EMERGENCY FUEL CONVERTIBILITY

A REPORT OF THE

NATIONAL PETROLEUM COUNCIL

1965

REPORT OF THE
NATIONAL PETROLEUM COUNCIL'S
COMMITTEE ON EMERGENCY FUEL CONVERTIBILITY (1964)

JULY 20, 1965

HOWARD BOYD
CHAIRMAN OF THE COMMITTEE

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* Served as a member until April 25, 1965.

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20240

C
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Y

March 16, 1964

Dear Mr. Follis:

In fulfilling the responsibilities assigned to the Secretary of the Interior by the President with respect to preparedness planning to meet emergency situations, there is a recognized need to know the extent to which residential and industrial consumers of various types of fuels could convert from one type of fuel to another in emergency situations.

Under conditions of a nuclear attack upon the United States, for example, disruptions to normal fuel supply could bring about serious shortages of various fuels in many sections of the country. The ability to convert from one fuel to another would materially improve the capability of the nation to survive such an attack, or to increase the potential for retaliatory measures.

A comprehensive survey on the emergency convertibility of fuels has not been made since the end of World War II. In the intervening years there have been so many changes in fuel usage by consumer category that a new survey of inter-fuel convertibility is required as a part of the basic information necessary to fulfill adequately the emergency responsibilities assigned to the Secretary of the Interior.

A survey of inter-fuel convertibility at electric utility generating stations is currently being made by the Federal Power Commission. The results of this survey will provide useful information on the possibilities of emergency fuel convertibility in this segment of the national economy. However, it is conceivable that additional capability to change from one type of fuel to another may be found in other areas of fuel consumption, such as dwelling units, commercial buildings and industrial plants.

Accordingly, it is requested that the National Petroleum Council explore approaches to the problem of emergency fuel convertibility in the national economy (excluding electric utility generating stations), and advise me as to the categories of fuel consumers that may be advantageously studied with reference to this subject.

We stand ready to discuss any aspect of this situation that seems useful, and should appreciate such comments and recommendations as the Council deems appropriate in connection with this request.

Sincerely yours,

/S/ JOHN M. KELLY

Assistant Secretary of the Interior

Mr. R. G. Follis
Chairman
National Petroleum Council
1625 K Street, N. W.
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FINDINGS AND CONCLUSIONS

The U.S. Department of the Interior, in fulfilling responsibilities assigned to it by the President with respect to preparedness planning to meet emergency situations, advised the National Petroleum Council in 1964 that it required information on the extent to which residential, commercial and industrial consumers of various types of fossil fuels could convert from one type of fuel to another in emergency situations.

To assist with the problem, Interior asked the Council to explore approaches leading to some assessment of emergency fuel convertibility in the national economy and to advise it as to the categories of fuel consumers that might be advantageously studied with reference to the subject. The request excluded electric utility generating stations, which are under separate study by the Federal Power Commission.

It is important to note that the Council, in agreeing to undertake this assignment, limited the scope of the study to physical facilities only, without regard to economics or the important question of availability of alternate sources of fuel supply.

This NPC report, then, is in response to the Interior Department's above request, and is the result of the efforts of its Committee on Emergency Fuel Convertibility, assisted by the Technical Subcommittee thereto. The Committee has (a) considered the technical problems inherent in converting from one type fuel to another; (b) assessed existing or possible sources of data on fuel convertibility and cited those categories of fuel consumers which might be advantageously studied further; and (c) developed some general estimates of the extent of fuel convertibility in the United States. It is felt that the report will serve as a base for supplementary studies in this area.

The Committee's specific findings and conclusions are presented below. The body of this report (Sections I - VI) sets forth the detailed discussion and calculations upon which these findings and conclusions are based.

1. EMERGENCY FUEL CONVERTIBILITY, ASIDE FROM FUEL SUPPLY PROBLEMS, IS DEPENDENT UPON SEVERAL FACTORS INCLUDING FUEL IN USE, EQUIPMENT DESIGN, AND ALTERNATE CONVERSION HARDWARE

Throughout this report it is noted that fuel convertibility in the United States under emergency conditions, or even normal conditions, is

difficult to quantify and identify. The many different circumstances and conditions in which all sizes of consumers utilize fuels for various purposes is beyond statistical description. Nevertheless, there are several factors which give practical meaning to emergency convertibility.

To a degree, the type of fuel already utilized by the consumer has an important bearing on whether he could convert to another fuel. This is particularly so in industrial applications for heat and power where oil or natural gas can often be interchanged quickly. Conversions of these fuels to coal and vice versa, however, present problems, many of which could not be solved in a short time period.

The original design of the combustion equipment and the availability of parts needed for alternate fuel usage pose major difficulties for emergency conversions. These problems are minimum in most boiler units, but become more serious in the more complex units for process heat. A definite bottleneck also would occur among residential and the smaller commercial fuel consumers because of a lack of sufficient qualified personnel to accomplish conversions.

2. THERE IS NO DIRECT STATISTICAL INFORMATION AVAILABLE ON THE EXTENT OF EMERGENCY FUEL CONVERTIBILITY

The Committee canvassed all known statistical sources on fuel utilization in the United States. It could uncover no data which could identify convertibility potential directly. The Committee believes, however, that this finding does not reflect a statistical deficiency, but rather that this information has not, in the past, been of such sufficient interest to warrant quantification.

The myriad sources of information on fuel utilization do provide a reliable guide to convertibility potential, for the Nation as a whole and for major geographic subdivisions thereof, although significant error could be implicit in any attempt to define convertibility for small geographic areas.

3. ALTHOUGH MOST FUEL-CONSUMING EQUIPMENT IS CONVERTIBLE TO ALTERNATE FUEL USAGE, DESIGN TRENDS ARE AWAY FROM SUCH FEATURES

As a general rule, equipment to burn fossil fuels for heat and power, and even some raw material uses, can be converted to other fossil fuels, given adequate time and availability of materials. Design trends of new units, however, are decidely away from these features particularly among residential and commercial units, but also to some extent in industrial equipment, other than large boilers. Specialized burners, flue passages, and

heat exchangers, and the trend toward more compact units, have increased the difficulty of fuel conversion. In addition, because of current popularity of oil and gas boilers, U.S. capacity to manufacture coal stokers has reached a low level, and technical knowledge is rapidly disappearing.

4. IN AN EMERGENCY THE QUANTITY OF CONVERTIBLE FUEL USAGE IN THE TRANSPORTATION SECTOR IS NEGLIGIBLE, AND FUEL INTERCHANGEABILITY AMONG RESIDENTIAL AND COMMERICAL CONSUMERS IS VERY LIMITED

In 1962, the distribution of all energy consumption in the United States by consuming sector was as follows:

	PERCENT
Industrial	31
Residential and Commercial	23
Transportation	24
Electric Generation	19
Miscellaneous	3
	100

Fuels consumed for electric generation have been excluded from this study, although it is well known that convertibility in this sector is quite extensive. In the transportation category where the fuel usage is mostly gasoline, diesel and aviation fuels, the Committee considers convertibility possibilities essentially non-existent in an emergency.

The focus of the report is, therefore, on the two remaining categories--which accounted for 54 percent of all fuel usage in 1962. Most emergency convertibility was found to be in industrial fuel usage. In the residential and commercial category a very limited potential of fuel interchangeability is possible, most of which is among the larger commercial fuel consumers.

5. THE PREDOMINANT AMOUNT OF EMERGENCY FUEL CONVERTIBILITY IS IN LARGE WATERTUBE INDUSTRIAL BOILERS

Within the industrial sector the use of fossil fuels for raising steam in boilers is the largest single energy application, and by far the most significant source of emergency fuel convertibility. Through the cooperation of the American Boiler Manufacturers Association (ABMA) the Committee estimates that the number and capacity of large industrial watertube boilers in use as of January 1, 1965 are as follows:

	UNITS	STEAM CAPACITY MILLIONS OF LB./HR.
Coal, Coke and Breeze	8,210	410
Gas and Oil	22,890	875
Total	31,100	1,285

The Committee estimated that approximately 75 percent of the fuel requirements of these watertube boilers is primarily convertible (could be changed to at least one other fossil fuel within 5 days in an emergency), and the remaining 25 percent of fuel requirements is secondarily convertible (could be changed up to a period of 30 days). An important factor missing in these new figures is the geographical distribution of this convertibility.

6. ALTHOUGH THERE APPEARS TO BE A SIGNIFICANT AMOUNT OF EMERGENCY CONVERTIBILITY, WHERE FUEL IS USED FOR HEAT AND POWER, BY ALL TYPES OF MANUFACTURERS, THE EXTENT IS LARGEST IN THE PRIMARY METALS, PETROLEUM AND COAL, AND PAPER AND ALLIED PRODUCT INDUSTRIES

The Committee examined the particular traits in fuel utilization by industrial groupings as used in the 1963 Census of Manufactures. By this analysis it was possible to make estimates of conversion potential on a semi-quantitative basis by industry type. The greatest amount of emergency convertibility was found to be in the following industries:

a. Primary metals - This steel and allied metal group consumed almost one-quarter of all fuels among manufacturers, even excluding the large amount of coke used in iron ore reduction. A variety of fuels is commonly used and fuel interchangeability is widely practiced even under normal operating conditions.

b. Petroleum and coal products - This group's energy requirements represent essentially usage in petroleum refineries where fuels are largely needed in boilers for raising steam. Boiler fuel requirements, as already mentioned, are almost totally convertible to alternate fuels.

c. Paper and allied products - Fuels used in these industries amount to over 10 percent of all manufacturers' fuel consumption. Plant size is commonly large with more than average fuel needs, particularly for steam raising. Conversion to alternate fuels is, therefore, particularly adaptable in an emergency.

7. STATISTICS OF INTERRUPTIBLE NATURAL GAS SALES, WHILE INDICATIVE OF SOME ASPECTS OF FUEL CONVERTIBILITY, CANNOT BE USED AS A RELIABLE ESTIMATE OF CONVERSION POTENTIAL

The Committee has investigated the feasibility of using statistical data on interruptible natural gas sales as a means of identifying convertibility potential. In 1963, about 40 percent of all industrial natural gas sales were on such a basis. Unfortunately, with some exceptions, there appears to be no direct relationship between interruptible sales statistics and convertibility because of reporting inconsistencies between companies and also particularly the fact that no information exists to ascertain whether or not the fuel consumer keeps alternate fuels on hand.

8. SOME ROUGH ESTIMATES OF FUEL CONVERTIBILITY ON A GEOGRAPHIC BASIS COULD BE MADE BY USING INFORMATION ON FUEL CONSUMPTION; HOWEVER, THE USEFULNESS OF THESE ESTIMATES WOULD BE LIMITED

Fuel consumption statistics, such as those provided by the Census of Manufactures, provide some geographic breakdown into state and metropolitan areas. This information, therefore, would provide a rough guide to convertibility potential by area. The usefulness for practical emergency planning would, however, be limited to only broad studies of regional fuel supply and demand. More detailed geographic information could presumably be best obtained by government, on a confidential basis, by a detailed examination of material already on hand from past Census surveys.

9. THE COMMITTEE ESTIMATES THAT THE AMOUNT OF FUEL CONVERTIBILITY IN THE UNITED STATES IS IN THE ORDER OF 6,850 TRILLION BTU'S OF WHICH TWO-THIRDS IS PRIMARY CONVERTIBILITY (COULD BE CHANGED WITHIN 5 DAYS) AND THE REMAINING THIRD OF SECONDARY CONVERTIBILITY (COULD BE CHANGED WITHIN A PERIOD OF 30 DAYS)

Relying chiefly on the results of the survey of industrial watertube boilers, the Committee has estimated that under ideal conditions of continuing energy supply, the fuel convertibility in the United States is as shown in the following table:

SECTOR	EMERGENCY CONVERTIBILITY (TRILLION BTU) Annually, PRIMARY	SECONDARY	TOTAL
Industrial	4,625	1,675	6,300
Residential and Commercial	--	550	550
Total	4,625	2,225	6,850

In practical terms, this convertibility represents about 70 percent of energy requirements by manufacturing companies for heat and power. This is equivalent, however, to only 40 percent of total industrial energy requirements which include fuel raw material uses (coal for coke, for example). In the residential and commercial sector, convertibility is essentially only among the larger commercial fuel users and a very minor percentage of residential users.

It must be understood that the above estimates are subject to substantial possible error and represent at best maximum convertible volumes.

10. THE COMMITTEE BELIEVES THAT THE BEST PROCEDURE TO FURTHER IDENTIFY EMERGENCY FUEL CONVERTIBILITY, SHOULD SUCH INFORMATION BE REQUIRED FOR PREPAREDNESS PLANNING, WOULD BE AN UNELABORATE SURVEY OF LARGE INDUSTRIAL BOILER INSTALLATIONS

This report points out in detail the problems associated with the identification of emergency fuel convertibility. Even with these difficulties it was possible to make estimates of the degree of interchangeability and describe many of its technical and economic characteristics. This material may be sufficient for the needs of preparedness planning envisioned in the initiation of this study.

However, if further identification of fuel convertibility would be desired of greater accuracy as to fuel quantities and their geographic location, the Committee believes that this could be accomplished best by an unelaborate survey of large industrial boiler installations, preferably by geographical regions. Such a procedure would canvass a very large portion of convertible fuel quantities in the smallest number of equipment units. For maximum response, the survey should be constructed to cover only those factors which could easily be answered by the fuel consumers.

The Committee further believes that an all-inclusive survey of all types and sizes of fuel consumers to solicit convertibility data would be unrealistic since material from other than the large boiler installations would be of only marginal value and relevancy to significant fuel convertibility in an emergency.

I. INTRODUCTION

A. Statement of the Problem

The National Petroleum Council's Committee on Emergency Fuel Convertibility has been assigned the task of identifying, as far as is possible from available information, those fuel consumers (or types of consumers) in the United States which can convert from one fossil fuel to another fuel under emergency conditions. In addition, the Committee was asked to suggest measures which could be used in identifying convertibility of fuel consumers where data is not now available or is not sufficiently detailed for practical emergency planning. The Committee was further instructed to make its findings without regard to economics or availability of alternate sources of fuel supply and thus to consider only the physical adaptability of conversion to alternate fuels. Excluded from this study are electric generating stations and fuel requirements of Federal Government facilities, including the military.

B. Objectives and Scope of the Study

The identification of the physical units of fuel convertibility presents a number of problems, not the least of which is the defining of the conditions of time and effort required of the fuel consumer to convert to another energy form. Therefore, it is necessary, initially, to formulate standard measures of interchangeability. Since the characteristics of different fuel users are known to be of such a complex and varied nature, these definitions must be flexible enough to provide a workable means of describing these manifold fuel consumption situations, but still descriptive enough to be useful in identifying the full extent of convertibility in the United States.

While there are many degrees of fuel interchangeability depending upon time and supplies available, for the purposes of this study "emergency fuel convertibility" is divided into two main types, "primary" and "secondary" emergency convertibility. In the first type, the fuel consumer can change utilization of energy supplies quickly without any

significant alteration of consuming equipment. "Primary emergency convertibility" is thus defined to include those situations where conversion can take place easily within five (5) days' time, even allowing for the time needed to rearrange fuel stock locations, etc., but without need for off-premises equipment or supplies. Included in this type of interchangeability, the report also reviews "instantaneous" convertibility where essentially no time or effort is required for conversion.

The second type of emergency fuel convertibility extends the limit of the period of time required for full conversion to 30 days, but more importantly includes the provision that the consumer must make a minor change to his consuming equipment which may necessitate some supplies from outside the premises of his establishment. Even if this alteration of consuming equipment could be handled within five (5) days, (i.e. with off-premise supplies or equipment) the convertibility would still be considered as of the second type or "secondary emergency convertibility."

The objective of this report, therefore, is to evaluate the quantity of fuel and the number of fuel consumers, which can be included in these two types of emergency fuel convertibility. To maintain a standard of comparability between industrial fuel consumers, conditions are assumed to be the same as existed in the year 1962, the most recent year for which fuel consumption statistics have been surveyed by the Census of Manufactures. However, where more current data are available, these have been included.

While this study does not try to examine in detail the fuel conversion possibilities of the individual consumer, it does attempt to bring together all available information on the subject so as to make tentative estimates of the order of magnitude of fuel interchangeability. In many cases these estimates have had to be made from partial data. The report further examines the appropriateness and practical usefulness of such estimates and the underlying assumptions from which these are based. These estimates are presented to pinpoint where convertibility is most prevalent and to provide a basis for further, more detailed studies which may be required.

Emphasis in the report is also placed on qualitative aspects of fuel conversions such as technological trends and advancements in burning equipment which have a bearing on conversion possibilities. This material is included to present some background to the practical physical problems which are encountered in fuel conversion. Also, this discussion sheds some light on the convertibility possibilities of certain consumers which could not readily change fuels under emergency conditions, but might make conversions under less stringent conditions.

Finally, the report suggests the best procedure, in the opinion of the Committee, which emergency planners could use to further identify areas of fuel convertibility which would be significant in an emergency.

C. Assumptions and Limitations of the Study

The matter of fuel convertibility, and particularly the quantitative measurement of its prevalence in the United States, is a complex subject with many ramifications. Determining how many fuel consumers there are, of what kind and of what geographic location who could be converted to alternate fuels, could tax the energies of numerous persons for many years. This study, then, must be considered only as a first attempt to analyze the convertibility possibilities from existing data and the experience of Committee members.

It has been necessary for the Committee to define certain emergency conditions in order to put some limits on convertibility. This is necessary because, theoretically, given enough time and available manpower and supplies, essentially all fuel usages are convertible. In a sense, the Committee has restricted its definitions only to conditions adjacent to the fuel consumer and his equipment. The Committee could not consider the many additional factors, of which fuel transportation facilities are only a part, which would affect the fuel consumer from outside his location in an emergency.

This report is, therefore, a first determination and not a comprehensive survey of the problem of the identification of convertibility, and therefore, should be utilized as such. The background provided here could serve to pinpoint further

areas of investigation if required for emergency planning. On the other hand, the information herein may serve within the specified limits of reliability for such planning procedures, and could lend credence to information already in use.

II. TYPES OF CONSUMERS AND INFORMATION SOURCES

A. Types of Fuel Consumers

Although it is beyond the scope of this report to analyze in detail the characteristics of all fuel consumers, it is useful to recognize some general breakdowns of energy usage. In 1962, total energy consumption in the United States was almost 48,000 trillion Btu's. This large quantity of energy usage can be broken down into the broad categories shown in the following table:

UNITED STATES ENERGY CONSUMPTION
BY CONSUMING SECTOR

	TRILLION BTU [a]	PERCENT
Industrial	14,983.5	31
Residential & Commercial	10,996.0	23
Transportation	11,416.2	24
Electric Generation	9,220.5	19
Miscellaneous	1,281.2	3
Total	47,897.4	100

Source: U. S. Department of the Interior "An Appraisal of the Petroleum Industry of the United States," January 1965, Table 2.

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a/ One trillion (10^{12}) Btu is, on the average, the equivalent of the following:

38,760 tons of bituminous coal
930 million cubic feet of natural gas
164,989 barrels of residual fuel oil

As mentioned previously, the convertibility of fuels for electric generation has been excluded from this study. For a balanced convertibility study, steam-electric generating plants should be included. It is understood that the Federal Power Commission has collected such data. While there are several minor possibilities for interchangeability in the transportation sector, that is, substitute fuels for motor gasoline, diesel and jet fuels, the limitation of emergency convertibility makes these situations extremely unlikely. Therefore, convertibility in the transportation sector is likewise excluded from consideration.

The focus of this report, then, is on the convertibility possibilities in the two remaining categories--industrial, and residential & commercial--which accounted for 54 percent of all fuel usage in 1962.

A key statistical source used in this study for the industrial category is the 1963 Census of Manufactures which lists the fuels and energy consumed in manufacturing industries in 1962. These data show that manufacturers used the thermal equivalent of 8,600 trillion Btu's of purchased fuel for heat and power, and 4,900 trillion Btu's of fuel as raw material (such as coal for coke) or secondary fuels produced and consumed on their own premises (still gas and heavy fuel oil at oil refineries and blast furnace gas at steel mills). The latter figure represents fuel usage which is essentially not interchangeable in that the raw material processing requirement, and the secondary fuels derived from such processing, would not permit replacement by another fossil fuel to any great extent in an emergency.

The Census fuel statistics represent a manufacturing fuel usage in 1962 of approximately 13,500 trillion Btu's, which is below the figure of 14,983 trillion Btu's shown in the above table. This difference represents noninterchangeable fuel usage in mining and fuel production (particularly field use of natural gas), mineral preparation, and various other smaller categories which are generally considered industrial in nature, but are excluded from the manufacturing classification.

B. Review and Assessment of Available Information

The Committee conducted a thorough investigation of the literature, and determined that there is no published information which identifies the amount of convertibility of American

fuel consumers. There is, however, a substantial amount of statistical data about fuel usage which indirectly can be very useful in discussing conversion possibilities. In fact, information of this kind is so extensive that the problem becomes more to ascertain which sources are the most useful.

In order to approach the subject of fuel interchangeability in the residential, commercial, and industrial sectors, some basic definition or classification of customers is required. To the extent that it is possible to do so, the customer classification system used by the American Gas Association is recommended for two reasons: (1) natural gas is the primary source of energy for heating purposes; and (2) the customer and fuel requirement statistics maintained by the gas industry appear to be more comprehensive and uniform than those reported by other fuel industries.

Classifications are determined by the customer's primary business or economic activity at the location served.[a/] In brief, these are as follows:

> Residential - Service supplied to customers for cooking, water-heating, space-heating, and air-conditioning through an individual meter in a single family dwelling or in a multi-unit dwelling not exceeding four households.
>
> Commercial - Service to customers primarily engaged in wholesale or retail trade, agriculture, forestry, fisheries, transportation, communication, sanitary services, finance, insurance, real estate, personal services (hotels, apartments where five or more households are served as a single customer, auto repair, etc.) and Government. This service includes cooking, water-heating, space-heating, and air-conditioning.

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a/ Described in detail in Appendix to annual "Gas Facts", published by the American Gas Association.

Industrial - Service to customers engaged primarily in a process which creates or changes raw or unfinished materials into another form or product. This includes fuel used for space-heating, air-conditioning and process heat. Size of customer is no determinant of classification.

Other - Service to governmental agencies for lighting, to public authorities under special rates, and to other utilities or governmental agencies for resale.

RESIDENTIAL

Natural gas and No. 2 heating oil are the primary fuels consumed in residences, although certain areas of the country consume significant amounts of electricity, liquefied petroleum gas, kerosine, bituminous coal and anthracite. There are a number of sources which periodically report data pertaining to this sector, all of which have some shortcomings. Appendix 1 lists those sources considered most likely to provide some assistance in quantifying fuel usage patterns.

COMMERCIAL

No additional sources of data are available on commercial installations or fuel use other than those listed in Appendix 1. The natural gas industry provides the only figures on commercial customers, differentiated from residential, and subdivided to the state level.

INDUSTRIAL

The American Gas Association and the U.S. Bureau of Mines report statistics on industrial fuel consumption. The principal problems associated with these reports are:

1. AGA data exclude direct sales by producers to ultimate consumers within a state. They include sales of gas to electric utilities but exclude those to a combination electric-gas utility where the gas used in generating power is considered an interdepartmental transfer. Separate tabulations provide information on sales to large volume industrial users but no information as to geographic location.

2. Bureau of Mines data on gas include direct sales by producers and all electric utility use. However, in reality the industrial figures are only estimates since these are obtained by difference rather than by reports. No information is given on number of customers or type of industry (other than petroleum refineries).

3. Bureau of Mines data on coal shipments give no indication of ultimate consumers, and also are only estimates obtained by difference.

4. Bureau of Mines petroleum statistics also provide no indication of the number of customers or type of industry other than petroleum refining, although the LPG report does show volumes used at chemical plants and synthetic rubber plants.

In addition to these American Gas Association and U.S. Bureau of Mines reports, there are several other possible sources of data on industrial consumers. These are listed in Appendix 2. Again, none of these provide a complete picture of this market and must be used in conjunction with other reports.

III. TECHNICAL CONSIDERATIONS OF FUEL CONVERTIBILITY

To understand fuel convertibility, first it is necessary to examine not the characteristics of the various fuels, but rather some of the basic elements and types of fuel-consuming equipment. This is the key to convertibility, and particularly so under emergency conditions. Without the proper kinds of physical facilities to convert, the consumer would be seriously hampered in returning to normal operations, even though fuel supplies may be adequate. The following discussion first considers the concept of emergency convertibility, and then centers on aspects of types of fuel-consuming equipment and their convertibility features.

A. The Concept of Emergency Convertibility

Any expanded definition of the aspects of emergency fuel convertibility must begin with the assumptions underlying what is considered to be "emergency" and "convertibility". The extent of an emergency may range from strictly local to the national level and stem either from natural or man-precipitated disturbances. This does not preclude the possibility that a declared state-of-emergency could exist, reflecting a threat to the Nation's security by unfriendly interests. This could affect the character of fuel and energy consumption patterns depending upon the nature and intensity of the emergency.

Assumptions relating to convertibility can be more exactly pinpointed. This study concerns itself principally with the aspects of the physical equipment and the interchangeability of the various fuels which actuate that equipment. To be meaningful, the study considers convertibility within certain defined limitations: (1) time, (2) availability of conversion hardware, (3) technical feasibility, and (4) the existence of the technical skills and manpower required to execute the conversion.

In this study only two basic types of emergency convertibility are considered. Each definition considers the four limitations to the physical conversion process previously identified.

1. Primary Emergency Convertibility exists when fuel-burning equipment can be converted within a five day period of time and the conversion hardware and technical manpower are on the premises.

a. Primary convertibility is considered to be "instantaneous" when existing fuel consuming equipment is multi-fuel allowing the conversion to be accomplished by a mechanical changeover which takes place with no interruption in the fuel-burning process. (See Appendix 3)

b. Primary convertibility also may exist if changeover can be accomplished under the defined conditions, although not instantaneous, but within a five-day maximum time limitation. This may take place even when multi-fuel equipment is already installed but where some minor adjustment to the equipment or the complexity of the fuel burning process makes it infeasible or impractical to convert instantaneously. (See Appendix 4)

2. Secondary Emergency Convertibility exists when fuel burning equipment requires from 6 to 30 days before changeover can be completed. The consumer may need to acquire conversion equipment and technical manpower from outside the premises and major changes in equipment may be necessary. (See Appendix 5)

* * *

Convertibility beyond 30 days is not considered an important element of this study. Within certain limitations to the equipment conversion process, most fuel-burning equipment might be considered convertible. In the absence of an emergency, the economics of each consumer's fuel applications dictate feasibility. Some fuel uses are not readily convertible except by complex techniques or exotic devices. Although conversion ultimately can be accomplished, this entire segment has been excluded from this study.

In part, the exclusion is caused by certain aspects of emergency convertibility not directly related to fuel-consuming equipment that are important considerations. The first of these

are the geographic considerations of fuel source and accessibility to the consumer. Location and transportation factors are controlled by the type, character and magnitude of the emergency. The primary fuel upon which the consumer relies for normal operations is the limiting factor. For example, if natural gas is the consumer's primary fuel and normally is supplied on a noninterruptible basis, conversion to an alternative fuel would be much more difficult than if the consumer currently is served on an interruptible basis. Conversion equipment may not be readily available within defined time limits. If available, an extensive period of time may be required to establish an alternative fuel source and arrange for continuous supply.

The element of stockpiling alternate fuel and its related costs also is important in its effect on convertibility. A consumer's equipment may feasibly be converted to an alternate fuel, but the stockpiling of the other fuel in volume adequate for continuous operations poses quite a different problem. Large consumers, using dual fuel equipment, stockpile stand-by fuels on an annual or semi-annual schedule. In this way, operations continue without the hazards of interruption or unforeseen emergency situations. Again, the primary fuel and the alternative fuel types are an important consideration. If coal or oil is the primary fuel, the element of stockpiling and stated costs is less important than if natural gas is the primary fuel. A consumer using coal or oil already owns land, storage devices, handling equipment and other necessary auxiliary facilities. If natural gas is the primary fuel, the acquisition of land for sufficient coal stocks, storage vessels for oil and other facilities may not be readily available and could require major expenditures.

There are various other matters related to the problems of emergency convertibility. The most important centers on whether the emergency is of a nature that results in damage to the consumer's premises, his fuel consuming equipment, or to the means of transporting alternate fuels. In the latter respect, it should be stressed that convertibility potential must be used with caution; otherwise, serious imbalances for all fossil fuel supplies could result. For example, it is impractical to ignore consideration of fuel needs of electric generating plants. Also, to "over-convert" to gas might require additional pipeline capacity. To "over-convert" to oil might have the effect of

idling gas delivery facilities. These and other imponderables have been excluded from this study since these pose insurmountable barriers to the quantification aspects of the study.

B. Types of Fuel-Consuming Equipment

There are four broad classifications of fuel-consuming equipment: (1) factory-built home appliances, (2) factory-built residential water-heating and central heating systems, (3) commercial establishment equipment covering a number of uses, and (4) industrial process and power equipment. Illustrations of the various types of equipment and the types of fuels commonly used are shown in Appendix 6 for the residential-commercial sectors; and in Appendix 7 for the industrial sector. Also, general classifications of combustion systems for oil and gas, including descriptions of types of mixing, burner types and typical furnace or process uses are illustrated in Appendices 8 and 9.

C. Convertibility of Fuel-Consuming Equipment

Conversion from one type of fuel to another can be made depending upon the type of heat absorption unit that is being used. By absorption unit is meant the stove, heater, boiler or similar unit in which a burner is installed or in which the fuel is consumed. In this discussion, therefore, it is necessary to make a clear distinction between the burners which actually convert a fuel from latent to dynamic energy, and the units which utilize the energy derived from the fuel consumed.

To burn coal a set of grates or a stoker or pulverizer is needed; to burn oil a unit that will atomize or vaporize the fuel and mix it with air is required; and to burn gas a unit is required to mix gas with air. To convert from one fuel to another, the heat absorption unit must be such that it will accomodate more than one type of burner - that is, it must be able to accomodate a burner to burn oil, as well as a device to burn coal, or to accomodate a burner to burn gas, as well as a burner to burn oil. The greatest flexibility in conversion is possible when the absorption unit will accommodate a burner for all types of fuels.

The present trend in new equipment is away from convertibility, particularly in domestic and commercial equipment. The specialized burners, flue passages, and heat exchangers, and the trend toward more compact units make it difficult, if not impossible, to change fuels. Large industrial units still retain some degree of flexibility due to the changing economics in the use of different fuels, but even here the trend is toward less flexibility, particularly in "package units".

For technical considerations in this discussion it is assumed that the various types of burners, along with the required auxiliary equipment (controls, oil tanks, gas mains, etc.), are available. To convert from one fuel to another, it will only be necessary to switch burners to consume the desired fuel. Because the necessary auxiliary equipment frequently is not available, conversion from oil and/or gas to coal generally is not feasible - extensive modifications to add stokers, grates, ashpits and coal-handling equipment are required. Conversion to coal generally results in a one-third reduction in capacity. Changing from coal to gas or oil, or from oil to gas, or gas to oil (where feasible) does not require any extensive or unusual modification of the heat absorption unit, fireboxes, flues, regulators, etc.

A more detailed discussion of the technical considerations of convertibility of domestic commercial, and industrial heating equipment appears in Appendix 10.

IV. EMERGENCY CONVERTIBILITY OF INDUSTRIAL CONSUMERS

This section of the report will review quantitative and qualitative information on the emergency convertibility possibilities of industrial fuel consumers. As has already been mentioned, there is no single source or sources which directly provide convertibility data.

The Committee, therefore, has approached the problem by examining several alternative methods of analysis, each of which gives partial indication of the degrees of fuel interchangeability among industrial consumers. These methods are:

A. Statistics of Large Industrial Boilers

B. By Types of Industry

C. Interruptible Natural Gas Sales

D. Geographic Data

A. Statistics of Large Industrial Boilers

The lack of definitive data on fuel convertibility of the industrial consuming segments in this study indicated a need for information on fuel-burning equipment, primarily with regard to boilers in industrial use. As a result, the American Boiler Manufacturers Association (ABMA) was asked to develop an estimate of the population of industrial boilers[a/] and to comment on the convertibility of these units.

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a/ The following discussion refers only to watertube boilers which are the predominant boiler type in use today and have the largest convertibility potential. Firetube boilers, historically associated with steam locomotives, have not been treated in this study because of problems of statistical identification and their lower convertibility characteristics under emergency conditions.

The ABMA is a trade association representing firms which manufacture about 80-90 percent of all large industrial boilers in the United States. The Association tabulates the U. S. sales of watertube boilers with capacities of over 10,000 pounds of steam per hour. These sales data are available from 1937 to date. Statistics for the last several years include information on primary and alternate fuels, size of unit, packaged and field assembly, export and domestic use, and operating information such as pressure and temperature.

There are several limitations in ABMA data. Only sales are covered, with no statistics available on the total installed capacity or, except for recent years, on the convertibility of fuels. Furthermore, no data are available for the geographic distribution of the sales, and neither are historic sales available by types of industry. Certain portions of the statistics can be traced from 1937 to date, while other information is available only for shorter periods, usually from 1949 and from 1954.

To develop a boiler population, ABMA totalled their annual statistics regarding boiler sales. This necessitated certain basic assumptions, as follows:

1. Watertube boilers have a service life of 30 years.

2. No boiler sold since 1937 has been retired.

3. All boiler sales, excluding those to electric utilities or marine services, are assumed to be for industrial applications.

4. No units have been converted to other fuels since being installed.

ABMA has estimated the total watertube boiler population as of January 1, 1965, to be 31,100 units, which represents a total capacity of 1,285 million pounds of steam per hour as shown in the following table:

INDUSTRIAL WATERTUBE BOILERS IN THE U. S.*
AS OF JANUARY 1, 1965
(Excluding Electric Utilities)

FUEL DESIGNED FOR:	UNITS	CAPACITY MILLIONS OF LBS/HR	CAPACITY PERCENT OF TOTAL
Coal, Coke & Breeze	8,210	410	32
Gas & Oil			
Packaged	6,920	200	16
Field Assembled	15,970	675	52
Sub-Total	22,890	875	68
Total	31,100	1,285	100

The next table estimates the total energy consumed in these boilers in 1964. In this estimate, assumptions were made concerning the amount of time the boilers were used at capacity, as well as the average thermal efficiency. The fuel consumption in 1964 was estimated to be 6,300 trillion Btu.

ESTIMATED TOTAL FUEL FIRED IN INDUSTRIAL
WATERTUBE BOILERS IN THE U. S. IN 1964

Size Category - 10,000 to 100,000 lb/hr
28,300 units with 848 x 10^6 lb/hr total capacity
848 x 10^6 x .25 use factor = 212 x 10^6 lb/hr

Size Category - over 100,000 lb/hr
2,800 units with 437 x 10^6 lb/hr total capacity
438 x 10^6 x .75 use factor = 328 x 10^6 lb/hr

All Boilers
(212 x 10^6) + (328 x 10^6) = 540 x 10^6 lb/hr
540 x 10^6 x 1000 Btu/lb = 540 x 10^9 Btu/hr output
540 x 10^6 ÷ 0.75 eff = 720 x 10^9 Btu/hr fired
720 x 10^9 x 8760 hrs = 6,300 x 10^{12} Btu/year fired

* 10,000 lb/hr and over per unit.

Before discussing the convertibility of these boilers, it is helpful to estimate the total purchased fuels consumed in manufacturing for heat and power. The estimate of fuel consumption was made for the year 1964, to be consistent with the boiler population on January 1, 1965. The following table shows this estimate by fuels. The percentages for the fuels consumed in 1964 are identical with those for the fuels consumed in 1962, from the Census of Manufactures, although the estimate was arrived at separately.

ESTIMATED 1964
FUEL USAGE BY MANUFACTURERS FOR HEAT AND POWER

	QUANTITY	ENERGY TRILLION BTU	ENERGY PERCENT
Coal, Coke, & Breeze	111 Million Tons	2,875	31.8
Fuel Oils	229 Million Barrels	1,395	15.4
Gas	4,433 Billion Cubic Feet	4,765	52.8
Total		9,035	100.0

As has just been shown, use of fuels under watertube boilers amounted to 6,300 trillion Btu's in 1964, or approximately 70 percent of all fuel consumed for heat and power. It should also be noted that the percentage fuel use of coal, coke, and breeze for all manufacturing consumption for heat and power (31.8%) is approximately the same as the percentage of boiler units which use coal (see page 17). For this reason, it has been assumed that the use of each fossil fuel for boilers is in the same proportion as for all fuel use for heat and power. This assumption is necessary, as will be shown, in determining estimates of convertibility.

The Committee, after study of the ABMA's statistical information, determined the following general characteristics for the convertibility of large boilers:

1. Of the units designed for firing solid fuels, about 25 percent probably are equipped to burn gas and/or oil, and could be converted in a short time.

2. The remaining 75 percent firing solid fuels could be converted to gas or oil without loss of steam capacity; however, this conversion would require 3 to 4 weeks after all materials had been obtained.

3. Packaged units fired by gas or oil are not convertible to solid fuels. However, packaged units can be easily switched from oil to gas, or gas to oil.

4. Field assembled units firing gas or oil are capable of burning either of these fuels and the conversion could be made in a very short time.

5. Field assembled units firing gas or oil could be converted to solid fuels with a loss in steam capacity of about one-third. Major mechanical changes would be necessary and probably would require more than 30 days.

One sidelight of the ABMA study which is significant, concerns the present status of the coal stoker industry. Because of the continued popularity of oil and gas boilers, U. S. capacity to manufacture stokers has reached an all-time low and technical knowledge is rapidly disappearing. In the event of an emergency little could be done short-term to increase production of coal stokers.

From the preceding discussion and tables on large industrial boilers, it is apparent that essentially all fuel requirements are convertible within a 30-day period. In fact, all except 25 percent of the capacity of these boilers are primarily convertible within a period of five days.[a/] This 25 percent of secondary convertibility would be in those units fired by solid fuels which did not have immediate dual-firing

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a/ Coal, coke, and breeze units comprise 32 percent of boiler capacity. 75 percent of these units cannot be converted immediately. This then represents 75% x 32%, or about 25 percent of all boiler capacity.

equipment. All units fired by natural gas and fuel oil, and a minor portion of the solid fuel fired units would be of primary convertibility.

To summarize, the amount of emergency convertibility (1964) in the industrial sector was the equivalent of 6,300 trillion Btu's, with 75 percent of this amount being primary convertibility, and the remaining 25 percent being secondary convertibility. This convertibility represents all use of fuels for watertube boilers, which in turn represents 70 percent of all fuel use by manufacturers for heat and power, and 40 percent of over-all industrial fuel usage, including raw material and other requirements.

It must be pointed out that because of the many assumptions required to estimate convertibility, these percentages should be viewed as maximums. While convertibility of the estimated boiler capacity appears high, other considerations such as geographic locations of the boilers, availability of parts and materials to make conversions, as well as the improbability of converting to all oil or to all gas, provide a strong basis for lowering the estimate by a significant amount. Further, this estimate, per se, should not be used on a geographic basis.

B. By Type of Industry

The identification of industrial fuel convertibility also can be examined on the basis of the various industry groups. The most useful classification is that provided by the Standard Industrial Classification (SIC) used by all Federal statistical agencies, by most state agencies, and most private organizations. For this report these industries are classified into four groups of approximate equal fuel usage for heat and power. The table on the following page shows the four groups into which these industries are classified, together with data on fuel consumed. Each group will be discussed separately as to its emergency fuel convertibility possibilities.

Any evaluation of fuel convertibility for specific industries necessarily must be estimated using judgment factors in the absence of factual information. The Committee has no accurate knowledge of the proportions of total fuel employed under boilers for specific two-digit SIC industries, nor does it know the proportion of boiler firing done in equipment where alternative fuel is presently feasible and where fuel stockpiles exist.

FUEL USED FOR HEAT AND POWER IN 1962 BY MANUFACTURING GROUPS

SIC NO.		TRILLION BTU	PERCENT OF TOTAL
	GROUP I		
33	Primary metal industries	2,045.7	23.9
34	Fabricated metal products	172.7	2.0
		2,218.4	25.9
	GROUP II		
28	Chemicals & allied products	1,554.6	18.2
22	Textile mill products	196.1	2.3
23	Apparel & related products	19.0	0.2
30	Rubber & plastic products	117.0	1.4
24	Lumber & wood products	58.0	0.7
25	Furniture & fixtures	27.0	0.3
31	Leather & leather products	26.3	0.3
27	Printing & publishing	18.2	0.2
		2,016.2	23.6
	GROUP III		
29	Petroleum & coal products	1,116.3	13.0
26	Paper & allied products	866.8	10.1
37	Transportation equipment	224.9	2.6
		2,198.0	25.7
	GROUP IV		
32	Stone, clay & glass products	984.1	11.5
20	Food & kindred products	710.1	8.3
35	Machinery, except electrical	191.4	2.2
36	Electrical machinery	127.7	1.5
39 & 19	Misc. manuf. incl. ordnance	50.4	0.6
38	Instruments & related products	33.5	0.4
21	Tobacco products	11.7	0.1
	Undistributed	13.0	0.2
		2,131.9	24.8
	Total All Groups	8,564.5	100.0

Source: 1963 Census of Manufactures

Nevertheless, the Committee can make some estimates of emergency convertibility by industry group, and does so to quantify its findings. This is done primarily on the basis that it has already been shown that 70 percent of manufacturers' fuel usage for heat and power, which is consumed in boilers, is convertible. The following quantitive convertibility estimates are advanced to show that certain groups of industries are above or near this average, while others are below 70 percent of their fuel needs.

GROUP I - Primary Metal Industries (SIC 33)
Fabricated Metal Products (SIC 34)

The manufacturers in this group are essentially in the "steel industry" and as such are tremendous consumers of fuels. They generally are large-size companies most of which use a number of types of fuels for various energy needs. As such, they are prime candidates for emergency fuel convertibility. The major exceptions are coke, when used as a ballast and carbon ingredient in blast furnaces and cupolas, and natural gas when used as a chemical agent in atmospheric generators.

The following industries are included in the Primary Metal Industry grouping:

Steel Rolling and Finishing
- Blast furnaces and steel mills
- Electrometallurgical products
- Steel wire drawing
- Cold finishing of steel shapes
- Steel pipe and tubes

Iron and Steel Foundries
- Gray iron foundries
- Malleable iron foundries
- Steel foundries

Primary Nonferrous Metal
- Primary copper
- Primary lead
- Primary zinc
- Primary aluminum
- Primary nonferrous metals

Secondary Nonferrous Metals

Nonferrous Rolling and Drawing
- Copper rolling and drawing
- Aluminum rolling and drawing
- Rolling and drawing
- Nonferrous wire drawing

Nonferrous Foundries
- Aluminum castings
- Brass, bronze, copper castings
- Nonferrous castings

Primary Metal Industries
- Iron and steel forgings
- Nonferrous forgings
- Primary metal industries

In 1962, of the total consumption of fossil fuels, by all manufacturing industries, these industries consumed the following percentage of each fuel:

Fuel	COAL	COKE	FUEL OIL	GAS
Percent of Total	15.1%	93.1%	23.6%	21.8%

Fuel consuming equipment used in these industries varies from simple boilers, car thawing and flame cutting to the more sophisticated equipment such as atmosphere generators, continuous furnaces, die heating equipment, etc. The following is a list of the major fossil fuel consuming equipment or processes normally used in these industries:

Age Hardening Furnaces
Air Furnaces
Annealing Furnaces
Atmosphere Generators
Billet Furnaces
Blast Furnaces
Blast Furnace Stoves
Boilers
Burn Off Ovens
Car Thawing
Continuous Furnaces
Cupolas
Core Ovens
Crucible Furnaces
Cutting (Flame)
Electric Furnaces
Forge Furnaces
Galvanizing Pots
Heat Treating
Investment Casting Ovens
Ladle Heating
Mixer Heating
Mold Dryers
Open Hearths
Pelletizing
Reheat Furnaces
Reverbatory Furnaces
Salt Pots
Sand Drying
Scarfing
Shell Molding Ovens
Sinter Furnaces
Soaking Pits
Solution Heating
Tin Plating
Upsetting

Under emergency conditions it is estimated that 90 percent of fossil fuel requirements (excluding coke) could be converted within a time limit of 30 days, and with the necessary equipment alterations.

The following industries are included in the Fabricated Metal Products Industry grouping:

Metal Cans

Cutlery, Hand Tools, Hardware
- Cutlery
- Edge tools
- Hand saws and saw blades
- Hardware, n.e.c.

Screw Machine Products and Bolts
- Screw machine products
- Bolts, nuts, washers, and rivets

Metal Stampings

Plumbing and Nonelectrical Heating
- Plumbing fixtures
- Plumbing fittings, brass goods
- Nonelectric heating equipment

Structural Metal Products
- Fabricated structural steel
- Metal doors, sash, and trim
- Boiler shop products
- Sheet metal work
- Miscellaneous metal work, n.e.c.

Metal Service, N.E.C.
- Plating and polishing
- Metal coating, engraving, etc.

Fabricated Wire Products, N.E.C.

Fabricated Metal Products, N.E.C.
- Metal barrels, drums and pails
- Safes and vaults
- Steel springs
- Valves and pipe fittings
- Collapsible tubes
- Fabricated pipe and fittings
- Fabricated metal products, n.e.c.

In 1962, of the total consumption of fossil fuels by all manufacturing industries, these industries consumed the following percentage of each fuel.

Fuel	COAL	COKE	FUEL OIL	GAS
Percent of Total	1.2%	0.7%	3.6%	2.2%

After converting to a Btu basis, we find that these industries account for 2 percent of the total energy consumed by all manufacturing industries.

Fuel-consuming equipment used in these industries varies from simple boilers and melting pots to the more complex equipment such as atmosphere generators. The following fossil fuel-burning equipment is normally used in these industries:

- Atmosphere Generators
- Bending Furnaces
- Boilers
- Brazing
- Cutting (Flame)
- Coating Pots
- Drying Ovens
- Enameling Furnaces
- Flame Hardening
- Forge Furnaces

Galvanizing Pots	Salt Pots
Heat Treating Furnaces	Solder Pots
Non-ferrous Melting Pots	Solution Tanks
Preheat Furnaces	Stress Relieving Furnaces
Plastic Drying Ovens	

Convertibility in the fabricated metal products is also extensive and is estimated also to be 90 percent of fuel requirements for heat and power. This convertibility is mostly in large boilers which account for the vast majority of energy requirements. The convertibility potential for Group I is centered in OEP-OCD Regions 2 and 4 where the metal industries are concentrated.

GROUP II - Chemical and Allied Products (SIC 28)
Textile Mill Products (SIC 22)
Apparel and Related Products (SIC 23)
Rubber and Plastic Products (SIC 30)
Lumber and Wood Products (SIC 24)
Furniture and Fixtures (SIC 25)
Leather and Leather Products (SIC 31)
Printing and Publishing (SIC 27)

The chemical and allied product industry encompasses a wide variety of establishments, many of which vary from each other in their fuel characteristics. Looking only at the three-digit subdivision of this major category, we find that these include industrial inorganic and organic chemicals; plastics materials and synthetic resins; drugs, soap, detergents and cleaning preparations; perfumes, cosmetics and other toilet preparations; paints, varnishes, lacquers and enamels; gum and wood chemicals; agricultural chemicals; and miscellaneous chemical products (glue, explosives, ink and others). Information on fuel usage by OEP Region is available only for the aggregate two-digit category, but there is no doubt that the fuel requirements of such subcategories as drugs and agricultural chemicals vary immensely. Looking at the industry as a whole, we estimate that about 75 percent of the aggregate fuel requirements are used under boilers. Furthermore, of this amount, it is estimated that essentially all of such boiler usage might be convertible to other fuels.

The textile industry similarly is composed of a number of subcomponents which include broad woven cotton fabric mills; broad woven man-made fibre and silk fibre mills; broad woven wool fabric mills; narrow fabric mills; knitting mills; dye and finishing textiles; floor covering mills; yarn and thread mills; and miscellaneous textile goods. Here once again energy requirements vary considerably - establishments converting fibres into material and dyeing such fibres will use substantially more energy than those subsequently converting the material into consumer products. It is estimated that 2/3 of the aggregate fuel usage of this major category represents boiler fuel, and is thus convertible.

The lumber and wood products industry similarly consists of categories concerned with initial processing of lumber, as well as the subsequent conversion of lumber into final products. In this industry, the preponderance of fuel used

represents waste products from the operations; coal, oil and gas in the aggregate represent only 22 percent of their total fuel requirements. It is probable that the overwhelming preponderance of these waste products are used under boilers and reliance upon coal, oil or gas is substantially for use other than boilers. It is estimated that 1/4 of the coal, oil and gas used represents convertible boiler fuel.

The leather and leather products industry includes establishments concerned with the preparation of basic leather, as well as processing the leather into consumer goods of all types. Most of the energy requirements are undoubtedly concentrated in the former type of establishment, and it is estimated that 2/3 of the total fuel requirements of this industry represent boiler fuel.

Appendix 11 shows for each of these four two-digit industries, the amounts of fuel used (by OEP Region) during 1962. Such data are not available for any finer subdivision of industry than the two-digit classifications. They do indicate the major importance of the chemical category and the relatively minor importance of the other three categories. Within the chemical group a significant part of the total fuel used is employed in OEP Region 5 where natural gas is used exclusively and where alternative fuel supplies and firing equipment are sparse. On the other hand, almost as much fuel is used in Region 2, where competition between alternative suppliers of energy is vigorous and where fuel interchangeability is significant.

For all industries within Group II it is estimated that convertibility potential is 50 percent of fuel usage for heat and power, or somewhat less than the average of all manufacturers.

GROUP III - Paper and Allied Products (SIC 29)
Petroleum and Coal Products (SIC 26)
Transportation Equipment (SIC 37)

Paper and Allied Products run the gamut in the paper industry from pulp mills to paperboard containers and boxes. The group includes the manufacture of wood pulp and other cellulose fibers, and rags; the manufacture of paper and paperboard into converted products of paper and paperboard such as paper coatings, paper bags, boxes and envelopes; also wallpaper, envelopes, sanitary food containers, etc.

The Census of Manufactures has compiled information on the location of establishments by states. In Appendix 12 is shown the volume of fuels used in these industries by OEP Regions. In Appendix 13 appears a list indicating the number of plants (paper mills, pulp mills, etc.), broken down as to type of mill.

The amount of fuel used in the production of paper and allied products is large and amounted to just slightly over 10 percent of all manufacturers' consumption of fuels. The plants in this category are of more than average size and thus have large fuel requirements per plant. In such circumstances fuel consuming equipment also is large. It is estimated that 75 percent of the fuel usage in this group is convertible.

The Petroleum and Coal Products industry essentially represents the petroleum refining industry. Although information on fuel usage is gathered by the Census of Manufactures, the most complete information on fuel consumption by petroleum refineries is that released by the Bureau of Mines. In February of each year its Monthly Petroleum Statement contains three tables:

1. Fuels Consumed at Refineries by States (See Appendix 14).

2. The same data by refining districts (See Appendix 15).

3. National percentages of the relative usage of different refinery fuels (See Appendix 16).

Petroleum refineries are large users of fuel amounting

to 13.0 percent of the national total for manufacturers in 1962. A very large part of a refinery's fuel needs is for process heat. For this reason, and for the fact that many types of petroleum fuels and also natural gas are readily available at the location, the convertibility possibilities essentially are total. It is estimated that 90 percent of this usage is convertible nationwide.

The Transportation Equipment group includes establishments engaged in manufacturing equipment for the transportation of passengers and cargo by land, air and water, namely:

Motor Vehicles and Motor Vehicle Equipment
Aircraft and Parts
Ship and Boat Building and Repairing
Railroad Equipment
Miscellaneous Transportation Equipment

It will be noted in Appendix 17 that, geographically, the greatest amount of fuel used by this category is in OEP-OCD Region 4. The convertibility possibility for this group of industries is estimated to be comparatively small because of the high degree of process heat required as opposed to boiler usage. Thus, only 25 percent is estimated to be convertible.

GROUP IV - Stone, Clay, and Glass Products (SIC 32)
Food and Kindred Products (SIC 20)
Machinery, Except Electrical (SIC 35)
Electrical Machinery (SIC 36)
Miscellaneous Manufacturing Including Ordnance (SIC 39 & 19)
Instruments and Related Products (SIC 38)
Tobacco Products (SIC 21)

This particular study concentrates on two of the categories listed above; stone, clay, and glass products, and food and kindred products; since the energy consumed by these two categories represented about 80 percent of the group's total energy consumption in 1962.

Each industry category covers a broad spectrum of products. For example, the category of food and kindred products includes meat products, dairy products, canned and frozen foods, grain mill products, bakery products, sugar, candy and related products, beverages, and other food preparations. As a result, the technology and processes for these products vary widely.

In the absence of specific data and technical information on the industry categories in Group IV, a discussion of the general factors affecting fuel use and convertibility will follow.

Economic considerations heavily influence the type of fuel to be used, the fuel-burning equipment, and the determination of need for convertibility. Appendix 18 shows fuel costs as a percent of total material costs for each industry category in Group IV. It should be noted that fuel costs represented only one percent of the costs of all materials in 1962. With such relatively low fuel costs, it is doubtful that convertibility could be justified on the basis of relative fuel costs. Other economic factors, such as initial investment costs with the associated operating and maintenance expenses, would appear to have more significance in fuel selection and potential convertibility.

Intangible factors concerning the physical properties of the fuels, the fuel-burning equipment, and the distribution systems for the fuels appear to be of importance. The more

important intangibles include cleanliness, ease of control, handling, convenience, and air pollution restrictions. The nature of the industry category, such as food products, may require one or more of these intangibles. With low fuel consumption per establishment in Group IV, these intangibles may also have a greater significance. This significance is indicated by the high percentage of gas consumed in the major coal producing regions such as in OEP-OCD Region 4, as shown in Appendices 19 and 20.

Another factor is geographic location of the processing plants. In the past, the source of fuel supply nearest plant locations tended to determine fuel consumption patterns; however, with the extension of major gas pipelines and more efficient distribution systems, geographic location is less of a determining factor.

Physical factors, such as process design or fuel contractual requirements can necessitate fuel convertibility. The process design may require a back-up or alternate fuel supply for instantaneous conversion to insure the source of energy for an uninterruptible process. Further, an alternate fuel may be required if the contract for the primary fuel indicates that this supply may be interrupted.

Appendices 19 and 20 show purchased fuels by OEP-OCD Regions in trillion Btu and as a percent of the total energy from all purchased fuels within each region for stone, clay, and glass products, and for food and kindred products, respectively. A significant point, which can be drawn from both tables, is the high degree of dependence on gas in all regions, even in the areas where other fuels are less expensive.

Within Group IV the dependence on fuel oil and gas as fuels in the two categories under consideration ranged from 66 percent to 69 percent of the total energy from all purchased fuels in 1962. This dependence, combined with the apparent use of oil- and gas-fired package boilers, would indicate there is probably significant percentage which is convertible to gas and oil, respectively. For Group IV this percentage is estimated to be 75 percent of fuel usage.

* * *

Summary of Convertibility By Type of Industry

The preceding discussion has shown that convertibility potential is widespread through all industry groups because, mainly, of the dependence by most industries on boilers as the principal fuel consuming units. There appears to be, however, a more than average convertibility potential in Group I, and less than average conversion situations in Group II, which include many light manufacturing industries. The greatest amount of convertibility was found to be in the "Primary Metals", "Petroleum and Coal Products", "Paper and Allied Products", and "Stone, Clay and Glass Products" industries.

C. Interruptible Gas Sales

In most areas of the country, natural gas companies find it economically desirable and/or necessary to sell gas to certain industrial users on an interruptible basis. The major differential in consumer demand between winter and summer requirements, created by the use of natural gas for space-heating purposes, results in substantial under-utilization of immense fixed investments during the summertime. As a result, many gas companies (both distributors and pipelines) have arrangements under which they sell gas to industrial users on an interruptible basis (only when the gas is available in excess of firm requirements) at a price which exceeds the incremental cost of service to such interruptible customers. This procedure results in defraying some of the fixed costs of the gas companies and lessening the revenue requirement which would otherwise be borne by firm residential, commercial and industrial users.

Information on interruptible sales is not available by industry classification. Virtually all gas companies do report to the American Gas Association the amounts of sales which they have made, distinguished between firm industrial and interruptible industrial. In 1963, the amount of interruptible industrial sales was 2,133 trillion Btu's out of a national total of 5,400 trillion Btu's. This amounts to 40 percent of total industrial sales. The limited usefulness of this data, for the following reasons, should be kept in mind:

1. The definition of what constitutes an interruptible customer is not uniform among all of the gas companies in the Nation. Furthermore, some gas companies, in reporting to the AGA, do not distinguish between firm and interruptible sales; for such companies their total industrial sales have been allocated between the two components (in the aggregate) in the same proportions as the sales of companies which did distinguish.

2. The presence of interruptible gas service in an establishment is not necessarily perfectly correlated with convertibility. Many plants with flexible scheduling can utilize interruptible gas when available without installation of alternate fuel-burning equipment. In addition, different gas companies follow different practices. Some require alternate fuel-burning

equipment as a condition of interruptible service; others have no such requirement. Some gas companies, because of climatic or other local conditions, may interrupt for only relatively few days, during which time the customer may simply reschedule operations.

3. For those gas companies which interrupt on only relatively few days, the magnitude of the stockpile of alternative fuel available to such customers may be quite small. This means that they could convert to another fuel for only a limited period of time under normal operating practices. Such customers are nevertheless included as interruptible sales to the extent so classified by the gas companies.

4. It is possible that a relatively few industrial customers (but possibly large plants where shutdowns would be economically disruptive) who are classified as firm may maintain equipment permitting them to use some alternate fuel and may maintain some modest stockpile of such alternative fuel.

5. The amount of interruptible industrial gas sales is not necessarily indicative of the aggregate fuel requirements of establishments using such gas service because no data are available on the average percent of time during which interruptible service was curtailed; no data are available on the amounts of alternate fuels used during the same year in the same equipment, and no data are available on the amounts of other fuels used for other applications in the same establishments.

Since no comparable information on the volume of petroleum fuel and coal interruptible sales are available, there seems to be little usefulness of raw data on interruptible sales. The Committee feels that this avenue to identifying convertibility, therefore, has little possibilities at the current stage of useable information.

D. Geographic Considerations

In an emergency, it would be important to know where convertibility exists. As has been mentioned previously, little, if any, geographic information is available outside of

the standard statistical sources which report fuel usage. This information can be important as a first start to identify convertible users if for no other reason that conversion would be nil where total fuel utilization is small.

An examination of the consumption of fossil fuels by OEP-OCD Regions in manufacturing in 1962, as shown in the following table, shows that almost 65 percent of the Nation's consumption was in Regions 2, 4 and 5. Almost 25 percent is in Region 2, which includes a large concentration of the Nation's heavy metal industries. (See OEP-OCD Regions Map, Appendix 21).

GEOGRAPHIC BREAKDOWN OF FOSSIL FUELS
CONSUMED BY MANUFACTURERS - 1962
(By OEP-OCD Regions)

REGIONS	TRILLION BTU	PERCENT
1	919	10.7
2	2,110	24.7
3	915	10.7
4	1,593	18.6
5	1,842	21.5
6	497	5.8
7	499	5.8
8	190	2.2
Total	8,565	100.0

Source: 1963 Census of Manufactures

Further geographic information at the state, county, and metropolitan area levels can also be obtained from the Census of Manufactures data. It should be noted that as the geographic area becomes smaller, the published Census data becomes more incomplete because of statistical inconsistencies and company disclosure problems. This information could be obtained on a confidential basis, it is presumed, for government use, assuming it is necessary. It appears more advantageous to expand identification of geographic industrial fuel conversions by a survey of industrial boilers.

V. EMERGENCY CONVERTIBILITY OF RESIDENTIAL AND COMMERCIAL FUEL USAGE

Characteristically, individual fuel users in the residential and commercial sector consume relatively small volumes. The Committee firmly believes that to accomplish any worthwhile volume of alternate fuel usage among residential fuel users would create severe logistical and manpower problems. It is undoubtedly a fact that there are some commercial fuel usages which are of sufficient magnitude to provide worthwhile alternate fuel usage. Among these would be large office and apartment buildings; state and municipal institutional, school and governmental buildings; hospitals; central heating enterprises; laundries; etc. Over-all, however, the greater proportion of total fuel usage in this classification lies within the residential heating and other appliances subcategory, but the Committee was unable to find any quantitative data or even accurate estimates of the volume relationships as divided between residential and commercial fuel usages. Some data is available on gas; none on oil or coal.

From the following table, it can be seen that the greatest concentration of housing units (residential) is geographically located in OEP Regions 1 and 2, which are comprised of all of New England plus New York and Delaware, together with Pennsylvania, Ohio, Virginia, West Virginia, Maryland and Kentucky. Much of this area, in addition to being most heavily possessed of residential units, also lies in the area of heaviest fuels usage during winter months. Thus, due to the seasonal nature of demand for fuels, an emergency falling during summer months would very conceivably create little or no necessity for emergency conversion for space-heating. This would also be true even among many smaller types of commercial fuel usages. Secondary convertibility among commercial usages is more likely too, than among residential users, in any season because of fewer logistical problems.

Primary emergency convertibility, by definition, exists when the fuel-burning equipment can be converted within 5 days by use of materials and manpower already on the site. Since neither hardware materials nor technically qualified manpower is customarily found at small commercial or at residential establishments, there is little likelihood of any conversion capability.

HOUSING UNITS IN THE U. S. - 1960
(By OEC-OCD Regions)

REGIONS	UNITS	PERCENT
1	11,216,483	19.2
2	10,632,788	18.2
3	7,629,112	13.1
4	9,735,630	16.7
5	5,815,792	10.0
6	4,728,641	8.1
7	6,411,503	11.0
8	2,156,408	3.7
Total	58,326,357	100.0

SOURCE: Census of Housing

However, the Committee finds that a limited amount of secondary emergency convertibility (that accomplishable within 30 days) does exist. It is estimated that not more than five percent of the total fuel usage in the residential and commercial category is readily convertible. This would amount to not more than 550 trillion Btu's. There is no available data with respect to geographic distribution except to infer that it will be about equally spread throughout those OEP Regions where space-heating is an important factor. In the more mild areas of the Nation, of course, there are so few units needed as to make space-heating emergency conversion unnecessary. A discussion of pertinent statistics on the number of residential and commercial burner installations is given in Appendix 22.

VI. SUMMARY

The previous discussion has shown that any estimates of emergency convertibility on a quantitative basis are difficult. However, the information on fuel usage in industrial boilers and by types of industry does provide tentative estimates of convertibility. The purpose of this last section of the report is to summarize these estimates and what they would mean in an emergency situation.

First, it must be stressed that the accuracy of the convertibility estimates is subject to substantial error. This is so for a number of reasons, but principally that the amount of fuel interchangeability will never be known exactly even with essentially a unit-to-unit survey of fuel-consumer installations.

The estimates provided here are ideal figures, since these assume that the fuel-consuming equipment would not be affected by external fuel supply or other constrictions. In this sense, the convertibility estimates are maximum limits of fuel conversion possibilities (within a monthly period). Any emergency condition which would seriously change the fuel-consuming equipment, such as fire damage, etc., would lower the volume of convertible fuels.

With these qualifications, the Committee estimates that the amount of emergency convertibility in the United States is in the order of 6,850 trillion Btu's annually. Approximately two-thirds of this convertibility is primary (conversion possible within a five-day period) with the remaining third secondarily convertible (within a thirty-day period). Essentially all of the convertibility is in the industrial category as is shown in the following table:

EMERGENCY CONVERTIBILITY (TRILLION BTU)

	PRIMARY	SECONDARY	TOTAL
Industrial	4,625	1,675	6,300
Residential & Commercial	-	550	550
Total	4,625	2,225	6,850

Referring again to the above table, total convertibility (both primary and secondary) in the industrial sector is approximately 40 percent of fuel usage including fuel raw material requirements, but 70 percent of requirements by manufacturing companies for heat and power. The remaining convertibility, outside the industrial sector, is the relatively minor amount in the residential and commercial categories.

APPENDICES

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APPENDIX 1

FUEL STATISTICS ON RESIDENTIAL CONSUMERS

A. TYPE OF HEATING EQUIPMENT

1. U. S. Census of Housing - conducted every ten years; provides data on total number of households using coal or coke, oil, utility gas, bottled LPG, electricity, wood, and other fuels for cooking, water-heating and space-heating, as well as the type of furnace used (warm air, steam, or hot water, floor, wall, or pipeless, etc.). Data are subdivided by states, counties, and metropolitan areas.

The two major drawbacks to the 1960 Census are: (a) There is no break-out of single family or multi-family units; and (b) the oil figures include all grades of heating oil from kerosine to No. 6.

2. AGA and GAMA surveys - published annually, these report the total number of residential gas customers and the number of gas heating customers in each state. For restricted use of its members, the AGA also publishes this information by individual utility.

In addition, the AGA publishes a special survey every 4-6 years which enumerates residential gas customers by county and the degree of gas saturation for heating, cooking, and water-heating purposes. The most recent survey was conducted in 1962.

The principal shortcomings of these reports are that a gas customer is not necessarily the same as a household using gas per the Census definition, and that heating customers include central and non-central furnace units. In conducting the 1964 survey, information was requested on the total number of dwelling units using gas for heating in addition to the total number of gas heating customers, but these data were published only on a Census region basis.

3. Heating Publishers, Inc. surveys - each year in one of its summer issues, Indoor Climate enumerates by state the central and non-central gas heating units and gas water heaters installed during the previous year and those operating at year end. Central units are subclassified furnace, boiler, or conversion burners. No. 2 oil burner installations are similarly reported in the April issue of Fuel Oil & Oil Heat. These data are based on the Bureau of Census reports on shipments of heating and plumbing equipment and supplemented by sample questionnaires from equipment dealers.

While the two series appear to be comparable to each other, these are not the same as either the Census or the AGA series, since these include commercial, as well as residential installations. However, the boiler and furnace shipment data probably provide the only clue to potential fuel interchangeability.

4. Electric Heat & Air Conditioning - annually publishes data on the number of homes completely heated by electricity. In addition, information is included on the number of commercial and multi-unit housing installations and on auxiliary electric heating.

Published data show only four regional breakdowns, but since these are obtained by utility surveys, state numbers must exist.

5. Federal Power Commission - "All Electric Homes" - surveyed number of electrically heated homes as of January 1, 1964 in cities of 50,000 or more population.

6. U. S. Bureau of Census - reports shipments of coal-fired stokers but does not publish any geographic breakdown or classification of consumer.

B. FUEL CONSUMPTION

1. U. S. Bureau of Mines - "Shipments of Fuel Oil and Kerosine" published in July-August each year reports shipments of heating oil by grade in each state. No classification of residential consumption is contained in this report.

2. U. S. Bureau of Mines - "Natural Gas Production and Consumption" issued annually in late summer or early fall reports by state the number of gas customers and the annual consumption by each class of consumer. Data are derived from AGA reports but are expanded to reflect direct producer sales.

3. AGA Publications - "Gas Facts" published annually provides data on number of utility customers and volume of utility sales by class of customer in each state. Quarterly reports provide similar data on a regional basis.

4. U. S. Bureau of Mines - "Shipments of Bituminous Coal and Lignite" provides annual tonnages shipped to retail dealers in each state, however, no information is available by class of consumer.

5. Anthracite Institute - publishes annual information on shipments of domestic size anthracite to consuming states for the coal year April 1 through March 31. No information is available by class of consumer.

6. U. S. Bureau of Mines - publishes annually shipments of LPG for domestic and commercial use by state. No information is available on final class of consumer.

7. Electric Heat & Air Conditioning - publishes annual average consumption figures for electric heating on a regional basis.

8. FPC Report "All Electric Homes" - also included average annual use figures for all electric dwelling units in cities of 50,000 or more population. Data were subdivided as to total, heating and air-conditioning use.

APPENDIX 2

FUEL STATISTICS ON INDUSTRIAL CONSUMERS

A. The U. S. Census of Manufactures - conducted in 1947, 1954, 1958, and 1962 provides data on the various fuels consumed by industrial establishments subdivided by industry type and by state; data by standard metropolitan area were shown in the 1962 Census.

Published statistics do not differentiate between types or grades of oil and gas used, although the 1962 questionnaire obtained this information. There is some evidence that by-product gas is still included in some of the state figures, however, the 1962 report shows blast furnace, coke oven, and still gas as a separate entry. In addition, a number of differences exist between this report and those previously described.

B. The Iron and Steel Institute - "Annual Statistical Report" contains information on the total volumes of the various fuels used in the steel-making process. No geographic breakdown is included in the fuel section, although blast furnace capacity by state is shown.

C. U. S. Bureau of Mines - "Cement" report gives similar information each year for the cement industry and has the same limitation.

D. The National Coal Association - "Direct Natural Gas Sales to Industrial Consumers" lists annual volumes of such sales made by pipeline companies subdivided by state and individual customer. Original source is the FPC. No information is included on direct sales made by producers to industrial consumers.

E. Keystone Coal Buyers Manual - Provides annual data on captive tonnage produced by various industrial concerns.

F. Power Magazine - publishes an annual survey on industrial and commercial boiler installations. Data do not reflect a controlled or random sample but merely the interest of the reporting company.

APPENDIX 3

EXAMPLE OF PRIMARY "INSTANTANEOUS" CONVERTIBILITY

An example of Primary Instantaneous Convertibility can be a processor of dairy products. Production centers around milk and other dairy products such as ice cream mix, condensed milk and cottage cheese.

Natural gas is the main fuel used by the plant on an interruptible basis, with Number 6 fuel oil as the standby fuel.

Fuel is used to operate boilers, milk dryers, and other heating and processing equipment. Ninety percent of the electric power used to operate motors, lights and air conditioning is generated on the premises with an oil-gas engine driven generator.

In the event of disruption in the natural gas supply, the firm can instantaneously convert to the oil standby fuel which is stored on the premises. This allows the firm to operate all processes including all but 10 percent of the capability of the electrical equipment. Although electric energy use is not a function of this study, this illustration highlights the complete interchangeability of such a plant for its total energy requirements.

APPENDIX 4

EXAMPLE OF
PRIMARY "NON-INSTANTANEOUS" CONVERTIBILITY

An example of Primary Non-Instantaneous Convertibility can be a manufacturer of hydraulic cement. Five different types of basic cement are produced as well as a specific type of masonry cement mix.

Natural gas is the main fuel used in the process with a soft 12,000 Btu per pound coal as the standby fuel.

The direct fired kilns require most of the fuel used by the company, although small amounts are used for space heating, hot water and employee food service. All electric energy for lights, motors and air conditioning is purchased from a local power distributor.

If a disruption in natural gas supply occurs, the process can be converted to coal. This requires a change of all burning equipment as well as a redesign of the raw mix ingredients due to the different firing characteristics of the coal. The length of time required for the change-over ranges from six to twenty-four hours depending on the production stage when natural gas is disrupted.

APPENDIX 5

EXAMPLE OF SECONDARY CONVERTIBILITY

An example of Secondary Convertibility can be a manufacturer of ammonia and other closely related products. The main production of the plant includes anhydrous ammonia, ammonia liquor, urea fertilizer, urea cattle feed, crystal urea, and other nitrogen solutions.

Natural gas is used as a feedstock to supply a non-interruptible source of hydrogen. Minor volumes of natural gas also are used as a boiler fuel for generating steam used in a steam reforming process and also for heating the building. All electric power for lights, motors and air conditioning is purchased locally.

In the event of the disruption of the natural gas supply, production ceases. Standby fuel is not stored on the premises, and no facilities are available for propane storage. Neither the conversion equipment nor the conversion manpower skills necessary to change the catalyst process are available on the company premises. However, the plant is located in the immediate proximity where equipment and manpower are readily available. The time required to make all necessary changes to continue operations using a substitute fuel is estimated to be within the thirty day limit.

APPENDIX 6

COMMON TYPES OF EQUIPMENT AND FUELS USED IN RESIDENTIAL AND COMMERCIAL ESTABLISHMENTS

CLASS OF EQUIPMENT	FACTORY-BUILT PACKAGED UNITS	
	OIL-GRADE	GAS
Residential (One and Two Family Dwellings)		
Ranges	No. 1	Yes
Refrigerators	No. 1	Yes
Water Heaters	No. 2	Yes
Central Heating Equipment	No. 2	Yes
Laundry Dryers	None	Yes
Room Heaters	No. 1	Yes
Commercial (Apartments, Hotels, Hospitals, Office Buildings, Institutions and, in General, Sellers of Retail Services)		
Commercial Kitchen Equipment	No. 2 (Rarely Used)	Yes
Water Heaters	No. 2	Yes
Boilers	No. 2, 4, 5, 6	Yes*

* Gas systems designed for either atmospheric or power burners are used.

APPENDIX 7

PRINCIPAL TYPES OF INDUSTRIAL FUEL-BURNING EQUIPMENT AS USED IN SELECTED INDUSTRIES

INDUSTRY (EQUIPMENT)	COMMONLY USED FUELS		
	OIL	COAL	GAS
Cement and Lime			
Rotary Kilns	Yes	Yes	Yes
Vertical Shaft	Yes		Yes
Fluidized Bed	Yes		Yes
Dryers	Yes		Yes
Steel Producing Plants			
Blast Furnaces	Small Amounts	Coke	Small Amounts
Open Hearths	Yes		Yes
Soaking Pits	Yes		Yes
Reheat Furnaces	Yes		Yes
Steel Fabricating			
Annealing Furnaces	Yes		Yes
Heat Treating Furnaces	Yes		Yes
Atmosphere Generators			Yes
Forge Furnaces	Yes	Infrequently	Yes
Paint & Other Finish Ovens	Rarely		Yes
Wire Patenting, Etc.			Yes
Metal Melting Shops			
Non-Ferrous Foundries	Yes	Some Coke	Yes
Cast Iron Foundries		Coke	Small Amounts
Core Ovens	Occasionally		Yes
Mould Dryers	Occasionally		Yes
Wholesale Bakeries			
Bake Ovens	Yes		Yes
Glass Plants			
Melting	Yes		Yes
Annealing Lehrs	Occasionally		Yes
Cut-off & Forming Fires			Yes
Lamp Machines			Yes
Brick Plants			
Kilns	Yes	Yes	Yes
Dryers	Yes		Yes

APPENDIX 8

GENERAL CLASSIFICATIONS OF COMBUSTION SYSTEMS
GAS

SYSTEM	TYPE OF MIXERS & METHOD OF MIXING	RATIO CONTROL METHOD	VOLUME CONTROL, MANUAL OR AUTO	BURNER TYPES USED	TYPICAL FURNACE OR PROCESS USES
I Separate gas and air feeds to combustion chamber	None (both gas and air under pressure)	1. Manual: 2-valve 2. Automatic: a. Pressure balance b. Mech. linkage	Separate valves on gas and air lines	-	Open-hearth glass tanks, and lime kilns (used in large industrial gas applications)
II Nozzle mixing	None except at point of combustion (both gas and air under pressure)	1. Manual: 2-valve 2. Automatic: a. Pressure balance b. Mech. linkage	Separate valves on gas and air lines	Nozzle mixing with combustion block	Air heaters, heat-treating furnaces and forge furnace boilers
III Partial premixing requiring secondary air	1. Gas jet mixers; gas at press., air at zero 2. Air jet mixers; air at press., gas at zero 3. Mechanical mixers; both air and gas at zero	Manual or automatic	Valve in line of entraining fluid or valve in discharge line from mech. mixer	Open burners: 1. nozzles 2. tips 3. line 4. ribbon	All applications in which excess air is not harmful; heat machines
IV Complete premixing using kinetic energy only	1. Gas jet mixers; gas at press., air at zero 2. Air jet mixers; air at press., gas at zero	Manual (variable) or automatic (fixed)	Valve in line handling entraining fluid	Sealed tunnel burners, some non-tunnel and open burners	Furnaces, kilns, melters, processes and heating machines using open burners, generators, and boilers (units requiring close control of atmosphere in combustion chamber)
V Complete premixing using mechanical mixers	Fans, compressors, pumps, and diluters (both gas and air at atmospheric press.)	Adjustable or fixed over range of operation; manual or automatic	Mech. control of inlet gas and air or valves in mixture line from mixer outlet	Sealed tunnel burners, some non-tunnel and open burners	Furnaces, kilns, melters, generators, boilers, and processes and heating machines using open burners (units requiring close control of atmosphere in combustion chamber and/or wide range of operation)
VI Combination using parts of Systems I-V					Special processes mainly
VII Gas-Oil Systems				Burn both fuels simultaneously	Forges and other operations requiring high radiation levels
VIII Dual Fuel Systems				Burn either oil or gas but not at same time	Boilers and other large equipment where interruptible gas contracts are involved

APPENDIX 9

GENERAL CLASSIFICATIONS OF COMBUSTION SYSTEMS
OIL

SYSTEM	METHOD OF MIXING COMBUSTION AIR AND FUEL	METHOD OF ATOMIZATION	AIR-FUEL RATIO CONTROL METHOD	BURNER TYPE	TYPICAL FURNACE OR PROCESS USE
I Mechanical Atomization	1. Use of an Air Register, Diffuser and Refractory Throat for both. a. Natural Draft b. Forced Draft	1. Straight pressure type using nozzle. 2. Straight pressure type using sprayer plate.	1. Manual-Hand Valve 2. Automatic: a. Pressure Balance Type b. Mechanical Linkage	1. Straight Pressure Mechanical Atomizer Gun Style 2. Variable pressure mechanical atomizer (return flow) Gun Style	Dryers, Blast Furnaces, Open Hearth, Rotary Kilns, Furnaces, Power Boilers, Generators, etc. See Note 1
II Mechanical Atomizers with Auxiliary Means of Atomization	Use of Air Register and Refractory Throat. Diffuser can also be used.	1. Straight pressure type using steam to assist in atomizing the oil. a. High Pressure Air 25#, or greater b. Low Pressure Approx. 2-4# 2. Straight pressure type using air to assist in atomizing the oil. a. High Pressure Air 25# b. Low Pressure Air 1/2 to 5#	1. Manual-Hand Valve 2. Automatic: a. Pressure Balance Type b. Mechanical Linkage	1. Pressure type mechanical atomizer (inside mix.) having internal passages for steam or air and oil-steam or air mixes with oil inside nozzle 2. Pressure type mechanical (outside mix.) atomizer. Steam mixes with oil after oil leaves atomizer nozzle	Kilns, Fluidized Beds, Dryers, Blast Furnaces, Heat Treating Furnaces, Boilers Bake Ovens, Foundries, Steam Generators, etc. See Note 1
III Rotary Cup Atomizer	Air & Atomized Oil mixes as the oil leaves atomizer. Cup-mixing accomplished by centrifugal force imparted to air & oil.	1. High Speed Conical Metal Cup-Centrifugal Atomization	1. Automatic: a. Mechanical Linkage b. Pressure Balance	1. Rotary Cup Type	* See Below Steam Boilers, Hot Water Boilers, Marine Boilers, Power Plant Boilers, Cement Kilns, Soft Metal Melting Pots
IV Ultrasonic	Mixing and Blending occurs in Open Area	Sonic Energy Created by low Pressure Air or Steam (1-15 psi) atomizes the oil which is fed into Sonic Stream	1. Automatic: a. Linkage b. Pressure Balance	Pressure Type Gun Style with Ultrasonic Fuel Atomizer	Power Plant Boilers, Steam Boilers, Hot Water Boilers See Note 2
V Electrostatic	Not known	Use of Electrical Charges to Atomized Fuel	----------Experimental State----------		

NOTES: 1. Investigation has found that various types of oil-fired systems are used in most applications noted. There does not seem to be a specific application limited to a specific type of oil-fired system (excluding rotary burners).

2. The advent of the ultrasonic burner has been too recent to be used in the various applications other than those indicated.

* Candy Pan Cookers, Heat Treating Furnaces, Core Baking Ovens

APPENDIX 10

TECHNICAL CONSIDERATIONS OF CONVERTIBILITY

This discussion covers, in the following order, technical considerations of convertibility of (1) domestic heating equipment, (2) commercial heating equipment, and (3) industrial heating equipment.

DOMESTIC HEATING EQUIPMENT

In general, domestic heating equipment is built for use with one specific fuel and often only one grade of that fuel. Each of the general types of equipment in this class is discussed below. Exhibit A gives a summary for domestic equipment.

Incinerators

Incinerators fired by oil or gas are available for destruction of waste or garbage. Those presently fired by oil can be converted to gas, while those designed for gas firing might be convertible to oil only with some of the new, low-capacity burners appearing on the market.

Unvented Space Heaters

Unvented space heaters burning oil and gas are largely used for animal comfort, although some are used for human comfort. These heaters are not convertible.

Vented Space Heaters

Heaters of this type are available for coal, oil, or gas. Some of those which burn coal can be converted to gas or oil. Those designed for oil or gas cannot be converted to another fuel.

Recessed Wall Heaters

These vented wall heaters burn either oil or gas. It would be possible to put a gas burner in some oil-fired heaters, but most unlikely that a gas heater could be switched to oil.

Water Heaters

Heaters are available using all three fuels. Depending upon the design, most of the coal-fired heaters can be fired with the other two fuels. Some of the oil-fired heaters can be converted to gas, but none to coal. Gas-fired heaters cannot be converted.

Warm-Air Furnaces

Furnaces are available for all three types of fuel. Any coal furnace is readily convertible to either gas or oil. Oil furnaces can be converted to gas but not to coal. Although there may be a few furnaces designed for gas which could be converted to oil, generally the combustion chamber and flue-passage design would not permit it.

Boilers - Steam or Hot Water

Again, equipment is available for all three fuels. Coal-fired equipment is readily convertible to either oil or gas. Oil-fired boilers can burn gas but not coal. Some of the larger gas-fired boilers might be convertible to oil but not to coal.

COMMERCIAL HEATING EQUIPMENT

Commercial equipment is of considerably larger capacity than domestic equipment and enjoys a little more flexibility in the grade of fuel consumed, particularly with oil. The discussion on commercial equipment is summarized in Exhibit B.

Unit Heaters

These heaters are relatively small heaters suspended from the ceiling in large open areas, and are designed to heat a specific space in the total enclosed area. Those designed for oil can be converted to gas. Those designed for gas cannot be changed to oil.

Incinerators

In general, commercial incinerators can be fired interchangeably with either oil or gas.

Portable Unvented Heaters (Salamanders)

Equipment is available for all three fuels. Salamanders utilizing coal or coke are generally of too crude a design to consider conversion to oil or gas. Oil- and gas-fired designs are too specific to permit conversion to other fuels.

Water Heaters

Any of the three fuels can be used for water heating. Coal heaters can be readily converted to oil or gas. Oil heaters can be converted to gas but not coal. It is possible to convert some gas heaters to oil, but not to coal.

Warm-Air Furnaces

Equipment is available for all three fuels. Coal-fired equipment is readily converted to oil or gas. Oil equipment can be converted to fire gas but not coal. Some of the larger gas-fired equipment can be fired with oil, but not with coal.

Boilers - Steam or Hot Water

Equipment is available for all three fuels. Coal-fired equipment is readily converted to oil or gas. Oil equipment can be converted to gas, but not to coal. Some of the larger gas equipment can be fired with oil, but not coal. Some commercial equipment is large enough so it is built to fire either gas or oil interchangeably. This equipment cannot be converted to coal.

INDUSTRIAL HEATING EQUIPMENT

Industrial equipment may have very high firing rates and is much more flexible with respect to fuel type and quality than the smaller equipment. The discussion is summarized in Exhibit C.

Incinerators

Large industrial incinerators can be fired with either gas or oil interchangeably.

Boilers

Industrial boilers are very flexible in their fuel demands. Most of them are designed initially to handle at least two of the fossil fuels and sometimes all three fuels. A large industrial installation is rarely designed to burn only one fuel. If an installation is designed to burn coal alone or coal and gas or oil, it is a simple matter to add the capabilities for the other fuel(s). If the installation is designed for oil or gas, or oil and gas, it cannot be converted to coal without extensive modification.

Process Heating

The same points apply to process heating as to industrial boilers.

Heat Treating

Heat treating is done with oil or gas and cannot be done with coal. In general, oil and gas are readily convertible for this purpose.

APPENDIX 10 (CONT'D.)
Exhibit A

CONVERTIBILITY OF DOMESTIC HEATING EQUIPMENT

TYPE OF EQUIPMENT	DESIGNED TO BURN			CAN BE CONVERTED TO BURN		
	COAL	OIL	GAS	COAL	OIL	GAS
Incinerators		X		No	X	Yes
			X	No	Perhaps	X
Unvented Space Heaters		X		No	X	No
			X	No	No	X
Vented Space Heaters	X			X	Difficult	Difficult
		X		No	X	No
			X	No	No	X
Recessed Wall Heaters		X		No	X	Perhaps
			X	No	No	X
Water Heaters	X			X	Probably	Probably
		X		No	X	Perhaps
			X	No	No	X
Warm-Air Furnaces	X			X	Yes	Yes
		X		No	X	Yes
			X	No	No	X
Boilers - Steam or Hot Water	X			X	Yes	Yes
		X		No	X	Yes
			X	No	Perhaps	X

APPENDIX 10 (CONT'D.)
Exhibit B

CONVERTIBILITY OF COMMERCIAL HEATING EQUIPMENT

TYPE OF EQUIPMENT	DESIGNED TO BURN			CAN BE CONVERTED TO BURN		
	COAL	OIL	GAS	COAL	OIL	GAS
Unit Heaters		X		No	X	Yes
			X	No	No	X
Incinerators		X		No	X	Yes
			X	No	Yes	X
Portable Unvented Heaters (Salamanders)	X			X	No	No
		X		No	No	X
			X	No	No	X
Water Heaters	X			X	Yes	Yes
		X		No	X	Yes
			X	No	Perhaps	X
Warm-Air Furnaces	X			X	Yes	Yes
		X		No	X	Yes
			X	No	Perhaps	X
Boilers - Steam or Hot Water	X			X	Yes	Yes
		X		No	X	Yes
			X	No	Perhaps	X
		X	X	No	X	X

APPENDIX 10 (CONT'D.)
Exhibit C

CONVERTIBILITY OF INDUSTRIAL HEATING EQUIPMENT

TYPE OF EQUIPMENT	DESIGNED TO BURN			CAN BE CONVERTED TO BURN		
	COAL	OIL	GAS	COAL	OIL	GAS
Incinerators		X		No	X	Yes
			X	No	Yes	X
Boilers	X	X	X	X	X	X
	X	X		X	X	Yes
	X		X	X	Yes	X
		X	X	No	X	X
Rare	X			X	Yes	Yes
Rare		X		Perhaps	X	Yes
Rare			X	Perhaps	Yes	X
Process Heating	X	X	X	X	X	X
	X	X		X	X	Yes
	X		X	X	Yes	X
		X	X	No	X	X
	X			X	Yes	Yes
		X		Perhaps	X	Yes
			X	Perhaps	Yes	X
Heat Treating		X	X	No	X	X
		X		No	X	Yes
			X	No	Yes	X

APPENDIX 11

USE OF FUELS BY CERTAIN INDUSTRIES
IN GROUP II IN 1962 BY OEP REGIONS [a]

	COAL (000 TONS)	OIL (000 BBLS.)	GAS (MIL. CF.)
TEXTILES (SIC 22)			
1	195	5,126	5,196
2	590	1,099	2,875
3	2,198	1,591	38,467
4	16	16	722
5	0	45	1,758
6	0	0	0
7	-	-	-
8	-	-	856
Total	3,051	9,945	53,075
LUMBER & WOOD (SIC 24)			
1	0	242	00
2	14	215	370
3	8	384	2,757
4	96	125	942
5	0	0	5,763
6	0	24	836
7	-	746	2,564
8	-	1,074	7,707
Total	324	3,843	24,451
CHEMICALS (SIC 28)			
1	2,462	10,019	13,343
2	10,659	4,698	52,736
3	2,640	1,709	80,328
4	4,597	1,522	38,760
5	0	0	518,014
6	844	316	36,257
7	-	655	34,421
8	-	389	3,949
Total	22,600	19,866	782,894
LEATHER (SIC 31)			
1	84	1,077	359
2	142	198	734
3	13	0	339
4	50	37	424
5	0	0	0
6	23	0	148
7	-	-	-
8	-	-	-
Total	404	1,462	6,531

a/ Sums of volumes of eight OEP-OCD Regions do not always correspond to nationwide totals because some volumes are not reported by state to avoid disclosure of individual company data.

SOURCE: 1963 Census of Manufactures; Fuels and Electric Energy Consumed in Manufacturing Industries, 1962.

APPENDIX 12

FUELS USED BY REGIONS BY PAPER AND ALLIED PRODUCTS INDUSTRY IN 1962

OEP-OCD Regions	Bit. Coal & Lignite 1000 Tons	Coke & Breeze 1000 Tons	Fuel Oil Distillate and Residual 1000 BBLS	Gas MMCF
1	2,982	100	11,407	1,996
2	4,351	2	2,765	8,035
3	2,267	-	9,138	89,416
4	5,039	-	1,267	13,636
5	7	-	31	64,332
6	-	-	53	3,008
7	-	-	1,426	13,890
8	-	-	3,299	35,560
Total Eight Regions	14,646	102	29,386	229,873

SOURCE: 1963 Census of Manufactures.

APPENDIX 13

NUMBER OF CONCERNS OWNING MILLS, TOGETHER WITH THE NUMBER OF PAPER AND PULP MILLS IN THE UNITED STATES

LOCATION	CONCERNS	ESTABLISHMENTS	PAPER MILLS	PULP MILLS WHETHER CONNECTED WITH PAPER MILLS OR NOT	GROUND WOOD MILLS	SULPHITE PULP MILLS	SODA PULP MILLS	SULPHATE PULP MILLS	ROOFING	SEMI-CHEMICAL PULP MILLS	MISCELLANEOUS PULP MILLS
Alabama	10	12	11	13	3	0	0	8	2	0	0
Alaska	2	2	0	2	0	2	0	0	0	0	0
Arizona	2	2	1	3	2	0	0	1	0	0	0
Arkansas	7	9	11	7	1	0	0	5	1	0	0
California	24	33	30	7	0	0	0	2	3	1	1
Colorado	1	1	1	1	0	0	0	0	0	0	1
Connecticut	19	25	25	2	0	0	0	0	1	0	1
Delaware	4	6	6	0	0	0	0	0	0	0	0
District of Columbia	0	0	1	1	0	0	0	0	0	0	1
Florida	13	15	13	10	0	1	0	9	0	0	0
Georgia	16	17	16	13	0	0	0	9	2	1	1
Idaho	2	2	2	1	0	0	0	1	0	0	0
Illinois	28	30	28	9	1	0	0	0	4	1	3
Indiana	12	15	15	3	0	0	0	0	0	2	1
Iowa	3	3	3	2	0	0	0	0	0	2	0
Kansas	2	2	2	0	0	0	0	0	0	0	0
Kentucky	1	1	1	0	0	0	0	0	0	0	0
Louisiana	13	15	15	12	1	0	0	6	2	2	1
Maine	20	27	24	30	14	8	2	3	0	1	2
Maryland	6	5	5	2	0	1	0	0	0	0	1
Massachusetts	50	61	77	1	0	0	1	0	0	0	0
Michigan	38	39	54	15	4	1	0	3	0	3	4
Minnesota	11	12	16	15	5	2	1	2	0	3	2
Mississippi	8	9	8	9	3	0	0	2	0	1	3
Missouri	9	9	9	4	1	0	0	0	1	0	2
Montana	1	1	1	1	0	0	0	1	0	0	0
New Hampshire	20	23	27	5	0	2	0	1	0	1	1
New Jersey	33	36	40	4	1	0	0	0	1	1	1
New Mexico	1	1	1	1	0	0	0	0	1	0	0
New York	81	94	85	26	11	3	2	1	1	1	7
North Carolina	9	12	11	7	0	0	0	4	0	3	0
Ohio	39	48	48	8	0	0	1	0	3	2	2
Oklahoma	3	3	3	1	0	0	0	0	1	0	0
Oregon	21	26	22	20	1	6	0	5	0	3	5
Pennsylvania	47	53	53	17	1	1	1	5	3	2	4
Puerto Rico	3	3	3	1	0	0	0	0	0	0	1
Rhode Island	1	1	2	0	0	0	0	0	0	0	0
South Carolina	6	6	7	7	1	0	0	4	0	2	0
Tennessee	11	13	13	9	1	0	1	2	1	2	2
Texas	14	14	15	8	2	0	0	3	3	0	0
Vermont	10	10	10	2	2	0	0	0	0	0	0
Virginia	15	15	15	9	1	0	0	3	0	4	1
Washington	23	28	23	32	9	13	0	8	0	2	0
West Virginia	3	3	3	0	0	0	0	0	0	0	0
Wisconsin	38	49	50	42	16	14	0	3	0	4	5
TOTAL	464	791	806	362	81	54	9	91	30	44	53

SOURCE: Lockwood's Directory, 1965 Edition

APPENDIX 14

FUELS CONSUMED AT REFINERIES IN THE UNITED STATES, BY STATES: 1961 AND 1962

STATE	FUEL OIL (1,000 BBLS.)		ACID SLUDGE (1,000 BBLS.)		LIQUEFIED PETROLEUM GAS (1,000 BBLS.)		NATURAL GAS (MIL. CU. FT.)		REFINERY GAS (MIL. CU. FT.)		PETROLEUM COKE (1,000 S.T.)		COAL (1,000 S.T.)		PURCHASED ELECTRICITY (MIL. KWHS.)		PURCHASED STEAM	
	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962
Arkansas	8	54	-	-	28	3	10,217	12,182	7,763	6,112	65	68	-	-	63	87	-	-
Calif., Wash., Ore., Hawaii	6,438	7,636	8	-	654	796	76,752	69,362	148,075	146,788	1,495	1,458	-	-	2,315	2,459	2,241	2,367
Colorado	209	179	-	-	49	82	3,055	2,666	2,635	2,917	-	23	-	-	61	242	-	-
Delaware, Mass., R.I., Va.	840	743	-	-	-	-	117	142	18,788	18,304	555	548	-	-	493	464	6,290	6,488
Georgia, South Carolina, Fla.	286	184	-	-	-	-	263	881	-	17	-	-	-	-	8	9	-	-
Illinois	3,006	3,024	26	14	932	375	9,503	13,543	71,942	121,163	948	859	207	208	829	702	-	-
Indiana	5,497	4,667	4	-	32	2	5,940	8,152	37,983	32,353	402	323	37	24	176	329	-	-
Kansas	910	774	-	-	237	385	24,297	28,728	26,302	24,441	270	268	-	-	451	477	-	-
Kentucky, Tennessee	155	80	-	-	136	444	5,491	5,037	7,062	7,121	32	32	88	89	137	162	-	-
Louisiana	8	19	-	-	-	-	113,725	106,751	43,365	46,693	996 1/	1,054	-	-	1,091	1,157	16	17
Maryland	417	611	-	-	-	-	-	-	26	34	-	-	-	-	23	22	311	294
Michigan	1,735	1,953	-	-	69	214	2,031	1,902	9,057	8,703	34	35	-	-	250	250	821	655
Minnesota, Wisconsin, N. Dak.	1,752	1,753	-	-	50	45	940	1,761	8,657	8,717	113	112	-	-	106	142	-	-
Mississippi, Alabama	227	234	-	-	-	110	3,539	2,916	2,613	3,164	74	83	-	-	28	29	-	-
Missouri, Nebraska	459	437	-	-	285	309	2,659	3,631	6,696	7,786	110	113	-	-	5	5	-	-
Montana	722	874	-	-	68	48	3,261	2,510	4,647	5,757	135	155	-	-	68	72	-	-
New Jersey	8,085	7,904	27	40	341	102	-	-	26,125 1/	30,171	463	405	-	-	435	390	6,984	7,464
New Mexico	-	-	-	-	1	173	1,797	1,481	3,024 1/	2,567	13	31	-	-	22	23	-	-
New York	715	592	-	-	97	123	-	-	7,287	8,042	39	46	21	20	153	161	-	-
Ohio	1,779	1,703	-	-	258 1/	396	7,528	8,749	40,821	41,735	590	639	64	67	716	646	-	-
Oklahoma	228	314	176	123	332	568	49,048	48,599	41,929	45,480	443	420	-	-	462	475	-	-
Pennsylvania	5,799	6,021	91	94	2	159	23,859	27,617	41,591	43,821	606	671	284	310	884	880	448	516
Texas	385	604	206	89	278	942	412,461	427,359	197,669	217,772	2,492	2,742	-	-	2,263	2,030	186	948
Utah	452	455	-	-	128	198	4,221	4,651	3,194	5,932	76	83	-	-	98	101	-	-
West Virginia	47	47	-	-	-	-	638	651	508	502	-	-	13	18	18	19	-	-
Wyoming	753	856	-	-	32	28	10,686	10,606	8,856	9,220	98	95	-	-	88	87	-	-
Total United States	40,912	41,718	538	360	4,009 1/	5,502	772,028	789,877	766,615 1/	845,312	10,049 1/	10,263	714	736	11,243	11,420	17,297	18,749

1/ Revised

SOURCE: U. S. Bureau of Mines

APPENDIX 15

FUELS CONSUMED AT REFINERIES IN THE UNITED STATES BY DISTRICTS: 1961[1] AND 1962 AND SUMMARIES FOR 1952-1960

REFINERY DISTRICTS	FUEL OIL[2] (1,000 BBLS.)	ACID SLUDGE (1,000 BBLS.)	LIQUEFIED PETROLEUM GAS (1,000 BBLS.)	GAS (MIL. CU. FT.) NATURAL	GAS (MIL. CU. FT.) REFINERY	PETROLEUM COKE[3] (1,000 S.T.)	COAL (1,000 S.T.)	PURCHASED ELECTRICITY (MIL. KWHS.)	PURCHASED STEAM (MIL. LBS.)	TOTAL B.T.U. EQUIVALENT (BILLION B.T.U.)	CRUDE RUNS TO STILLS (1,000 BBLS.)	B.T.U. PER BARREL OF CRUDE RUN
1961[1]												
East Coast	15,206	109	341	22,920	85,352	1,663	-	1,745	13,616	278,454	409,923	679,000
Appalachian No. 1	910	9	99	1,959	8,984	-	318	268	417	26,818	36,406	737,000
Appalachian No. 2	129	-	44	1,119	12,016	80	64	148	-	18,644	35,855	520,000
Ind., Ill., Ky., etc.	12,055	30	1,383	29,372	154,838	1,926	332	2,058	821	340,573	544,776	625,000
Minn., Wis., N. & S. Dak.	1,752	-	50	940	8,657	113	-	106	-	24,547	44,746	549,000
Okla., Kans., Mo., etc.	1,596	176	854	76,004	74,927	823	-	918	-	196,365	262,730	747,000
Texas Inland	310	-	74	40,000	24,860	326	-	1,023	172	82,376	110,872	748,000
Texas Gulf	75	206	204	372,461	172,809	2,166	-	1,240	14	633,827	688,042	921,000
Louisiana Gulf	9	-		110,639	41,302	996	-	1,076	16	190,782	255,378	747,000
Ark., La. Inland, etc.	233	-	28	16,842	12,438	139	-	78	-	36,029	41,115	876,000
New Mexico	-	-	1	1,797	3,024	13	-	22	-	5,350	8,906	601,000
Rocky Mountain	2,136	-	277	21,223	19,333	309	-	246	-	66,181	103,639	639,000
West Coast	6,501	8	654	76,752	148,075	1,495	-	2,315	2,241	326,439	444,770	734,000
Total United States	40,912	538	4,009	772,028	766,615	10,049	714	11,243	17,297	2,226,385	2,987,158	745,000
B.t.u. equivalent[4] (Billion b.t.u.)	257,214	2,421	17,275	810,629	758,489	302,676	18,564	38,361	20,756	2,226,385		
1962												
East Coast	15,235	134	102	27,617	90,969	1,670	-	1,660	14,354	290,254	406,223	715,000
Appalachian No. 1	866	-	282	1,673	9,923	-	347	284	409	28,852	36,723	786,000
Appalachian No. 2	134	-	64	1,178	11,559	87	67	156	-	18,843	35,047	538,000
Ind., Ill., Ky., etc.	11,293	14	1,367	36,206	199,515	1,801	322	1,933	655	385,080	546,649	704,000
Minn., Wis., N. & S. Dak.	1,753	-	45	1,761	8,717	112	-	142	-	25,665	46,636	550,000
Okla., Kans., Mo., etc.	1,525	123	1,263	80,958	77,707	801	-	957	-	205,921	270,683	761,000
Texas Inland	462	-	203	40,631	30,193	342	-	501	551	89,397	112,979	791,000
Texas Gulf	142	89	739	386,728	187,579	2,400	-	1,530	396	676,666	724,841	934,000
Louisiana Gulf	19	-	-	104,571	44,946	1,053	-	1,146	17	190,645	270,470	705,000
Ark., La. Inland, etc.	289	-	113	17,278	11,023	151	-	127	-	36,483	42,153	865,000
New Mexico	-	-	173	1,481	2,567	31	-	23	-	5,887	9,433	624,000
Rocky Mountain	2,364	-	355	20,433	23,825	357	-	502	-	74,210	110,980	669,000
West Coast	7,636	-	796	69,362	146,788	1,458	-	2,459	2,367	26,641	456,814	715,000
Total United States	41,718	360	5,502	789,877	845,312	10,263	736	11,420	18,749	2,354,544	3,069,631	767,000
B.t.u. equivalent[4] (Billion b.t.u.)	262,281	1,620	23,708	829,370	847,848	309,120	19,136	38,963	22,498	2,354,544		
Year												
1952	40,018	3,599	N.A.	536,402	425,835	1,466	766	4,251	6,680	1,556,356	2,441,259	638,000
1953	41,342	2,910	N.A.	558,695	477,931	1,806	735	4,727	7,309	1,674,946	2,554,865	656,000
1954	47,410	2,474	N.A.	563,315	501,574	1,895	876	5,364	7,018	1,759,617	2,539,564	693,000
1955	41,971	2,228	N.A.	615,243	591,234	2,450	884	6,134	7,765	1,944,279	2,730,218	712,000
1956	37,935	1,934	N.A.	679,343	653,690	2,671	1,067	6,917	8,586	2,083,145	2,905,106	717,000
1957	39,613	1,525	4,209	682,270	694,668	4,101	939	8,609	13,838	2,226,346	2,890,436	770,000
1958	43,661	1,101	3,695	681,384	715,152	4,498	1,027	8,632	18,837	1,975,973	2,776,094	712,000
1959	41,853	895	3,249	752,239	743,052	5,354	951	9,355	17,694	2,075,489	2,917,661	711,000
1960	41,212	881	3,679	775,154	752,881	9,204	742	10,357	17,863	2,196,589	2,952,534	744,000

1/ Revised.
2/ Includes a small quantity of crude oil used directly as fuel amounting to less than 1 percent of total fuel oil consumed.
3/ Includes catalyst coke.
4/ Conversion factors: Fuel oil, 6,287,000 b.t.u./bbl.; Acid sludge, 4,500,000 b.t.u./bbl.; L.P.G., 4,309,000 b.t.u./bbl.; Natural gas, 1,050 b.t.u./cu. ft.; Refinery gas: for 1962, 1,003 b.t.u./cu.ft.; 1961, 989 b.t.u./cu.ft.; Petroleum coke, 30,120,000 b.t.u./short ton; Coal 26,000,000/short ton; Purchased electricity, 3,412/kwh.; Purchased steam 1,200/lb.

SOURCE: U. S. Bureau of Mines

APPENDIX 17

FUELS USED BY REGIONS IN TRANSPORTATION EQUIPMENT INDUSTRY IN 1962

OEP-OCD Region	Bit. Coal & Lignite 1000 Tons	Coke & Breeze 1000 Tons	Fuel Oil Distillate and Residual 1000 BBLS.	Gas MMCF
1	239	36	2,802	3,383
2	911	2	1,114	11,279
3	-	-	64	2,626
4	2,495	118	1,552	31,526
5	-	-	-	697
6	108	2	143	6,453
7	-	-	283	8,779
8	-	-	26	416
Total U. S.	3,753	158	5,984	65,159

SOURCE: 1963 Census of Manufactures

APPENDIX 18

PURCHASED FUEL AS PERCENT OF TOTAL MATERIAL COST
(Miscellaneous Manufactured Products)

TOTAL U. S. - 1962

	COST OF ALL MATERIALS (Million $)	COST OF PURCHASED FUELS (Million $)	FUEL COST AS PERCENT OF MATERIAL COST
1. Clay, Stone and Glass Products	4,976	338	6.8
2. Food and Kindred Products	46,021	325	0.7
3. Machinery, Except Electrical	12,423	107	0.9
4. Electrical Machinery	12,311	70	0.6
5. Misc. Manufacturing, Incl. Ordnance	4,830	31	0.6
6. Instruments and Related Products	2,449	18	0.7
7. Tobacco Products	2,894	5	0.2
TOTAL	85,904	894	1.0

SOURCE: Census of Manufactures.

APPENDIX 19

STONE, CLAY, AND GLASS PRODUCTS
ENERGY OF PURCHASED FUELS - YEAR 1962

OEP-OCD REGION	COAL AND COKE		FUEL OIL		GAS		OTHER		TOTAL	
	TRIL. BTU	PERCENT	TRIL. BTU	PERCENT	TRIL. BTU	PERCENT	TRIL. BTU	PERCENT	TRIL. BTU	PERCENT
1	24.5	32.6	23.1	30.8	24.3	32.4	3.2	4.2	75.1	100.0
2	116.8	45.0	12.4	4.8	126.0	48.5	4.4	1.7	259.6	100.0
3	14.6	14.6	12.1	12.1	70.5	70.7	2.6	2.6	99.8	100.0
4	64.4	47.2	11.5	8.4	57.2	41.9	3.4	2.5	136.5	100.0
5	0.8	0.8	0.2	0.2	96.7	95.6	3.5	3.4	101.2	100.0
6	15.4	21.7	1.2	1.7	52.9	74.6	1.4	2.0	70.9	100.0
7	3.2	3.1	5.0	4.8	92.8	89.6	2.6	2.5	103.6	100.0
8	-	-	1.2	21.0	4.2	73.7	0.3	5.3	5.7	100.0
TOTAL U. S.	239.7	28.2	66.7	7.8	524.6	61.5	21.4	2.5	852.4	100.0

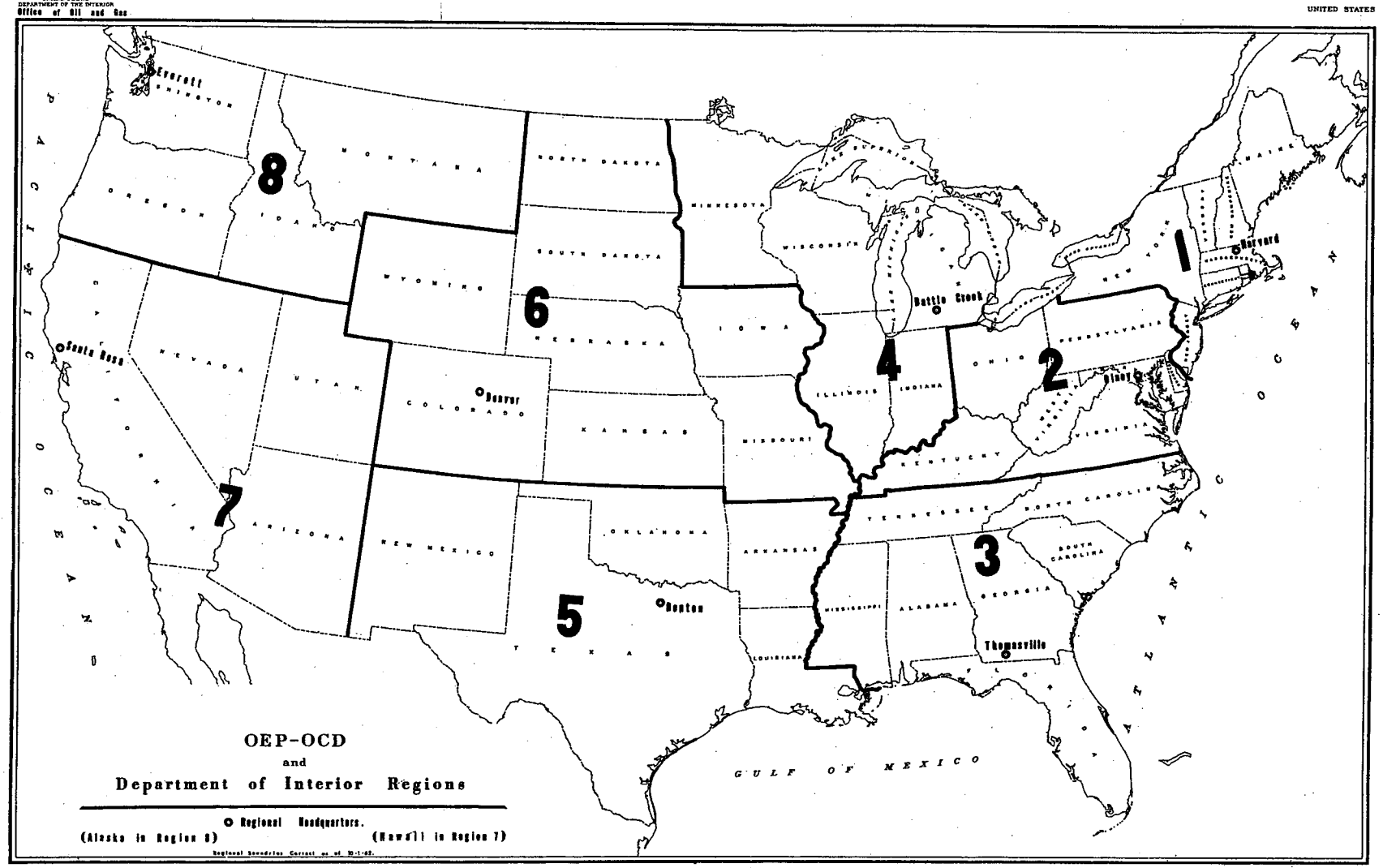
SOURCE: Census of Manufactures.

APPENDIX 20

FOOD AND KINDRED PRODUCTS
ENERGY OF PURCHASED FUELS - YEAR 1962

OEP-OCD REGION	COAL AND COKE		FUEL OIL		GAS		OTHER		TOTAL	
	TRIL. BTU	PERCENT	TRIL. BTU	PERCENT	TRIL. BTU	PERCENT	TRIL. BTU	PERCENT	TRIL. BTU	PERCENT
1	16.7	19.4	46.1	53.5	18.3	21.2	5.1	5.9	86.2	100.0
2	44.1	44.5	22.4	22.6	27.1	27.4	5.4	5.5	99.0	100.0
3	3.0	6.2	10.8	22.4	30.4	63.1	4.0	8.3	48.2	100.0
4	95.3	49.3	23.1	11.9	66.9	34.6	8.2	4.2	193.5	100.0
5	-	-	-	-	42.1	94.7	2.3	5.3	44.4	100.0
6	34.4	31.9	4.0	3.8	64.2	59.4	5.3	4.9	107.9	100.0
7	0.5	0.7	8.5	12.1	58.0	82.6	3.2	4.6	70.2	100.0
8	2.2	7.5	4.7	16.0	21.0	71.4	1.5	5.1	29.4	100.0
TOTAL U. S.	196.2	28.9	119.6	17.6	328.0	48.3	35.0	5.2	678.8	100.0

SOURCE: Census of Manufactures.


UNITED STATES
DEPARTMENT OF THE INTERIOR
Office of Oil and Gas
UNITED STATES
Everett
Denver
Santa Rosa
Battle Creek
Harvard
Dallas
Thomasville
Boston
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OREGON
MONTANA
IDAHO
WYOMING
SOUTH DAKOTA
NEBRASKA
COLORADO
NEVADA
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ARIZONA
NEW MEXICO
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ARKANSAS
LOUISIANA
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PENNSYLVANIA
NEW YORK
MAINE
FLORIDA
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
OEP-OCD
and
Department of Interior Regions
Regional Headquarters.
(Alaska is Region 8)
(Hawaii is Region 7)
Regional Boundaries Current as of 10-1-82.
17830

APPENDIX 22

DISCUSSION OF RESIDENTIAL AND COMMERCIAL BURNER STATISTICS

During the year of 1964, Fueloil and Oil Heat Magazine estimates that there were 551,703 distillate oil burner installations in the United States, including both residential and small commercial applications, using domestic types of burners and No. 2 fuel oil. This figure included 163,690 units for new homes; 269,341 as replacements, and 118,672 as conversions. The range of installations per month was from a high of 66,998 in December, to 34,413 in February. These figures provide an indication of what industry manpower might be able to accomplish at residences within a 30 day period, if hardware were available. For 1964, Fueloil and Oil Heat also estimated that 36,133 commercial oil burners were shipped. A monthly average would be 3,012.

Inventories of hardware would be found at three levels: manufacturers, wholesalers, and dealers. For use during an emergency, dealer stocks would be more available than manufacturer stocks.

According to Fueloil and Oil Heat, dealer stocks, as of December 31, 1964, were 9,399 oil boilers; 15,530 oil furnaces, and 15,938 separate burners. Inventory of tank stocks was 26,162.

No information about wholesale inventory is available, but as of January 1, 1965, manufacturers' stocks of oil burners and complete units were 43,584. No data is available concerning inventories of commercial burners.

From similar data obtained from the Gas Appliance Manufacturers Association, the average monthly shipments, by manufacturers, of gas burning units, are calculated in the table at the top of the following page.

RESIDENTIAL	MANUFACTURER STOCKS ON HAND	MANUFACTURER SHIPMENTS
Warm-Air Furnaces	133,640	92,127
Conversion Boilers	10,447	8,395
Boilers	23,077	884
Totals	167,164	101,406
COMMERCIAL		
Unit Heaters	15,698	13,533
Duct Furnaces	5,655	2,776
Totals	21,353	16,309

Investigation into the magnitude of availability of small oil or gas fired, more or less portable "space heaters," has brought forth the impracticality of dependence upon these appliances to any extent for emergency conversions, because they are not produced or available in sufficient quantity to provide reliance.

The Institute of Appliance Manufacturers reported total 1964 factory shipments of 182,120 vented oil fired room heaters and 144,713 portable unvented oil fired room heaters (mostly for export). December 31, 1964 manufacturer inventories were 43,880 vented heaters and 17,519 unvented heaters. No data is available for dealer installations or inventories. In any case, the numbers are too small to be significant.

The Gas Appliance Manufacturers Association also provided data for gas fired space-heating equipment. The table below provides average monthly manufacturers' shipments for 1964, and their company-owned stock on hand (units) as of December 31, 1964.

PERCENT OF INDUSTRY COVERED		MANUFACTURER SHIPMENTS	MANUFACTURER STOCK ON HAND
70.4	Gas Fired Direct Heating Equipment	72,093	196,322

If the data at the bottom of the preceding page is projected for the entire industry, the figures would be estimated as follows:

	MANUFACTURER SHIPMENTS	MANUFACTURER STOCK ON HAND
Gas Fired Direct Heating Equipment	102,405	278,866

This review of available data does indicate a very limited degree of Secondary Emergency Convertibility for residences and commerical establishments, subject to very modest inventories of hardware, and manpower resources to install it.