of investment capital.

The textile industry appears to be a good candidate for the early adoption of solar technologies. Significant energy savings may be able to be demonstrated with state-of-the-art solar process heat systems. However, until economic barriers are mitigated, and (possibly) incentives are provided, the prospects for widespread acceptance by the textile industry

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[8)] SCS Engineers, Inc; "Energy Efficiency Improvement Target in the Textile Mill Products Industry, SIC 22," Draft Target Support Document, Reston, VA: 1976.

are remote. Although the majority of industry officials were encouraged by the concept of solar process heat, none of them voiced a willingness to underwrite a system under present economic conditions.

The following concerns were representative of those expressed most frequently by respondents:

- o system space requirements;
- o technical feasibility and efficiency;
- o temperature and volume capabilities;
- o corporate acceptance of cost sharing;
- o operating and maintenance costs;
- o tax credits or incentives; and
- o useful life of the equipment.

Efforts in the near term should be concentrated in the following areas:

- o disseminating user-oriented information;
- o soliciting cooperators for demonstration projects;
- o encouraging mass production of solar delivery systems; and,
- o providing low-interest loans and other economic incentives.

With a large number of willing cooperators and energy intensive processes to choose from, the textile industry provides a good opportunity for facilitating the realization of federal industrial process heat program objectives.

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Appendix A

Questions Asked of Interviewees with Frequencies of Responses and Coded Variable Name and Number
Total Sample = 34

Variable Name	Variable Number	
		DEMOGRAPHIC VARIABLES
LOCATION	I.	State in which interview was conducted: 1. North Carolina (9) 2. South Carolina (18) 3. Georgia (7)
TYPE	II.	How would you characterize this plant by type of operation? 1. Fully Integrated Floor Covering (2) 2. Fiber or Yarn Dyeing (8) 3. Floor Covering Finishing (3) 4. Fully Integrated Woven Fabric (6) 5. Woven Fabric Finishing (7) 6. Fully Integrated Knit Fabric (6) 7. Knit Fabric Finishing (2)
NEMP	III.	How many persons are employed at this facility? 1. (1-49) (3) 2. (50-149) (6) 3. (150-499) (18) 4. (500-999) (2) 5. (>1000) (5)
ASV	IV.	What is this plant's Annual Sales Volume ($)? 1. <2 million (4) 2. 2-5 million (5) 3. 5-10 million (8) 4. 10-50 million (9) 5. 50-100 million (2) 6. >100 million (5) 1 missing value

Variable Name	Variable Number	
PLSVC	V.	What pipeline company services this facility?
		1. Transco Utility (16)
		2. Transco Municipal Utility (7)
		3. Southern Municipal Utility (7)
		4. Southern Utility (2)
		5. Southern Direct Service (2)
PCTNATG	VI.	When available, what percentage of your process fuel is Natural Gas?
		1. 0-24% (3)
		2. 25-49% (3)
		3. 50-74% (3)
		4. 75-100% (25)
BLRCAP	VII.	What boiler capabilities did you have prior to the winter of 1976-77?
		1. Combination boiler(s) (26)
		2. Coal only (2)
		3. Natural Gas only (3)
		4. Fuel Oil only (2)
		5. Other, no boiler (1)
SBFUEL	VIII.	What standby fuels did you have prior to 1976-77?
		1. Propane only (3)
		2. Fuel Oil only (7)
		3. Other (coal, kerosene) (4)
		4. None (9)
		5. Propane and Fuel Oil (11)
CONSV	IX.	Was a conservation program in force prior to the 1976-77 natural gas curtailments?
		1. Yes (28)
		2. No (6)
HOW IMP	X.	How were you impacted by the 1976-77 natural gas curtailments?
		1. No effect (15)
		2. Production Slowdown (9)
		3. Laid-off Majority (9)
		4. Other (1)

Variable Name	Variable Number			
LEN_IMP	XI.	How long were the impacts felt?		
		1.	None	(13)
		2.	Less than one week	(4)
		3.	One to two weeks	(5)
		4.	More than two weeks	(11)
			1 missing value	

SHORT-TERM ENGINEERING STRATEGIES

Variable Name	Variable Number			
	XII.	What was done within six months of the time natural gas was curtailed?		
V12P1		1.	Nothing	(0)
V12P2		2.	Switched to Existing Alternate Fuel Capacity	(25)
V12P3		3.	Initiated Conservation Measures	(20)
V12P4		4.	Added an Alternate Fuel Capacity	(5)
V12P5		5.	Increased Storage Capacity of Existing Alternate Fuel	(7)
V12P6		6.	Made Special Fuel Purchases	(14)
V12P7		7.	Other	(5)
SHORTCST	XIII.	What was the estimated dollar cost of Short-Term Measures?		
		1.	0 to 9,999	(13)
		2.	10,000 to 99,999	(8)
		3.	100,000 to 500,000	(8)
		4.	More than 500,000	(2)
			3 missing values	

LONG-TERM ENGINEERING STRATEGIES

Variable Name	Variable Number			
	XIV.	What long-term engineering controls have been implemented since the fuel curtailments of 1976-77?		
V14P1		1.	Boiler Economizers	(6)
V14P2		2.	Boiler Fuel Conversion	(0)
V14P3		3.	Waste Water Heat Recovery	(16)
V14P4		4.	Condensate Heat Recovery	(5)
V14P5		5.	Load Management System	(6)
V14P6		6.	Demand Control System	(3)
V14P7		7.	Heating and Air Conditioning Modifications	(9)
V14P8		8.	Automating Controls	(12)
V14P9		9.	Process Modifications	(15)

Variable Name	Variable Number		
V14P10		10. Other Engineering Measures	(10)
V14P11		11. Other Housekeeping Measures	(4)
V14P12		12. No Action	(2)
V14P13		13. Other	(2)
TOTAL	XV.	How much will the engineering controls cost in total?	
		1. 0-9,999	(11)
		2. 10,000 to 99,999	(9)
		3. 100,000 to 500,000	(5)
		4. More than 500,000	(8)
		1 missing value	
LTMOTIV	XVI.	What motivated the long term engineering changes?	
		1. Planned Modernization	(5)
		2. Changes Accelerated by Fuel Curtailment	(10)
		3. Part of Prior Energy Conservation Program	(1)
		4. Cost Justification; to Compete Better	(1)
		5. Two or more of the Above	(13)
		6. None Implemented	(3)
		1 missing value	
FY78	XVII.	How much will be spent in fiscal year 1978-79?	
		1. 0-9,999	(12)
		2. 10,000-99,999	(13)
		3. 100,000-500,000	(5)
		4. More than 500,000	(3)
		1 missing value	
STATUS	XVIII.	What is the corporate status of this plant?	
		1. Private Company, Headquarters (only mfg. location)	(6)
		2. Public Company, Branch Plant	(13)
		3. Subsidiary of Public Company, Branch Plant	(2)
		4. Subsidiary of Public Company, Headquarters	(6)
		5. Private Company, Branch Plant	(3)
		6. Public Company, Headquarters	(4)

APPENDIX B

Considerations in the Selection of the Sample from the Energy Intensive Sectors of the Textile Industry.

This appendix examines the considerations which influenced the selection of the thirty-four firms from which interview data was gathered. Samples drawn from the population at large are often used to facilitate the analysis of certain aspects relating to the entire population. However, the method by which a sample is selected from a population impinges directly upon the validity of the inferences that can be drawn. Selection of the textile firms sampled in this analysis was influenced by two primary objectives:

- o to focus on the natural gas intensive segments of the industry which held the greatest promise of exhibiting curtailment impacts; and,
- o to accurately represent the true nature of the textile industry with regard to measurable parameters.

These objectives helped to insure that a balanced sample was selected for analysis within the time and cost constraints of the project. A discussion of the considerations leading to the attainment of the objectives is presented below.

Energy Intensive Sectors

In order for an industrial concern to be adversely impacted by a natural gas curtailment, the plant had to be dependent on natural gas either directly (for process heat) or secondarily (as boiler fuel).* Two methods were used to determine the generic plant types that were heavily dependent on natural gas and therefore, were to be included in the sample. The initial screening based on four-digit Standard Industrial Classification (SIC) codes, and the quantity of natural gas consumed and number of establishments in each, is presented in Exhibit B-1. This comparison led to the identification of industry groups with the highest average natural gas consumption per establishment. SIC 22 natural gas consumption ranged from between less than 1 to more than 37 Mcf/year. Groups with consumption equal to or greater than 10 Mcf/year were considered to be natural gas intensive and are listed below:

SIC Group		Average Annual Consumption (Mcf) Per Establishment	Number of Establishments
2297	Nonwoven Fabrics	37	48
2296	Tire Cord and Fabric	37	43
2272	Tufted Carpets & Rugs	24	593
2262	Finishers of Synthetic Fabrics	23	429
2261	Finishers of Cotton Fabrics	15	505
2257	Circular Knit Fabric Mills	14	333
2258	Warp Knit Fabric Mills	10	261

Source: References 8 and 17.

*This study disregarded "ripple effects," where a company not dependent on natural gas was shutdown or otherwise impacted as a result of gas curtailments to one of its suppliers or customers.

EXHIBIT B-1

Quantity, Cost and Consumption of Natural Gas By Industry Group Per Establishment, 1976

SIC Industry Grouping		Quantity (billion cf)	Cost (million $)	Number of Establishments*	Average Quantity Per Establishment (billion cf)
Weaving Mills, Cotton	2211	7.1	9.4	1,241	.006
Weaving Mills, Synthetics	2221	8.9	12.8	1,035	.009
Weaving and Finishing Mills, Wool	2231	.8	1.0	387	.002
Narrow Fabric Mills	2241	.7	1.0	658	.001
Womens Hosiery	2251	.9	1.2	403	.002
Hosiery, n.e.c.	2252	.9	1.3	494	.001
Knit Outerwear Mills	2253	1.2	1.9	1,753	.001
Knit Underwear Mills	2254	(D)	(D)	162	X
Circle Knit Fabric Mills	2257	4.8	7.7	333	.014
Wrap Knit Fabric Mills	2258	2.7	4.8	261	.010
Knitting Mills, n.e.c.	2259	(D)	(D)	184	X
Finishing Plant Cotton	2261	7.5	10.9	505	.015
Finishing Plants Synthetics	2262	9.7	14.9	429	.023
Finishing Plants, n.e.c.	2269	2.4	3.5	312	.008
Woven Carpets, Rugs	2271	.7	.8	245	.003
Tufted Carpets, Rugs	2272	14.1	17.4	593	.024
Carpets, Rugs, n.e.c.	2279	.3	.5	113	.003
Yarn Mills Except Wool	2281	3.4	4.3	489	.007
Throwing and Winding Mills	2282	1.6	2.3	178	.009
Wool Yarn Mills	2283	.4	.5	216	.002
Thread Mills	2284	.7	1.3	156	.004
Felt Goods, n.e.c.	2291	(S)	(S)	157	X
Lace Goods	2292	(D)	(D)	133	X
Paddings and Upholstery Fillings	2293	(D)	(D)	168	X
Processed Textile Waste	2294	.1	.2	173	.001
Coated Fabrics Not Rubberized	2295	3.0	5.6	318	.009
Tire Cord, Fabric	2296	1.6	2.2	43	.037
Nonwoven Fabrics	2297	1.8	2.9	48	.037
Cordage, Twine	2298	(D)	(D)	292	X
Textile Goods, n.e.c.	2299	.4	.8	418	.001
Total SIC 22*		78.7	113.1	10,874	.007

Source: Reference 8 and 17

* = national aggregate

D = Withheld to avoid disclosing figures for individual companies
S = Withheld because the estimate did not meet publication standard
X = Not applicable

These seven plant classifications accounted for only twenty-one percent of the physical plants in SIC 22 (regardless of size), but fifty-three percent of the industrywide gas consumption in 1976.

As a preliminary indicator of natural gas intensive operations, the SIC system proved to be adequate. It directed attention to the four-digit industry groups worthy of closer scrutiny. Process components within the industry as a whole were not readily distinguishable, however. For example the equipment used and energy consumed for finishing cotton (2261), synthetics (2262), and others not elsewhere classified (2269), is very similar. No distinction is made between knit fabric or woven fabric finishing, yet the number and type of processing steps (and energy consumption) are markedly different.

By focusing on the process components of the four-digit groups identified as being large gas consumers (as per Exhibit B-1), specific natural gas intensive plant types were isolated. Central to this determination was a parallel classification system which emphasized the major operational divisions of the industry. This classification is presented as Exhibit B-2, and includes the corresponding SIC codes which serve to cross-reference the results displayed in Exhibit B-1.

The major process components identified as being the most significantly* natural gas intensive are:

1. Woven fabric finishing;
2. Knit fabric finishing;
3. Yarn Dyeing; and
4. Floor covering.

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*As a result of this combined classification scheme, SIC's 2296 and 2297 were determined to be insignificant users of natural gas due to the small number and diffuse location of the plants.

EXHIBIT B-2

Industry Components As Related To SIC Codes

Components	SIC's Included
Primary Processes[a]	
Spinning (includes: opening, blending, carding, lapping, combing, drawing and roving)	Parts of 2211, 2221, 2281, 2282, 2284
Texturizing (includes: torsional compression, edge crimping and air texturizing)	Parts of 2221, 2281, 2282, 2284
Weaving (includes: warping and slashing)	2211, 2221, 2231, 2241
Knitting (includes: warp and circular knit)	2257, 2258
Greige Mills (includes: two or more of the above)	Parts of 2211, 2221, 2257, 2258, 2281
* Finishing Woven Fabrics (includes: preparation, bleaching, dyeing, printing and drying)	Parts of 2261, 2262, 2269
* Finishing Knitted Fabrics (includes: preparation, bleaching, printing, dyeing and drying)	Parts of 2257, 2258, 2261, 2262
* Yarn Dyeing (includes: preparation, bleaching, mercerizing, dyeing and drying)	Parts of 2211, 2221, 2257, 2258, 2281
* Floor Coverings (includes: yarn preparation, tufting, dyeing, printing, drying and backing)	2271, 2272, 2279
Secondary Processes[b]	
Piece goods, hosiery, felts, lace, tire cord, coated and nonwoven fabric, cordage and processed wastes	All other portions of the industry: 2231, 2251-4, 2259, 2283, 2291-9

Source: References 13, 16, and 17

* = Energy Intensive Components Employed in Sample Selection

[a]Primary process components include the operations which account for the majority of goods manufactured within the industry.

[b]Secondary process components account for the highly specialized products of the industry, less significant from an energy consumption point of view.

After the interviews were conducted, it was concluded that, in order to describe the sample accurately, some additional plant type categories needed to be included. These were deemed necessary in order to account for possible differences between the fully integrated mill and the contract mill. The seven categories ultimately employed in the data analysis of the industry by natural gas intensive plant type are found in Appendix A, Variable Number II. Verification of the accuracy of this classification scheme was computed as a by-product of a Discriminant Analysis, using the SPSS statistical package.

The classification system developed for use in the statistical analysis was influenced by several considerations;

- o The greatest amount of energy consumed per unit of production is in the "wet" processes (dyeing, printing, and finishing) where heated air, water, and steam are generated.
- o Differences between plant types under the SIC system are drawn along lines other than operational criteria. Materials employed, or value of production are the usual determinants of class membership. This was found to be inappropriate for an analysis of energy requirements.
- o The classification system employed was compatible with commercially available directories of the textile industry.[1,2] These directories served as the source for identifying plants to be included in the sample.

The classification system was designed to identify the energy intensive segments of the industry and thereby restrict the population from which the sample to be analyzed was drawn. A combination of the most relevant aspects of theSIC system and the operational criteria was ultimately employed. The actual composition of the sample is discussed in the following section.

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[1] Davison, Publishing Co., Davison's Textile Blue Book, 112th edition, Ridgewood, N.J.: 1978.

[2] Davison Publishing Co., Davison's Salesman's Book, 67th edition, Ridgewood, N.J.: 1978.

Characterization of the Sample

Each of the thirty-four firms in the sample contributed certain demographic characteristics which resulted in a balanced cross-section of the energy intensive sectors of the textile industry. In sampling from a normally distributed population, it is valid to assume that the demographic variables (e.g., annual sales, number of employees, etc.) will be normally distributed around the mean value obtained experimentally. The classic bell-shaped curve would result when the values obtained were plotted opposite the frequency with which they were observed. Such linear relationships are highly amenable to statistical analyses. The textile industry is not, however, a normally distributed population.

It was assumed that the energy intensive segments of the industry would exhibit the same skewed distribution characteristics of the industry as a whole. At this point in the analysis, the emergence of a tradeoff became apparent. While skewed distributions would have exhibited the true nature of the industry, normal distributions were desirable for the statistical analyses.

To achieve the desired accuracy expressed in a format compatible with the planned statistical analyses, a compromise was reached. The segments of the industry which perform energy intensive operations were identified in the previous section by means of two classification schemes. The system that most accurately defined energy requirements was expressed in terms of the operational processes employed. The SIC system was shown to emphasize economic or business considerations.

In selecting the sample, some means of measuring the relative size of the firms was necessary. This was to insure that the sample would accurately reflect the industry bias towards the "small business." Size was measured in terms of Number of Employees and Annual Sales Volume, (Variables III and IV, Appendix A).

Figures compiled by the U.S. Department of Commerce use the SIC system to report comparable statistics for the textile industry. These data were used to obtain an estimate of the size of firms which operate in the SIC's relevant to this study. Values of Industry Shipments and Number of Production Workers were tallied for the SIC codes that correspond to the energy intensive components of the industry (Exhibit B-2). A ratio of Value of Industry Shipments to Number of Production Workers was calculated and served as a target for the median values of Variables III and IV. These calculations are presented in Exhibit B-3.

This comparison facilitated a grouping of the data in class intervals that would approximate a normal distribution with a realistic sample. The results of this effort are presented in Exhibit B-4. The sample ratio was within five percent of the energy intensive segments ratio of Production Workers to Value of Shipments. A median sales volume of $10 million was employed in later analyses of the sample by plant size.

The industry is known to be dominated by a few large firms. The sample was selected to reflect this structure as realistically as possible. By defining the class intervals used to measure the indices of size, we were able to rearrange the date into a configuration which more closely approximated a normal distribution. This was desirable because it allowed the statistical techniques to function optimally.

EXHIBIT B-3

CHECK OF SAMPLE ACCURACY BY COMPARISON OF VARIABLES II AND IV TO REPORTED INDUSTRY STATISTICS*

As verification of sample accuracy, a comparison was made between U. S. Department of Commerce statistics and the median values from Exhibit 3. The government figures were labeled "Number of Production Workers" and "Value of Industry Shipments," and were broken down by four-digit SIC codes. The SIC codes included in the sample (as per Table B-2) were tallied and compared to the sample by simple ratio:

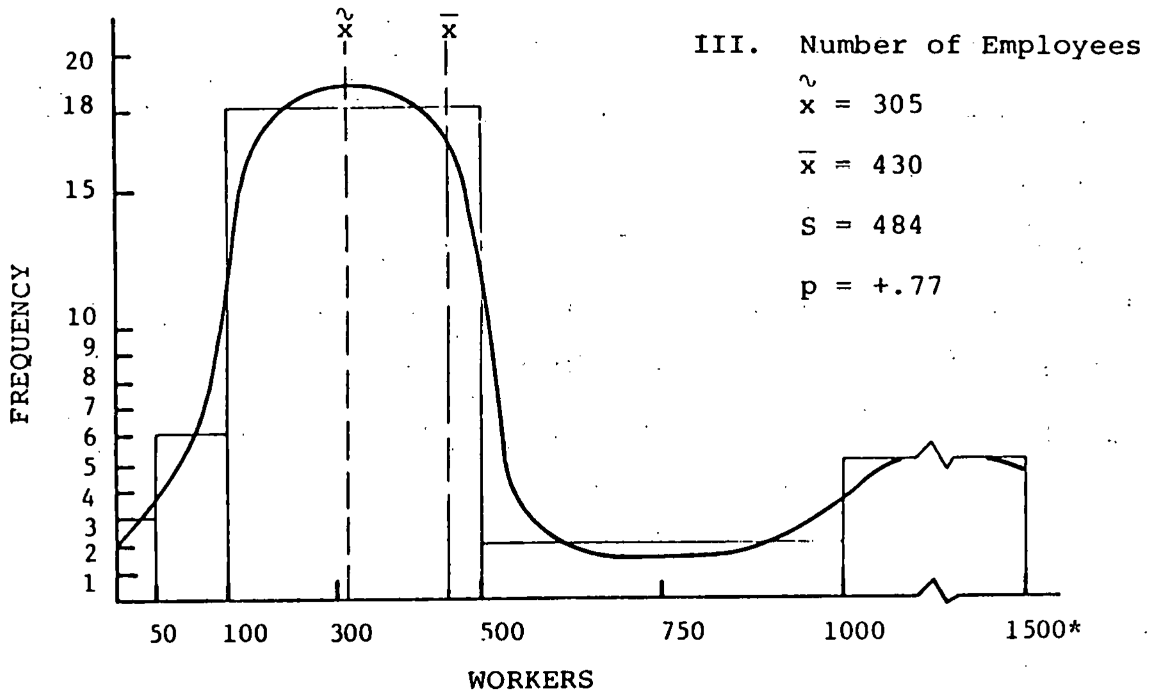
U.S.D.C. Figures		Firms in Sample
$\left(\frac{\text{Value of Industry Shipments}}{\text{\#Production Workers}}\right)$		$\left(\frac{\text{Median Annual Sales Volume}}{\text{Median \# Employees}}\right)$
$\left(\frac{14{,}936{,}900{,}000}{492{,}100}\right)$		$\left(\frac{x}{305}\right)$
$x(.4921)\ (10^6)$	=	$(45.557)\ (10^6)$
$(10^6)x$	=	$9.258(10^6)$
x	=	$9{,}258{,}000$

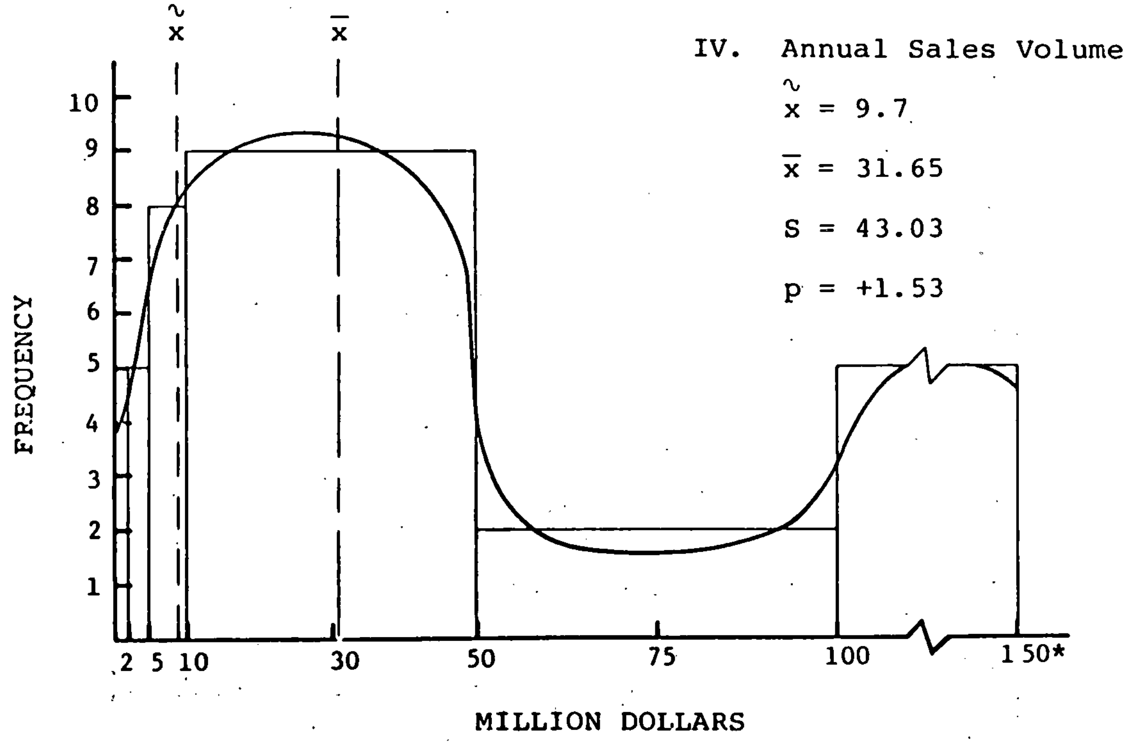
The expected value of x calculated from the sample was $9,700,000, or +5% difference.

*U.S. Department of Commerce, Annual Survey of Manufactures 1976, General Statistics for Industry Groups and Industries, U.S. Government Printing Office: Washington, December 1977.

EXHIBIT B-4

FREQUENCY HISTOGRAMS, MEDIAN ($\tilde{x}$), MEAN ($\bar{x}$), STANDARD DEVIATION (S), AND PEARSONIAN COEFFICIENT OF SKEWNESS (p), FOR VARIABLE NUMBERS III AND IV.





*Upper class limits left open during interviewing.

Geographic location was identified as a variable that would potentially account for differences in the textile industry's reactions to gas curtailments, for two reasons. First, specific segments of the industry were known to be concentrated in sub-regions of the study area. Secondly, the service areas of two interstate and five intrastate gas pipelines were involved. An overall balanced representation of the industry segments and pipeline service areas was sought in addition to the "size" distribution discussed earlier.

The composition of the sample was defined to include as many different types of pipeline service and energy intensive segments as possible. This consideration was assigned less priority than the measures of "size" when conflicts arose in the selection process.

APPENDIX C

Procedures and Results of the Factor Analysis

This appendix is included to clarify the procedures employed and results obtained at the intermediate levels of the Factor Analysis. Three main procedures are used in the Factor Analysis to manipulate the data to the simplest level of generalization that retains statistical validity. The three procedures are:

- o preparation of a correlation matrix;
- o the extraction of initial factors from the correlation matrix; and,
- o the rotation of the initial factors to a final factor solution.

The objectives and results of each step will be discussed in turn.

Correlation Matrix

The objective of a correlation matrix is to simplify a complex data set. In this case, the data set is comprised of 34 observations and 16 variables. The data set is capable of being reduced because some of the variation observed in the data set is redundant, or accounted for by more than one variable. The amount of redundant variation is determined by calculating a correlation or variance/covariance matrix for the variables. The resulting correlation coefficients (for every possible pair of variables) measure this redundancy on a scale of -1 to +1, with 0 signifying no redundancy at all, and ± 1 signifying the maximum positive or negative correlation.

Geometrically, the variables in this study, can be expressed as vectors in a 34 dimensional space. The correlation coefficient is the cosine of the angle between the vectors of any two variables.

The usefulness of correlation coefficients is twofold. First, the values indicate the degree of independence with which the variables measure the various characteristics of the sample. Secondly, they serve as the basis from which new variables (termed: "initial factors") are constructed on the assumption that the observed correlations are the result of some underlying regularity in the data.

The ability of the data variables to act independently is important because their significance will be overstated in later analyses if they are not independent. Thus, highly correlated variables were eliminated from the correlation matrix used in the initial factor extraction and final factor solution. This precluded the identification of spurious factors in the analysis. The final correlation matrix is presented in Exhibit C-1.

Initial Factor Extraction

The initial factor extraction seeks, as its prime objective, to construct a set of new variables based on the relationships assumed to exist between the correlation matrix variables and the rest of the data. These new variables are simply linear combinations of the old variables. The number of initial factors can be less than the number of old variables because of the redundancy within the data set.

EXHIBIT C-1

CORRELATION MATRIX*

	LOCATION	ASV	TYPE	PLSVC	PCTNATG	BLRCAP	SBFUEL	CONSV	HOW_IMP	LTMOTIV	FY 78	STATUS
LOCATION	1.000	0.200	-0.330	0.522	0.085	0.447	-0.097	-0.073	0.173	-0.015	-0.076	-0.107
ASV		1.000	-0.024	0.348	0.028	-0.196	0.012	-0.515	-0.018	0.325	0.408	0.077
TYPE			1.000	-0.250	-0.073	-0.214	0.322	-0.010	0.107	0.021	0.108	-0.246
PLSVC				1.000	-0.160	0.351	0.081	-0.243	0.306	0.021	0.287	-0.206
PCTNATG					1.000	0.241	0.113	0.093	0.045	0.224	-0.236	-0.010
BLRCAP						1.000	0.124	0.205	0.395	0.202	-0.058	-0.278
SBFUEL							1.000	0.174	0.220	-0.090	-0.088	-0.168
CONSV								1.000	0.043	-0.074	-0.362	-0.322
HOW_IMP									1.000	0.423	0.360	-0.083
LTMOTIV										1.000	0.527	-0.149
FY 78											1.000	-0.046
STATUS												1.000

*Correlation coefficient values range from -1 to +1, where -1 = maximum negative correlation: +1 = maximum positive correlation; and, 0 = no correlation. The correlation coefficient for two variables (x and y) indicates how much variation of the y's can be attributed to their relationship with x. The value can be expressed as a percent by squaring the correlation coefficient and multiplying times 100. See text for significance of above values.

The program seeks to uncover relationships that are not apparent with the data in its original form. There is no judgment of the significance of the relationships by the Factor Analysis. Its only purpose is to reduce the data to a set of assumptions about the composition of the variables and the causes of variation.

Five initial factors were extracted from the correlation matrix. They collectively accounted for 75 percent of the variance in the data. At this intermediate stage of the analysis, the factors were still too complex to provide a meaningful pattern of variable interrelationships. The five initial factors and their composition are presented in Exhibit C-2. These factors were redefined in the terminal factor solution which used a rotation technique to achieve the simplest possible combination of the variables.

Initial Factor Rotation

Each of the five initial factors can be graphically depicted as a point on a plane defined by x and y axes. The relative positioning of the factors in the x,y plane did not indicate clusters or patterns because the axes were fixed. To identify such patterns, a rotation of the factors around the axes was performed. The rotation sought to minimize the number of variables which comprised each factor. The resultant simple structure solution defined the least complex rearrangement of the five initial factors. The rotated factor pattern which comprises the final factor solution is presented in Exhibit C-3.

EXHIBIT C-2

UNROTATED FACTOR PATTERN
FROM INITIAL FACTOR EXTRACTION

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
LOCATION	0.529	0.343	-0.553	-0.126	0.125
ASV	0.558	-0.533	-0.042	-0.014	0.430
TYPE	-0.173	-0.098	0.749	-0.286	0.194
PLSVC	0.732	0.118	-0.289	-0.454	0.038
PCTNATG	0.023	0.334	0.015	0.666	0.567
BLRCAP	0.446	0.727	-0.112	0.110	-0.062
SBFUEL	0.003	0.324	0.453	-0.350	0.569
CONSV	-0.374	0.683	0.179	0.051	-0.256
HOW IMP	0.585	0.296	0.383	0.076	-0.160
LTMOTIV	0.573	-0.068	0.431	0.562	-0.147
FY 78	0.630	-0.452	0.377	0.003	-0.297
STATUS	-0.179	-0.475	-0.354	0.306	0.105
Percent of Sample Variance Accounted for by Factor (Total = 74.6)	21.6	18.0	15.0	10.8	9.2

EXHIBIT C-3

ROTATED FACTOR PATTERN

VARIABLES	FACTORS*				
	Process Fuel	Size	Region	Motivation	Preparedness
LOCATION	0.096	0.092	0.836*	-0.053	-0.125
ASV	0.066	0.847*	0.151	0.182	0.070
TYPE	-0.140	0.019	-0.447	0.125	0.696*
PLSVC	-0.283	0.290	0.803*	0.133	0.114
PCTNATG	0.932*	-0.016	0.032	0.071	0.043
BLRCAP	0.257	-0.397	0.667*	0.292	0.043
SBFUEL	0.184	-0.010	0.074	-0.082	0.843*
CONSV	0.103	-0.823*	-0.025	-0.034	0.131
HOW_IMP	0.010	-0.119	0.290	0.679*	0.219
LTMOTIV	0.251	0.124	-0.057	0.876*	-0.089
FY 78	-0.365	0.410	-0.040	0.727*	-0.012
STATUS	0.156	0.367	-0.247	-0.235	-0.461
Percent of Sample Variance Accounted for by Factor (Total - 74.6%)	21.6%	18.0%	15.0%	10.8%	9.2%

* = Variables above factor loading criteria of ±0.5 were used to name the factors.

The VARIMAX rotation option was selected because it sought to identify one variable per factor that exerted the greatest influence in defining that factor. A scale of -1 to +1 was used to measure each variable's contribution to the factors. These values are termed "factor loadings" and can be converted to percentages by squaring and multiplying by one hundred. The total percentage of variance (of the data) accounted for by each factor is the sum of the squared factor loadings times one hundred. The five factors identified in the final solution accounted for nearly 75 percent of the textile plants variations in response to natural gas curtailments.

The factors identified in the rotated factor pattern (Exhibit C-3) were assigned names based on the variables that loaded highly on each factor. These names are used in the interpretation of the results in Chapters 3 and 4 of the text. While each of the factors was assumed to be uncorrelated, the variables that comprised a factor were not. Factor names were chosen to identify the factor in terms of the relationship between its component variables.

The major outputs of the Factor Analysis provide explanations of plant to plant variations noted in response to natural gas curtailments. The final factor solution identified five groups of related variables from the correlation matrix that accounted for clusters of variance. For an interpretation of the significance of these factors, see Chapters 3 and 4 of the text.

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