Data Sources and Methods for Industrial Energy Analysis

Final Report

MASTER

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Prepared for
U.S. Department of Energy
Assistant Secretary for Energy Technology
Office of Fossil Energy

Under Contract EX-76-C-01-2344

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**Energy and Environmental Analysis, Inc.
Arlington, Virginia 22209**

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SECTION I

INTRODUCTION AND OVERVIEW OF INDUSTRIAL ENERGY USE PATTERNS

A. MAJOR SEGMENTS OF THE INDUSTRIAL ENERGY MARKET

In 1974 the industrial sector consumed about 25 quadrillion Btus (quads) of energy for fuels and feedstock. More than twenty quads of this energy was used by the manufacturing sector.^{1/} Table I-1 presents a summary of current energy use in the manufacturing sector based on FEA's Energy Consumption Data Base (ECDB). It is the purpose of this paper to describe the data sources and methods with which one can more fully understand energy use patterns in the industrial sector at less aggregated levels of detail than shown in Table I-1.

The industrial market is an important one for fossil energy technologies such as coal gasification and liquefaction. Industrial firms can be the actual investors in the technologies and/or can purchase the output of the plants from utility or refinery type suppliers. The industrial market is large in that it consumes roughly one-third of the energy used in the economy. It is also a market where users are seriously investigating alternatives to current sources of energy. This search for alternatives has been prompted by higher energy prices, energy availability problems, government regulatory action and environmental constraints. The industrial market is clearly one where the ERDA/FE technologies could potentially play an important role. The exact role which the technologies can realistically expect to play can only be determined after careful study of industrial energy use patterns.

^{1/} The other segments of the industrial sector are construction, agriculture, and mining.

TABLE I-1

1974 CONSUMPTION OF ENERGY IN THE MANUFACTURING SECTOR, BY INDUSTRY (10¹² BTU)

<u>SIC/Industry</u>	<u>Natural Gas</u> <u>10¹²BTU(%)</u>	<u>Petroleum</u> <u>Products^{a/}</u> <u>10¹²BTU(%)</u>	<u>Coal</u> <u>10¹²BTU(%)</u>	<u>Electricity</u> <u>10¹²BTU(%)</u>	<u>Other^{b/}</u> <u>10¹²BTU(%)</u>	<u>Total</u> <u>10¹²BTU(%)</u>
20 Food	476 (51%)	132 (14%)	75 (8%)	127 (14%)	125 (13%)	935 (100%)
26 Paper	414 (19%)	577 (26%)	209 (9%)	133 (6%)	891 (40%)	2,224 (100%)
28 Chemicals	2,093 (40%)	2,085 (40%)	322 (6%)	437 (8%)	274 (5%)	5,211 (100%)
32 Stone, Clay, Glass	696 (53%)	125 (10%)	233 (18%)	100 (8%)	147 (11%)	1,301 (100%)
33 Metals	1,315 (27%)	418 (9%)	2,639 (55%)	536 (11%)	-91 ^{c/} (NA)	4,817 (100%)
All Others	2,103 (37%)	1,082 (19%)	164 (3%)	759 (13%)	1,524 (27%)	5,632 (100%)
Total Manufacturing	7,097 (35%)	4,419 (22%)	3,642 (18%)	2,092 (10%)	2,870 (14%)	20,120 (100%)

a/ Includes distillate oils, residual oils, miscellaneous petroleum products, and liquified petroleum gas.

b/ Other includes the sum of coke, asphalt, other gas, hydro, and other energy.

c/ Negative numbers are used to avoid double counting of BTUs, e.g., coal used in coke production.

SOURCE: Energy Consumption Data Base (ECDB), FEA.

The heterogeneity of energy demand in the industrial sector is suggested by Table I-2, which shows the variation within the manufacturing sector in the degree to which different regions are dependent upon the various fuel forms. This heterogeneity would also be apparent from any one of a number of other types of market segmentation. For example, there are significant variations in the functional uses (direct heat, raw material, steam raising, etc.) of the energy used by different industries. This is illustrated in Table I-3, which is also derived from ECDB data. It shows the differences in the ways that energy forms are used in the manufacturing sector.

In order to assess the potential for penetration of various coal conversion and other fossil energy technologies into the industrial market, it is necessary to be able to utilize this type of market segmentation data. The fossil energy technologies will always be evaluated by industrial users in comparison to other available options. While no two users may be faced with identical circumstances and/or evaluate those circumstances similarly (equally), certain generalizations can be made about how users in a given segment of the market (geographical, type of industry, type of process) will evaluate the costs of the fossil energy technologies relative to conventional fuel options and to each other. Market segmentation is an important consideration for ERDA/FE in assessing the extent to which fossil energy technologies can be expected to penetrate the industrial market.

In general, the better a market segment is specified, the more accurate the generalization about the attractiveness of a particular energy option will be. Data availability often provides constraints on the degree to which markets can be segmented. The descriptions of available data bases and the sample applications in this paper will provide information about the types of useful information available as well as areas of weakness in the available data. The discussion in Section IV provides a methodology for segmenting the industrial energy market as a means of analyzing low and medium Btu gas potential. This section will also deal further with the usefulness of market segmentation techniques to ERDA/FE in assessing market penetration.

TABLE I-2

1974 REGIONAL CONSUMPTION OF ENERGY IN THE MANUFACTURING SECTOR (10^{12} BTU)

Region	Natural Gas 10^{12} Btu(%)	Petroleum Products ^{a/} 10^{12} Btu(%)	Coal 10^{12} Btu(%)	Electricity 10^{12} Btu(%)	Other ^{b/} 10^{12} Btu(%)	Total 10^{12} Btu(%)
Northeast	60 (12%)	237 (49%)	5 (1%)	73 (15%)	112 (23%)	487 (100%)
Mid Atlantic	546 (21%)	607 (23%)	991 (38%)	287 (11%)	203 (8%)	2,634 (100%)
South Atlantic	500 (21%)	594 (25%)	472 (20%)	297 (13%)	499 (21%)	2,362 (100%)
East North Central	1,400 (32%)	576 (13%)	1,438 (33%)	486 (11%)	471 (11%)	4,371 (100%)
East South Central	502 (34%)	176 (12%)	347 (23%)	280 (19%)	132 (12%)	1,487 (100%)

^{a/} Consists of Distillate, Residual, Misc. Petroleum Products, and LPG.

^{b/} Consists of coke, asphalt, other gas, hydro, and other energy.

SOURCE: Energy Consumption Data Base (ECDB), FEA.

TABLE I-2
(Continued)

1974 REGIONAL CONSUMPTION OF ENERGY IN THE MANUFACTURING SECTOR (10^{12} BTU)

Region	Natural Gas 10^{12} Btu(%)	Petroleum Products ^{a/} 10^{12} Btu(%)	Coal 10^{12} Btu(%)	Electricity 10^{12} Btu(%)	Other ^{b/} 10^{12} Btu(%)	Total 10^{12} Btu(%)
West North Central	457 (51%)	107 (12%)	129 (15%)	98 (11%)	98 (11%)	889 (100%)
West South Central	2,727 (50%)	1,752 (32%)	88 (2%)	219 (4%)	702 (13%)	5,488 (100%)
Mountain	261 (46%)	57 (10%)	73 (13%)	72 (13%)	99 (18%)	562 (100%)
Pacific	631 (37%)	275 (16%)	92 (5%)	278 (16%)	444 (26%)	1,720 (100%)
United States Total	7,097 (35%)	4,419 (22%)	3,642 (18%)	2,092 (10%)	2,870 (14%)	20,120 (100%)

^{a/} Consists of Distillate, Residual, Misc. Petroleum Products, and LPG.

^{b/} Consists of coke, asphalt, other gas, hydro, and other energy.

SOURCE: Energy Consumption Data Base (ECDB), FEA.

TABLE I-3

1974 FUNCTIONAL USES OF ENERGY IN THE MANUFACTURING SECTOR (10^{12} BTU)

Functional Uses	Natural Gas 10^{12} Btu(%)	Petroleum ^{a/} Products 10^{12} Btu(%)	Coal 10^{12} Btu(%)	Electricity 10^{12} Btu(%)	Other ^{b/} 10^{12} Btu(%)	Total 10^{12} Btu(%)
Total Direct Heat	2,706 (38%)	1,137 (26%)	238 (7%)	103 (4%)	1,120 (23%)	5,304 (26%)
Process Steam	1,700 (24%)	706 (15%)	545 (15%)	---	1,280 (26%)	4,231 (21%)
Raw Materials	475 (7%)	1,882 (43%)	--- ---	---	1,519 (31%)	3,976 (19%)
Electrical Generation	377 (5%)	114 (3%)	228 (6%)	- 293	90 (2%)	516 (3%)
Coke Production	1 (-)	3 (-)	2,363 (65%)	7 (-)	-2,022 ^{c/} (NA)	352 (2%)

a/ Includes distillate oils, residual oils, miscellaneous petroleum products, and liquified natural gas.

b/ Includes coke, asphalt, other gas, hydro, and other energy.

c/ Negative numbers are used to avoid double counting of Btus, e.g., coal used in coke production. Percentages are calculated by excluding negative values.

SOURCE: Energy Consumption Data Base (ECDB), FEA.

TABLE I-3
(Continued)

1974 FUNCTIONAL USES OF ENERGY IN THE MANUFACTURING SECTOR (10^{12} BTU)

Functional Uses	Natural Gas 10^{12} Btu(%)	Petroleum Products ^{a/} 10^{12} Btu(%)	Coal 10^{12} Btu(%)	Electricity 10^{12} Btu(%)	Other ^{b/} 10^{12} Btu(%)	Total 10^{12} Btu(%)
Machine Drive	118 (2%)	47 (1%)	---	810 (34%)	30 (1%)	1,005 (5%)
Electrolyte Processes	---	---	---	374 (16%)	13 (-)	387 (2%)
Space Conditioning and Lighting	40 (1%)	13 (-)	5 (-)	77 (4%)	0 (-)	135 (1%)
Uses Not Specified by Kind	1,680 (24%)	518 (12%)	264 (7%)	1,013 (42%)	838 (17%)	4,313 (21%)
Total	7,097 (100%)	4,419 (100%)	3,643 (100%)	2,091 (100%)	2,870 (100%)	20,120 (100%)

a/ Includes distillate oils, residual oils, miscellaneous petroleum products, and liquified natural gas.

b/ Includes coke, asphalt, other gas, hydro, and other energy.

c/ Negative numbers are used to avoid double counting of Btus, e.g., coal used in coke production. Percentages are calculated by excluding negative values.

SOURCE: Energy Consumption Data Base (ECDB), FEA.

B. OVERVIEW OF REPORT

Section II of this report describes a number of the major industrial energy use data bases which are often used to analyze industrial energy use. The descriptions include information about the type of data collected, the comprehensiveness of the data collected, and the strengths and weaknesses of the data as a means of performing highly disaggregated analysis of industrial energy use. Major energy projections and industrial location data bases are also briefly described.

Section III gives the results of an analysis which used a number of energy and industrial location data bases to estimate plant-specific energy use in ten of the largest energy-using industries. The methodology is outlined in detail, and assumptions needed to overcome data insufficiencies are made explicit. The Section summarizes the results of the analysis and discusses the implications of the energy use per plant distributions for the industrial market for high and low Btu coal gasification and coal liquefaction.

Section IV outlines a methodology for segmenting the industrial energy market and evaluating the competitiveness of low and medium Btu gas relative to other alternatives. Sample calculations and the resulting cost comparisons are shown for certain important segments of the market. The methodology demonstrates the uses of the industrial energy data bases in performing market penetration analysis.

SECTION II

DATA BASES AVAILABLE FOR ANALYSIS OF INDUSTRIAL ENERGY USE PATTERNS

A. INTRODUCTION

There are a number of data bases which can be utilized in performing detailed analysis of industrial markets for specific fossil energy technologies. As the discussion below indicates, no single data base has all of the characteristics necessary for analysis of all segments of the industrial sector at a highly disaggregated level. Examples are presented in Sections III and IV of how some of these data bases could be utilized to estimate plant-specific energy use and evaluate the market for a particular technology (low Btu gas).

Many of the data bases have characteristics which are not discussed below. In order to focus the data base descriptions, characteristics are noted if they are relevant to the following type of analysis:

- Evaluation of current and recent historical energy use patterns in specific industries.
- Location of industrial plants and processes utilized in specific industries.
- Analysis of regional and plant-to-plant variations in types and quantities of energy used.
- Assessment of current and future economic and environmental pressures on industrial energy users.
- Projections of future energy use and future economic activity, industrial location, industrial production, etc.

While the industrial sector includes manufacturing, construction, mining, and agriculture,^{1/} the emphasis of this discussion is placed on the manufacturing sector. Manufacturing sector energy use is well documented, accounts for about 80 percent of total industry energy use, and can adopt most new fossil energy technologies.

Three types of data bases and projections are discussed below:

1. Current and historical energy use data bases
2. Industrial location data bases
3. Energy and general economic projections

As stated in Section I, it is assumed that the purpose of using these data bases is to analyze future industrial energy markets at a disaggregated level. It will often be necessary to combine elements of all three data bases in order to do this. For example, since most energy projections are highly aggregated (sometimes only showing national or broad regional totals), it may be necessary to use more detailed (state-specific) historical energy data to estimate how a projected total usage of industrial energy is distributed among states. To accurately estimate the future industrial market for some of the fossil energy technologies, it may be necessary to go even one step further and estimate how a state's or an industry's projected energy use is distributed among individual plants. For this type of analysis it may be necessary to use industrial location data bases and relate a plant's energy use to some non-energy variable such as production or capacity.

^{1/} According to the definitions in the Standard Industrial Classification (SIC) System.

B. DATA BASE DESCRIPTIONS

1. Energy Data Bases

A number of energy data bases are described below. This is not an all-inclusive list of available data bases, and the emphasis is on large-scale general data bases compiled through actual surveys. Literally hundreds of contractor studies dealing with specific energy problems have been done in the last three or four years for EPA, FEA, ERDA, Commerce, and Interior. Almost all of these studies have involved compilation of some sort of energy "data base". An effort has been made to describe some of the major energy data bases such as those of the Bureau of Mines or Census on which these studies are often based but it would clearly be impractical to describe all of the ways in which specific studies have compiled this basic data or added to it with original research and surveys.

Greatest detail is provided for descriptions of the Census and Bureau of Mines data bases and the ECDB. These are the most important and comprehensive data bases. Sample entries from the actual data bases are presented in Appendix A. Table II-1 presents a summary of the major energy data bases. The Table is for comparisons of coverage and detail available, but generalizations may be misleading in some cases.

a. Energy Consumption Data Base (ECDB)

The Energy Consumption Data Base (ECDB) is a large scale data base of energy consumption in the United States. It has been compiled for the Federal Energy Administration (FEA) and has over 7.5 million pieces of energy consumption and expenditure information. The agricultural, mining, construction, manufacturing, transportation, commercial, household, and electric utility sectors were examined in different levels of detail, and data on all of these sectors are included in the ECDB. Full documentation is provided for all data, and all data is presented in a consistent format and according to uniform definitions of fuel types, categories, etc. The discussion below will focus on the manufacturing sector, and it should be noted that the types of data collected and the level of detail available varies between sectors. Similar but not identical energy consumption and expenditure data is available in the ECDB on the construction, agricultural, and mining sectors.

TABLE II-1

SUMMARY OF MAJOR ENERGY DATA BASES

DATA BASE	Comprehensive			Level of Disaggregation			Energy Prices	Comments
	All Industries	All Energy Usage	Periodic Updating	Fuel Types Listed	Industries	Geographical		
ECDB	Yes (I)	Yes	No	All	2-Digit*	State	Yes	Functional Use Data
MFBI	No	No	No	Major Fuels	4-Digit	Plant-Specific	No	Only Combustors 100MMBtu/hr
CENSUS	Yes (M)	No	Yes	All Purchased, Heat & Power	4-Digit	State (3-digit), SMSA, city	Yes	-----
BOM	Yes (I)	Yes	Yes	All	Aggregated	State	No*	Shipments, not consumption
COMMERCE V.E.C.	No	No	Yes	Varies	Specific, but no SIC	National	No	-----
Trade Association	No	Yes*	Yes	All*	Specific, but no SIC	Varies	Varies	-----
Gas Req'ts. Comm.	Yes (I)	No	Yes	Nat. Gas	2-Digit	State	No	Also data on curtailment; SIC incomplete
AGA	Yes (I)	No	Yes	Nat. Gas	Aggregated	Region	Yes	-----
FPC	Yes (I)	No	Yes	Gas/Elec.	Aggregated*	Varies	Yes	-----
NEDS	Yes (I)	No	Yes ^{2/}	Major Fuels	4-Digit, Aggregated	County, Plant	No	Plant data only for large plants

*Generalization about a non-homogeneous group or characterization. May not be true in all cases.

1/ Total Industrial Sector(I) or Total Manufacturing Sector(M).

2/ Updating not uniform.

For all sectors, the ECDB has data for 1967, 1971, and 1974. All data is annual, with no monthly or quarterly data. For the manufacturing sector, the ECDB represents a compilation of published data, and is not based on any direct survey data. Its sources include many of the individual data bases described below. The ECDB is a data base of historical data, and no plans are known at this point for regular up-dates.

The data base contains information on the quantities of energy consumed in specific categories and expenditures for each energy type. The fuel type detail given for industries in the manufacturing sector is shown in Table II-1. The functional uses of the various energy sources are shown in the ECDB, and the categories used are also given in Table II-1. The manufacturing sector is broken down into specific industries according to Standard Industrial Classification (SIC) conventions as shown in Table II-2. All data is also broken down geographically, and is presented by state and Census Region. The ECDB is cross-stratified such that, for example, the quantity of natural gas consumed in the Chemical Industry in Texas for direct heat in 1971 would be given.

While the "Manufacturing Sector Codes" provided in Tables II-1 and II-2 are the categories in the data base, for many industries only incomplete data are available. This is especially true for the functional use categories in many industries. In some cases, for example, a large segment of the functional use energy breakdown may be in Code 59: "Other Uses, Not Specified By Kind, Not Elsewhere Classified". This is used when data is not available to justify an estimate of the functional use of all energy. For most industries only national total data is presented for functional use breakdowns, but these national averages can be applied as shares to regional data.

Each data element is fully documented as to the source of the information and any assumptions used to derive an estimate. Most data in the manufacturing sector in the ECDB are from the Census of Manufactures and the Annual Survey of Manufactures. In those industries where non-purchased energy or energy used for purposes other than heat and power are important, sources other than the Census were used. Special industry studies and trade association data provided most of that information.

TABLE II-2

FUEL TYPE AND FUNCTIONAL USE CATEGORIES USED
IN ECDB - MANUFACTURING SECTOR

A.	<u>Fuel Type</u>	<u>Code</u>
	Coal	10
	Coke and Breeze	11
	Distillate Oil (including Diesel)	25
	Residual Oil	26
	Asphalt	27
	Miscellaneous Petroleum Products	29
	Liquefied Petroleum Gases	30
	Natural Gas	41
	Other Gas, NSK/NEC	49
	Hydroelectricity	60
	Electricity	70
	Other Energy, NSK/NEC	80
	Total All Energy	99
B.	<u>Functional Use</u>	<u>Code</u>
	Space Heating	11
	Space Cooling	12
	Space Conditioning, NSK/NEC	13
	Lighting	23
	Total Direct Heat	30
	Direct Heat - below 600°F	31
	Direct Heat - 600°F - 1000°F	32
	Direct Heat - 1000°F - 1500°F	33
	Direct Heat - above 1500°F	34
	Direct Heat, NSK	35
	Raw Material	41
	Process Steam	42
	Electricity Generation	43
	Coke Production	44
	Machine Drive	45
	Electrolyte Processes	46
	Other Uses, NSK/NEC	59
	Total All Functional Uses	99

TABLE II-3

INDUSTRY CATEGORIES USED IN ECDB
- MANUFACTURING SECTOR

C. <u>Industry</u>	<u>Code</u>
Food and Kindred Products	120
Tobacco Manufacturers	121
Textile Mill Products	122
Apparel	123
Lumber	124
Furniture	125
Paper (total)	126
Pulp, Paper, Paperboard, Building Paper and Board Mills	158
Other Paper Products, NSK/NEC	159
Printing, Publishing	127
Chemicals (total)	128
Petroleum Refining	129
Rubber & Miscellaneous Plastics	130
Leather	131
Stone, Clay, Glass, Concrete (total)	132
Cement	178
Other Stone, Clay, etc., NSK/NEC	179
Primary Metals (total)	133
Blast Furnace and Steel Mills	187
Aluminum	188
Other Primary Metals, NSK/NEC	189
Fabricated Metal Products	134
Machinery (except electrical)	135
Electrical & Electronic Machinery	136
Transportation Equipment	137
Measuring, etc. Equipment	138
Miscellaneous Manufacturing Industries	139
Other Industries, NSK/NEC	199
Total All Industries	100

TABLE II-4

PARTICIPANTS IN THE COMMERCE VOLUNTARY INDUSTRIAL
ENERGY CONSERVATION PROGRAM

Aluminum Association
American Bakers Association
American Feed Manufacturers Association
American Foundrymen's Society
American Iron and Steel Institute
American Meat Institute
National Independent Meat Packers Association
American Mining Congress
American Paper Institute
American Petroleum Institute
American Textile Manufacturers-Institute
Biscuit and Cracker Manufacturers Association
Brick Institute of America
Can Manufacturers Institute
Computer and Business Equipment Manufacturers Association
Glass Container Manufacturers Institute
Glass Container Manufacturers Institute
Glass-Flat Glass (Third Party)
Glass-Pressed and Blown (Third Party)
Gypsum Association
Manufacturing Chemists Association
National Cannery Association
Portland Cement Association
Tile Council of America
Aerospace Industries Association
Air-Conditioning and Refrigeration Institute
American Frozen Food Institute
American Home Appliance Manufacturers
Asphalt Roofing Manufacturers Association
Commercial Refrigeration Manufacturers Association
Electronic Industries Association
The Fertilizer Institute
Gas Appliance Manufacturers Association
General Aviation Manufacturers Association
Grocery Manufacturers Association
Hand Tools Institute
Milk Industry Foundation
National Association of Food Chains
National Clay Pipe Institute
National Lime Association
National Soft Drink Association
Pharmaceutical Manufacturers Association
U.S. Brewers Association
U.S. Independent Telephone Association
Western Electronic Manufacturers

the industry breakdowns shown in Table II-2 are mainly two-digit SIC industries.^{1/} Some three- and four-digit detail is provided for those large energy-using industries (paper, metals, and petroleum) where data was available and the more disaggregated industries are particularly significant. As with all of the sectors, the data at the more aggregated levels generally have lower probable error estimates than the less aggregated level. For example, a particular industry's functional use breakdown of coal is less certain than the total quantity of coal used.

The ECDB is most useful as a compilation of numerous other data sources. By putting all the data into a consistent format, it avoids problems presented in comparing different sources of data whose definitions (such as "consumption" versus "shipments" or "sales") may differ. While considerable detail is provided in the ECDB, the industry detail (mainly two-digit SIC codes is sometimes insufficient for highly disaggregated analysis.

b. FEA's Major Fuel Burning Installation Survey (MFBI)

The Major Fuel Burning Installation (MFBI) Report was a survey of industrial plants which was performed in May, 1975 by the Office of Fuel Utilization, FEA. A follow-up survey was sent to a subset of the total survey, but the MFBI is not a periodic survey. All firms consuming more than 99 MMBtu/hr at specific plant sites were required to complete and forward requested information to FEA.

The primary purpose of this survey was to identify large combustors capable of firing coal which at the present time are relying heavily on either oil or gas. Under ESECA, FEA has the authority to force these plants to convert to coal. Total coverage is about 6,300 combustors at 3,400 plants.

The data from the MFBI deals with specific plants (and government installations) and with specific combustors within particular plants. The plants are identified

^{1/} The SIC codes in Table II-2 are the last two-digits in the ECDB codes except for numbers greater than 39. Numbers greater than 39 are subdivisions of the two-digit industry, and may be three- or four-digit industries.

according to company name, street address, zip code, and state. For the plant as a whole, the total number of boilers and the number of "other combustors" are specified. The total designed firing rate for all combustors is given. For individual combustors with a designed firing rate greater than 99 million Btus per hour, the following information was collected:^{1/}

- Kind of combustor (boiler, burner, other)
- Combustor capacity
- Date installed and manufacturer
- Primary and alternate energy sources (coal, residual, distillate, gas, other)
- Information about current and historical coal burning capability
- 1974 and 1973 fuel use (Btu content and physical quantity consumed of coal, residual, distillate, and gas)
- Percent of combustor output devoted to: electric generation, space heating, process steam, "other"
- Information about type of air pollution control equipment and removal efficiencies

The MFBI survey does not provide complete coverage of the industrial sector's energy usage. It is focused on the large boilers, burners, and other combustors, and detailed fuel usage information is not available for any combustor which uses less than 100 MMBtu per hour. Even for a given plant with several large combustors, the data in the MFBI survey does not give information about all of

^{1/} See Appendix A for a copy of the actual survey form and all data collected.

that plant's energy demands since much of the fuel could conceivably have been burned in smaller units or used for non-fuel purposes (i.e., chemical feedstocks). Total 1974 energy use by the approximately 6,300 large combustors covered in the survey was about 6.6 quadrillion Btus, of which about 3.5 quads was gas, 1.3 quads was oil and about 1.8 quads was coal.

The MFBI data has not been published by FEA, and is considered to be confidential due to the information provided on individual companies. Aggregated summaries by SIC code and state were prepared by Energy and Environmental Analysis, Inc. (EEA) for use by FEA's 1975 Natural Gas Task Force. Other than this use (which was with preliminary data), it is not clear that the MFBI data has been utilized for purposes other than FEA's coal conversion analyses. The MFBI probably represents the only source of actual survey data on the energy use characteristics of large combustors in specific plants.

c. U.S. Department of Commerce, Bureau of the Census

The economic censuses are conducted in order to provide a comprehensive statistical profile of a large segment of the national economy. Forestry is not surveyed, but the other three segments of the industrial sector (manufacturing, construction, and mining) are surveyed. While the major purpose of the surveys is to collect information on the overall structure of the industries, questions on energy consumption are included in the Census of Manufactures and the Census of Mineral Industries.

The Census of Manufactures (COM) and Census of Mineral Industries (CMI) are conducted every five years. Recent censuses have been conducted in 1967 and 1972, with the next census planned for 1978 (1977 data). The 1972 COM energy data (for manufacturing) was actually collected in 1971 as a means of spreading the work load associated with collecting and compiling the data. The Annual Survey of Manufactures is a smaller survey which is conducted in non-census years. The 1974 Annual Survey was the first one to include questions on fuel and energy

use,^{1/} and this data collection effort will continue annually. The Census of Manufactures surveys all firms having more than 10 employees. The annual survey coverage is all firms with more than 250 employees. Those with fewer employees are sampled, and data for the non-covered firms is estimated. In 1972, the Census of Mineral Industries did not directly canvass single-unit establishments with fewer than four employees, and previous administrative records were used for estimation. For both the COM and CMI, the firms not surveyed accounted for a very small over-all share of both total value added and energy use, although these firms may be significant in certain specific industries.

The COM (and annual survey) asks firms to report only purchased fuels used for heat and power. The survey does not include energy sources that firms do not purchase or use for non-fuel purposes (e.g. Feedstocks). Quantities consumed and expenditures are reported for the following energy sources: coal, coke (including breeze), distillate and residual fuel oil, natural gas, "other fuels", and purchased electricity. Self-generated electricity (less the quantity sold) is also reported. While the 1972 COM and the 1974 annual survey do not specify energy used as a raw material or non-purchased fuels, the 1967 COM did collect such data for some of the major industries where these uses are significant.

The CMI collects data separately for purchased fuels and electric energy and for energy purchased and consumed at the same establishment. The purchased fuel types specified are: coal, distillate and residual fuel oil, gas, gasoline, purchased electricity, and generated electricity (both "used" and "sold"). Both quantities and costs are provided for each of these categories, and a cost of "other purchased fuels" is also given. The quantity of coal, crude petroleum, and gas produced and consumed at the same establishment is also specified.

The Census of Manufactures publishes the energy consumption and cost data disaggregated both geographically and by industry. The published data for the 1967

^{1/} Only questions on electricity usage and total energy cost had been asked previously.

COM presents only national totals; but the 1972 COM and the future Censuses and Annual Surveys present state data (including SMSAs). The Census data is also broken down by SIC code, with three and four-digit SIC codes being shown at the national level. Only three-digit SIC detail is provided at the state level for 1974 and only two-digit detail is provided for 1972. Publishing individual industrial detail with four-digit SIC detail at the state level would involve disclosure of individual company data in a number of the less heavily industrialized states, and Census has adopted a policy of only publishing three-digit state data.

The published information on energy consumption and costs from the CMI gives less detail than the COM. National totals are provided for two, three, and four-digit SIC codes within the mining sector, and state totals are provided for the mining sector totals. However, no 1974 data is available from Census on the mining sector's use of energy.

There are long time lags between the year for which the data is collected and the date of publication. The Special Report on "Fuels and Electric Energy Consumed" for 1971 (1972 Census of Manufactures) was not published until July, 1973, with the data on electrical energy consumption and cost not published until September, 1974. The 1974 "Fuels and Electric Energy Consumed" report was not published until April, 1976 and the state data was not available until about September, 1976.

Because the Census reports are the result of an actual survey of the firms using the energy, actual consumption is measured and considerable detail as to industry and location is possible. However, the data has several deficiencies. Non-purchased sources of energy and energy used for non-fuel purposes are not reported in the manufacturing sector. These are especially important in the steel, chemicals, petroleum refining, and paper industries. The state data published is shown only at the three-digit SIC level, and there are numerous cases where data is not published due to the disclosure of company information which would result. While considerable detail is shown for the various types of fuels, some minor fuels such as LPG and gasoline are grouped into an "other fuels" category

and in many small industries a "fuels not specified by kind" category includes a relatively large amount of the total energy usage. This category represents estimated fuel use by the non-sampled companies. Finally, no plant-specific information is published, and no information is collected on functional uses of energy.

d. Department of the Interior, Bureau of Mines

The Bureau of Mines (BOM) collects data on reserves, production, and consumption of fuels and energy. Separate collection efforts are conducted for coal, natural gas, and petroleum products. BOM data provides complete coverage of the fuels used by the economy. However, because the agency is most concerned with production rather than consumption, much of the end-user data published is of limited usefulness for detailed analysis of consumption patterns. With a few exceptions, most of the data on consumption is collected through producers and distributors who are asked to specify who receives shipments of the various fuels. End-use data is usually not specified beyond aggregated sectoral designations such as "industrial" or "household-commercial".

Most of the BOM energy data is published in the Mineral Industry Surveys (usually monthly and annual) and the Minerals Yearbook (annual). Since the Bureau's collection and publication procedures are different for the various fuels, a separate discussion will be given for each of the major fuel types. The discussion will focus on those data elements relevant to industrial consumption, although the Bureau also publishes data on production, storage, transportation, reserves, etc. for the various fuel types.

1) Natural Gas

While production of natural gas is published monthly, industrial sales are only reported on an annual basis. Producers and distributors of natural gas are asked to specify the sector to which they sell natural gas, but no breakdown is available which is less aggregated than "industrial" deliveries. Because the quantities reported are the amount "delivered to consumers", the actual consumption in a given year is not known. Secondary storage by end-users, for

example, would result in deliveries over-stating consumption. The value of the gas delivered is also reported, and State breakdowns are provided for deliveries to the industrial sector. State breakdowns are also given for the quantities of natural gas used for fuel on natural gas leases and by natural gas processing plants.

BOM coverage is of both intra-state and inter-state sales, with State agencies reporting production. The sales to various classes of customers are reported by the pipelines and distributors and the value of gas delivered is also reported. Actual end-users of natural gas are not surveyed.

2) Coal

The Bureau of Mines conducts an annual survey of coal producers. While production data is of high quality, end-users are not well defined for most end-uses in the industrial sector. Basic production data is collected from State agencies which license coal mines. Data on production and uses are based on voluntary reports by producers, sales agents, distributors, and wholesalers.

National data is available annually on coal consumption by the following categories of users in the mining and manufacturing sectors: beehive coke plants, oven coke plants, steel and rolling mills, and "other manufacturing and mining industries". The Bureau of Mines surveys of coke plants give good coverage of consumption by this category of users. Consumption by the other categories of users is estimated on the basis of surveys done of selected steel and rolling mills and manufacturing plants. State data is available annually from BOM on the distribution of coal to the various states, but the data is broken down into only four categories: electric utilities, coke and gas plants, retail dealers, and "all others".

3) Petroleum Products

Separate reports are published as part of the Mineral Industry Surveys series on a number of specific types of petroleum products. End-user specifications are made for a number of products on an annual basis. Annual reports on sales of fuel oil and sales of liquified petroleum gas both give sales to industrial users. State sales to industrial users are specified for distillate, residual, and

liquified petroleum gases (with propane, butane, and butane-propane mixture shown separately). While monthly reports from all refiners are the basis for BOM's production data, surveys of dealers and jobbers handling more than 50,000 barrels of oil per year are the basis for the end-user designations. End-users of petroleum products not surveyed are estimated based on the results of the survey. All data in these reports are "sales for industrial use", and do not necessarily accurately represent consumption in the particular year.

No end-user specifications are given for a number of "minor" industrial fuels such as gasoline (important in construction and agriculture), kerosene, special naphthas, or petrochemical feedstocks. A special annual report is published on sales of asphalt. Type of use and state are specified. While "petrochemical feedstocks" may seem to be both a product and an end-use, this category does not include the feedstocks coming from natural gas processing plants, and hence, gives only partial coverage of this important product.^{1/}

4) Other Bureau of Mines Reports

There are several other BOM energy reports which are relevant to the industrial sector. In the Minerals Yearbook chapter on cement, fuel consumption in cement plants is given, though only at a national level. BOM data is published annually on fuels used for all purposes at petroleum refineries. This data is disaggregated by state, (with some groupings of states to prevent disclosure) and includes both purchased fuels and non-purchased fuels (including still gas, etc.). The data is collected from an annual survey of all petroleum refineries. Although not a regular report, BOM conducted a specific canvass of mining and mineral processing. The data, however, is not placed into categories which can be readily classified as to SIC code. There is considerable overlap between the mining and manufacturing sectors in the reporting of smelting and other mineral processing activities.

^{1/} The various products which are produced at gas processing plants are not split between "fuel use" and "chemical use".

On an annual basis, the Bureau of Mines publishes its energy data from the various Mineral Industry Surveys in a publication called "Fuel and Energy Data, United States by States and Regions". This report presents state, regional, and national consumption estimates by type of fuel and sector. No disaggregation below a total for the industrial sector is given. The fuel types given are: anthracite, bituminous coal and lignite, petroleum products, and natural gas. A further breakdown is available for some of the petroleum products, but it should be noted that BOM must assume end uses for certain fuels (e.g., all gasoline is assumed to be used in the transportation sector). It also does not distribute a number of petroleum products to states. Although listed as "consumption", the sources of data used for the publication imply that most of the quantities shown are actually shipments or sales. There are relatively long lags in publication of this summary volume of Bureau of Mines data. As of December, 1976, 1972 data is the most recent available in summary form.

The major strength of Bureau of Mines data is that it gives complete coverage of total energy use. However, as an agency which has emphasized data relating to production, reserves and transportation of the various fossil fuels, BOM's information on end-users of fuels is of limited usefulness for detailed analysis of industrial energy use. For natural gas and petroleum products, end-use designations are requested of producers and distributors, and the data reported is sales, rather than actual consumption. Coal consumption is reported on the basis of a limited survey of industrial end-users. Good consumption data is only available for coke plants, where coverage is quite high. A major limitation of BOM data is its lack of detail in specifying end-users. For the most part, end-users are not specified with more precision than "industrial" use. Reporting of sales and shipments is also not an accurate representation of consumption.

Time lags vary depending on the fuel type being reported. Time lags for publication of monthly reports are generally quite short. However, these contain mainly production data, and end-user specifications are contained in annual reports. The 1974 natural gas report was published in late August, 1975, the 1974 fuel oil report in September, 1975, and the 1974 coal distribution report in April, 1975.

For an analysis of industrial energy consumption patterns, the Bureau of Mines data is useful in providing a control total of industrial use of various fuels. The lack of detailed end-user specification, (e.g., even manufacturing, agriculture, construction, and mining are not separated) the producer survey approach, and the reporting of shipments or sales instead of consumption all limit the usefulness of BOM data for analysis of industrial energy use at a disaggregated level. Coal consumption by coke plants and fuels used in petroleum refineries are two exceptions to this generalization.

e) Department of Commerce Voluntary Industrial Energy Conservation Program (VEC)

The voluntary Industrial Energy Conservation Program is a program sponsored by the Federal Energy Administration and the Department of Commerce, with Commerce conducting the day-to-day operation of the program. In 1974 a group of industries agreed to adopt voluntary energy management programs and report their progress. Thirty-two groups are now reporting energy efficiency data on a regular basis and thirty-six others are considering participation.^{1/} The energy data is reported by industry groups which are generally trade associations for the various industries. The major energy using industries are represented by the following groups: Aluminum Association, American Iron and Steel Institute, American Paper Institute, Manufacturing Chemists Association, and Portland Cement Association. In addition, there are representatives of the food, glass, metal, textile, and brick industries as well as a number of other industries. A list of the program participants is shown in Table II-4.

All data reported is on a national level only. There is wide variation in the degree to which the data reported represents complete coverage of the industry. In the case of the American Feed Manufacturers Association, for example, only 25 percent of the total industry production of commercially manufactured feed

^{1/} As of December, 1976. This program is under development, and the number of participants and details of the program are changing.

is accounted for by the ten reporting companies, while the American Paper Institute's reporting members account for 85 percent of production.

The program is designed to measure energy efficiency improvements relative to a specified base period (usually 1972). Data reported generally includes production (in some unit appropriate to the industry), total Btus consumed, Btus consumed per unit of production, and the percent improvement in efficiency over the base year. In some cases associations report data on the types of energy consumed in the particular period.

The Department of Commerce published reports periodically, with reports issued recently including one in July, 1976 and a second in November, 1976. The data base is not comprehensive, and does not give a level of detail sufficient for performing detailed analysis of the industrial sector's energy use.

f. Trade Association Energy Data

A number of trade associations collect and publish data on energy consumption in their industries. Some industries collect data only for the highly aggregated reports which are submitted to the Department of Commerce Voluntary Industrial Energy Conservation Report. A few trade associations collect energy data and publish reports which are more detailed than the submissions to the Commerce Voluntary program in terms of either greater fuel type detail or regional distributions of energy use. These trade association data bases will not be discussed here in detail, mainly because the Energy Consumption Data Base represents a compilation of most of the useful energy consumption information from the various trade associations. The American Paper Institute, American Iron and Steel Institute, the Portland Cement Association, and the Aluminum Association are four major trade associations whose published energy reports provide useful information.

g. Gas Requirements Committee

This committee analyzes U.S. gas requirements and consumption. The work is sponsored by the Gas Industry Committee representing the American Gas Association, the American Petroleum Institute, and the Independent National Gas Association of America.

In response to a request from the Federal Power Commission for data that would improve knowledge of industrial use of gas, the GRC requested respondents in its 1973 survey to report for the first time on the industrial uses of gas by Standard Industrial Classification (SIC). The American Gas Association presents data on industrial use of gas in its annual publication Gas Facts, but the A.G.A. coverage is limited to utility sales. The U.S. Bureau of Mines has never published a detailed breakdown of industrial use. The Bureau of Census in its reports on manufacturing does include fuel use but the data does not distinguish between firm and interruptible categories.

Respondents to the 1975 Annual SIC survey reported in specific use categories about 76 percent of the total firm industrial sales and 83 percent of industrial interruptible sales, excluding the gas delivered to electric utilities for electric power generation. The 24 percent of firm industrial sales that were unclassified or unreported includes: industrial gas that did not fall in one of the SIC categories listed; industrial deliveries where the respondent company did not know the specific type of end-use; and volumes which were not accounted for by SIC number by the respondent. In the interruptible listing, these same circumstances also prevailed. In addition, there are interruptible deliveries to both commercial and residential users which cannot be distinguished from unreported interruptible industrial use. The 1975 data was presented by state and by two digit SIC code (with primary metals divided into iron, steel, and non-ferrous metals). Each industry's use was further separated into "firm" and "interruptible" service. The major weakness of the SIC data is the relatively large amount of gas which is not classified by SIC.

The estimates of natural gas consumption published by the GRC are based on responses from the various companies that deliver gas to the ultimate consumers. The 1974 survey covered 1,078 respondents who accounted for 93 percent of total natural gas consumption. Non-reporting companies were estimated based on state utility commission data and/or data reported by pipe line companies serving those distributors. The Gas Requirements Committee also publishes annual data on gas curtailments, and the GRC collects data on number of industrial gas customers in each state at year end. In all reports, data is also collected on residential, commercial, and electric utility gas consumption.

h. American Gas Association

The American Gas Association (AGA) is a national trade association of the natural gas transmission and distribution industries. All members are regulated public utilities serving franchised service areas under certificates of public convenience and necessity, or interstate pipelines regulated by the Federal Power Commission.

Data on industrial gas consumption is reported quarterly and is compiled annually in Gas Facts. This publication contains current and historical data relating to the gas utility industry which is defined to consist of the regulated distribution and transmission companies. Statistical information contained in the volume is developed from data provided to the AGA Department of Statistics by individual gas companies. The information is derived from the Uniform Statistical Report, a detailed report form prepared annually by industry companies, which is used by many gas companies to report their operations to the financial community. Data has also been obtained from short form questionnaires furnished to AGA from reports filed with regulatory commissions supplemented by investigation of financial publications and from statistical reports prepared by government and private agencies.

The AGA, by reporting only gas utility industry sales, is dealing with only a subset of total gas sales. Especially in the industrial sector and electric utility sectors, a significant quantity of gas is purchased directly from producers and pipeline companies. The AGA reports use by sector for each state, with an "industrial sector" category which includes both the industrial sector and electric utilities. Total 1974 "industrial" sales were shown to be about 8.1 quads as opposed to the Bureau of Mines report of about 14.4 quads for industrial and electric utility consumption. The AGA reports industrial use by region in a number of industry classifications. Also shown are state industrial gas sales according to type of contract (firm or interruptible) and number of customers in each category. The AGA report is published annually.

i. Federal Power Commission

The FPC publishes information on natural gas and electricity consumption and prices. Because it only regulates interstate sales of natural gas, and does not have information on the important intrastate market, its data in this area is of limited usefulness. Information on sales of electricity to industrial users also does not provide a comprehensive data base.

Information on industrial generation of electricity is published and gathered monthly. Form 4 gathers information on large industrial producers of electricity. The approximately 700 respondents included in this survey report net generation of electricity. The FPC does not publish data on fuels consumed in the generation of the electricity. This data is collected by State, and address information is available. Information on capacity size is also available. Form 12-C collects the same data as Form 4; however, it details electric production for smaller companies.

Industrial consumption of electricity is given in several FPC reports, with the basic information derived from Form 6. Data in this form is reported monthly. Utilities that report include only "jurisdictional-utilities" which market electricity across state lines. Therefore, coverage ranges from 50 to 95 percent. The information included in this report is upgraded by annual end-user data that has more complete coverage.

Annual statistics on end-user consumption of electricity are generated from data from Form 5, Form 1, Form 1M and information from FEA. This information details consumption by state and sector (residential, commercial, and industrial). No detailed end-user breakdown is provided for industrial sales.

The FPC publishes price data for electricity sold to industrial users in its annual publication Typical Electric Bills.

These surveys provide comprehensive coverage of the cost to consumers for representative amounts of electricity used per month for residential, commercial,

and industrial service in all sections of the nation. Bills for residential electric service are reported for five different energy consumption levels in all communities with populations of 2,500 or more. For commercial and industrial service, bills are presented for all large cities. Commercial bills are shown for five combinations of billing demands in kilowatts (kW) and monthly consumption levels in kilowatt hours (kWh); industrial bills cover five billing demands and ten consumption levels.

The FPC data on natural gas provides information on only one segment of total industrial use. FPC requires annual reports of main line natural gas sales to industrial users by interstate natural gas companies. This data has been compiled by the Bureau of Mines for 1974, with customer names, State summaries, and SIC breakdowns, as well as specification of whether the sales are "firm" or "interruptible".^{1/} It should be noted that such direct sales represented approximately 16 percent of the total 1974 gas deliveries to industrial users.

j. National Emissions Data Systems (NEDS)

The Aerometric and Emissions Reporting System (AEROS) was established by the Environmental Protection Agency to serve as a management information system for EPA's air pollution research and control programs. As such, AEROS is mainly concerned with the collection, processing, and reporting of basic air pollution data. One of the principal subsystems of AEROS is the National Emissions Data System (NEDS), which stores and reports source and emission-related data for five major pollutants. Among the information collected and stored in NEDS is data on industrial fuel consumption.

The NEDS system organizes all data into two files: point sources and area sources. A point source in NEDS is generally defined as any major stationary source with a potential for emitting more than 100 tons/year of any of the criteria pollutants.

^{1/} "Main Line Natural Gas Sales to Industrial Users" 1974, Bureau of Mines, March 2, 1976.

The area source file provides a record for each county equivalent in the U.S. with sufficient data to estimate emissions for all sources in the county not recorded as point sources in NEDS. State agencies are required to make semi-annual reports for selected point sources in the standard NEDS format, and there is also updating through voluntary state submissions of data. The point source file includes data for more than 94,000 emission sources at nearly 34,000 facilities throughout the country. The area source file, with one record per county (or county equivalent), contains about 3,200 records.

The emission sources in the point source file are large utility boilers, industrial boilers, process heaters, etc. For industrial sources, the following types of information relevant to energy use are given:

- Location and name of plant
- SIC code of plant
- Type of source (e.g., "boiler")
- Fuel used in the combustor (type, quality)
- Operating rate of unit (annual operating rate, design capacity)
- Percent of output used for space heating

The majority of the data collected on the combustor and plant is information about air pollutants, emissions, stacks, control equipment, etc.

The area source file contains energy use data for a particular county broken down by sector and fuel type. The sectoral designations include an "industrial" category, and the quantities consumed of the following fuels are specified: anthracite coal, bituminous coal, natural gas, coke, distillate oil, residual oil, wood, process gas.

Data can be retrieved from the NEDS system for either individual point sources and counties (area sources) or for various levels of aggregation. The "Annual Fuel Summary Report" for example, summarizes fuel use by fuel type for both point

and area sources in a specific geographic area. The area source fuel use data are reported in this summary for both stationary and mobile area sources. The point source fuel use is broken down according to the kind of equipment in which the fuel is consumed (e.g., external combustion equipment such as boilers, internal combustion engines, or inprocess fuel use (dryers, furnaces)). The data in this report is summarized at national, state, county, and AQCR levels. While the fuel use data for the point sources are based on a survey of the actual use, in the case of the area reports it appears that aggregate energy data such as that available from the Bureau of Mines is apportioned among the various counties.

The major weakness of the NEDS data is that the system is not up-dated systematically. For this reason, at any particular time, there will be a combination of data from different years in the data base. In its coverage of point sources (including industrial) the NEDS data is not comprehensive since it deals only with those sources with a potential for emitting more than 100 tons per year of a criteria pollutant.

k. FEA Conservation Data Base

The Data Base - The Potential for Energy Conservation in Nine Selected Industries is a 1974 FEA data base done by Gordian Associates, Inc. It provides basic historical energy consumption data and energy conservation opportunities for nine selected industries. This industrial group includes petroleum refining, copper, aluminum, steel, paper, plastics, cement, synthetic rubber and glass. The data presented for energy consumption and processing steps are generally representative of 1970. The study is not an on-going one and provides only national data.

The data base contains information about the following:

- 1) The most energy intensive industries in terms of Btus per unit of output.
- 2) Energy consumption during specific processing steps (i.e., catalytic refining, smelting, pulping, etc.)

- 3) Percentage of product value represented by energy costs
- 4) Energy consumption by primary fuel types (i.e., oil products, natural gas, coal, nuclear fuels, and electricity)

Major sources of information used in the study were the "1963 Census of Mineral Industries", "1967 Census of Manufactures", and the "1971 Bureau of Mines Mineral Yearbook". Additional sources include published trade literature, and personal discussions.

1. Dow Chemical - Evaluation of New Energy Sources for Process Heat

In September, 1975, Dow Chemical completed a study for N.S.F. of several alternative energy sources which have been proposed as replacements for oil and gas in the production of industrial process heat. It is significant as a data base because of its quantitative description of industrial fuel use patterns.

The study reviewed available published data and also surveyed 85 leading companies in five industry groups. The industry groups surveyed and Dow's estimate of their coverage of energy use in the industry are: Paper (30%), Chemicals (55%), Petroleum (60%), Stone, Clay, and Glass (18%), and Primary Metals (35%). Data collected from the companies and presented in summary form in the N.S.F. study includes:

- data on 1973 fuel use, by type of fuel
- geographical location of plants (urban/rural, near transportation, etc.)
- functional uses of energy (steam production, furnaces, kilns, other)
- use of energy in different size ranges

The study also projects energy use in each major industry group up to 1985.

The limitations of the study are primarily in the area of comprehensiveness of coverage. By surveying only 85 companies, the study attains relatively high coverage, (energy use is heavily concentrated in a few companies) but it is still

important to note that only a subset of the industrial sector is covered. To the extent that small companies use energy differently than large companies, the data base may not be representative of the entire industrial sector.

2. Industrial Location Data Bases

The data bases described below are listings of plant locations, geographically disaggregated compilations of industrial activity data, and inventories of industrial fuel using equipment. Although not actual energy data bases, they are important in any energy analysis which is concerned with characterizing industrial energy use at highly disaggregated levels such as SMSA, county, or plant-specific. In general, actual energy data is only published for entire states. In order to characterize industrial energy use more fully, it is often necessary to relate energy use to other economic indicators for which greater detail is published.

a. Bureau of the Census

The Bureau of the Census collects and publishes a large volume of data on the manufacturing sector through its Census of Manufactures and Annual Survey of Manufactures. The fuel and energy data collected has been discussed, but the Census data also provides information about industrial location and activity.

Data is published at seven levels of geographical detail: national totals, groupings into four regions and nine geographical divisions, state totals, and Standard Metropolitan Statistical Areas (SMSAs) counties, and cities. There are about 260 SMSAs, with each being a grouping of individual counties. In all cases, the Bureau of the Census is limited in the level of detail they can publish. In no case can they publish any data which would disclose information about an individual company. In the 1972 Census data, detail for two, three, and four-digit industries is shown for any SMSA when there was no disclosure problem and the industry had at least 250 manufacturing employees. The level of detail which can be published at even the state level varies greatly according to the industry and the state, and published Census data is often subject to omissions.

Plant-specific data is obviously never published, but some of the relevant information about industrial location includes the following for a particular industry in a given geographical area:

- Number of companies
- Number of establishments (total and with 20 employees or more)
- Number of employees
- Number of production workers
- Number of man-hours
- Size of payroll and wages
- Value added by manufacture
- Value of industry shipments
- Capital expenditures (new) shown separately for machinery and equipment and structures and additions to plant

Data is also available on the concentration ratios in given industries as determined by the total value added accounted for by different subsets of the total industry (e.g., largest four plants, etc.) Size distributions of establishments are given by ranges of number of employees (e.g., 1 to 4, 5 to 9, 1000 to 2,400, etc.).

County data is published in a Bureau of the Census publication entitled County Business Patterns. Much of the Census data, including all of the County Business Patterns, is available on computer tapes in addition to the printed form. The computer tapes often present greater detail than the published data.

b. Trade Associations and Trade Journals

Trade associations often publish relatively detailed information about plants in their industries. To list all of the trade association directories would be

beyond the scope of this report, but the American Iron and Steel Institute (AISI) and the Portland Cement Association (PCA) publications are examples of trade associations providing plant-specific information.^{1/} In the case of the AISI data, information on the number of coke ovens, size of blast furnaces (by type) and capacity of rolling mills is given for each steel plant. The PCA data provides information about clinker capacity and kiln type (wet or dry process) for each cement plant.

Trade journals and directories are another source of published information about individual industrial plants. Examples include the Oil and Gas Journal's directory of petrochemical plants and the American Glass Review's glass factory directory. Lockwood's Directory is an example of a directory of plants in the paper industry. At a minimum, these directories generally list the plants in the industry and give locations and parent companies. They often provide some measure of size (e.g., capacity, number of production machines, etc.) and information about process used, types of product manufactured, etc.

c. American Boiler Manufacturer Association/Battelle

The American Boiler Manufacturers Association (ABMA) makes available data on boiler sales. This data, which is available on an annual basis back to 1965, gives information about sales of different types of boilers (watertube, firetube) in various size ranges. Battelle has used this data in two reports to EPA which analyzed the boiler population.^{2/} In the October 1975 report by Battelle, the ABMA data was supplemented by EPA National Emissions Data System (NEDS) data and by Census data on power boilers. The Battelle report compiles the data only for national totals in various categories such as: number count, total installed capacity and average hourly fuel consumption as a function of designed firing

1/ "Assessment of Industrial Boiler Toxic and Hazardous Emissions Control Needs", R. E. Barrett, et. al., October 16, 1974 and "Evaluation of National Boiler Industry", A. A. Putnam, et. al., October, 1975, both reports for EPA.

2/ The National Trade and Professional Associations of the United States and Canada, Columbia Books, Inc., is an annual directory which is a quite comprehensive and cross-indexed directory of industry trade associations.

rate (5 categories), fuel type, (6 fuels) and use (commercial, Industrial, Utility). Using sources such as ABMA, NEDS, and Commerce boiler data bases, it would be possible to compile an even more detailed inventory data base.

d. Stanford Research Institute (SRI) Directory of Chemical Producers

The Stanford Research Institute publishes an annual Directory of Chemical Producers which is a specialized directory for the chemical industry. The directory is available on a subscription basis, and provides a cross-indexed listing of companies and plants in the chemical industry. The list includes all plants which produce a given chemical, and gives the plant location, parent company, capacity, and total capacity in the particular industry. In some cases the process and/or the feedstock used at a particular plant is given. Cross indexing is provided in the form of listings of companies and regions. The directory contains no information about energy use or actual production.

e. Economic Information Systems, Inc. (EIS)

Economic Information Systems, Inc. (EIS) is a private market research firm which primarily provides detailed market information to producers of industrial goods. EIS reports list all prospective buyers for industrial goods on a state and county level. Actual plant locations, market shares, SIC codes, and estimated consumption of the product in question are provided. The EIS data base is constantly under revision, and draws heavily upon the latest editions of the "Census of Manufactures" and "County Business Patterns".

Other data sources include the continued review of published material on industrial markets and client feedback. Although primarily a marketing tool for companies selling various products, the EIS data base provides a fairly thorough listing of about 115,000 plants with more than 20 employees which could be used as a location data base for energy analysis. Dun and Bradstreet is another example of a commercially available major industrial location data base which provides a fairly comprehensive listing of individual industrial plants.

3. Energy Projections

There are literally dozens of published energy projections which could be combined with the historical data bases described above in order to arrive at detailed projections of future industrial energy markets. No attempt will be made here to describe all of these projections in detail. A list of some of the major energy projections is given, with a brief description of FEA's Project Independence Evaluation System (PIES) projections, since this is the most sophisticated energy projection currently available. With the exception of PIES, it is probably a valid generalization to say that most energy projections forecast only total U.S. energy demand or consumption, and do not give regional detail or projections of industrial energy use.^{1/} In order to derive projections of energy use for specific regions or industries, it would generally be necessary to either apply historical shares to the totals, apply modified shares which reflect assessments of shifts in the historical pattern of industrial energy use and/or location, or rely on industry-specific energy projections.

a. Project Independence Evaluation System (PIES)

The PIES projections by FEA are the result of a very large scale analysis and modeling effort. The original results were published in November, 1974 as part of FEA's Project Independence Report. The projections were revised and published as part of the 1976 National Energy Outlook. PIES is composed of various models: a demand model, a collection of supply models, and an integrating model. The model is a general equilibrium one, with the integrating model estimating market clearing prices, supplies, and demands.

The model is run under a number of different scenarios, each of which has a different set of assumptions concerning variables such as energy prices, supply

^{1/} PIES has regional projections (9 census regions) and a sectoral breakdown (for U.S. total only).

responses, conservation, and government regulations. The National Energy Outlook publishes summary tables for ten different scenarios, most of which include three assumptions concerning the price of imported oil (\$8.00, \$13.00, and \$16.00 per barrel). All model runs are only for 1985, with a Reference Scenario shown for 1980 and 1990.

The model projects supply, demand, and prices for nine regions of the U.S. and for all of the major fuel types. While regional totals are given, no sectoral (e.g., residential, industrial, etc.) or industry (e.g., steel, chemicals, etc.) detail is given in the regional projections. The projections do show total industrial consumption for the U.S.

b. Other Aggregate Energy Projections

The 1974 Project Independence Report compared its projections to a number of other non-FEA projections. The projections they listed are:

1. U.S. Energy Through the Year 2000, Department of the Interior, Bureau of Mines.
2. NPC Report on U.S. Energy Outlook, National Petroleum Council.
3. Exploring Energy Choices, Energy Policy Project, Ford Foundation.
4. U.S. Energy Prospects: An Engineering Viewpoint, National Academy of Engineering.
5. MIT Econometric Model, Massachusetts Institute of Technology.

All of these are highly aggregated projections, and many have been revised since the FEA compilation. There are a number of other projections which have been done by various government agencies, universities, and private organizations. Energy companies themselves have also published energy projections. Two examples are Exxon's Energy Outlook, 1976-1990, and Shell's The National Energy Outlook, 1980-1990. While the Shell projection does not give any regional detail or price projections, it does make estimates of projected energy demand by sector, including an "industrial" category.

c. Conference Board: Energy Consumption in Manufacturing

Unlike the aggregate projections described above, this projection deals specifically with the manufacturing sector and its future use of energy. Energy Consumption in Manufacturing was written by The Conference Board for the Energy Policy Project of the Ford Foundation and was published in 1974. This study attempts to understand the past developments in the manufacturing sector's use of energy. Another objective of the study is to identify future changes in production and technology that will significantly alter energy use patterns.

Six groups of⁰ industries in manufacturing were selected because of their high energy consumption. These groups were: food industries, paper industries, chemical industries, petroleum and coal products industries, stone, clay, and glass industries and primary metals industries.

For each four-digit SIC within these groups, a brief introduction is given to describing the historical development of that SIC. Projections of the energy/output ratios for 1975 and 1980 are also provided.

These energy/output ratios were based on the assumption that the economy will operate near capacity during the projection years. Energy Consumption in Manufacturing provides only national data with no geographical information.

d. Energy Conservation in the Manufacturing Sector, 1954-1990

This report was prepared for the Council on Environmental Quality by Energy and Environmental Analysis, Inc. as input into the 1974 Project Independence Report. The report focuses on the ability of the manufacturing sector to economize on its use of energy. It analyzes six major energy-using industries^{1/}, and projects total energy use for each industry to the year 1990, including both Btus of

^{1/} Pulp and Paper, Chemicals, Petroleum Refining, Cement, Steel, and Aluminum.

energy (fuel and electricity) and energy/output ratios. Included in these estimates are an evaluation of those factors, such as conservation and changing product mix, which can affect the quantities of energy used in these industries.

SECTION III

SAMPLE APPLICATION OF DATA BASES TO ESTIMATE PLANT-SPECIFIC ENERGY USE

A. OVERVIEW OF APPROACH

The output from the ERDA Fossil Energy gasification and liquefaction technologies can be utilized by industrial users in two ways:

- Industrial companies can build gasification or liquefaction plants for their own use as a source of fuel or feedstock. This might be called a "producer-user" arrangement.
- Industrial users can purchase the output of a gasification or liquefaction plant from another company which builds and operates the plant and sells the output to a number of customers, some of whom may not even be in the industrial sector. This arrangement might be termed "producer-seller".

The purpose of the analysis described in this section is to use existing industrial energy and location data bases to characterize plant-specific energy usage patterns in the industrial sector. This characterization can, at a minimum, allow for an assessment of whether the producer-user approach is a viable one for some of the large-scale ERDA/FEA technologies. The analysis can also be used to gain an understanding of the size distribution of energy use in the industrial sector, independent of matching users with specific technologies.

The high-Btu gasification and liquefaction technologies which form the major portion of ERDA's Fossil Energy program^{1/} are being proposed as very large-scale

^{1/} 50 percent of ERDA/FE FY 1976 Budget (ERDA 76-63, p. 3).

units. The 250 million cubic feet per day high-Btu gasification plants and 50,000 barrel per day coal liquefaction plants produce the equivalent of 80 and 100 trillion Btus per year, respectively. This far exceeds the total demand for energy of most entire industries, and equals or exceeds the demands of such energy intensive industries as copper, (105 trillion Btus consumed per year) meat packing (77 trillion Btus), and baking (55 trillion Btus). Investment decisions are, of course, made by individual companies rather than entire industries, and the plant-specific energy analysis was therefore directed at the largest energy using industries. An upper limit to the size of an industrial producer-user market for high-Btu gasification and liquefaction can be ascertained through analysis of these large energy using industries. The data availability and manipulation constraints discussed below were also important in selecting the large energy-using industries for analysis and screening.

Published data is not available on energy usage by individual industrial plants. This information is considered confidential, and any analysis which requires such information must estimate it based on published energy use and plant size data. The energy screening methodology utilizes two major sources of information:

- energy use by a specific industry in a given geographical area, and
- location and capacity of individual plants in an industry.

These two types of data are available at different levels of disaggregation and with varying degrees of completeness for different industries. For example, in the petroleum refining industry detailed data is available on energy use by type of fuel in each state.^{1/} Capacities of individual refineries are also available, including information on mixes of processes.

^{1/} Some states are grouped to avoid disclosure of company-specific data.

In the cement industry, however, only regional energy usage data is available^{1/}, and in the aluminum industry only national energy usage data is available and no state or regional data is published. In the iron and steel industry no data is published on the capacities of individual steel mills. Only such proxies for capacity as number of coke ovens or number of furnaces of various types are published. The paper industry also lacks any single simple measure of capacity for a particular plant. While the methodology relates energy use at plants to the plant capacities, these data constraints sometimes necessitated estimates for determining plant capacities, and use of the least aggregated energy use data available. The full methodology is explained below.

B. METHODOLOGY

Table III-1 gives the sources of both the fuel and plant size data. The fuel data generally is similar or identical to that in the Energy Consumption Data Base (ECDB).^{2/} For the five chemicals included, the ECDB's two digit chemical data did not provide sufficient detail, and it was necessary to use another data base as a source of energy data. The ECDB contains no information on plant capacities, and therefore a number of different trade associations and industry directories were utilized to either directly or indirectly arrive at some measure of relative plant sizes.

In order to estimate energy consumption by type of fuel in individual industrial plants, the energy use and plant capacity data is combined with the following assumptions:

- energy use in a particular plant is proportional to its productive capacity, and
- all plants in a given geographic area utilize the same mix of fuel types (i.e., that fuel type mix which is the area's average).

^{1/} Broken down into nine Census regions.

^{2/} The ECDB was described in Section II.

TABLE III-1

SOURCES FOR PLANT ANALYSIS OF ENERGY USE

<u>Industry</u>	<u>Fuel Consumption Data</u> ^{1/}	<u>Plant Size Data</u>
Petroleum Refining	BOM's Annual Petroleum Statement	Crude oil & gas output capacity from BOM. Lube capacity from Nat'l Petroleum Refiners' Assoc.
Iron & Steel	AISI's Annual Statistical Report & the Institute's geographical breakdown	Capacities = combination of number of coke ovens, size of blast furnaces and steel furnaces (by type) & capacity of rolling mills from AISI's <u>Directory of US Steel Works</u>
Ethylene	Intenat'l Research & Technology Corp.'s <u>Data Base for the Industrial Energy Study of the Industrial Chemicals Group</u>	SRI's <u>Directory of Chemical Producers</u> (capacities of individual plants)
Styrene	"	"
Chlorine	"	"
Ammonia	"	"
Carbon Black	" (Census also used for process fuel data)	"
Aluminum	Aluminum Association	BOM <u>Mineral's Yearbook</u> (plant capacities of primary aluminum)
Paper	American Paper Institute	<u>Lockwood's Directory</u>
Cement	Portland Cement Association	PCA - Clinker capacity by plant (wet and dry kiln types)

1/

With the exception of the various chemicals, the major energy data source was the ECDB. The sources listed here are the energy data bases used by EEA in developing the ECDB data.

Both of these assumptions have certain obvious shortcomings. Energy use will obviously correlate better with production than with capacity, since a given plant could be idle or be operating at reduced levels in a particular year. However, production data is not available for individual plants, and capacities are the only published information in most industries which give an indication of the relative size of individual plants. Given that capacity is an imperfect measure of a plant's production, there is another qualification to this assumption. Energy use can be expected to be roughly proportional to the size of a plant's output, but only to a certain extent. Large plants may exhibit certain economies of scale which result in a lower energy usage per unit of output relative to smaller plants. Data is not generally available to adjust for this size effect, if in fact it does exist. Energy use in a given size of plant can also vary according to age of plant, process utilized, and exact product type produced.

Confirmation of the hypothesis that energy use is generally proportional to size of plant is not possible for most industries. In the cement industry the energy survey noted the size of the reporting plant, and a summary of the size/energy use relationship is available and shown below:^{1/}

<u>Clinker Production</u>	<u>Million Btu Per Ton</u>	
	<u>1972</u>	<u>1974</u>
Less than 300,000 tons	8.32	8.08
300,000 to 600,000 tons	7.83	7.77
600,000 tons or more	7.08	6.96

As can be seen from the data in this table, large cement plants tend to be somewhat more efficient than small plants in terms of energy use per unit of output. There is a 15 percent difference in 1974 energy use between the largest and smallest categories shown by the Portland Cement Association. However, no data is available with which to make a systematic adjustment to the data in the energy

^{1/} Portland Cement Association, Annual Energy Survey.

analysis data base. The non-size factors mentioned above which can cause energy use to vary between plants with identical capacities may well introduce more than a 15 percent variation in energy use per unit of output.

Where data is available, the different energy use in different processes and operations is accounted for. In the case of the petroleum refining industry, for example, energy use in a given refinery is assumed proportional to: (1 x distillation capacity) + (3 x alkylation capacity) + (10 x lube capacity). These process-weighted capacities are calculated for each of the petroleum refineries in a given state for which the ECDB gives energy usage data. The state's (or region's) energy usage is then distributed in proportion to these capacities. These weighted capacities recognize the higher energy requirements associated with lube and gasoline production. For the cement industry, the average energy use per ton of cement is different for the wet and dry processes. Data is available on wet and dry capacities, and an energy-weighted capacity was calculated for each cement plant based on the type of operation.

While total energy use can be expected to be roughly proportional to productive capacity, use of individual fuel types can be expected to vary among plants of the same size. The methodology assumes that all plants in a given area use the same mix of fuels. While data is not available which would allow a more detailed assessment, it is obvious that one plant may depend on coal for its energy while another plant of the same size in the same region may use primarily natural gas. It should be noted, however, that if a small quantity of coal is known to be used in a chemical industry in the West South Central region, for example, and the overwhelming majority of energy comes from natural gas, then the margin of error in attributing the coal use to all plants is quite small.

For each of the ten industries, the same procedure was used in arriving at estimates of plant-specific energy use. In some industries, however, it was necessary to calculate a single "capacity" measure on the basis of a weighted combination of several individual indicators of plant size. The energy use data at the highest available level of geographical breakdown (state, region, or national) was used in a particular industry. For a given state, for example, consumption of oil, gas, coal and electricity by all plants in the industry

may be available. Capacity data (used directly or derived) is available for each individual plant in the state. The total Btus consumed in the state are first attributed to each plant in proportion to its share of total capacity. If there are ten plants, for example, and one plant has 60 percent of total capacity in the state, it is allocated 60 percent of total Btus. Once total Btus are distributed, the mix of fuel types is determined by applying the state average fuel type breakdown to each plant. For some industries regional or national data is not disaggregated. In such a case, total energy at the regional or national level is attributed to all plants in direct proportion to capacity, and the fuel type breakdown is determined using the regional or national fuel proportion.

The data generated by this procedure is obviously more accurate for total Btus than for specific fuel types. It is also more accurate for those industries where state or regional energy use data was available. Without such data, it is impossible to capture the substantial regional variations in fuel types utilized, and national averages must be used to estimate fuel type breakdowns.

The procedure outlined above can identify large energy-using plants which may be hidden by national or regional averages. For example, the seven petroleum refineries in the state of Indiana use a total of about 39 trillion Btus per year; an average of less than 6 trillion Btus per year each. However, this state's total weighted capacity^{1/} and estimated energy use is accounted for by one large refinery. Depending on the scale of a particular coal conversion technology, this large refinery may have a sufficiently large demand for process energy to use at least a substantial share of the technology's output.^{2/}

^{1/} Weighted by process and energy-intensity of process.

^{2/} For petroleum refineries, only process energy needs are considered at this point. The products of a liquefaction technology could be a source of crude feed to a refinery.

C. RESULTS OF ANALYSIS

Tables III-2, III-3, and III-4 provide summaries of the results of the analysis. As shown in Table III-2, there are only 32 industrial plants in the industries analyzed whose total demand for energy is greater than or equal to the 80 trillion Btus per year output of a typical proposed high-Btu gasification or liquefaction plant. Twenty-two of these plants are in the steel industry, but this is a deceptively high figure due to the inclusion of coal in the data on total Btus consumed. Since presumably synthetic gas or synthetic oil will not substitute for most uses of coal in the steel industry, it can be excluded from the energy consumption of the plants. Such an exclusion results in only two steel plants using more than 80 trillion Btus per year, and only nine plants consuming between 51 and 80 trillion Btus per year.

Fuel form considerations are obviously important in any analysis which attempts to link specific synthetic fuel plants with specific industries. Tables III-3 and III-4 present the distribution of natural gas and petroleum product consumption per plant. When considering only natural gas use, only 14 of the 1,605 total plants in the industries evaluated use more than 30 trillion Btus per year. Only 12 plants (all ethylene producers) consume more than 30 trillion Btus of petroleum products. Thirty trillion Btus per year demand is well below the size of the output of the high Btu gasification and liquefaction technologies being proposed.

The national summaries in Tables III-2, III-3, and III-4 are aggregations from plant-specific data. All data is printed out in the form of histograms which make it easy to visually impose certain "cut-offs" in the quantity of energy used. Sample histograms are shown in Appendix B, where the quantity of energy (total Btus or Btus of gas or petroleum) is given for each plant in a state and then plotted on an axis for visual comparison with other plants in the same state or plants in other states or industries.

A histogram similar to that shown in Appendix B can be produced for any of the ten industries which have been analyzed. The histogram can show the estimated use per plant of natural gas, petroleum products, or total Btus. In addition,

TABLE III-2

TOTAL ENERGY USAGE IN INDIVIDUAL INDUSTRIAL PLANTS^{1/}
 (10¹² Btu/yr)

Industry	Total Number of Plants	Number of Plants in Each Range					
		<10	10-20	21-35	36-50	51-80	>80
Steel	187	124	9	13	12	7	22
Ethylene	33	7	2	10	4	6	4
Petroleum Refining	258	171	44	23	7	7	6
Ammonia	85	60	20	5	0	0	0
Chlorine	64	53	10	0	0	1	0
Carbon Black	34	29	5	0	0	0	0
Styrene	14	10	2	2	0	0	0
Cement	172	171	1	0	0	0	0
Paper	727	714	13	0	0	0	0
Aluminum	31	6	14	7	1	3	0
TOTAL	1605	1345	120	60	24	24	32

^{1/} Fuels and Feedstocks included, except for exclusion of feedstocks in petroleum refining. Non-fossil fuels in the paper industry excluded.

TABLE III-3

NATURAL GAS USAGE IN INDIVIDUAL INDUSTRIAL PLANTS^{1/}
 (10¹² Btu/yr)

Industry	Total Number of Plants	Number of Plants in Each Range				
		<5	5-10	11-20	21-30	>30
Steel	187	141	20	22	2	2
Ethylene	33	10	12	7	3	1
Petroleum Refining	258	201	33	16	0	8
Ammonia	85	50	15	15	5	0
Chlorine	64	53	10	0	0	1
Carbon Black	34	31	3	0	0	0
Styrene	14	10	3	1	0	0
Cement	172	169	3	0	0	0
Paper	727	718	9	0	0	0
Aluminum	<u>31</u>	<u>20</u>	<u>7</u>	<u>1</u>	<u>1</u>	<u>2</u>
TOTAL	1605	1403	115	62	11	14

^{1/} Fuels and feedstocks included.

TABLE III-4

PETROLEUM PRODUCT USAGE IN INDIVIDUAL INDUSTRIAL PLANTS^{1/}
 (10¹² Btu/yr)

<u>Industry</u>	<u>Total Number of Plants</u>	<u>Number of Plants in Each Range</u>				
		<u><2</u>	<u>2-5</u>	<u>6-10</u>	<u>11-30</u>	<u>>30</u>
Steel	187	142	30	11	4	0
Ethylene	33	0	3	3	15	12
Petroleum Refining	258	199	42	12	5	0
Ammonia	85	85	0	0	0	0
Chlorine	64	63	1	0	0	0
Carbon Black ^{2/}	34	20	10	4	0	0
Styrene	14	5	2	5	2	0
Cement	172	171	1	0	0	0
Paper	727	664	49	13	1	0
Aluminum	<u>31</u>	<u>6</u>	<u>19</u>	<u>6</u>	<u>0</u>	<u>0</u>
TOTAL	1605	1355	157	54	27	12

^{1/} Fuels and feedstocks included, except for exclusion of feedstocks in petroleum refining.

^{2/} Includes only "liquid hydrocarbon feedstocks". Some process fuel usage is excluded, but included in listing of all fuels.

for some industries such as steel and aluminum, other fuel types such as coal and electricity have been included.

For example, in the steel industry it is possible to print out histograms which show the following for each steel plant in the country (grouped by state):

1. estimated use of total Btus,
2. estimated use of natural gas, fuel oil, or any one of nine other different fuel or energy types (coking coal, steam coal, other coal, self-generated electricity, purchased electricity, blast furnace gas, coke oven gas, liquefied petroleum gas, and tar and pitch); and
3. aggregations of different fuel types (e.g., oil and gas in the various plants).

Not all industries have this much detail currently available on fuel type breakdowns. For example, only use of petroleum products, natural gas, and total Btus by petroleum refineries is currently available as an output. Data is available and could be added on petroleum refinery use of coal, electricity, and other fuel types, although these fuel types are not as relevant in screening for matches with coal gasification or liquefaction.

This analysis is based on data concerning the current energy use patterns of these industries. By 1995, it may be argued, consumption per plant may have increased and/or fuel conversions may result in greater use of a particular fuel form. As far as fuel conversions are concerned, taking total Btus consumed as an upper limit to the demands for energy by individual plants of a gaseous or liquid fuel still results in the conclusion that the energy demands of industrial plants are generally small compared to the output of most high Btu gasification and liquefaction technologies. Energy use per plant may increase over time as plants get larger, but preliminary analysis of future trends in plant sizes in these industries suggests limits to sizes which are often based on the size of regional markets and product transportation costs.

Industries such as paper and cement are sometimes mentioned as "good markets" for the products of high Btu gasification and liquefaction technologies. However, as Table III-2 clearly shows, even if the present demands for all forms of energy were to be converted to demand for gas or for oil, it would take four to ten of the paper or cement industry's largest plants to utilize the output of a large scale synthetic fuel plant. Cement and paper plants may use the output of the large-scale fossil energy technologies, but from this energy-based screening, it appears unlikely that they will be major investors in the construction and operation of a commercial sized plant for their own use (producer-user). Rather, it is more likely that they would be served by a plant that was either operated as a utility serving a number of industrial users or operated by several industrial users (i.e., a producer-seller arrangement).

As stated earlier, this energy screening is not just useful for evaluating industrial use of the large scale high Btu and liquefaction technologies. A state-by-state aggregation done for each of the ten industries is shown in Appendix C, with Table III-5 showing the national summary. In this tabulation, the screening categories were chosen such that the breakdown of smaller plants can be analyzed. As can be seen from Table III-5, most plants in these ten industries have an energy demand exceeding one trillion Btus per year. One trillion Btus per year would be the size of the output of a moderate size low-Btu gas unit, but would be smaller than proposed medium Btu gas plants. Excluding the paper industry (which has a large number of small plants, 73 percent of the 878 plants in the other nine industries have total energy demands exceeding one trillion Btus per year.

D. CURRENT COVERAGE AND POSSIBLE EXPANSIONS

The industries currently included in the energy screening data base are shown in Table III-6. A total of 1605 plants are included in the ten industries. The ten industries consume a total of 11.7 quadrillion Btus. Of this total, 4.1 quads are petroleum products and 3.9 quads are natural gas. The ten industries account for 56 percent of manufacturing energy consumption and 45 percent of

TABLE III-5

NATIONAL SUMMARY OF PLANT-SPECIFIC ENERGY ANALYSIS^{1/}

<u>Industry</u>	<u>Number of Plants</u>	<u>Number of Plants Where Total Energy Use is >10¹²BTU</u>	<u>Number of Plants Where Natural Gas & Petroleum Use is >10¹²BTU</u>
Paper	727	242	189
Chlorine	64	19	13
Cement	172	160	100
Steel	187	102	82
Petroleum Refining	258	186	154
Aluminum	31	31	31
Styrene	14	14	14
Ethylene	33	33	33
Carbon Black	34	18	18
Ammonia	<u>85</u>	<u>76</u>	<u>76</u>
TOTAL	1605	882	710

^{1/} See Appendix C for state aggregations of this data.

TABLE III-6

INDUSTRIES INCLUDED IN THE ENERGY SCREENING ANALYSIS

 10^{12} BTU's/yr

	<u>Number of Plants</u>	<u>Total Energy</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>
Petroleum Refining	258	2,972	1,773	1,072
Iron and Steel	187	3,396	296	689
Ethylene ^{1/}	33	1,560	1,157	367
Styrene	14	145	92	46
Chlorine	64	408	10	203
Ammonia	85	671	23	617
Carbon Black	34	128	87	41
Aluminum	31	644	114	214
Paper	727	1,327	503	444
Cement	<u>172</u>	<u>503</u>	<u>57</u>	<u>212</u>
Total of 10 Industries	1,605	11,754	4,112	3,905
Total Manufacturing		21,079	5,488	8,765
Total Industrial		25,836	8,415	10,264

^{1/} Including by-products.

total industrial energy use.^{1/} About 75 percent of manufacturing use of petroleum products and 45 percent of natural gas use is accounted for by the ten industries.

Energy use is heavily concentrated in the industries which are currently included in the energy screening data base. Energy use per industry drops off quite rapidly when considering industries outside of the large energy users. Tables III-7 and III-8 show other relatively large energy-using industries. If all 29 of the industries in these two tables were to be included in the energy screening, only 11 percent greater coverage of the manufacturing sector's use of energy would be attained. Table III-7 includes ten of the largest energy using chemicals which are included in the IR&T data base of 37 chemicals used for four of the five chemicals analyzed so far. These ten chemicals account for a total of only about 0.7 quads. The 19 industries shown in Table III-8 are of the four digit SIC codes which according to the 1974 Census of Manufactures use more than 50 trillion Btus per year. These 19 industries used a total of about 1.6 quads in 1974.

EEA's estimate (in the ECDB) of total energy consumption in SIC 28 (Chemicals and Allied Products) is 5.2 quads. This includes energy used for heat and power as well as all uses of natural gas, coal, and petroleum products for feedstocks. The data in the ECDB is not broken down into individual chemicals, and was therefore not used in the energy analysis. The 37 chemicals in the IR&T data base are estimated to use about 3.7 quads. The four chemicals from that data base already included in the energy analysis (ethylene, styrene, chlorine, and ammonia) account for 75 percent of the 3.7 quads of total energy used. By including all ten of the chemicals shown in Table III-7, only about .69 quads more energy use would be included. This represents about 3.3 percent of total manufacturing energy use.

^{1/} Non-manufacturing uses in the industrial sector are in the mining, construction and agriculture sectors.

TABLE III-7

LARGE ENERGY-USING CHEMICAL INDUSTRIES^{1/}
 (10¹² BTU per year)

	<u>Number of Plants</u>	<u>Total Energy</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>
Acetylene	20	52	-	43
Alumina	19	38	1	36
Phenol	19	54	37	11
Cyclohexane	10	42	41	1
Ethylene Oxide	17	31	1	13
Sodium Carbonate	12	73	6	46
Oxygen	215 ^{2/}	84	1	2
Phosphoric Acid	45	75	-	1
Propylene	64	112	112	0
Methanol	<u>12</u>	<u>128</u>	<u>-</u>	<u>126</u>
	433	689	199	279

1/ Includes all of the chemicals in the IR&T data base of 37 selected chemicals which use more than 30 trillion BTUs per year for fuel and feedstocks. (Ethylene, chlorine, ammonia, and styrene are not included here.)

2/ Includes "Air Separation Plants" which also produce argon and nitrogen.

SOURCE: Data Base for the Industrial Energy Study of the Industrial Chemicals Group, IR&T, September 1974.

TABLE III-8
LARGE ENERGY USING INDUSTRIES^{1/}
(10¹² Btu per year)

<u>SIC</u>	<u>Number of Establishments</u>	<u>Total Energy</u>	<u>Fuel Oil^{2/}</u>	<u>Natural Gas^{2/}</u>
2011 Meatpacking	2472	77.1	6	41
2046 Wet Corn Milling	41	78.8	7	43
2063 Beet Sugar	61	81.5	3	34
2421 Sawmills	8071	84.6	16	19
3011 Tires	206	84.3	13	34
3079 Misc. Plastics	7698	109.2	20	34
3211 Flat Glass	32	63.5	3	48
3221 Glass Containers	117	140.6	20	103
3229 Pressed & Blown Glass (nec)	252	71.3	6	54
3251 Brick & Clay Tile	417	72.0	4	53
3273 Ready Mixed Concrete	4915	60.7	13	8
3274 Lime	103	98.3	1	28
3296 Mineral Wood	108	55.6	3	32
3313 Electrometallurgical Prod.	40	68.9	(D) ^{3/}	(D) ^{3/}
3321 Gray Iron Foundries	993	118.7	2	43
3331 Primary Copper	31	82.2	13	49
3462 Iron & Steel Forgings	280	52.2	7	34
3711 Motor Vehicles & Equip.	231	110.2	8	49
3714 Motor Vehicles Pts. Acess.	<u>2119</u>	<u>123.2</u>	<u>7</u>	<u>49</u>
	28,189	1,632.9	152	755

1/ All industries shown by the 1974 Annual Survey of Manufactures to have consumed more than 50 trillion Btus in 1974. Excluded are chemicals, petroleum, cement, steel, aluminum, and paper.

2/ Not including fuel oil and natural gas included in Census as "Fuels, not specified by kind". This could be significant in industries with small plants because of Census' sampling techniques.

3/ Withheld to avoid disclosing figures for individual companies.

SOURCE: 1974 Annual Survey of Manufactures, "Fuels and Electric Energy Consumed", Bureau of the Census, U.S. Department of Commerce. Number of establishments from 1972 Census of Manufactures.

The IR&T chemical data base contains no information on energy use by individual chemical plants, and no plant size data. Plant capacities could be derived for most of the chemicals from SRI's Directory of Chemical Producers. In a few cases, such as acetylene, alumina, and oxygen, there is either no capacity information in the SRI data base or else incomplete information. Capacities would have to be estimated for about 430 plants.

The 19 four-digit industries shown in Table III-8 are all of the four-digit SIC's which used more than 50 trillion Btus in 1974 and are not now included in the energy analysis. Their total energy use was about 1.6 quads. About .15 quads was fuel oil and about .76 quads was natural gas. Adding these plants to the energy analysis would add 1.6 quads, or about eight percent of total manufacturing energy use. However, only about three percent of total petroleum use and nine percent of natural gas use in the manufacturing sector is accounted for by these industries.

No regional energy use data is available for most of these four-digit industries. The energy data shown in Table III-8 is taken from the 1974 Annual Survey of Manufactures, where only three-digit SIC state data is available. The ECDB has energy data only for two-digit SIC codes, with a few very large energy-using four-digit industries (such as paper, steel, aluminum, and petroleum refining) shown separately. State data is available in the ECDB for these two-digit SIC codes. However, two-digit and three-digit SIC codes usually do not define specific enough "industries" for which meaningful plant size data could be obtained. For example, SIC 20 (Food and Kindred Products) includes meat, dairy, bakery, and grain products. Even SIC 204 (Grain Mill Products) includes a diversity of products: flour, breakfast cereal, pet food, rice milling. This lack of good state energy data for these four-digit industries would limit the usefulness of energy analysis of regional differences in energy use patterns.

Neither the ECDB nor the Census have information on capacities of individual plants in these four-digit industries. It is not known whether such data exists for many of these industries. Trade associations sometimes have directories of plants in their industries, but trade association membership often does not correspond precisely with the SIC codes upon which the energy data is based.

Information on individual plants often consists of only data on the number of machines of various types which a particular plant has. To determine a single total measure of size, it would be necessary to determine a weighting procedure based on energy use characteristics of different machine types. The resulting measure of capacity often only very roughly approximates the output of the plant. For some of the industries in Table III-8, capacity information would have to be developed for an extremely large number of plants. Five of these industries have over 2,100 plants, and unless total industry capacity is very heavily concentrated in a few plants, the energy use per plant will be very small. Capacity data would have to be developed for about 28,000 plants if all of the industries in Table III-8 were to be included. Excluding the five industries which each have over 2,100 plants would leave about 2,900 plants in the ten remaining industries. This total exceeds the 1,605 plants currently included in the energy analysis data base, and the 14 industries consume a total of only 5.6 percent of the total energy consumed in manufacturing.

E. USES AND LIMITATIONS OF THE ENERGY ANALYSIS

The purpose of the energy screening was to identify industries which have plants whose energy demands could conceivably be compatible with the output of various synthetic fuel technologies. The plant sizes most often proposed for high-Btu gas and liquefaction are about 80 to 100 trillion Btus per year. The plant size for low-Btu gas units is not as uniform, and some relatively small "first generation" units are available. Although the cut-off points on the size distributions of Tables III-2, III-3, and III-4 of the Interim Report were designed to identify users at the upper end of the spectrum of energy use per facility, the size ranges can be changed in order to "search" for smaller users. This was done in Table III-5, with detailed results shown in Appendix C.

A problem exists in using this energy screening procedure to identify candidates for adoption of very small low-Btu gas units. EEA personnel have recently inspected a Wellman Galusha fixed bed gasifier in a brick plant in York, Pennsylvania. The gasifier was installed in the 1950's, and has an output of about 183 billion (0.18 trillion) Btus per day. A screening procedure designed to determine plants in these industries whose total energy demands are greater

than 0.2 trillion Btus per year would probably exclude only a very few plants. Even screening for only natural gas usage in this size range would probably exclude few plants. Most of the plants excluded would probably be in the Northeast; an area which even highly aggregated data of the type published by the Bureau of Mines identifies as using very little natural gas in the industrial sector. Picking very low cut-off points in energy magnitudes results in very little definition of results: nearly all plants are identified as likely candidates. The problems associated with gathering meaningful data to include additional small energy-using industries were discussed above. However, even if data were to be developed such that these industries could be included, it is not clear that a substantial split could be identified between candidates and non-candidates if very low cut-offs are chosen. Further segmentation of the market is needed based on criteria other than amount of energy use in order to evaluate the market for low Btu gas. Such a segmentation is described in Section IV.

Another limitation which exists in analysis of the lower end of the magnitude of energy use spectrum occurs because of the margin for error in the estimating procedures. These limitations were discussed above in the methodology description, and as was stated in the previous discussion, the total Btu estimates for the individual plants are felt to be more accurate than the estimates for individual fuel types. This is especially true in those cases where no energy data is available for a particular state (or that state's region). In such a case, the national fuel mix is assumed for each plant in that state. Therefore, it may be that an excessive quantity of natural gas use may be attributed to each plant in a state where very little (or no) natural gas is actually used. This problem would greatly limit the usefulness of any regional analysis for smaller energy using industries where detailed energy data is not available in a geographically disaggregated form.

One possible solution might be to define "industries" by two-digit and three-digit SIC codes instead of the four digit and individual chemical definitions used to this point. This would increase the amount of regional energy data available from the ECDB and the Annual Survey of Manufacturers. However, plant

capacities for the more aggregated "industries" could no longer be used to derive meaningful shares to apply to this data. For example, hydraulic cement (3241), flat glass (3211) and ready-mixed concrete (3273), are four digit SIC codes. Clay refractories (3255) and Brick and Structural Clay Tile (3251) are both within the three digit Structural Clay Products (325). All of these very different industries (as well as a number of others) are in Stone, Clay, and Glass Products (SIC 32). The heterogeneity of the products in these two and three-digit industries would make it difficult to determine a meaningful common denominator for all plants such as "tons of capacity".

F. CONCLUSIONS

The analysis of energy use in ten of the largest energy-using industries suggests that industrial users are not likely to be producer-users of high Btu gasification and liquefaction technologies. Only in a few cases could even a consortium arrangement provide a large enough demand from several industrial plants to use the output of one of these large-scale technologies. In terms of industrial compatibility with smaller scale technologies, there are 882 plants in the ten industries whose total demand for energy exceeds one trillion Btus per year. This would be an average size for a low-Btu gas plant, thus indicating that the producer-user approach might be a viable one for low-Btu gas in terms of magnitude of energy use. Fuel type considerations are, of course, also important. All of this data deals with the "retro-fit" market, since the energy data is for historical usage. Expansion of this analysis to include plant-specific energy use in the smaller energy using industries would be difficult to do because of data availability problems.

SECTION IV

ASSESSMENT OF INDUSTRIAL MARKETS FOR LOW AND INTERMEDIATE BTU GAS

A. INTRODUCTION

One of the most important factors bearing on any decision to commercialize new products or technologies is an accurate assessment of the potential market. From ERDA's perspective, market potential is extremely important in the areas of inter-technology and inter-fuel competition, in targeting demonstration programs, and in assessing research priorities.

One area where ERDA is currently conducting research activities and the market potential has not been well characterized is low and intermediate Btu gas. Many of these technologies are relatively near term and offer the possibility for immediate market penetration. They can be small in scale, involve relatively low financial risk and produce products which are competitive with conventional alternatives. They can also potentially be substitutes for curtailed natural gas supplies and can be operated in a manner consistent with existing environmental regulations.

While many of these attributes are recognized by industry there are constraints to immediate penetration. Potential investors in these technologies may be unfamiliar with the system and many have never utilized coal in any form. Sizing may be incompatible with existing load requirements and higher initial capital costs may dissuade many users even though life cycle costs are lower.

ERDA's role in this area may be seen as analogous to that of a firm in the private sector which wants to market a new product. Typically industry will attempt to focus its marketing efforts on those markets which are the easiest to penetrate. The demonstration program may be seen as improving the dissemination of information pertaining to economics, reliability, and operating

characteristics for both new and retrofit applications. To perform this function it is important not only to understand the capabilities of the technology but also the size and characteristics of various markets.

The purpose of this section is to outline a methodology for analyzing the markets for low Btu gas (LBG) and intermediate Btu gas (IBG). Certain segments of the methodology are demonstrated here as an example of how existing data bases can be used both to segment the industrial market and to investigate energy option costs within different segments. The discussion is structured to include four sections:

1. An overview of market analysis methods which can be used to evaluate markets for LBG and IBG.
2. A description of the technologies, including an example of how LBG and IBG technologies can be differentiated according to characteristics which are significant for matching markets.
3. An example of how the retrofit market for LBG and IBG can be analyzed by segmenting the market and using the energy data bases described in Section II to characterize those segments where penetration is most likely.
4. A summary of the results of this preliminary analysis and a brief discussion of factors which a more extensive analysis would consider.

B. OVERVIEW OF THE ANALYTICAL PROBLEM - METHODS AVAILABLE

There are two inter-related types of analysis necessary to assess the potential for use of LBG and IBG in the industrial sector. The first is a cost comparison which evaluates the cost of gasification relative to the cost of other options in a particular market segment. The second is a determination of the size of the particular segment in terms of number of users or energy consumed. Based on the cost comparison from the first step, the screening can either start with the total industrial market and determine the size of segments which can be eliminated from consideration (negative screening) or it can determine the size of segments where the economics of gasification appear favorable (positive screening). The

example presented below will demonstrate both the cost analysis and segment size determination steps.

Ideally, it would be possible to do an analysis of each plant in the industrial sector and all of the factors which affect the use of low and medium Btu gas in the particular plant. The analysis would consist of an economic and technical evaluation of all of the energy alternatives available to the plant. It is presumed that this is not possible, and a workable approach is therefore to perform an analysis of alternatives for particular areas or industries (segments) from which it is possible to generalize about the conditions at individual plants. The choice of meaningful and useful segments to analyze is obviously a key part of the analysis.

It should be emphasized that the example below is representative of the type of analysis that would be needed to assess LBG and IBG market potential, but it does not consider IBG and does not look at new markets for either LBG or IBG. In addition, it relies on assumptions or national averages for data inputs which, in a more detailed study, would be obtained from regional or industry-specific data bases. The example below demonstrates both a method of analysis as well as the nature of the basic cost relationship, but in estimating the market potential for low Btu gas, it does not adequately consider the following:

- the variation in actual delivered coal costs to individual users in different regions; according to both quantities delivered and sulfur content,
- regional differences in the prices paid by industrial users for oil and gas,
- area-specific environmental regulations and the effect these have on the cost and feasibility of various options,
- natural gas curtailments in different regions, and the extent to which fear of such curtailments may be as significant to industrial users as the economics of non-gas options, and

- specific subsets of the industrial direct heat market, where there may be variations between industries and processes in retrofit costs and feasibility, fuel performance characteristics needed, etc.

These possible refinements and expansions to the analysis are discussed further in Section E.

C. LOW AND INTERMEDIATE BTU GASIFICATION TECHNOLOGY DESCRIPTIONS

1. Summary

Combustible gases manufactured from coal are conveniently classified as:

- Pipeline quality or high Btu (about 1000 Btu/scf);
- Intermediate Btu (about 300 Btu/scf); or
- Low Btu (about 130 Btu/scf).

Pipeline gas is the resource being depleted and low and intermediate Btu gas are potential replacements.

The combustion properties and the gas producer characteristics influence both the market potential and the penetration rate for both low and intermediate Btu gas. Low Btu gas can be produced in small units (2 billion Btu/day is reasonable when using bituminous coal) which are suitable for small industrial users if the gas burns cleanly enough and hot enough for the process application.

Intermediate Btu gas burns very similarly to pipeline gas and is a better substitute for it than low Btu gas, particularly when retrofitting an existing facility. However, intermediate Btu gas is much more capital intensive than low Btu gas unless large plants are built. Plants large enough to have the required economies of scale are generally so large that their product gas is likely to be supplied to industrial users by a utility-type producer via a distribution system.

2. Low Btu Gas

There are several types of low Btu gasifiers available to industrial users, but the most common type is a "fixed bed gasifier." It has a grate enclosed in a vessel which has coal piled above the grate. Air and Steam are blown up through the grate which oxidizes, pyrolyzes, and hydrogenates the coal to form gases, oils, and tars. The use of air to oxidize the coal (to produce the energy required to gasify the coal) is what makes the gas "low Btu gas." The large volume of inert nitrogen in the air is carried through the coal bed and dilutes the produced combustible gases.

The low ratio of energy to volume makes it uneconomical to either store large volumes of gas or transport the gas long distances. Any distance over a half mile is generally considered to be uneconomical.

The oils and tars produced can be handled two ways. The way selected depends on the required cleanliness of the gas' combustion products. Some applications, such as primary retorting of minerals, may not require absolutely clean combustion gases. For these applications, hot producer gas along with the tars and oils (both as vapors and in suspension) can be fired directly. This direct procedure eliminates the loss of the sensible heat from gasifier's oxidation reaction (about five percent of the total gas energy). It also uses the tars and oils as a fuel supplement and thereby boosts its energy to keep the gas hot so that condensation of tars and oils does not occur, and condensed droplets thereby agglomerate and deposit onto the pipes and burners.

The other way to handle the tars and oils is to separate them from the fuel gas. There are two procedures to separate them. One is to cool the raw gas so that droplets form and then either use a water wash or an electrostatic precipitator to remove the tar and oil. The resulting liquid can either be burned, reinjected into the unit, or attempted to be marketed as a chemical feedstock akin to coke oven liquids.

The second way to separate coal tars and oils from the gas is to draw the gas off in two places of the coal bed. One place is at the top of the unit (which

is where the temperatures are low enough to allow tars and oils to form) where the oils are either processed or injected into a lower, hotter zone to continue gasifying. The other gas draw-off area is at the edge of the hot zone where no tars or oils have formed. The gas drawn off here will have a much less tar and oil that is likely to condense.

The tar and oil free gas is less likely to contaminate products which come in contact with the gas's combustion products. Direct drying of paint or food products are examples of applications where quality of product is sensitive to hot gas purity. The food industry would be particularly sensitive to the carcinogenic potential and flavor off-taste that would result from aromatic compounds that are present in the tars and oils.

Because low Btu gasifiers are relatively small and inexpensive (less than \$1 million will buy at least an 80 million Btu/hour "dirty" gas unit) they are well within the range of an individual plant wishing to have an assured heat source. An example is the Glen Gary Corporation in Pennsylvania. The Glen Gary Corporation has several brick kilns using producer gas as a standby fuel. The installations are atypical in that they use anthracite coal and hereby avoid problems with tars. However, a larger unit is required to produce the same amount of gas as a bituminous coal fed unit.

Another technical limitation in using low Btu gas is that the maximum temperature attainable is about 3000°F. This is important for industries such as high temperature refractory brick manufacturing.

An important characteristic of low Btu gas is that it requires larger lines than natural gas or intermediate Btu gas to carry an equivalent amount of energy value. The combustion gases of low Btu gas are also more voluminous than those of either natural or intermediate Btu gas. These two characteristics can limit the potential to retrofit low Btu gas in some processes and industries. The amount of space required for larger flues and feed lines can be critical in certain plants. The lower flame temperature coupled with the higher gas velocity (due to the larger combustion gas volume) shifts the heat loads in boilers so it is sometimes impossible to economically convert a natural gas fired boiler to low Btu gas.

Another potential problem is sulfur. Sulfur in coal reacts with water, carbon, and air. It may be removed with various absorption systems, but these appear to be uneconomical for units smaller than about 100 million Btu/hour. For some products where sulfur specifications are important, such as lime for glass manufacturing, the sulfur requirement can be met using low sulfur coal. Other applications, such as food processing, would require a thorough removal of sulfur compounds, particularly off-taste and odor-producing compounds such as mercaptans.

3. Intermediate Btu Gas

Intermediate Btu gas is produced using oxygen rather than air. The absence of nitrogen boosts the gas' heating value to about 300 Btu/scf. The flame characteristics are such that temperatures higher than those of natural gas are possible. Because the combustion products have about the same volume as natural gas little or no derating of boilers designed to fire natural gas is required.

A small commercial scale intermediate Btu gas installation is estimated to produce about four trillion Btu of gas per year.^{1/} Only about 15 percent of the plants in the nine largest energy consuming industries consume this much energy.^{2/} An intermediate Btu gas plant that is large enough to capture most economies of scale produces about 40 trillion Btu of gas per year.^{3/} Less than one percent of the industrial plants in the nine largest energy consuming industries are this large. Therefore the likely application of intermediate Btu gas is as fuel supplied by a utility from a central plant to its customers.

^{1/} H.J. Michaels and J.F. Kamody, "Fuel Gas Production Via Koppers-Totzek Gasification -- An Economic Analysis", Symposium on Comparative Economics for Synthetic Fuel Processing, ACS, National Meeting, New York, April 4-9, 1976, p. 1.

^{2/} See Section III.

^{3/} Michaels and Kamody, p. 1.

D. METHODOLOGY DEVELOPMENT AND APPLICATION -- THE INDUSTRIAL MARKET FOR LOW-BTU GAS

In the market analysis for LBG and IBG, there are four major areas where cost relationships are different enough that separate analyses would be required. The market for LBG would be assessed separately from the market for IBG, and in both cases a distinction would be made between "new" applications and "retrofit". The discussion below is confined primarily to the industrial retrofit market for LBG, although the methodology for evaluating retrofit markets for IBG and new markets for both systems would be similar.

Three gasification systems were selected in developing a methodological approach for screening the industrial market for LBG. The three units were differentiated on the basis of capacity, gas treatment, and the quality of the coal feed. Table IV-1 provides a summary description of the major characteristics of these units. While these systems do not include all the systems available, they are fairly representative of the range of alternatives.

1. Comparative Economics

As discussed earlier, the first step in the analysis is a comparison of the costs of various energy options available to a particular market segment. In the example below, the market segment chosen was a retrofit boiler application. The ECDB shows this to be an important segment of the industrial market, with about a quarter of the energy classified according to functional use accounted for steam generation.

Data collected included literature estimates of capital and non-fuel operating costs for various gasification systems. Vendors were contacted to obtain similar data for small coal-fired boilers (using the coal directly instead of gasifying it). For demonstration purposes, an oil cost of \$3.00 per million Btus and a gas cost of \$2.50 per million Btus were used.

A simple model was constructed to calculate the cost per million Btu using financing accounting conventions appropriate for a relatively small investment. The cost per million Btus was calculated for the number of hours of operation

TABLE IV-1
HYPOTHETICAL LOW BTU
GASIFICATION SYSTEMS

	Plant Capacity (10 ⁶ Btu/hr)	Coal Quality	Tar/Oil Removal	Sulfur Removal
LBG 1	80	Sized/Low Sulfur	no	no
LBG 2A	150	Run of mine/High Sulfur	yes	no
LBG 2B	150	Sized/Low Sulfur	yes	no
LBG 3	127	Run of mine/High Sulfur	yes	yes*

*Stredford System

per year. Figure IV-1 shows the model results for eight different energy options. The breakeven costs between the four LBG units and direct coal firing with gas and oil are summarized in Table IV-2. Technical and environmental considerations were incorporated on the basis of coal quality and whether tars and oils were removed prior to combustion.

The results of this analysis imply that LBG may be competitive with oil and gas in direct fired applications (where most of these cost relationships are the same as in the raising of steam) depending primarily on the number of hours of operation per year and environmental requirements. In general, however, Table IV-2 suggests that it is not competitive in the steam raising market where even for retrofit applications coal fired steam generators are less expensive over the entire range of operating rates. The latter conclusion is dependent on the assumption that sulfur regulations would be approximately the same for direct coal firing and gasification. If less stringent regulations were imposed on gasification units they would be competitive with coal fired steam generators operating more than 3000 hours per year.

2. Market Segmentation

Once a cost analysis like the one above is completed for a particular aspect of the market, the segment can be classified as either likely or unlikely to be penetrated by LBG. The next step in the analysis is to determine the size of the applicable segments. Energy data bases can be used for this segmentation step. The cost relationships suggest that annual hours of operation, environmental regulations, and type of unit (direct firing, steam generation, etc.) are all important characteristics.

3. Industrial Operating Rates

Figure IV-1 and Table IV-2 show that it is generally necessary for industrial users to operate over 4,000 hours per year (approximately 50 percent load) before they are likely to find the more capital-intensive LBG options to be competitive with oil and gas. The MFBI data base can be used to determine whether this is a significant segment.

Preliminary data prepared for FEA's Natural Gas Task Force showed that for large combustion units operating rates in excess of 4000 hours per year were typical within the industrial sector. Table IV-3 based on data from the Major Fuel Burning Installation Survey, which covers approximately five quadrillion Btu consumed in 1974. This table shows that load factors average 52.8 percent for boilers and non-boiler units with a capacity rating in excess of 99 MMBtu/hr. Operating rates for coal and gas fired combustors were considerably above this level. Boilers averaged over 57 percent and burners 65 percent.^{1/}

The implication of this data is that LBG units can reasonably be assumed to operate more than 4000 hours per year in most industrial applications, making LBG highly competitive with oil and gas for direct fired application. If steam

^{1/} "Natural Gas Conversion Capacity Identified by MFBI Survey with Primary Emphasis on Heavily Impacted Natural Gas Consuming States During the Winter of 1975/76," Energy and Environmental Analysis, Inc., August 4, 1975.

FIGURE IV-1, PART A
COMPARATIVE ANNUAL COSTS OF BOILER OPERATION,
VARIOUS FUELS AND PLANT SIZES (Retrofit Options for Natural Gas Boilers)

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* See Table IV-2 for specifications.

FIGURE IV-1, PART B
COMPARATIVE ANNUAL COSTS OF BOILER OPERATION,
VARIOUS FUELS AND PLANT SIZES (Retrofit Options for Natural Gas Boilers)

* See Table IV-2 for specifications.

TABLE IV-2

BREAKEVEN OPERATION RATES (HOURS/YEAR) - COAL AND LBG COMPARED WITH OIL AND GAS

OIL PRICE: \$3/MMBTU

GAS PRICE: \$2.50/MMBTU

RETROFIT BOILER APPLICATIONS

Boiler Fuel	Capital Costs (\$)	Annual Plant Capacity 10 ¹² BTU	Coal Price		Annual Non-fuel Operation Cost (\$)	Gas Quality	Breakeven # of Hours of Plant Operation Per Year With:	
			(\$/MMBTU)	(\$/ton)			Oil	Gas
1. LBG	0.52 x 10 ⁶	0.69	1.87	\$45	70,000	Dirty	820	2,790
2. LBG	3.09 x 10 ⁶	1.331	1.04	\$25	336,000	Clean	1,600	2,590
3. LBG	3.09 x 10 ⁶	1.331	1.87	\$45	336,000	Clean	4,480	NEVER
4. LBG	5.36 x 10 ⁶	1.119	1.04	\$25	285,000	Clean	3,370	5,620
5. Coal (with precipitator at \$30,000/ MW)	0.87 x 10 ⁶	0.69	1.04	\$25	50,000	-----	640	1,000
6. Coal (with precipitator at \$30,000/ MW)	0.87 x 10 ⁶	0.69	1.87	\$45	50,000	-----	1,180	2,500

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TABLE IV-3

1974 COMBUSTOR DATA:
CAPACITY, BTU'S CONSUMED AND LOAD FACTOR

Capacity by Combustor
and Fuel Type (10⁹ BTU/hr.)

Primary Fuel Type	Boiler		Non-Boilers ^{1/}		Total	
	Capacity	Percent	Capacity	Percent	Capacity	Percent
Coal	172.8	23.9%	67.2	20.1%	240.0	22.7%
Residual	154.8	21.4%	35.5	10.6%	190.4	18.0%
Distillate	11.9	1.6%	11.3	3.4%	23.2	2.2%
Gas	276.3	38.1%	165.0	49.5%	441.3	41.7%
Other	108.6	15.0%	54.4	16.3%	163.0	15.4%
Total	724.4	100.0%	333.6	100.0%	1,058.0	100.0%

BTUs Consumed 1974

Primary Fuel Type	Boiler		Non-Boilers ^{1/}		Total	
	10 ¹² BTU	Percent	10 ¹² BTU	Percent	10 ¹² BTU	Percent
Coal	869.0	26.8%	406.0	24.8%	1,270.0	26.0%
Residual	662.0	30.4%	157.0	9.6%	819.0	16.7%
Distillate	32.0	1.0%	28.9	1.8%	61.0	1.2%
Gas	1,380.0	42.6%	952.0	58.0%	2,330.0	47.6%
Other	303.0	9.4%	96.2	5.0%	399.0	8.2%
Total	3,240.0	100.0%	1,640.0	100.0%	4,890.0	100.0%

c. 1974 Load Factors

Primary Fuel Type	Boiler	Non-Boilers ^{1/}	Total
Coal	57.4	69.0	60.4
Residual	48.8	50.5	49.1
Distillate	30.7	29.2	30.0
Gas	57.0	65.9	60.3
Other	31.8	20.2	27.9
Total	51.1	56.1	52.8

^{1/} Includes burners and other combustors

SOURCE: Major Fuel Burning Installation Survey, FEA. Survey contains data on 4,770 boilers, burners and other combustors.

TABLE IV-4

SO₂ REGULATIONS FOR SMALL COMBUSTION PLANTS

<u>State</u>	<u>Industrial Coal Consumption^{1/} (10⁶ tons/year)</u>	<u>#SO₂/MMBTU (for units 50-250 MMBTU/hour)</u>
New York (by county)	2.1	.2 to 2.5
Pennsylvania	5.6	2.95 to 2.35
Ohio	11.3	none
Indiana	4.6	5.88 to 2.75
Illinois	4.3	1.8
Michigan	4.4	1.0
Wisconsin	2.3	none
Iowa	1.3	5.0
Missouri	1.6	none
Virginia	2.3	2.64
West Virginia	4.3	3.1
North Carolina	1.5	1.6
South Carolina	1.3	2.3
Kentucky	2.1	2.5 to 1.0
Tennessee (by county)	2.1	1.6 to 4.0
Alabama (by county)	2.3	1.2 to 4.0
Texas	<u>2.3</u>	3.0
Total	55.7	

1/ Bureau of Mines

2/ Regulations Affecting Coal Production and Consumption, Department of Interior, prepared by Energy and Environmental Analysis, Inc.

raising is required, however, direct coal firing would probably continue to be the preferred alternative even in retrofit applications. The only exception would be if different SO_2 regulations were imposed on these sources.

4. Environmental Regulations Applicable to Industrial Units

LBG plants will generally be sized in a range compatible with a plant's energy requirements. The LBG units under consideration here would generate gas in a range of 80 to 150 MMBtu/hr which is equivalent to roughly 8 to 15 MW. New source performance standards for coal fired boilers are only applicable for plants using over 25 MW. The applicable regulation for these units is 1.2 # SO_2 /MMBtu of coal. Depending on the Btu content, this is the range of .6 to .8 percent sulfur. Smaller combustion units are currently subject only to a State Implementation Plan. Regulations for combustion units in the range of 50 to 250 MMBtu/hours are provided in Table IV-4. This data is drawn from EEA's data base of environmental regulations.

While a more detailed analysis would be required to determine the environmental regulations which would probably be imposed on these smaller units, most of the regulations currently in effect would allow SO_2 emissions in excess of two lbs. per million Btu. Coal in this range can be purchased at a cost substantially below that of low sulfur coal. This cost would probably be in the range of \$25/ton, based on small unit shipments. This cheaper coal cost obviously enhances the competitiveness of LBG with oil and natural gas.

5. Functional Uses of Industrial Energy

The preceding analysis showed that LBG does not appear to be competitive in the industrial sector retrofit steam generation market, where on the basis of economics it loses to direct coal firing. For oil and gas direct process heat applications it appears to be competitive, because coal is not generally a retrofit option. The MFBI data suggests that the low load factors which would exclude LBG from this segment are not prevalent. Two other areas where it would be competitive would be electrical generation (combined cycle) and space heating.

In order to provide a rough estimate of the size of these various applicable segments^{1/} of the retrofit market, the Energy Consumption Data Base (ECDB) was screened by:

- industry,
- fuel type,
- functional use; and
- geographic location

Since the LBG unit requiring sized metallurgic coal without gas clean-up and the larger LBG unit using unsized steam coal with gas clean-up were competitive with oil and gas for units operating 3000 hours per year it was not necessary to screen on the basis of whether the industry could utilize dirty gas. In fact over the range of coal cost and operating rates considered, the large unit producing a clean fuel was generally competitive with the smaller unit implying that even in areas of inter-technology competition it might be the preferred alternative.

The ECDB contains information on industrial energy consumption covering approximately 25 quads of energy. This sample application only considered manufacturing energy consumption which includes approximately 20.1 quads of which residual, distillate and natural gas accounted for 9.1 quads in 1974.

The ECDB contains functional use breakdowns at a national level for approximately 80 percent of total manufacturing sector energy consumption. At the regional level of disaggregation functional use information is less complete, but still

^{1/} "Feedstocks in the Chemical Industry" and "Electrolytic Processes" were two ECDB functional use categories also excluded as not applicable for LBG retrofit.

accounts for roughly 65 percent of total consumption. Since regional considerations for LBG are important, the data base was screened both on a regional and national basis.

The results of this analysis in Table IV-5 show that the natural gas, distillate, and residual market potential for LBG based on 1974 manufacturing energy consumption would be around 4.0 quadrillion Btu. Geographically, this potential is concentrated in the Middle Atlantic, East North Central, and West South Central regions. Most of the potential is for replacement of natural gas, with considerably less residual and (especially) distillate fuel oils used in the relevant functional processes.

Table IV-6 combines data on natural gas use with FEA's projections of natural gas curtailments. In combination with the LBG regional market potential shown in Table IV-5, it raises some important questions about the targeting of "key" regional markets for LBG. Table IV-6 shows that there is not a correspondence between the large gas using regions, the regions projected to be most severely curtailed, and the regions identified as having most of the potential for LBG.

If ERDA were to pick regions to emphasize in demonstration programs and/or in commercial adoption of LBG, Tables IV-5 and IV-6 suggest three possible rationales for picking target regions:

- a. Pick those regions facing the most severe curtailments, and thereby meet the most urgent needs first. This would mean focusing on the Mountain, East South Central, and South Atlantic regions, even though the total size of the LBG Markets is not large.
- b. Concentrate on regions where the largest market is located (in terms of volume of gas). A rationale for this is that even if these large markets (West South Central, East North Central, and Middle Atlantic) are not projected as areas of heaviest curtailments, the large volumes of gas which could be "freed up" by use of LBG could be re-directed to areas of greatest need.

TABLE IV-5

ESTIMATED MARKET POTENTIAL FOR LBG IN THE MANUFACTURING SECTOR (1974)

Fuel/Function of use	Region									Total Regional	Total U.S. ^{1/}
	NE	MA	SA	PHC	ESC	WNC	WSC	MT	PAC		
Natural Gas											
Space Heating	---	.1	---	.7	1.9	---	1.0	.5	4.4	8.6	39.8
Direct Process	3.1	161.2	84.7	371.5	124.2	71.4	903.1	50.9	166.7	1,936.8	2,705.9
Electrical											
Generation	---	3.2	6.0	25.0	20.1	8.7	276.3	1.1	11.3	351.7	376.9
Sub total	3.1	164.5	90.7	397.2	146.2	80.1	1,180.4	52.5	182.4	2,297.1	3,122.6
Residual											
Space Heating	---	---	---	---	---	---	---	---	---	---	7.4
Direct Process	3.9	157.0	69.5	180.0	20.3	13.6	25.4	13.8	38.9	522.4	579.0
Electrical											
Generation	50.7	14.4	9.5	5.6	12.0	1.0	17.9	.1	4.8	96.0	99.8
Sub total	34.6	171.4	79.0	185.6	32.3	14.6	43.3	13.9	43.7	618.4	686.2
Distillate											
Space Heating	---	---	---	---	---	---	---	---	---	---	6.2
Direct Process	.8	22.8	17.9	12.6	1.5	.5	17.3	.8	7.2	81.4	144.6
Electrical											
Generation	.5	1.8	2.9	2.1	.6	---	.9	---	.3	9.1	12.7
Sub total	1.3	24.6	20.8	14.7	2.1	.5	18.2	.8	7.5	90.5	163.5
Total											
Space Heating	---	.1	---	.7	1.9	---	1.0	.5	4.4	8.6	53.4
Direct Process	7.8	346.0	172.1	564.1	146.0	85.5	945.8	65.5	212.7	2,540.6	3,429.5
Electrical											
Generation	31.2	19.9	18.4	32.7	32.7	9.7	292.4	1.2	16.4	456.8	489.4
Total	39.0	366.0	190.5	597.5	180.6	95.2	1,239.2	67.2	233.5	3,006.0	3,972.6

^{1/} Total U.S. is larger than the sum of regions because the ECDB does not always specify the regional distribution of functional uses.

TABLE IV-6

REGIONAL SUMMARY OF RELATIVE IMPACTS OF NATURAL GAS CURTAILMENTS

Region	Total Natural Gas Use (A)	Rank (B)	Percent Dependent on Natural Gas (C)	Rank (C)	Percent Projected Curtailment 1976-1977 ^{1/} (E)	Rank (F)	Percent of Energy Projected to be Curtailed ^{2/} (Col. CxF) (G)	Rank (H)
West South Central	4,600	1	77%	1	9.4%	8	7%	8
East North Central	1,668	2	39%	6	20.2%	7	8%	6/7
Pacific	950	3	58%	4	27.3%	5	16%	4
South Atlantic	742	4	35%	7	56.2%	1	20%	2/3
West North Central	701	5	64%	2	24.2%	6	15%	5
Middle Atlantic	637	6	28%	8	29.1%	4	8%	6/7
East South Central	603	7	42%	5	46.8%	2	20%	2/3
Mountain	576	8	64%	2	34.8%	3	22%	1
New England	<u>71</u>	<u>9</u>	<u>20%</u>	<u>9</u>	<u>4.1%</u>	<u>9</u>	<u>1%</u>	<u>9</u>
U.S. Total	10,549	--	53%	--	25.0%	--	13%	--

^{1/} Percent dependence for all regions and U.S. determined on the basis of fuels allocated to states and regions. Including the petroleum products such as still gas, and special naphthas not allocated and the unallocated coal reduces total industrial dependence to 45 percent.

^{2/} FEA projected curtailments, based on an assumption of a "normal" winter temperature.

c. Focus on those specific markets where it is most economically feasible in terms of coal availability, high cost of alternatives, etc. This is obviously also a factor in a and b.

Preferred locations for demonstrating these technologies can be determined with certainty once an ERDA policy decision with regard to these issues has been made. However, since fifty percent of the LBG potential identified geographically is in the West South Central and East North Central, process heat applications in these areas would certainly provide useful demonstrations. Retrospective analysis of this winter's actual curtailments will help identify good markets in terms of the curtailment criteria.

In the aggregate it would appear that the potential for LBG units as retrofit applications would be in the range of 4000 based on 80 to 150 MMBtu per hour. The rate at which these markets could be penetrated will depend significantly on the price and future availability of natural gas. Based on the simplistic cost evaluation performed earlier it would appear that at least in the intrastate market for natural gas LBG may already be competitive. The cost comparisons were done assuming a natural gas price of \$2.50 per million Btus. Prices in this range have already been reported in some intrastate markets.

E. POSSIBLE REFINEMENTS TO THE ANALYSIS

In the discussion above, the estimate of market potential was arrived at by using assumed values for certain key parameters (coal, oil, and gas cost, plant costs, etc.) and by assuming that market segments such as "direct process heat" are more homogenous than they actually are. The methodology overview in Section B outlined some of the areas where more detailed analysis is needed. This Section will elaborate on that discussion.

The characteristics discussed below need to be considered when evaluating low and medium Btu gas as an alternative in specific segments of the industrial market. There is, in some cases, considerable overlap between characteristics,

but all of the factors listed are at least partial indicators of technical and economic conditions relevant to an assessment of the viability of low and medium Btu gas as an energy alternative. Each represents one aspect of a determination of the total costs (direct and indirect) of using low and medium Btu gas relative to the cost of alternatives. Some of the characteristics are appropriate by themselves as a means of segmenting the market for positive or negative screening, while others must be combined to be meaningful screening criteria. While the description given of the various characteristics suggest that analysis is done of each plant, data availability limitation will dictate what level of geographical or industry breakdown is feasible.

The total cost of utilizing an energy alternative is what ultimately needs to be determined, and what the factors below are expected to approximate. Included are the delivered cost of the various energy forms (coal, oil, gas, electricity) as well as any costs associated with utilizing the energy forms (such as equipment modifications or purchase cost). Also included are "indirect" costs such as the cost of meeting environmental regulations or the per-unit cost penalty from a low load factor.

The first five factors discussed below were to some extent evaluated quantitatively in the example and the discussion above. More detailed analysis would include incorporation of more detailed data into the evaluation. For example, coal costs and the price of competing oil and gas would be varied systematically according to differences by region and size of delivery in order to assess the competitiveness in specific regions and user size ranges. Other factors are discussed below which would probably not be dealt with quantitatively, but their importance in potentially modifying a quantitative estimate of LBG or IBG market potential should be considered.

1. Present and Projected Price of Delivered Energy

This includes a determination of what a plant will have to pay for the present form of energy as well as the cost of alternative forms. It can be approximated

for an individual plant by determining the average price paid for a particular energy form by users in the appropriate geographical area. It can be more closely approximated if the size of the energy purchaser also is considered, since quantity purchased can affect the cost per unit of coal, oil, gas, or electricity. The Census, ECDB, and FPF data bases are all possible sources of this price information. Regional variations will be significant, and cost-of-option calculations will therefore be done for each region.

2. Capital Costs Associated with Utilization of an Energy Form

Included in this are the capital costs associated with using gas, oil, coal, or electricity. This includes the costs of necessary equipment modification when switching fuel types. For low and medium Btu gas as a retrofit alternative for a furnace, for example, it would include costs of changing burners and controls, modifying ducts, disposing of ash, etc. These can be approximated for an individual plant by considering the type of unit using the energy (boiler, process heater, kiln). Since conversion costs could vary significantly by the exact size and type of unit involved, greater precision could be attained by considering the size and industry location of the unit (e.g., a small kiln in the lime industry). Conversion costs will be investigated to see whether they vary significantly enough between industries and processes that industry-wide generalizations about "direct process heat", or "steam generation" may not be valid.

3. Current and Projected Availability of Energy

Aside from the price considerations discussed above, the availability of a particular fuel form to a particular user can be of importance in weighing alternatives. This especially applies to current and projected curtailments of natural gas to a particular plant. This can be approximated by the geographical area of the plant or the pipeline company or gas utility serving it. Since FPC curtailment priorities are determined by the quantity of natural gas used and the functional use (process heat versus boiler) these are important to

consider in estimating curtailments. Local Public Utility Commission priorities also are a determinant of the availability of natural gas to a particular plant.

4. Availability of Coal with Desirable Characteristics

In determining both the total cost of either a direct firing or a gasification option, the coal types available to a particular plant are important. Sulfur content, for example, may be a determinant of the utilization cost because of its effect on the environmental control systems required. Other coal characteristics, such as ash content or caking tendencies can affect the cost or even the technical feasibility of gasification options by requiring special feed systems or ash removal systems. The range of coal types available to a particular plant can be estimated by considering the geographical location of the plant and the coal types available in that region. Regional coal costs would also be determined regionally.

5. Environmental Constraints

Like rising energy prices, environmental regulations are an external force acting on a particular plant to effectively limit the energy options open to it. Tight environmental regulations can limit the ability of a plant to burn high sulfur coal directly, and can result in higher capital costs due to gas clean-up requirements for coal gasification plants. The process used at a plant can have a significant effect on the cost of meeting environmental standards. For example, scrubber costs for direct firing of coal might be significantly lower in industries such as pulp paper or paint where plant waste streams could provide a scrubber liquor. This factor could put gasification of coal at a serious disadvantage relative to direct firing. The conditions facing a particular plant can be characterized through the location of the plant (for the environmental standards which apply) and the industry or process (for control problems and options available).

6. Premium value Perceived to be Associated with a Gaseous Fuel

For particular uses within an individual plant, there may be a premium value placed on use of gas relative to coal, petroleum or electricity alternatives.

This premium would be after consideration of the different fuel and direct capital cost associated with a particular fuel form. For new boilers, the premium would be low since there is not special "need" for gas. For certain process uses, however, there may be either a technical requirement for gas or else a familiarity with gas which results in a significant premium being associated with it. For retrofit applications, this premium can be largely incorporated by considering a plant's utilization costs for non-gas options. For new plants, however, the premium may be assessed by considering the industry which the plant is in (e.g., baking or glass). It can be more precisely determined by examining the use of the energy within the plant in categories which may cut across industry boundaries (e.g., annealing, process heating with product exposure to combustion products, etc.). For each of these specific functional uses, a determination can be made of the extent to which gas is actually "needed", and any special characteristics such as high Btu value which might be necessary. This may be a difficult factor to quantify, but it should be evaluated as a possible qualification to any estimate of market potential.

In addition to these six factors, the attractiveness of gasification options to industrial users will be dependent on several economic factors which should be at least considered, if not quantitatively evaluated for each market segment. For example, some gasification options have very high capital cost relative to other energy alternatives. Many smaller companies may not be able to raise the capital required to build a gasification unit. This constraint is lessened somewhat by the possibility of industrial park arrangements whereby users essentially share the capital costs. It is also lessened if the low and medium Btu gas plants do not display considerable economies of scale. The ability to raise a specified amount of capital would probably have to be evaluated separately for each company, although inter-industry differences in capital budgets may be significant enough to allow for some meaningful generalizations about specific industries and their ability to raise capital.

Another consideration in estimating market potential is that in an older plant there may be a reluctance to choose an option, which involves a large capital

investment. A decision about an energy option also may be influenced by the percentage of total costs or product price which energy represents. For an industry with a high value product where energy is only a small component of total cost, a user may be able to "afford" a more expensive fuel option if it has certain non-economic benefits like reliability of supply, convenience or proven reliability. The first factor, age of plant or unit, is difficult to approximate for a particular plant by using industry or geographical area averages. The contribution of energy costs to total costs can be estimated on the basis of industry averages, with specification of a narrowly defined industry (e.g., four-digit SIC code) and geographical area. Market potential would encompass all of the factors discussed above. The economic analysis would be best approached from a model plant type of analysis in which any inputs to the cost analysis were based on regional and plant specific characteristics. Fuel price data can be obtained from a variety of data bases discussed previously, and future price projections may be obtained from modeling efforts performed by FEA and ERDA or private contractors such as EEA's National Coal Forecasting Model. Such projections would be especially necessary for either an evaluation of the new markets for LBG and IBG or for any analysis focusing on a more distant time horizon.

Plant specific data can be obtained in a fashion similar to the method described in Section III of this report or based on survey information. The most appropriate method for this type of analysis would be to select sample plants representative of various industrial sectors differentiated on the basis of:

- annual energy requirements,
- continuous versus batch processing; and
- fuel quality based on technical requirements.

These data in conjunction with regional fuel price data would be integrated with the comparative economic models for the various technologies to determine which of the systems might be the preferred alternative. The ECDB would then be screened to determine the size of the potential market for LBG by state and region.

The discussion to this point has emphasized low as opposed to intermediate Btu gas. Two important differences regarding plant sizes and gas transportability suggest that there are areas where separate analysis of low and medium Btu gas may be necessary. While some industrial users have energy demands large enough to utilize the output from a medium Btu gas plant, it is probable that most industrial users would be served by centrally located plants. With greater transportability of medium Btu gas, size of individual plants and their energy demands may be of secondary importance to the pattern of industrial concentration when analyzing the size of applicable market segments.

If the minimum economic size for medium Btu gas plants is quite large (and the oxygen plant requirement suggests that it is) then the potential for this technology's penetration is dependent on the extent to which industry location patterns are compatible with possible medium Btu gas plant locations. Concentration of industrial energy use into relatively small areas would suggest a greater potential for the industrial sector to be served by centrally located medium Btu gas plants. A more dispersed location pattern would tend to limit economic use (low total cost per million Btus) of the technology to those relatively few uses whose consumption per plant is large.

Most of the geographically disaggregated data bases such as the ECDB or the Bureau of Mines, give total energy use by state, but give no information concerning use patterns within the state. Since medium Btu gas can probably be economically transported within a radius of 50 to 200 miles, it is necessary to find areas of concentrated industrial energy use within individual states. There are at least three data bases which could be used to do this. The Bureau of the Census data for purchased fuels used for heat and power in the manufacturing sector gives information about energy use by type of fuel in individual Standard Metropolitan Statistical Areas (SMSA). While SMSAs are not of uniform size, they do represent what are generally urban areas within states, and could

at least roughly approximate market areas for medium Btu gas plants. Some SIC code detail is given for some SMSAs, and the data base will, at a minimum, give an indication of the geographical concentration or dispersion of consumption of the approximately 13 quads of energy covered by the Census.

A second method of estimating concentration or dispersion of industrial energy use involves use of data bases which give industrial locations rather than energy use. As an example, the Economic Information Systems, Inc. (EIS) data base is a commercially available marketing data base with information on about 115,000 plants with more than 20 employees. It classifies the plants according to SIC code, and gives some information about the size of the plant. It could be used to locate plants as precisely as zip code areas or even street addresses. In combination with average ratios of energy per employee or energy per unit of shipment, rough estimates of energy use per plant could be made. Detailed information on fuel types used could not be derived, however.

A third technique which could deal even more precisely with the issue of industrial concentrations and IBG plants would be to use the Major Fuel Burning Installations (MFBI) Survey data base.^{1/} The MFBI data base has data on individual plants using more than 99 MMBtu/hour and detailed fuel usage information on combustors using more than 99 MMBtu/hour. One way of utilizing this data would be to sort the MFBI data on the basis of zip codes.

An optimization computer algorithm could then be constructed to select plant sites that would minimize transportation costs to industrial facilities with the objective of maximum potential demand. The model could be run for optimization on the basis of shipping distances of 50, 100, 200, and 300 miles from the plant site. An additional constraint that could be imposed would be that the plant must be located near a rail line with direct access to coal fields.

^{1/} ERDA would have to obtain FEA approval in order to use the data.

F. SUMMARY

Existing data on industrial fuel consumption, regional growth patterns and fuel prices and availability can be used to define market potential. This data can be extremely important in selecting sites for demonstration units and setting research priorities. The West South Central and the East North Central were identified as large potential markets for LBG. In order to provide a more complete analysis it would be necessary to further develop the technical and economic characteristics of competing technologies at model plants. It would also be necessary to provide for inter-technology competition between LBG and IBG and to intergrate regulatory considerations explicitly.

An analysis of this type would provide:

- a comparative economic analysis of fuel choices for new and existing industrial facilities,
- demand profiles by states and regions,
- priority ranking of industries based on fuel price differentials,
- potential sites for intermediate Btu gasification plants; and
- estimates of total market potential for low and intermediate Btu gasification.

While this data would only be an approximation of the actual market they would be fairly reliable guides to determining the size of the markets and the areas where these technologies would be most competitive.

PREFACE

Although this report was prepared in 1977, the information contained herein is current enough to be relevant today for those interested in industrial sector energy usage.

Three of the more useful sources of data are the Energy Consumption Data Base (ECDB), the Major Fuel Burning Installation (MFBI) Survey, and the National Emission Data System (NEDS).

The Department of Energy's Energy Consumption Data Base provides energy data by application (e.g., process steam) by industry (two or three digit SIC Code) by region and by fuel. The Department of Energy's Major Fuel Burning Installation Survey provides specific data for combustors over 100 MM BTU/hr. The Environmental Protection Agency's National Emission Data System is the most comprehensive data base for units smaller than 100 MM BTU/hr.

The most comprehensive and current model for estimating future industrial energy usage has been developed by Energy and Environmental Analysis, Inc. and is called the Industrial Sector Technology Use Model (ISTUM). This effort is documented in a four volume report, of which the third volume includes data from the Energy Consumption Data Base and engineering estimates of efficiency.

Cyril W. Draffin
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Fossil Energy
Assistant Secretary for
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APPENDIX A

Sample Entries-

Major Industrial Energy Consumption Data Bases

The sample entries which follow are representative of the level of detail generally provided by the energy data bases. Certain data bases have information of a type other than what is shown here.

Data bases included in this Appendix are:

- Energy Consumption Data Base (ECDB), developed by Energy and Environmental Analysis, Inc. for FEA
- Major Fuel Burning Installations Survey (MFBI), FEA
- Annual Survey of Manufacturers (Bureau of Census, DOC)
- Bureau of Mines
- Commerce/FEA Voluntary Energy Conservation Program
- Gas Requirements Committee
- American Gas Association
- National Emissions Data System (NEDS), EPA

ENERGY CONSUMPTION DATA BASE (ECD8)
 Sample Entry
 West Virginia, Steel Industry (SIC 3312)
 Functional Uses (10^9 Btu)

	Total Direct Heat	Raw Material	Process Steam	Electricity Generation
YEAR= 3 STATE= 49 XY= 1 *				
1	2729.471	0.0	0.0	0.0
2	57624.949	0.0	0.0	0.0
3	0.0	0.0	132534.750	188115.137
4	0.0	0.0	0.0	0.0
5	5117.660	0.0	0.0	0.0
6	517.331	0.0	0.0	0.0
Fuel	152.154	0.0	0.0	0.0
Types	0.0	0.0	0.0	1126.506
(See	0.0	0.0	0.0	0.0
Key)	0.0	3217598.00	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	3145.112	4465.711
13	0.0	0.0	0.0	0.0
14	159031.137	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	114.077	0.0	6.551	9.262
17	0.0	0.0	0.0	0.0
18	15822262.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0

YEAR= 3 STATE= 49 XY= 2

1	-1.000	0.0	0.0	0.0
2	-1.000	0.0	0.0	0.0
3	0.0	0.0	-1.000	-1.000
4	0.0	0.0	0.0	0.0
5	4.175	0.0	0.0	0.0
6	-1.000	0.0	0.0	0.0
7	2.146	0.0	0.0	0.0
8	0.0	0.0	0.0	15.286
9	0.0	0.0	0.0	0.0
10	0.0	232.440	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	1.230	1.746
13	0.0	0.0	0.0	0.0
14	14.313	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.002	0.0	0.000	0.000
17	0.0	0.0	0.0	0.0
18	4.319	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0

* XY = 1 is energy consumption
 XY = 2 is expenditures

Source: Draft ECD8,
 Energy and Environ-
 mental Analysis, Inc

ENERGY CONSUMPTION DATA BASE (ECDB)

Sample Entry (cont.)

West Virginia, Steel Industry

Functional Uses

	<u>Coke Production</u>	<u>Electrolytic Processes</u>	<u>Other</u>	<u>Total</u>
1	981.383	0.0	552.028	4262.563
2	0.0	0.0	11483.676	69105.525
3	0.0	0.0	0.0	320753.062
4	0.0	0.0	6411.043	6411.047
5	12.221	0.0	2016.511	7148.395
6	0.0	0.0	561.674	1079.005
7	21.294	0.0	461.372	634.387
8	0.0	0.0	0.0	1126.500
9	5261999.00	0.0	0.0	5262000.00
10	0.0	0.0	0.0	3217000.00
11	3550998.00	0.0	0.0	3550000.00
12	24987.133	0.0	26829.020	59427.000
13	59426.988	0.0	0.0	59427.000
14	14442.113	0.0	91774.625	265246.000
15	0.0	0.0	265247.937	265246.000
16	0.0	0.0	75.110	205.000
17	395.000	0.0	0.0	395.000
18	0.0	0.0	900453.875	16722720.0
19	4265996.0	0.0	0.0	42650000.0
20	8006876.00	0.0	0.0	8008880.00
1	-1.000	0.0	-1.000	-1.000
2	0.0	0.0	-1.000	-1.000
3	0.0	0.0	0.0	-1.000
4	0.0	0.0	-1.000	-1.000
5	0.010	0.0	1.045	05.830
6	0.0	0.0	-1.000	-1.000
7	0.300	0.0	6.507	5.947
8	0.0	0.0	0.0	85.888
9	160.228	0.0	0.0	160.226
10	0.0	0.0	0.0	232.440
11	256.614	0.0	0.0	256.814
12	9.770	0.0	10.490	23.236
13	23.235	0.0	0.0	23.230
14	1.300	0.0	8.260	23.872
15	0.0	0.0	23.872	23.872
16	0.0	0.0	0.001	0.003
17	0.006	0.0	0.0	0.000
18	0.0	0.0	0.240	4.565
19	11.546	0.0	0.0	11.646
20	3.341	0.0	0.0	3.341

Key to ECDB Fuel Types
Used in Steel Industry

1. Distillate
2. Residual
3. Steam Coal
4. Other Coal
5. Natural Gas
6. LPG
7. Electricity Consumption
8. Electricity Production
9. Metallurgic Coal
10. Coke Consumed
11. Coke Produced
12. Coke Oven Gas Consumed
13. Coke Oven Gas Produced
14. Blast Furnace Gas Consumed
15. Blast Furnace Gas Produced
16. Breeze Consumed
17. Breeze Produced
18. Tar and Pitch Consumed
19. Tar and Pitch Produced
20. Light Oil

Major Fuel Burning Installations (MFBI) Survey

See Attached Survey Form. MFBI data
has not been published, hence there is
no "sample entry" to show data format.

FEDERAL ENERGY ADMINISTRATION
WASHINGTON, D.C. 20461

APPROVED BY GAO
B-181254 (S75022)
EXPIRES 6-30-75

THIS REPORT IS MANDATORY UNDER P.L. 93-275

MAJOR FUEL BURNING INSTALLATION COAL CONVERSION REPORT

FEA C-602-S-0

INSTRUCTIONS

I. PURPOSE

Form FEA C-602-S-0 is a request for information from "major fuel burning installations" to aid FEA in carrying out its responsibilities under the Energy Supply and Environmental Coordination Act of 1974 (P.L. 93-319). (A major fuel burning installation will be referred to in this form as "MFBI".) The survey is designed to obtain data required by FEA to examine the feasibility and effect of issuing orders to specified major fuel burning installations prohibiting them from burning oil or natural gas as their primary energy source.

II. WHO SHOULD SUBMIT

Form FEA C-602-S-0 must be submitted by every MFBI. MFBI is defined on page 3 of this form. The form may be filled out by a responsible official at either the installation or, if applicable, the parent organization.

III. TO WHOM

Two copies of the Form FEA C-602-S-0 must be filed with:

Federal Energy Administration
ATTN: OFU/CRB Room 6117
Washington, D.C. 20461

IV. WHEN

Form FEA C-602-S-0 must be submitted on or before May 21, 1975.

V. GENERAL INSTRUCTIONS

This report is mandatory, and is being required pursuant to the authorities granted to FEA by the Federal Energy Administration Act of 1974 (P.L. 93-275).

A single Section I shall be filed for each facility, even if it is comprised of more than one combustor of fuel. Sections II and III shall be filed for each separate combustor with an individual capacity of 100 million Btu's/hr or greater.

Fill in the combustor number and installation name at the top of each applicable page in order to facilitate handling should the pages be inadvertently separated in mailing.

For all questions which can be answered by a "Yes" or "No" "1" (for "Yes") or "0" (for "No") shall be entered in the appropriate block unless otherwise stated.

A blank page has been provided at the end of this questionnaire to permit comments to be continued where inadequate space is provided on the form.

VI. SPECIFIC INSTRUCTIONS

Section I

Item No.

- 1 Limit responses to the number of blocks provided, using standard abbreviations where appropriate.
- 1 *Air Quality Control Region*: As designated by the Environmental Protection Agency. Do not fill in the line if the AQCR is unknown.
- 4, 5 Includes all boilers and other combustors regardless of design firing rate. If there are more than 99 in either of these categories insert the number 99.
- 8 Place the 4-digit primary Standard Industrial Classi-

fication Code (SIC) in the first column and the percent of total shipments or services (by value) in the second. Three entries are available for multi-commodity installations. If it is possible to enter more than three SIC entries, list the three with the highest percentage of total shipments. If the SIC is unknown, describe the products or services on the line provided.

Section II

Item No.

- 1 Assign each combustor a two-digit identification number if it does not already have one.
- 7a Fill in the blank with 1, 2, or 3.
- 19b The term "rank" of coal refers to anthracite, bituminous, sub-bituminous, or lignite.
- 19g The term "other unique characteristics" refers to % moisture, hardness, fusion, temperature, and all other applicable coal parameters which must be maintained to insure proper operation of the combustor.
- 21, 22 Fill in the estimated "average" Btu content.

Section III

Item No.

- 1 Assign each stack a one-digit identification number.
- 3h The "% Availability" refers to the percentage of time the FGD equipment is available for operation (regardless whether or not it is actually operated).
- 4c, d & If it would be necessary to either install FGD or obtain conforming coal, please complete both item (c), assuming FGD is used, and item (d), assuming conforming coal is used.

VII. DEFINITIONS

1. "Major Fuel Burning Installation". An installation or unit other than a powerplant that has or is a fossil-fuel fired boiler, burner, or other combustor of fuel, or any combination thereof at a single site, that has individually or in combination, a design firing rate of 100 million BTU's per hour or greater, and includes any person who owns, leases, operates, controls or supervises any such installation or unit. Gas turbines and combined cycle or internal combustion engines are excluded from this classification.

2. "Powerplant": A fossil-fuel fired steam electric generating unit that produces electric power for purposes of sale or exchange, and includes any person who owns, leases, operates, controls or supervises any such unit.

3. "Total Designed Firing Rate". The sum total of all design firing rates of all combusting devices located at the facility, expressed as $[(A) \times 10^6 \text{ Btu/hr}]$.

4. "Combustor". An individual fossil-fuel boiler, burner, or other combustor of fuel.

5. "Combustor Capacity". The design firing rate of a combustor expressed as $[(A) \times 10^6 \text{ Btu/hr}]$.

6. "Topping Turbine". This refers to either steam driven electric generating sets or gas turbine electric generating sets associated with a process steam generating boiler.

7. "Primary Energy Source". That amount of fuel used for all purposes except for the minimum amounts required for start-up, testing, flame stabilization, control uses, and fuel preparation.

FEA C-602-S-0

FEDERAL ENERGY ADMINISTRATION
Washington, D.C. 20461APPROVED BY GAO
B-181254 (S75022)
EXPIRES 6-30-75**This Report is Mandatory Under P.L. 93-275**

MAJOR FUEL BURNING INSTALLATION COAL CONVERSION REPORT

DO NOT FILL IN

1	2	3	4	5
---	---	---	---	---

FILL IN THIS PAGE FOR EACH COMBUSTOR OVER 99 MILLION BTUs/HR

MFB I NAME _____

SECTOR II COMBUSTOR DATA

1. COMBUSTOR NUMBER

6

2. WHAT KIND OF COMBUSTOR IS THIS?

1 = boiler 2 = burner 3 = other combustor of fuel

--

3. COMBUSTOR CAPACITY (x 10⁶ BTU/HR)

--	--	--	--

4. MANUFACTURER _____

5. DATE INSTALLED (YEAR)

19	
----	--

6. a. If Combustor has been Modified to be Capable of Burning Coal, What Year was it Modified?
b. How was it Modified?

19	
----	--

7. DO YOU INTEND TO INSTALL A TOPPING TURBINE ON THIS COMBUSTOR?

a. If Yes, Will You Need to:

- (1) Replace Your Combustor.
(2) Modify Your Combustor.
(3) Make No Combustor Modification.

b. If the Answer to 7(a) was "1" or "2", Do You Intend to Modify/Replace Your Combustor so that You Can Burn Coal?

8. PRIMARY ENERGY SOURCE FOR EXISTING COMBUSTOR

1 = coal 2 = residual 3 = distillate 4 = gas 5 = other (specify) _____

--

9. ALTERNATE ENERGY SOURCE FOR EXISTING COMBUSTOR

1 = coal 2 = residual 3 = distillate 4 = gas 5 = other (specify) _____ 6 = no alternate.

--

List secondary alternate energy sources, if any: _____

10. IF COAL IS THE PRIMARY ENERGY SOURCE, DO YOU INTEND TO CONTINUE ITS USE?

--

11. IF COAL IS NOT THE PRIMARY ENERGY SOURCE, DO YOU INTEND TO CONVERT TO COAL IN THE NEAR FUTURE?

--

12. WAS THIS COMBUSTOR ORIGINALLY DESIGNED TO BE CAPABLE OF BURNING COAL?

--

13. WAS COAL EVER BURNED IN IT?

--

14. CAN COAL NOW BE BURNED IN THIS COMBUSTOR?

--

15. IS LAND AVAILABLE FOR COAL STORAGE?

--

16. IF THE ANSWER TO NO. 12 OR 13 IS "YES", IS ANY OR ALL OF THE COAL BURNING SUPPORT EQUIPMENT STILL IN PLACE?

--

17. IF THE ANSWER TO NO. 12 OR 13 IS "YES", IS ANY OR ALL OF THIS EQUIPMENT STILL OPERATIONAL?

--

29

18. IF THE ANSWER TO NO. 16 OR 17 WAS "NO", PLEASE IDENTIFY ANY ANTICIPATED ACQUISITION OR REFURBISHING OF COAL HANDLING AND FIRING EQUIPMENT.

COMBUSTOR NUMBER _____ A-8
MFB1 NAME _____

FILL IN THIS PAGE FOR EACH COMBUSTOR
OVER 99 MILLION BTUs/HR

19. IF COAL WAS EVER USED AS THE PRIMARY FUEL SOURCE PRIOR TO 1973 GIVE (for the last year coal was used):

a. Year

19

30

b. Rank of Coal _____

c. Percent Ash by Weight (to the nearest percent) _____

d. Percent Sulfur by Weight (to the tenth of a percent) _____

e. BTU/lb _____

f. Quantity _____ Tons/Year

g. Other Unique Characteristics

h. Method of Delivery: (Train, Truck, Barge, etc.)

i. If Coal is not Presently Being Used, Do You Anticipate that it Could be Obtained if you Were to Convert?

☐

j. If Not, Why Not?

20. ESTIMATE YOUR ANNUAL NON-COAL FUEL SAVINGS IF YOU WERE TO CONVERT TO COAL

RESIDUAL

QUANTITY

35

10³ bbls/yr

DISTILLATE

39

10³ bbls/yr

GAS

43 46

10³ MCF/yr

21. 1974 ANNUAL FUEL USE

	% ASH (by weight)	% SULFUR (by weight)	BTU CONTENT ($\times 10^3$)		QUANTITY	
COAL	_____	_____	<input type="text"/> 47	(lb)	<input type="text"/> 54	10 ³ tons/yr
RESIDUAL	_____	_____	<input type="text"/> 55	(gal)	<input type="text"/> 62	10 ³ bbls/yr
DISTILLATE	_____	_____	<input type="text"/> 63	(gal)	<input type="text"/> 70	10 ³ bbls/yr
GAS	_____	_____	<input type="text"/> 71	(MCF)	<input type="text"/> 78	10 ³ MCF/yr

COMBUSTOR NAME _____
MFBI NAME _____

A-9

FILL IN THIS PAGE FOR EACH COMBUSTOR
OVER 99 MILLION BTUs/HR

22. 1973 FUEL USE

79	80	1	5	DO NOT FILL IN
----	----	---	---	----------------

	% ASH (by weight)	% SULFUR (by weight)	BTU CONTENT (x10 ³)	QUANTITY	
COAL	_____	_____	<div><div></div><div></div><div></div><div></div></div> (lb) 6	<div><div></div><div></div><div></div><div></div></div> 13	10 ³ tons/yr
RESIDUAL	_____	_____	<div><div></div><div></div><div></div><div></div></div> (gal) 14	<div><div></div><div></div><div></div><div></div></div> 21	10 ³ bbls/yr
DISTILLATE	_____	_____	<div><div></div><div></div><div></div><div></div></div> (gal) 22	<div><div></div><div></div><div></div><div></div></div> 29	10 ³ bbls/yr
GAS	_____	_____	<div><div></div><div></div><div></div><div></div></div> (MCF) 30	<div><div></div><div></div><div></div><div></div></div> 37	10 ³ MCF/yr

23. INDICATE (to the nearest percent) THE PERCENT OF COMBUSTOR OUTPUT THAT IS DEVOTED TO:

ELECTRIC GENERATION	<div><div></div><div></div><div></div><div></div></div> 38
SPACE HEATING	<div><div></div><div></div><div></div><div></div></div> 41
PROCESS STEAM	<div><div></div><div></div><div></div><div></div></div> 44
OTHER (Specify)	<div><div></div><div></div><div></div><div></div></div> 47

SECTION III AIR QUALITY

1. STACK NUMBER

2. STACK HEIGHT (Feet Above Ground)

3. CURRENTLY INSTALLED POLLUTION CONTROL EQUIPMENT AS PERTAINS TO THE COMBUSTOR (Answer Yes or No with a "1" or "0" respectively).

a. Precipitator (Also referred to as Dust Collector)

Type (Centrifugal, Electrostatic, Etc.) _____

Date Installed _____

Date Last Operated _____

Design Efficiency (%) _____

Actual Efficiency (%) _____

b. FLUE GAS DESULFURIZATION (FGD) EQUIPMENT (Also referred to as Scrubber or Sulfur Dioxide Absorber)

Type (MAG Ox, LIMESTONE, Etc.) _____

Date Installed _____

Date Last Operated _____

Design Efficiency (%) _____

Actual Efficiency (%) _____

% Availability _____

COMBUSTOR NO. _____
MFBI NAME _____

A-10

FILL IN THIS PAGE FOR EACH COMBUSTOR
OVER 99 MILLION BTUs/HR

4. TO BURN COAL AND MEET THE SIP EMISSION LIMITATIONS RELATING TO ATTAINMENT OF THE FEDERAL PRIMARY AMBIENT AIR QUALITY STANDARDS. THIS INSTALLATION MUST:
(Answer with Yes (1) or No (0) in the blocks provided)

a. Upgrade Precipitators

☐
56

If yes, give approximate cost \$ _____ time _____ (weeks)

b. Install Precipitators

☐

If yes, give approximate cost \$ _____ time _____ (weeks)

c. Install FGD

☐

If yes, give approximate cost \$ _____ time _____ (weeks)

d. Obtain Conforming Coal

☐

This coal must be _____ % Sulfur by weight, _____ % Ash by weight.

Do you anticipate that you will be able to obtain conforming coal?

☐

5. TO BURN COAL AND MEET OTHER APPLICABLE SIP REQUIREMENTS. (THIS INSTALLATION MUST: (Answer with a Yes (1) or No (0) in the blocks provided)

a. Upgrade Precipitators

☐

If yes, give approximate cost \$ _____ time _____ (weeks)

b. Install Precipitators

☐

If yes, give approximate cost \$ _____ time _____ (weeks)

c. Install FGD

☐

If yes, give approximate cost \$ _____ time _____ (weeks)

d. Obtain Conforming Coal

☐

This coal must be _____ % Sulfur by weight, _____ % Ash by weight.

Do you anticipate that you will be able to obtain conforming coal?

☐
65

DO NOT FILL IN

☐
79 80

FEDERAL ENERGY ADMINISTRATION
MAJOR FUEL BURNING INSTALLATION COAL CONVERSION REPORT
FEA C-602-S-0

SECTION I GENERAL PLANT INFORMATION

52

MFB I NAME _____

5. TOTAL NUMBER OF OTHER COMBUSTORS AT THIS INSTALLATION

53	

6. TOTAL DESIGNED FIRING RATE (X 10⁶ Btu's/hr) (of #4 and #5)

55		59		

7. IDENTIFY PAIRINGS (ETC) OF COMBUSTORS (Example: Boilers 04, 05, and 06 Share a Common Manifold and are Vented through a Common Stack)

8. PRINCIPAL PRODUCTS PRODUCED AT, OR SERVICES PROVIDED BY THIS INSTALLATION (If SIC Codes are Unknown, Provide Written Description in Space Provided).

Standard
Industrial
Classification
(4 Digit)

60			

67			

73			

Percent of
Total Shipments
or Services
by Value

68	

72	

78	

9. IDENTIFY THE MAJOR TECHNICAL, REGULATORY, ECONOMIC, AND ENVIRONMENTAL IMPEDIMENTS, IF ANY, TO YOUR UTILIZING COAL TO A GREATER EXTENT AT THIS INSTALLATION)

DO NOT FILL IN

79 80	

10. WHAT ACTIONS BY THE FEDERAL GOVERNMENT WOULD ENCOURAGE YOU TO UTILIZE COAL TO A GREATER EXTENT?

11. CERTIFICATION:

CERTIFYING OFFICER I certify to the best of my knowledge that the information in this report is correct.

NAME _____ SIGNATURE _____ DATE _____

TITLE _____

Title 18 USC 1001, makes it a crime for any person knowingly and willingly to make to any agency or department of The United States any false, fictitious or fraudulent statements as to any matter within its jurisdiction.

CENSUS ANNUAL SURVEY DATA^{1/}

1974

West Virginia

SIC 331: Blast Furnace, Basic Steel Production

	<u>Total Fuel Oil</u> (10 ³ bbls)	<u>Distillate</u> (10 ³ bbls)	<u>Residual</u> (10 ³ bbls)	<u>Coal</u> (10 ³ tons)	<u>Coke and Breeze</u> (10 ³ tons)	<u>Natural Gas</u> (10 ⁹ ft ³)	<u>Other Fuels</u> (\$10 ⁶)	<u>Fuels N.S.K.</u> (\$10 ⁶)	<u>Purchased Electric Energy</u> (10 ⁶ kWh)	<u>Total kWh Equivalent</u> (x10 ⁹)
Quantity Consumed	(D)	(D)	(D)	(D)	(D)	9.0	(D)	(D)	1,580.2	16.1
Total Cost (\$10 ⁶)	(D)	(D)	(D)	(D)	(D)	7.4	(D)	(D)	21.6	73.6

A-13

1/ Also shown by Census are categories for "Purchased Fuels" and "Electric Energy, Generated Less Sold".

(D) = withheld to avoid disclosing figures for individual companies.

SOURCE: Annual Survey of Manufacturers, 1974, "Fuels and Electric Energy Consumed", U.S. Department of Commerce, Bureau of the Census.

BUREAU OF MINES AGGREGATE DATA^{1/}
Sample Entry

1972
West Virginia^{2/}

Total Industrial Energy Use (10¹² Btu)

<u>Anthracite</u>	<u>Bituminous Coal and Lignite</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total Gross Consumption</u>	<u>Utility Electricity Distributed</u>	<u>Total Net Consumption</u>
0	252.9	75.6	133.3	462.3	35.5	497.8

Industrial Use of Petroleum Products

<u>Gasoline</u>	<u>Jet Fuel</u>	<u>Kerosene</u>	<u>Distillate Fuel Oil</u>	<u>Residual Fuel Oil</u>	<u>LPG</u>	<u>Asphalt</u>	<u>Total</u>
0	0	0.2	6.2	3.4	65.8	0.0	75.6

1/ Also shown by BOM are physical units (barrels, tons, etc.) for all fuels shown here. BOM also has state data on fuels and electricity used at petroleum refineries (included here, but not shown separately).

2/ Does not include the quantities of coal and petroleum products which BOM does not distribute to states.

SOURCE: "Historical Fuels and Energy Consumption Data, 1960-1972, United States by States and Census Region".
(IC 8704)

CENSUS ANNUAL SURVEY DATA^{1/}

1974

West Virginia

SIC 331: Blast Furnace, Basic Steel Production

	<u>Total Fuel Oil</u> (10 ³ bbls)	<u>Distillate</u> (10 ³ bbls)	<u>Residual</u> (10 ³ bbls)	<u>Coal</u> (10 ³ tons)	<u>Coke and Breeze</u> (10 ³ tons)	<u>Natural Gas</u> (10 ⁹ ft ³)	<u>Other Fuels</u> (\$10 ⁶)	<u>Fuels N.S.K.</u> (\$10 ⁶)	<u>Purchased Electric Energy</u> (10 ⁶ kWh)	<u>Total kWh Equivalent</u> (x10 ⁹)
Quantity Consumed	(D)	(D)	(D)	(D)	(D)	9.0	(D)	(D)	1,580.2	16.1
Total Cost (\$10 ⁶)	(D)	(D)	(D)	(D)	(D)	7.4	(D)	(D)	21.6	73.6

^{1/} Also shown by Census are categories for "Purchased Fuels" and "Electric Energy, Generated Less Sold".

(D) = withheld to avoid disclosing figures for individual companies.

SOURCE: Annual Survey of Manufacturers, 1974, "Fuels and Electric Energy Consumed", U.S. Department of Commerce, Bureau of the Census.

VOLUNTARY INDUSTRIAL ENERGY CONSERVATION PROGRAM

Sample Entry

AMERICAN IRON AND STEEL INSTITUTE

<u>Energy Efficiency Trends</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>
Production (10^6 tons)	84.05	95.52	96.92	78.40
Btu's (10^{12})	2742	3031	3073	2633
Ratio (10^6 Btu/ton)	32.62	31.73	31.71	33.58
1980 Goal is 10 Percent	Base Year	2.7	2.8	(2.9)

SOURCE: Voluntary Industrial Energy Conservation Program Progress Report 3, FEA/Department of Commerce, April, 1976.

GAS REQUIREMENTS COMMITTEE

Sample Entry

1975 Gas Consumption
Millions of cubic feet

STANDARD INDUSTRIAL CLASSIFICATION		VIRGINIA			WEST VIRGINIA		
Group	Description	Firm	Interruptible	Total	Firm	Interruptible	Total
10-14	Mining	29	54	83	614	—	614
20	Food and Kindred Products	640	86	726	118	19	137
21	Tobacco Manufactures	7	142	149	—	—	—
22	Textile Mill Products	1,560	1,209	2,768	188	—	188
23	Apparel and Other Textile Products	469	84	553	—	—	—
24	Lumber and Wood Products	546	151	697	83	10	93
25	Furniture and Fixtures	69	68	137	11	—	11
26	Paper and Allied Products	3,487	81	3,568	494	—	494
27	Printing and Publishing	20	115	135	14	—	14
28	Chemicals and Allied Products	11,219	399	11,618	27,124	—	27,124
29	Petroleum and Coal Products	—	—	—	962	—	962
30	Rubber and Misc. Plastic Products	800	17	817	146	—	146
31	Leather and Leather Products	—	5	5	—	—	—
32	Stone, Clay, Glass & Concrete Products	1,361	571	2,432	14,970	—	14,970
331-332	Primary Iron and Steel	485	540	1,025	5,191	—	5,191
333-339	Primary Nonferrous Metals	425	232	657	4,570	—	4,570
34	Fabricated Metal Products	710	135	845	681	—	681
35	Machinery, except Electrical	—	—	—	857	—	857
36	Electric and Electronic Equipment	123	167	290	1,329	—	1,329
37	Transportation Equipment	10	47	57	55	—	55
38	Instruments and Related Products	—	—	—	—	—	—
39	Other Manufacturing	350	1	351	199	—	199
	Other SIC Classes Not Listed Above	638	125	763	1,216	—	1,216
	Not classified according to SIC and/or unreported	2,812	1,310	4,122	2,152	11	2,163
	TOTAL CONSUMPTION	26,360	5,539	31,799	60,976	40	61,016

SOURCE: "United States Gas Consumption in 1975," Gas Requirements Committee.

AMERICAN GAS ASSOCIATION

Sample Entry

1974
West Virginia

Gas Utility Sales

(10¹² Btu)

<u>Total</u>	<u>Residential</u>	<u>Commercial</u>	<u>Industrial</u> ^{1/}		<u>Other</u>	<u>Avg. Btu Value</u>
			<u>Firm</u>	<u>Interruptible</u>		
164.8	55.6	24.4	81.3	1.5	2.0	1,023

Gas Utility Sales for Electric Generation^{2/}

<u>Firm</u>	<u>Industrial</u>		<u>Other</u>	<u>Total Sales</u>	<u>Transfers</u> ^{3/}		<u>Total Sales and Transfers</u>
	<u>Firm</u>	<u>Interruptible</u>					
0.0		0.0	0.0	0.0	0.0		0.0

1/ Includes electric utility consumption. Also reported are sales to users in a number of industry categories by region. For example, 1974 sales of 34.9 trillion Btu of gas to "Primary iron and steel industries" are reported.

2/ Excludes direct sales by producers to straight electric utilities.

3/ Represents transfers by the gas department to the electric department of combination gas and electric companies.

SOURCE: 1974 Gas Facts, Department of Statistics, A.G.A.

NATIONAL EMISSIONS DATA SYSTEM (NEDS)

Sample Entry: Point Source Listing

FILE CREATED BY: SATURDAY

MAY 11, 1976

PAGE 2,290

NATIONAL EMISSIONS DATA SYSTEM

POINT SOURCE LISTING

STATISTICAL DISCOUNT
COUNTY/DISTRICT: ROCK CO

AJCR13731: ROCKFORD-JAMESVILLE-RELOIT
PLANT ID: 0004 POINT ID: 04

CITY(1490): JAMESVILLE

NAME-ADDRESS: S.M. ASSEMBLY DIV. 1007 INDUSTRIAL AVE. SIC(3711): MOTOR VEHICLES AND PASSENGER CAR BODIES
PERSONAL CONTACT: S.M. STUTTARD SCC11-02-002-0411 EXT: COMB BOILER -INDUSTRIAL -BITUMINOUS COAL -10-100MMBTUSPDSTA

GENERAL INFORMATION	UTM GRID COORDINATES	HAND CALCULATED POINT EMISSIONS	ALLOWABLE EMISSIONS FOR POINT
DATE OF	UTM ZONE: 18	PARTICULATE: 135 TONS/YR	PARTICULATE: TONS/YR
LAST UPDATE: 1971		SOX: 489 TONS/YR	SOX: TONS/YR
OWNERSHIP: PRIVATE	HORIZONTAL: 334.3 KM	NOX: 84 TONS/YR	NOX: TONS/YR
	VERTICAL: 4,725.3 KM	HCI: 6 TONS/YR	HCI: TONS/YR
		CO: 11 TONS/YR	CO: TONS/YR
PROCESS: 70	STACK PARAMETERS	EMISSION ESTIMATION METHODS	COMPUTER CALCD SCC EMISSIONS
SOURCE: MILLER	STACK HEIGHT: 200 FT	PART: NADB-APPROVED NON-EPA EMISS FACTOR	PART: 135 TONS/YR
	STACK DIAMETER: 11.0 FT	SOX: EMISSION FACTOR(AP-42 OR PENDING)	SOX: 489 TONS/YR
	GAS TEMPERATURE: 375 F	NOX: EMISSION FACTOR(AP-42 OR PENDING)	NOX: 84 TONS/YR
	GAS FLOW RATE: 32,540 ACFM	HCI: EMISSION FACTOR(AP-42 OR PENDING)	HCI: 6 TONS/YR
	PLUME HEIGHT STACK: 0 FT	CO: EMISSION FACTOR(AP-42 OR PENDING)	CO: 11 TONS/YR
	SAME STACK VENTS POINTS 02-041		
HOURS/DAY: 24			
DAYS/WEEK: 7			
WEEKS/YEAR: 52			
ANNUAL THROUGHPUT	CONTROL DEVICE/METHOD IDENTIFICATION	CONTROL EFFICIENCIES	
	PRIMARY PART: CENTRIFUGAL COLLECTION - MEDIUM EFFICIENCY		
	SECOND. PART: NO CONTROL EQUIPMENT	PART: 87.0 %	
DEC-FEB: 23 %			
MAR-MAY: 78 %	PRIMARY SOX: NO CONTROL EQUIPMENT		
JUNE-AUG: 22 %	SECOND. SOX: NO CONTROL EQUIPMENT	SOX: 00.0 %	
SEPT-NOV: 77 %			
SPACE HEAT: 33.0 %	PRIMARY NOX: NO CONTROL EQUIPMENT		
	SECOND. NOX: NO CONTROL EQUIPMENT	NOX: 00.0 %	
COMPLIANCE INFO	PRIMARY HCI: NO CONTROL EQUIPMENT		
	SECOND. HCI: NO CONTROL EQUIPMENT	HCI: 00.0 %	
NOT SPECIFIED			
	PRIMARY CO: NO CONTROL EQUIPMENT		
	SECOND. CO: NO CONTROL EQUIPMENT	CO: 00.0 %	
SCHEDULE	FUEL CHARACTERISTICS	OPERATING RATES	
COMPLIANCE DATE: /			
		ANNUAL OPERATING RATE: 11,200 TONS BURNED	
		HOURLY MAXX DESIGN RATE: 4,070 TONS BURNED	
EMERGENCY CONTROL	FUEL SULFUR CONTENT: 2.30 %	BOILER DESIGN CAPACITY: 110 MILLION BTU/HR	
ACTION PLAN	FUEL ASH CONTENT: 07.3 %		
	FUEL HEAT CONTENT: 25 MILLION BTU/TONS BURNED		
STATUS UNKNOWN		COMMENTS:	

SOURCE: ACROS Manual Series, Volume III, Summary and Retrieval, EPA May, 1976.

NEDS Sample Entry (cont.) Area Source Report for Two Counties

SOURCE ID: A STATE- 41 COUNTY- 0060 AQCR- 120 YEAR- 72

EM-EST-PRT(100-TONS)-	EM-EST-SO2(100-TONS)-	EM-EST-NOX(100-TONS)-	EM-EST-HC(100-TONS)-
EM-EST-CO(100-TONS)-	% Sulf-ANTH-COAL-	0.7% Sulf-BITUM-COAL-	2.0% Sulf-DIST-OIL-
% Sulf-RESID-OIL-	0.7% Ash-ANTH-COAL-	11.0% Ash-BITUM-COAL-	8.0% RES-ANTH(10-TONS)-
RES-BITUM(10-TONS)-	0:RES-DIS-OIL(10E4-GAL)-	1034:RES-RID-OIL(10E4-GAL)-	0:RES-N-GAS(10E7-CUFT)-
RES-WOOD(100-TONS)-	2: CI-ANTH(10-TONS)-	4: CI-BITUM(10-TONS)-	3:CI-DIS-OIL(10E4-GAL)-
CI-RID-OIL(10E4-GAL)-	380: CI-N-GAS(10E7-CUFT)-	23: CI-WOOD(100-TONS)-	IND-ANTH(10-TONS)-
IND-BITUM(10-TONS)-	36: IND-COKE(10-TONS)-	IND-DIS-OIL(10E4-GAL)-	285:IND-RD-OIL(10E4-GAL)-
IND-N-GAS(10E7-CUFT)-	17: IND-WOOD(100-TONS)-	IND-PR-GAS(10E7-CUFT)-	
RES-OS-INC(10-TONS)-	40: IND-OS-INC(100-TONS)-	1: CI-OS-INC(100-TONS)-	4: PART-EHS(T/YR)-
RES-OP-BRN(100-TONS)-	73:IND-OPN-BRN(100-TONS)-	7: CI-OPN-BRN(100-TONS)-	6: SO2-EHS(T/YR)-
GAS-LT-VEH(1000-GAL)-	15879:GAS-HVY-VEH(1000-GAL)-	1859:GAS-OFF-HWY(1000-GAL)-	0: NOX-EHS(T/YR)-
DIE-HV-VEH(1000-GAL)-	1086:DIE-OFF-HWY(10E4-GAL)-	32: DIE-RR-LOC(10E4-GAL)-	4: HC-EHS(T/YR)-
COUNTY-POP(1000)-	45: DENSITY-CODE-	9:MIL-AIRCRAFT(100-TO)-	CO-EHS(T/YR)-
CIV-AIRCRAFT(10-LTO)-	COMM-AIRCRAFT(10-LTO)-	VES-BITUM(10-TONS)-	0:NO. 6-EHS(T/YR)-
VES-DIE-OL(10E4-GAL)-	VES-RID-OIL(10E4-GAL)-	VES-GAS(1000-GAL)-	711:NO. 7-EHS(T/YR)-
EVAP-SOLVENT(T/YR)-	112: EVAP-GAS(10E5-GAL)-	175:VEH-MI-LA-RD(10E4-MI)-	NO. 8-EHS(T/YR)-
VEH-MI-RURL(10E4-MI)-	VEH-MI-SUBAN(10E4-MI)-	VEH-MI-URBAN(10E4-MI)-	NO. 9-EHS(T/YR)-
DIRT-RD-TRV(1000-MI)-	DIRT-AIR-STRIPS(LTO)-	CONST-LAND(1000-ACRE)-	NO. 10-EHS(T/YR)-
ROCK-H-ST(1000-TONS)-	FOREST-FIRE-AR(ACRES)-	FOR-FIRE-QU(TON/ACRE)-	NO. 11-EHS(T/YR)-
SLASH-BRN-ARE(ACRES)-	SLASH-BN-QU(TON/ACRE)-	ORCHARD-HEATERS(100)-	NO. 12-EHS(T/YR)-
ORCH-DA-FIRED(DA/YR)-	STRUCTURE-FIRES(#/YR)-	CRB-SIZE-BK(100-CUFD)-	
COAL-REF-BURN(#/YR)-	COMMENTS-		

SOURCE ID: A STATE- 41 COUNTY- 0140 AQCR- 120 YEAR- 72

EM-EST-PRT(100-TONS)-	EM-EST-SO2(100-TONS)-	EM-EST-NOX(100-TONS)-	EM-EST-HC(100-TONS)-
EM-EST-CO(100-TONS)-	% Sulf-ANTH-COAL-	0.7% Sulf-BITUM-COAL-	2.0% Sulf-DIST-OIL-
% Sulf-RESID-OIL-	0.7% Ash-ANTH-COAL-	11.0% Ash-BITUM-COAL-	8.0% RES-ANTH(10-TONS)-
RES-BITUM(10-TONS)-	0:RES-DIS-OIL(10E4-GAL)-	3346:RES-RID-OIL(10E4-GAL)-	0:RES-N-GAS(10E7-CUFT)-
RES-WOOD(100-TONS)-	3: CI-ANTH(10-TONS)-	13: CI-BITUM(10-TONS)-	8:CI-DIS-OIL(10E4-GAL)-
CI-RID-OIL(10E4-GAL)-	1896: CI-N-GAS(10E7-CUFT)-	72: CI-WOOD(100-TONS)-	IND-ANTH(10-TONS)-
IND-BITUM(10-TONS)-	73: IND-COKE(10-TONS)-	IND-DIS-OIL(10E4-GAL)-	1388:IND-RD-OIL(10E4-GAL)-
IND-N-GAS(10E7-CUFT)-	35: IND-WOOD(100-TONS)-	IND-PR-GAS(10E7-CUFT)-	
RES-OS-INC(10-TONS)-	125: IND-OS-INC(100-TONS)-	2: CI-OS-INC(100-TONS)-	15: PART-EHS(T/YR)-
RES-OP-BRN(100-TONS)-	228:IND-OPN-BRN(100-TONS)-	20: CI-OPN-BRN(100-TONS)-	19: SO2-EHS(T/YR)-
GAS-LT-VEH(1000-GAL)-	52096:GAS-HVY-VEH(1000-GAL)-	6100:GAS-OFF-HWY(1000-GAL)-	0: NOX-EHS(T/YR)-
DIE-HV-VEH(1000-GAL)-	3366:DIE-OFF-HWY(10E4-GAL)-	102: DIE-RR-LOC(10E4-GAL)-	12: HC-EHS(T/YR)-
COUNTY-POP(1000)-	142: DENSITY-CODE-	9:MIL-AIRCRAFT(100-LTO)-	CO-EHS(T/YR)-
CIV-AIRCRAFT(10-LTO)-	COMM-AIRCRAFT(10-LTO)-	VES-BITUM(10-TONS)-	0:NO. 6-EHS(T/YR)-
VES-DIE-OL(10E4-GAL)-	VES-RID-OIL(10E4-GAL)-	VES-GAS(1000-GAL)-	519:NO. 7-EHS(T/YR)-
EVAP-SOLVENT(T/YR)-	710: EVAP-GAS(10E5-GAL)-	551:VEH-MI-LA-RD(10E4-MI)-	NO. 8-EHS(T/YR)-
VEH-MI-RURL(10E4-MI)-	VEH-MI-SUBAN(10E4-MI)-	VEH-MI-URBAN(10E4-MI)-	NO. 9-EHS(T/YR)-
DIRT-RD-TRV(1000-MI)-	DIRT-AIR-STRIPS(LTO)-	CONST-LAND(1000-ACRE)-	NO. 10-EHS(T/YR)-
ROCK-H-ST(1000-TONS)-	FOREST-FIRE-AR(ACRES)-	FOR-FIRE-QU(TON/ACRE)-	NO. 11-EHS(T/YR)-
SLASH-BRN-ARE(ACRES)-	SLASH-BN-QU(TON/ACRE)-	ORCHARD-HEATERS(100)-	NO. 12-EHS(T/YR)-
ORCH-DA-FIRED(DA/YR)-	STRUCTURE-FIRES(#/YR)-	CRB-SIZE-BK(100-CUFD)-	
COAL-REF-BURN(#/YR)-	COMMENTS-		

NEDS Sample Entry (Cont.) Annual Fuel Summary Report

NATIONAL REPORT

NEDS ANNUAL FUEL SUMMARY REPORT

USER FILE CREATE DATE: SATURDAY DECEMBER 06, 1975

DATE OF RUN: 01/09/76

	AKTH COAL TONS	BITH COAL TONS	RESID OIL 1000 GALS	DIST. OIL 1000 GALS	NAT GAS 1000 CUFT	WOOD/BARK TONS	GASOLINE 1000 GALS	DIESEL 1000 GALS
AREA SOURCES								
STATIONARY								
RESIDENTIAL	2876940	5387340	819730	14757640	5609690	4673800		
INDUSTRIAL	11440	16322180	4271170	4649110	3967620	157500		
COMM-INSTL	265380	4122730	5919150	7510250	2446390	4700		
MOBILE								
LIGHT VEHICLE							83607348	
HEAVY VEHICLE							7850729	7699684
RAILROAD								4573060
OFF-HIGHWAY							3741866	2996800
VESSELS	127310		512680				607190	1547790
AREA TOTAL	3201070	25432250	11422730	26917000	12023700	4836000	95947139	16817394
POINT SOURCES								
EXT COMB								
ELEC GEN	4241402	386963097	20377000	960020	4257339	452710		
INDUSTRIAL	665320	51658754	8536321	2768187	9593452	3344879		
COMM-INSTL	97274	3217785	599386	231315	9842910	134915		
INTPROCESS	373720	5109129	1272564	1780252	3618375	978971		
INTERNAL COMB								
ELEC GEN				1070042	396225			70599
INDUSTRIAL			13	33012	1215881		2061	91710
COMM-INSTL								
POINT TOTAL	5377726	446648765	30885874	6749530	23574193	35116276	2061	102303
GRAND TOTAL	8658793	472081015	42308604	33666936	35997893	39952275	95949200	16970697
FOUNT SOURCES								
EXT COMB								
ELEC GEN	8019397	40172		40564				
INDUSTRIAL	1147527	100042	7520107	2088499	219285		201213	
COMM-INSTL	161531				4349			
INTPROCESS		3928071		10576558	45501			
INTERNAL COMB								
ELEC GEN						699		
INDUSTRIAL						137		
COMM-INSTL								
GRAND TOTAL	9322435	3097935	7520107	12705893	329819	836	201213	

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APPENDIX B

Plant Specific Energy Analysis

The sample output attached below is representative of how the data from the plant-specific energy analysis is presented. The sample is from the aluminum industry, and shows that the two aluminum plants in Alabama use about 34 trillion Btus per year, with almost two-thirds of the energy being used in the larger of the two plants.

Similar output can be generated for 10 different industries, with "total Btus", "petroleum products", "natural gas", and "other fuels" being the fuel type options which can be specified.

Sample Output
 Plant Specific Energy Analysis
 (Aluminum Industry - Total Btu's Per Plant)

STATE: AL
 10 12 Btu

PLANT #1 11.943
 PLANT #2 21.541

STATE: AR
 10 12 Btu

PLANT #1 9.831
 PLANT #2 18.072

STATE: IN
 10 12 Btu

PLANT #1 55.015

STATE: KY
 10 12 Btu

PLANT #1 12.735
 PLANT #2 19.103

STATE: LA
 10 12 Btu

PLANT #1 8.593
 PLANT #2 62.061

APPENDIX C

State Aggregation of Histograms

APPENDIX C

PLANT-SPECIFIC ENERGY ANALYSIS: STATE AND REGIONAL SUMMARIES (10¹² Btu's)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # Of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
NEW ENGLAND						
Paper	88.9	76.2	0.0	111	21	21
Chlorine	2.3	0.4	0.0	2	1	0
Cement	2.5	0.8	0.0	1	1	0
Steel	4.3	1.4	2.0	2	2	2
Petroleum Refining	.7	0.0	0.0	1	0	0
Total	98.7	78.8	2.0	117	25	23
Maine						
Cement	2.5	1.8	0.0	1	1	0
Chlorine	2.1	0.3	0.0	1	1	0
Paper	63.3	53.0	0.0	22	14	14
Total						
Vermont						
Paper	2.6	2.2	0.0	10	0	0
Total	2.6	2.2	0.0	10	0	0
New Hampshire						
Paper	8.1	7.5	0.0	20	3	3
Total	8.1	7.5				
Massachusetts						
Paper	10.3	9.1	0.0	43	2	2
Total	10.3	9.1	0.0	43	2	2

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Rhode Island</u>						
Chlorine	0.2	0.1	0.0	1	0	0
Steel	1.2	0.5	0.5	1	1	1
Petroleum Refining	.7	0.0	0.0	1	0	0
Paper	1.2	1.2	0.0	1	1	1
Total	3.3	1.8	0.5	4	2	2
<u>Connecticut</u>						
Steel	3.1	0.9	1.5	1	1	1
Paper	3.4	3.2	0.0	15	1	1
Total	6.5	4.1	1.5	16	2	2
<u>MIDDLE ATLANTIC</u>						
Aluminum	28.0	5.4	6.0	2	2	2
Cement	72.1	22.2	0.0	27	24	9
Ammonia	2.8	0.0	2.2	3	1	1
Steel	1432.6	87.0	157.1	63	34	28
Paper	70.5	37.2	4.2	139	19	14
Petroleum Refining	270.0	94.1	28.7	19	17	15
Chlorine	8.0	1.7	0.4	2	2	1
Styrene	7.9	5.7	0.6	1	1	1
Total	1891.9	253.3	199.4	256	100	71
<u>New York</u>						
Aluminum	28.0	5.4	6.0	2	2	2
Cement	27.6	8.5	0.0	8	7	4
Ammonia	1.9	0.0	1.6	1	1	1
Steel	212.9	10.2	12.9	8	3	3
Paper	25.8	18.3	0.0	62	8	7
Petroleum Refining	17.7	8.2	0.0	2	2	2
Total	313.9	50.6	20.5	83	23	19

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>New Jersey</u>						
Steel	3.7	2.2	1.0	2	2	2
Paper	7.1	6.0	8.0	31	1	1
Petroleum Refining	101.4	36.0	9.6	6	5	5
Chlorine	<u>8.0</u>	<u>1.7</u>	<u>0.4</u>	<u>2</u>	<u>2</u>	<u>1</u>
Total	128.2	45.9	11.0	41	10	9
<u>Pennsylvania</u>						
Cement	44.5	13.7	0.0	19	17	5
Styrene	7.9	5.7	0.6	1	1	1
Ammonia	0.9	0.0	0.6	2	0	0
Steel	1216.0	74.6	143.2	53	29	23
Paper	37.6	12.9	4.2	46	10	6
Petroleum	<u>150.9</u>	<u>49.9</u>	<u>19.1</u>	<u>11</u>	<u>10</u>	<u>8</u>
Total	1457.8	156.8	167.7	132	67	43
<u>EAST-NORTH-CENTRAL</u>						
Aluminum	82.4	11.2	12.3	2	2	2
Cement	78.8	0.3	3.7	24	23	1
Ammonia	40.5	1.3	37.9	4	4	4
Chlorine	9.7	0.0	3.0	4	3	1
Steel	2009.3	136.2	340.1	55	41	34
Paper	161.6	9.9	59.2	179	57	24
Petroleum Refining	411.3	70.2	35.9	32	24	23
Carbon Black	2.1	1.6	0.3	2	1	1
Ethylene	97.7	75.2	12.0	4	4	4
Styrene	<u>7.1</u>	<u>4.5</u>	<u>0.9</u>	<u>1</u>	<u>1</u>	<u>1</u>
Total	2900.5	310.4	505.3	207	160	95

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Ohio</u>						
Aluminum	26.5	5.3	5.8	1	1	1
Cement	18.5	0.0	0.8	8	8	0
Ammonia	26.9	0.9	25.3	2	2	2
Chlorine	0.8	0.0	0.4	1	0	0
Steel	769.7	42.7	113.1	22	21	17
Paper	31.3	1.9	1.7	39	10	0
Petroleum Refining	100.5	10.5	18.8	6	6	6
Carbon Black	2.1	1.6	0.3	2	1	1
Total	976.3	62.9	166.2	81	49	27
<u>Indiana</u>						
Aluminum	55.9	5.9	6.5	1	1	1
Cement	17.2	0.0	0.8	5	5	0
Ethylene	8.0	5.7	1.3	1	1	1
Ammonia	3.1	0.1	2.6	1	1	1
Steel	733.3	68.8	101.0	8	5	4
Paper	6.6	0.3	2.0	14	2	0
Petroleum Refining	95.1	36.0	2.3	7	5	5
Total	919.2	116.8	116.5	37	20	12
<u>Illinois</u>						
Cement	9.8	0.0	0.4	4	4	0
Ethylene	74.1	56.9	9.7	2	2	2
Ammonia	10.5	0.3	10.0	1	1	1
Chlorine	2.8	0.0	0.2	1	1	0
Steel	229.6	18.2	75.0	20	10	9
Paper	13.3	0.5	4.3	25	3	1
Petroleum Refining	195.1	54.0	11.3	12	9	9
Total	535.2	129.9	110.9	65	30	22

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Michigan</u>						
Cement	31.6	0.3	1.7	5	5	1
Ethylene	15.6	12.6	1.0	1	1	1
Styrene	7.1	4.5	0.9	1	1	1
Chlorine	4.5	0.0	2.3	1	1	1
Steel	276.7	6.5	51.0	5	5	4
Paper	37.7	2.6	22.7	38	15	11
Petroleum Refining	16.2	4.4	3.3	6	3	2
Total	389.4	30.9	82.9	57	31	21
<u>Wisconsin</u>						
Cement	1.7	0.0	0.0	2	1	0
Chlorine	1.6	0.0	0.1	1	1	0
Paper	72.7	4.6	28.5	63	27	12
Petroleum Refining	4.4	1.0	0.2	1	1	1
Total	80.4	5.6	28.8	67	30	13
<u>WEST-NORTH-CENTRAL</u>						
Cement	72	0.5	28.9	21	21	11
Steel	11.6	1.0	7.1	5	2	2
Paper	29.2	2.1	20.7	16	8	7
Petroleum Refining	127.7	16.7	39.9	17	14	13
Ethylene	26.8	19.3	5.4	1	1	1
Ammonia	95.4	2.8	88.1	15	15	15
Aluminum	7.2	1.4	1.6	1	1	1
Chlorine	5.0	0.0	3.6	1	1	1
Carbon Black	0.8	0.6	0.1	1	0	0
Total	375.7	44.4	195.4	78	63	51

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Minnesota</u>						
Cement	1.7	0.0	0.7	1	1	0
Steel	6.9	0.6	4.2	2	1	1
Paper	26.0	1.9	18.2	11	8	7
Petroleum Refining	23.9	5.8	1.3	3	3	2
Total	58.5	8.3	24.4	17	13	10
<u>Iowa</u>						
Cement	17.1	0.1	6.9	5	5	5
Ethylene	26.8	19.3	5.4	1	1	1
Ammonia	43.2	1.3	40.2	6	6	6
Steel	0.1	0.0	0.1	1	0	0
Paper	1.9	0.1	1.5	3	0	0
Total	89.1	20.8	54.1	16	12	12
<u>Missouri</u>						
Aluminum	7.2	1.4	1.6	1	1	1
Cement	30.9	0.4	12.5	7	7	0
Ammonia	4.8	0.1	4.0	2	2	2
Steel	4.6	0.4	2.8	2	1	1
Petroleum Refining	18.5	3.1	3.7	1	1	1
Total	66.0	5.4	24.6	13	12	5
<u>North Dakota</u>						
Petroleum Refining	7.0	1.6	0.3	2	1	1
Total	7.0	1.6	0.3	2	1	1
<u>South Dakota</u>						
Cement	3.3	0.0	1.3	1	1	1
Total	3.3	0.0	1.3	1	1	1

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Nebraska</u>						
Ammonia	19.4	0.5	17.4	4	4	4
Petroleum Refining	<u>0.9</u>	<u>0.1</u>	<u>0.1</u>	<u>1</u>	<u>0</u>	<u>0</u>
Total	20.3	0.6	17.5	5	4	4
<u>Kansas</u>						
Cement	19.0	0.0	7.5	7	7	5
Ammonia	28.0	0.9	26.5	3	3	3
Chlorine	5.0	0.0	3.6	1	1	1
Paper	1.3	0.1	1.0	2	0	0
Petroleum Refining	84.4	6.1	34.5	10	9	9
Carbon Black	<u>0.8</u>	<u>0.5</u>	<u>0.1</u>	<u>1</u>	<u>0</u>	<u>0</u>
Total	138.5	7.7	73.2	24	20	18
<u>SOUTH ATLANTIC</u>						
Ethylene	12.1	10.5	1.1	1	1	1
Steel	357.5	26.3	17.9	15	4	2
Paper	328.4	172.1	44.5	90	48	44
Petroleum Refining	59.0	9.3	2.7	10	6	4
Aluminum	56.5	8.3	8.6	4	4	3
Cement	55.4	12.7	20.0	17	16	15
Ammonia	49.4	1.2	45.0	9	8	8
Chlorine	12.8	0.5	6.1	4	2	1
Carbon Black	<u>2.0</u>	<u>1.6</u>	<u>0.3</u>	<u>1</u>	<u>1</u>	<u>1</u>
Total	933.1	243.1	146.2	151	90	79
<u>Delaware</u>						
Ethylene	12.1	10.6	1.1	1	1	1
Steel	0.3	0.1	0.1	1	0	0
Paper	0.3	0.3	0.0	5	0	0
Petroleum Refining	<u>37.9</u>	<u>3.3</u>	<u>0.6</u>	<u>1</u>	<u>1</u>	<u>1</u>
Total	50.6	14.3	1.7	8	2	2

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Maryland & D.C.</u>						
Aluminum	9.0	1.8	2.0	1	1	1
Cement	8.8	2.0	3.2	3	3	3
Steel	232.8	17.3	11.0	3	1	1
Paper	9.8	6.0	1.2	5	3	3
Petroleum Refining	2.3	2.3	0.0	1	1	1
Total	262.7	29.4	17.4	13	9	9
<u>Virginia</u>						
Aluminum	17.5	0.6	0.0	1	1	0
Cement	3.2	0.7	1.1	1	1	1
Ammonia	17.0	0.6	16.2	1	1	1
Chlorine	0.8	0.3	0.0	1	0	0
Steel	0.1	1.0	0.0	2	0	0
Paper	90.2	19.6	2.3	15	9	7
Petroleum Refining	11.6	1.0	0.2	1	1	1
Total	140.4	22.8	19.8	22	13	10
<u>West Virginia</u>						
Aluminum	17.5	3.4	3.8	1	1	1
Cement	5.1	1.2	1.8	1	1	1
Ammonia	16.3	0.4	15.5	3	2	2
Chlorine	10.3	0.2	5.3	1	1	1
Steel	121.7	8.7	5.5	3	2	1
Paper	0.8	0.7	0.0	3	0	0
Petroleum Refining	5.4	2.5	1.0	3	3	1
Carbon Black	2.0	1.6	0.3	1	1	1
Total	179.1	18.7	33.2	16	11	8
<u>North Carolina</u>						
Aluminum	12.5	2.5	2.8	1	1	1
Cement	3.4	0.8	1.2	1	1	1

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>North Carolina - continued</u>						
Ammonia	4.9	0.1	4.0	1	1	1
Chlorine	0.6	0.0	0.3	1	0	0
Steel	0.1	2.5	2.8	1	1	1
Paper	42.1	22.0	0.0	18	6	6
Petroleum Refining	0.7	0.3	0.4	1	0	0
Total	64.3	25.7	8.7	25	9	9
<u>South Carolina</u>						
Cement	13.7	3.2	5.0	3	3	3
Steel	0.2	0.0	0.0	1	0	0
Paper	47.1	29.6	4.6	10	9	8
Total	61.0	32.8	9.6	14	12	11
<u>Georgia</u>						
Cement	7.0	1.6	2.6	3	3	2
Ammonia	6.5	0.1	5.4	2	2	2
Chlorine	1.1	0.0	0.5	1	1	0
Steel	0.4	0.2	0.1	1	0	0
Paper	73.9	39.6	28.2	20	13	12
Petroleum Refining	0.8	0.3	0.4	2	0	0
Total	89.7	41.8	37.2	29	19	16
<u>Florida</u>						
Cement	14.2	3.2	5.1	5	4	4
Ammonia	4.7	0.0	3.9	2	2	2
Steel	1.9	0.0	1.2	2	1	0
Paper	64.2	54.3	8.2	14	8	8
Petroleum Refining	0.3	0.1	0.1	1	0	0
Total	85.3	57.5	18.5	24	15	14

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
EAST SOUTH CENTRAL						
Aluminum	108.1	21.6	23.9	6	6	6
Cement	35.8	4.0	12.6	17	17	9
Ethylene	28.2	20.9	2.6	2	2	2
Chlorine	4.9	0.0	2.4	2	1	1
Steel	239.4	1.0	44.8	17	7	6
Paper	239.4	43.7	46.3	48	29	25
Petroleum Refining	101.8	11.6	31.1	14	7	7
Ammonia	63.2	1.9	57.6	7	7	7
Total	702.8	104.7	221.3	110	76	61
<u>Kentucky</u>						
Aluminum	31.8	6.3	7.0	2	2	2
Cement	2.4	0.3	0.8	1	1	1
Ethylene	28.2	20.9	2.6	2	2	2
Chlorine	4.0	0.0	2.0	1	1	1
Steel	15.7	0.4	9.4	4	1	1
Paper	3.9	1.4	1.6	5	2	2
Petroleum Refining	31.6	7.8	6.4	4	2	2
Total	117.6	37.1	29.8	19	12	11
<u>Tennessee</u>						
Aluminum	42.9	8.7	9.6	2	2	2
Cement	13.2	1.5	4.3	6	6	2
Ammonia	11.5	0.3	9.6	2	2	2
Chlorine	0.9	0.0	0.4	1	0	0
Steel	6.1	0.0	1.4	2	1	1
Paper	23.4	8.0	6.2	17	8	5
Petroleum Refining	5.3	1.3	1.1	1	1	1
Total	103.3	19.8	32.6	31	20	13

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Alabama</u>						
Aluminum	33.4	6.6	7.3	2	2	2
Cement	16.8	1.9	5.5	7	7	5
Ammonia	5.7	0.1	4.8	2	2	2
Steel	217.5	0.6	34.0	7	5	4
Paper	66.8	22.8	25.6	17	14	13
Petroleum Refining	<u>5.0</u>	<u>0.0</u>	<u>1.0</u>	<u>4</u>	<u>2</u>	<u>0</u>
Total	345.2	32.0	78.2	39	32	26
<u>Mississippi</u>						
Cement	5.8	0.6	2.0	3	3	1
Ammonia	46.0	1.5	43.2	3	3	3
Steel	0.1	0.0	0.0	1	0	0
Paper	27.3	11.5	12.9	9	5	5
Petroleum Refining	<u>61.9</u>	<u>2.5</u>	<u>22.6</u>	<u>5</u>	<u>2</u>	<u>2</u>
Total	141.1	16.1	80.7	21	13	11
<u>WEST SOUTH CENTRAL</u>						
Aluminum	219.2	25.6	144.9	7	7	7
Cement	82.5	0.6	73.0	29	26	26
Ammonia	307.9	8.9	285.4	30	30	30
Steel	92.7	0.9	43.8	11	3	3
Petroleum Refining	1433.1	48.4	791.3	83	62	53
Carbon Black	99.9	63.7	36.1	16	16	16
Ethylene	1191.8	862.8	317.3	23	23	23
Styrene	115.2	76.1	42.3	12	12	12
Paper	132.9	46.7	79.0	35	27	26
Chlorine	<u>97.6</u>	<u>1.8</u>	<u>50.3</u>	<u>9</u>	<u>7</u>	<u>7</u>
Total	3639.9	1123.5	1863.4	255	213	203

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Arkansas</u>						
Aluminum	27.8	4.0	14.5	2	2	2
Cement	8.3	0.1	7.4	2	2	2
Ammonia	21.8	0.6	20.2	2	2	2
Steel	0.3	0.0	0.0	1	0	0
Petroleum Refining	10.5	1.1	28.8	1	3	2
Carbon Black	1.3	1.0	0.2	1	1	1
Total	70.0	6.8	71.1	12	10	9
<u>Louisiana</u>						
Aluminum	70.5	6.2	63.8	2	2	2
Cement	9.4	0.0	8.3	3	3	3
Ethylene	371.4	270.0	96.9	7	7	7
Styrene	31.8	19.3	11.6	3	3	3
Ammonia	154.7	4.9	144.6	10	10	10
Paper	66.4	23.6	36.0	19	15	15
Petroleum Refining	318.7	33.8	109.7	21	14	11
Chlorine	17.2	0.3	8.9	2	2	2
Carbon Black	49.6	25.1	24.2	5	5	5
Total	1089.7	383.2	504.0	72	61	58
<u>Oklahoma</u>						
Cement	10.3	0.1	9.1	3	3	3
Ammonia	3.6	0.0	3.0	2	2	2
Steel	0.7	0.0	0.6	1	0	0
Paper	17.8	4.8	11.0	7	4	4
Petroleum Refining	108.4	1.7	52.2	12	11	10
Total	140.8	6.6	75.9	25	20	19

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Texas</u>						
Aluminum	120.9	15.4	66.6	3	3	3
Cement	54.5	0.4	48.2	21	18	18
Ethylene	820.4	592.8	220.4	16	16	16
Styrene	83.4	50.8	30.7	9	9	9
Ammonia	127.8	3.4	117.6	16	16	16
Chlorine	80.4	1.5	41.4	7	5	5
Steel	91.7	0.9	43.2	9	3	3
Paper	48.7	12.3	32.0	19	8	7
Petroleum Refining	995.5	11.8	600.6	46	34	30
Carbon Black	49.0	36.6	11.7	10	10	10
Total	2472.3	725.9	1212.4	156	122	117
<u>MOUNTAIN</u>						
Aluminum	19.3	1.4	4.2	1	1	1
Cement	30.7	0.9	23.2	14	14	12
Paper	17.6	4.9	8.9	5	3	3
Petroleum Refining	105.0	15.7	30.2	37	21	15
Ammonia	5.6	0.1	4.6	4	2	2
Steel	142.4	6.4	12.9	3	2	2
Total	320.6	29.4	84.0	64	43	35
<u>Montana</u>						
Aluminum	19.3	1.4	4.2	1	1	1
Cement	4.1	0.1	3.1	2	2	2
Paper	5.7	1.6	2.9	1	1	1
Petroleum Refining	28.2	5.4	5.3	8	3	3
Total	57.3	8.5	15.5	12	7	7

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Idaho</u>						
Cement	1.3	0.0	1.0	1	1	1
Ammonia	1.2	0.0	1.0	1	1	1
Paper	4.9	1.4	2.5	2	1	1
	7.4	1.4	4.5	4	3	3
<u>Wyoming</u>						
Cement	1.2	0.0	0.9	1	1	0
Ammonia	3.3	0.1	2.8	1	1	1
Petroleum Refining	31.3	4.2	10.6	12	7	5
Total	35.8	4.3	14.3	14	9	6
<u>Colorado</u>						
Cement	7.2	0.3	5.5	3	3	3
Steel	59.4	2.7	9.2	1	1	1
Petroleum Refining	9.9	1.3	2.9	3	3	3
Total	76.4	4.3	17.6	7	7	6
<u>New Mexico</u>						
Cement	2.7	0.1	2.0	1	1	1
Petroleum Refining	11.3	1.2	5.3	6	3	2
Total	14.0	1.3	7.3	7	4	3
<u>Arizona</u>						
Cement	7.1	0.2	5.4	2	2	2
Ammonia	1.1	0.0	0.8	2	0	0
Steel	0.1	0.0	0.0	1	0	0
Paper	7.0	1.9	3.5	2	1	1
Total	15.3	2.1	9.7	7	3	3

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Utah</u>						
Cement	3.3	0.1	2.4	2	2	2
Steel	82.9	3.7	12.6	1	1	1
Petroleum Refining	<u>24.4</u>	<u>3.6</u>	<u>6.1</u>	<u>8</u>	<u>5</u>	<u>3</u>
Total	110.6	7.4	21.1	11	8	5
<u>Nevada</u>						
Cement	<u>3.8</u>	<u>0.1</u>	<u>2.9</u>	<u>2</u>	<u>2</u>	<u>2</u>
Total	3.8	0.1	2.9	2	2	2
<u>PACIFIC</u>						
Aluminum	146.5	30.1	32.3	9		
Cement	59.0	5.4	43.3	21	18	17
Ammonia	49.3	1.2	44.2	12	9	9
Chlorine	5.5	0.1	2.8	2	2	1
Steel	30.7	4.9	21.5	18	7	3
Paper	126.4	38.7	55.9	89	30	25
Petroleum Refining	443.8	53.5	127.4	45	35	26
Ethylene	14.4	10.2	3.8	2	2	2
Carbon Black	<u>1.8</u>	<u>1.5</u>	<u>0.2</u>	<u>3</u>	<u>0</u>	<u>0</u>
Total	877.4	145.6	331.4	201	112	92

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Washington</u>						
Aluminum	123.5	24.5	27.2	7	7	7
Cement	5.6	0.4	4.0	4	3	2
Ammonia	3.6	0.0	2.9	2	1	1
Chlorine	5.5	0.1	2.8	2	2	1
Steel	4.7	0.1	3.3	4	2	1
Paper	71.9	27.4	27.3	23	13	12
Petroleum Refining	60.8	7.3	17.5	6	5	4
Total	275.6	59.8	85.0	38	33	28
<u>Oregon</u>						
Aluminum	23.0	4.6	5.1	2	2	2
Cement	3.2	0.3	2.3	2	1	1
Ammonia	2.0	0.0	1.6	2	1	1
Steel	0.3	0.0	0.2	2	0	0
Paper	34.1	9.8	13.9	26	10	9
Total	62.6	14.7	23.1	34	14	13
<u>California</u>						
Cement	47.0	4.5	34.7	13	12	12
Ethylene	14.4	10.2	3.8	2	2	2
Ammonia	18.7	0.3	15.9	7	6	6
Steel	25.7	4.8	18.0	12	5	2
Paper	19.8	1.3	14.5	38	7	4
Petroleum Refining	373.1	45.1	107.1	36	27	20
Carbon Black	1.8	1.5	0.2	3	0	0
Total	500.5	67.7	19.4	111	59	46

APPENDIX C (Continued)

	<u>Total Btu's</u>	<u>Petroleum Products</u>	<u>Natural Gas</u>	<u>Total # of Plants</u>	<u># of Plants Where Total Btu > 10¹²</u>	<u># of Plants Natural Gas & Petroleum Btu > 10¹²</u>
<u>Alaska</u>						
Ammonia	25.0	0.9	23.8	1	1	1
Paper	0.6	0.2	0.2	2	0	0
Petroleum Refining	4.4	0.5	1.2	2	2	1
Total	20.0	1.6	25.2	5	3	2
<u>Hawaii</u>						
Cement	5.2	0.2	2.3	2	2	2
Petroleum Refining	5.5	0.6	1.6	1	1	1
Total	8.7	0.8	3.9	3	3	3
Chlorine, Unallocated	248.7	4.6	128.4	38	--	--
Carbon Black, Unallocated	17.5	14.2	3.2	11	--	--
Total Unallocated ^{1/}	266.2	18.8	131.6	49	--	--
SUM OF STATES AND REGIONS						
Paper	1076.9	425.5	318.7	727	242	189
Chlorine	394.5	9.1	128.4	64	19	13
Cement	488.8	47.4	204.7	172	160	100
Steel	4320.5	265.1	647.2	187	102	82
Petroleum Refining	2952.4	320.0	1087.2	258	186	154
Aluminum	667.2	105.0	233.8	32	32	31
Styrene	130.2	80.3	43.8	14	14	14
Ethylene	1371.0	1006.5	342.2	33	33	33
Carbon Black	124.1	83.2	40.2	34	18	18
Total	12139.7	2359.5	3611.2	1605	882	710

^{1/} Includes data for chlorine and carbon plants whose parent company affiliation was given, but with no location information.