THE DEMAND FOR SULFUR CONTROL METHODS IN ELECTRIC POWER GENERATION

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INTRODUCTION

This paper examines the features of air quality legislation that have an impact on the demand for sulfur oxide control measures for the power industry; the limitations on sulfur imposed by emission regulations, and the electric power supply situation. Finally, estimates of probable demand are derived for various quality fuels and for sulfur oxide control equipment in the electric power industry in the next several years.

AIR QUALITY REGULATIONS

The Clean Air Act of 1967 called for the designation of air quality control regions by the Federal Government with the consent of the state and with local approval. Furthermore, the Federal Government had to issue for each pollutant, air quality criteria from which standards could be established. It had to issue companion reports on control technology for the reduction of emissions from various sources. Then, state governments were to establish air quality standards for their designated regions and adopt plans for implementation of control programs that would achieve constituted standards.

Under the provisions of the 1967 Act, areas were being designated as control regions in a sequence according to their severity of pollution, proceeding from the worst to the least polluted. This approach appeared to have a built-in mechanism for accelerated and achievable control activity while simultaneously permitting the primary energy supply and control equipment industries to adjust in an orderly and timely manner to a gradual, but intensified, demand for high quality fuels and emission control equipment. However, to some, the procedures appeared too tedious and slow. Consequently, the Clean Air Act as

Note: The views expressed herein are those of the author and do not necessarily represent the views of the Federal Power Commission.

amended in 1970 was designed to shorten the procedures and hasten the day in which all areas of the Nation would be brought under control, regardless of the current quality of its air. The provisions of this recent legislation accentuate the demand for control equipment and all forms of "clean" energy.

The Clean Air Act as amended in 1970 required that all areas of the Nation be designated very quickly as air quality control regions. Every part of the United States has now become part of an intrastate or interstate air quality control region. There are 237 control regions in the lower forty-eight states. All sources of pollution anywhere in the nation are now subject to regulation; thus, the demand for various control measures is immediately intensified nationwide. The location of the regions and the magnitude of their current pollution problem is shown in Figures 1 and 2.

The legislation also required the Environmental Protection Agency (EPA) to establish national primary ambient air quality standards to protect health and secondary standards to protect the public welfare. Ambient standards were greatly needed as a guide to the degree of emission controls required in various regions. National standards for particulates, sulfur oxides, nitrogen oxides, carbon monoxide and hydrocarbons, and photochemical oxidants were issued in April 1971. The states could set standards within their own boundaries more stringent than those of the Federal Government. However, by July 1975, the states had to achieve air quality equal to or better than the national standards.

The principal pollutants of concern to fossil fuel-fired electric power plants are sulfur oxides, particulates, and nitrogen oxides. The national ambient air quality standards for these three pollutants are shown in Table I.

NATIONAL AMBIENT AIR QUALITY STANDARDS

POLLUTANT	AVERAGING TIME	PRIMARY STD.		SECONDARY STD.	
		µg/m3	p.p.m.	µg/m3	p.p.m.
SULFUR OXIDES	Annual	80	0.03	60	0.02
	24 Hour*	365	0.14	260	0.1
	3 Hour*	-	-	1300	0.5
PARTICULATE	Annual	75	-	60	-
	24 Hour*	260	-	150	-
NITROGEN OXIDES	Annual	100	0.05	100	0.05
	24 Hour*	250	0.13	250	0.13

*Not to be exceeded more than once per year.

Table I

By January 30, 1972, each state was required to adopt and to submit to EPA a plan providing for the implementation, maintenance, and enforcement of a program which would enable it to meet the national primary ambient air quality standards within its regions by the middle of 1975. EPA must approve or reject these plans or portions of them by May 30, 1972.

Due to the shortness of time, the states had a tendency to determine the degree of reduction in emissions needed to meet the national or their own more stringent ambient air quality standards for their worst polluted region and then to apply the same degree of reduction to all other regions in the state. Lack of individual regional analysis which tailor regulations to each region's specific needs intensifies the demand for clean fuels and control equipment due to an aggregation of excessive requirements. Non-critical regions are thus put in competition with the critically polluted regions for the limited "clean" fuels and control devices.

EPA also had to establish national emission standards for certain categories of new sources. Table II shows the Federally mandated emission standards for new and modified fossil-fired steam generators. They apply to units with a capacity of 250 million Btu per hour (i.e., about 25 megawatts) or larger for which major construction or modification contracts were signed after August 17, 1971.

STANDARDS OF PERFORMANCE FOR
NEW FOSSIL-FIRED STEAM GENERATORS
(construction commenced after August 17, 1971)

	STANDARDS Lbs. per Million Btu		
FUEL TYPE	PARTICULATE	SULFUR OXIDES	NITROGEN OXIDES
SOLID	0.10	1.2	0.70
LIQUID	0.10	0.80	0.30
GASEOUS	-	-	0.20

Table II

Having examined the air pollution regulations influencing the demand for various quality fuels and for control devices, consider next the Nation's need for electric generation as a factor in the magnitude of the demand for controls.

OUTLOOK FOR ELECTRIC POWER GENERATION

Many of the projections used in this section were taken from the Federal Power Commission's 1970 National Power Survey. More than one hundred experts representing all segments of the electric power industry and branches of government contributed to its contents.

As illustrated in Figure 3 the electric power industry of the United States in 1970 generated nearly eighty-two percent of the electricity in fossil-fueled plants. Almost all of the remainder, except for 1.4 percent produced by nuclear plants, was generated by hydro-power. Nuclear generation is expected to make significant inroads into the generation picture of the next two decades and, consequently, the relative position of fossil-fueled generation will decrease from about 82 percent in 1970 to about 44 percent in 1990.

Figure 4 shows that the electric power industry generated 1.541 billion megawatt-hours in 1970. In the process it consumed approximately one-quarter of all the primary energy used during that year by all segments of the American economy. During the next two decades total electric power generation by electric utilities is expected to about double every ten years. Total generation is estimated to reach 3.11 billion megawatt-hours in 1980 and close to 6 billion megawatt-hours in 1990. In the same period, fossil-fueled generation will increase to about 1.9 billion megawatt-hours in 1980 and about 2.6 billion megawatt-hours in 1990. While fossil-fueled steam plants will supply a decreasing portion of the total as shown in Figure 3 the fossil-fueled units will supply twice as much electric energy in 1990 as in 1970. This is further reflected in projected fossil-fueled capacity additions from 1970 to 1990 shown in Table III.

The fossil-fueled energy was generated at plants having 3298 boiler-generator units with a total steam-electric generating capacity of 259 thousand megawatts. The capacity will increase to 558 thousand megawatts by 1990. Average size of the units will increase from 80 to 370 megawatts and the number of units will decrease to 1520 in 1990.

During the same period, 1970 to 1990, total generating capacity, including nuclear and hydroelectric plants, is expected to nearly quadruple from 340 thousand megawatts to 1260 thousand megawatts--an increment of 920 thousand megawatts.

Some of the 920 thousand megawatts of generating capacity will be required by the "clean" primary energy and control process industries sewage treatment plants, incinerators, and others to accomplish the environmental goals in the fields of air and water pollution control and solid waste management. Electricity is very necessary for the achievement of this Nation's environmental goals, and serious thought must be given to the trade-off of the environmental benefit of the use of electricity relative to the environmental impacts of its generation.

In the shorter range projection to the year 1975, when the state air pollution control programs are to be implemented, Table III shows that there will be about 2900 fossil-fueled units with a total estimated capacity of 320 thousand megawatts. The average size of the fossil-fueled units in operation during that year will be about 110 megawatts.

U.S. FOSSIL-FUELED STEAM-ELECTRIC CAPACITY

YEAR	CAPACITY MW (Thous.)	NO. OF UNITS	AUG. SIZE MW (Thous.)
1970	259	3,298	80
1975	320	2,900	110
1980	380	2,389	160
1990	558	1,520	370

Table III

The Federal Power Commission, with the cooperation of the Environmental Protection Agency, collects on FPC Form 67 air and water quality control data for each fossil fuel-fired electric generating plant of 25 megawatts and greater. Under this program the FPC collected information for the year 1969 from 655 fossil-fueled plants with 2995 boiler-generator units having a total capacity of 244 thousand megawatts, as compared with the 3298 units with a total capacity of 259 thousand megawatts reported in Table III for the year 1970.

Form 67 data shows that of the 2995 units surveyed for the year 1969, 1150 units were primarily coal-fired, 945 units were primarily oil-fired, and about 900 units were primarily gas-fired. Assuming that the 303 small units not covered by the Form 67 program divide in the same proportions, then the distribution of the number of units in operation in 1970 by type of fuel fire is shown in line 1 of Table IV.

PROJECTED MIX OF
FOSSIL-FUELED GENERATING UNITS

	TYPE OF FUEL		
	COAL	OIL	GAS
NUMBER OF UNITS 1970	1265	1045	990
ADDITIONS	+66	+26	+24
Subtotal	1331	1071	1014
RETIREMENTS	-281	-141	-80
Subtotal	1050	930	934
CONVERSIONS	-90	+120	-30
NUMBER OF UNITS 1975	960	1050	904

Table IV

From information reported on April 1, 1971, by the nine Regional Electric Reliability Councils in response to the Commission's Statement of Policy on Adequacy and Reliability of Electric Service, Order No. 383-2, the author estimates that about 116 additional units with 70 thousand megawatts of capacity might be in operation by the end of the year 1975. As shown in the second line of the Table, 66 are expected to be coal-fired, 26 oil-fired, and 24 gas-fired.

There were 1004 fossil-fueled units with a total capacity of about 18 thousand megawatts which were installed in 1940 or earlier, but were still in operation in 1970. Some of these units date back to the first two decades of this century. These units were an estimated 56 percent coal-fired, 28 percent oil-fired, and 16 percent gas-fired. Assuming that one half of each of the types of older units will be retired by 1975, then 281 coal-fired, 141 oil-fired and 80 gas-fired units will be retired. In addition 90 coal-fired and 30 gas-fired units are expected to be converted to oil-fired.

Consequently, by 1975 there will be 960 coal-fired and 1050 oil-fired for a total of 2010 units which will require some form of sulfur emission control either through the use

of stack devices for the removal of sulfur dioxide from power plant flue gases or through the use of low-sulfur fuels.

FOSSIL FUEL DEMAND FOR ELECTRIC POWER GENERATION

The National Power Survey projections of electric power generation, when translated into primary energy demand based on energy conversion efficiencies now demonstrated and anticipated during the next several years, indicate a continuing growth in fuel consumption in the form of coal, oil, and gas. Projected requirements of these fuels for electric power generation in terms of coal equivalent quantities is shown in Figure 5.

The most remarkable element of this projection is the very rapid decline in the rate of growth of natural gas usage for electric power generation. This projection is supported by a variety of gas curtailment cases currently before the Commission. It means, of course, that gas, the only "clean" fossil fuel, cannot be counted on to make a significant contribution to the reduction of undesirable emissions from electric power plants. The use in 1969 of the various fossil fuels for electric power generation expressed in their customary units of measure was 310 million tons of coal, 251 million bbls. of oil, and 3486 billion cubic feet of gas.

CURRENT QUALITY OF FUELS

Figure 6 prepared from information collected in FPC Form 67 shows the quantities of coal at the various sulfur levels consumed by electric utilities in 1969. The 303 million tons of coal burned by electric utilities reporting in 1969 ranged in sulfur content from 0.4 percent to as much as 6 percent by weight. The bulk of the coal, however, was in the two to four percent sulfur range; the weighted average was 2.58 percent. The distribution curve is bimodal, with one peak at below one percent sulfur. This, most likely, reflects an early response by several utilities to local air pollution control regulations requiring the use of fuels with less than one percent sulfur.

The quality of coal burned by electric utilities in 1969 was compared plant-by-plant and state-by-state with regulations in state implementation programs. About 44 million tons of coal consumed by electric utilities in 1969 in 255 units could meet the standards; whereas, 259 million tons with an average sulfur content of 2.81 percent was burned in 1010 units that could not meet standards and would require control measures.

Likewise, Figure 7 shows the quantities of oil at various sulfur levels consumed by electric utilities. Similarly, the sulfur content of the oil used in 1969 ranged from a fraction of a percent to nearly 3 percent, with a major portion of the oil in the 1.4 to 2.6 percent sulfur range. The weighted average was 1.66 percent. In the case of the oil distribution curve, three peaks were observed. One peak at 0.3 percent. Another at slightly below the one percent sulfur level, and the largest peak at an average sulfur content of 1.9 percent. Both peaks under 1 percent sulfur undoubtedly reflect response to local sulfur emission control regulations.

The quality of the oil burned by electric utilities in 1969, compared plant-by-plant and state-by-state, with the preliminary state implementation programs showing that 59 million bbls. of oil burned in about 310 units could meet the standards and that 199 million bbls. of oil burned in 735 units would require some type of control measures to meet the proposed sulfur limitations.

Table V shows fuel requirements projected in the National Power Survey. In 1975 when state plans are to be fully implemented, except where a two-year extension is asked, 425 million tons of coal will be required and 565 million bbls. of oil will be needed.

FOSSIL-FUEL REQUIREMENTS
FOR ELECTRIC POWER GENERATIONS

YEAR	COAL (Million Tons)	OIL (Million Bbls)	GAS (Billion Cu. Ft.)
1969	310	251	3486
1970	322	332	3894
1975	425	565	4110
1980	500	640	3800

Table V

Consider company plans for supplies of low sulfur fuels to get an order of magnitude of added supplies of low sulfur fuels that would be required in 1975 if control devices were not in operation at the electric generating units.

The National Coal Policy Conference estimated about a year ago that there would be 300 million tons of new mine capacity

by 1975 of which 75 million tons would be in low sulfur coal. Assume 2/3 or 50 million tons could be dedicated to the electric utilities. This quantity added to the 45 million tons of low sulfur coal which already meets the standards yields 94 million tons of naturally occuring low sulfur coal that could be available in 1975. Subtracting 94 million tons from the 425 million tons to total requirement leaves 331 million tons of high sulfur coal which will be burned in utilities with devices. Or in the absences of devices, this quantity of coal must be processed to low sulfur standards.

On the oil side, the Bureau of Mines in August 1970 in its study on Oil Availability by Sulfur Levels estimated the additional U.S. and Caribbean residual desulfurization capability would be around 300 million bbls. This added to the 59 million bbls. of low sulfur oil which already meets the standards yields a total of 359 million bbls. of low sulfur oil in 1975. Deducting this quantity from the total utility requirement of 565 million bbls. leaves about 206 million bbls. that will be burned in utilities with control devices, or in the absence of devices, 206 million bbls. must also be processed to low sulfur.

SUMMARY

The Clean Air Amendments of 1970 and the accompanying regulation have intensified the demand for "clean" fuels and control devices on a nationwide bases. These control measures must be in operation by 1975 or in some instances 1977.

In general there will be a demand for 425 million tons of low sulfur coal and 565 million bbls. of low sulfur oil. The majority of this will require some type of processing. Clean fuels are a preferred pollution control for electric generation because they are fail-safe and compatible with load changing characteristics of power plant operations. About 94 million tons of naturally occuring low sulfur coal and 359 million bbls. of low sulfur oil can be foreseen as a possible supply that meets air quality regulations. About 331 tons of coal and 206 bbls of oil will be burned in anywhere from 1300 to 1400 units each requiring control devices in operation in 1975. To the extent that control equipment manufacturers have a deficiency in these numbers of units operating in 1975, an equivalent demand will appear for processing portions of each of the high sulfur quantities of coal and oil.

The challenge is great, the time is short. Achievement of the ambient air quality objectives by the electric power industry in that short a period of time will require the utmost effort on the part of suppliers of low-sulfur fuels and manufacturers of sulfur emission control equipment, dedication on the part of the electric power industry, a great deal of investment capital, and the cooperative spirit of environmental groups and the public.

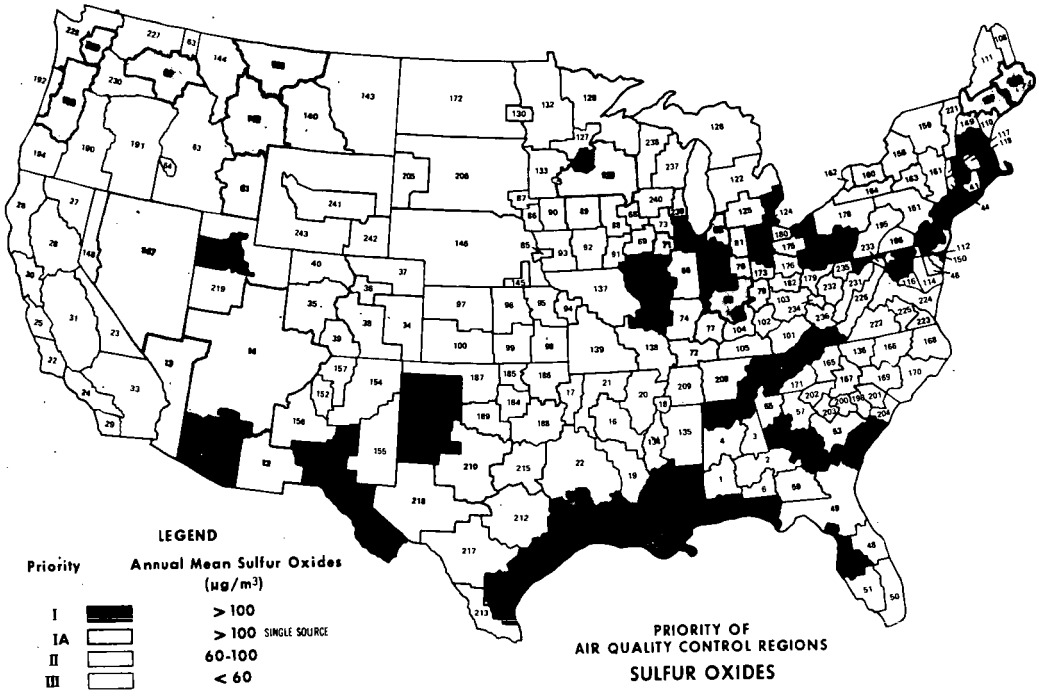

Figure 1

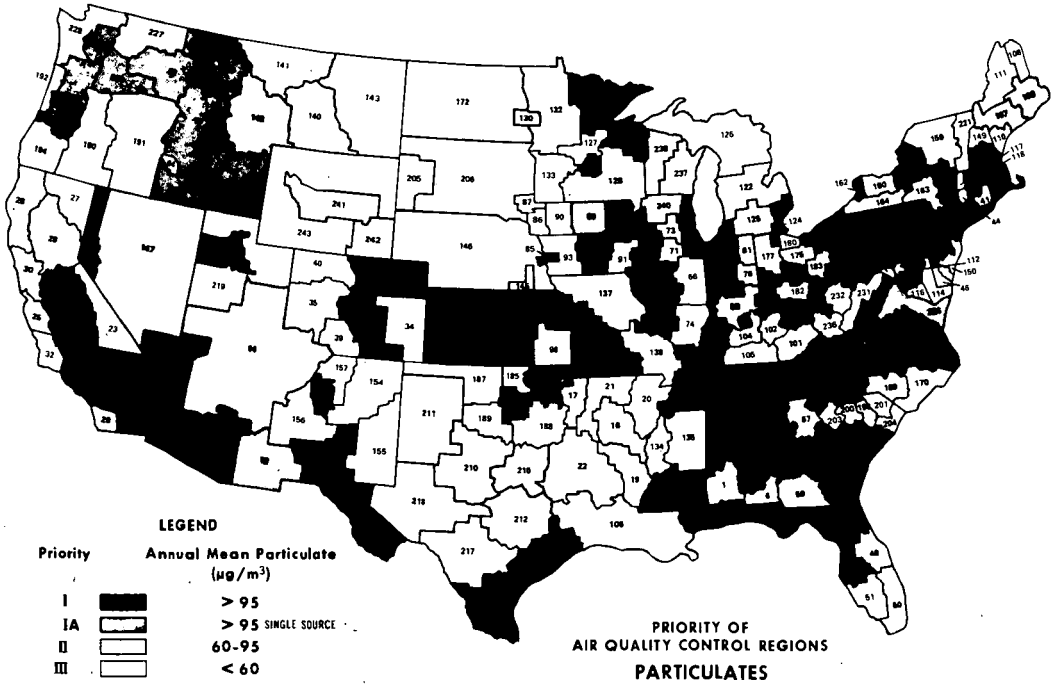

Figure 2

PROJECTED GENERATION MIX

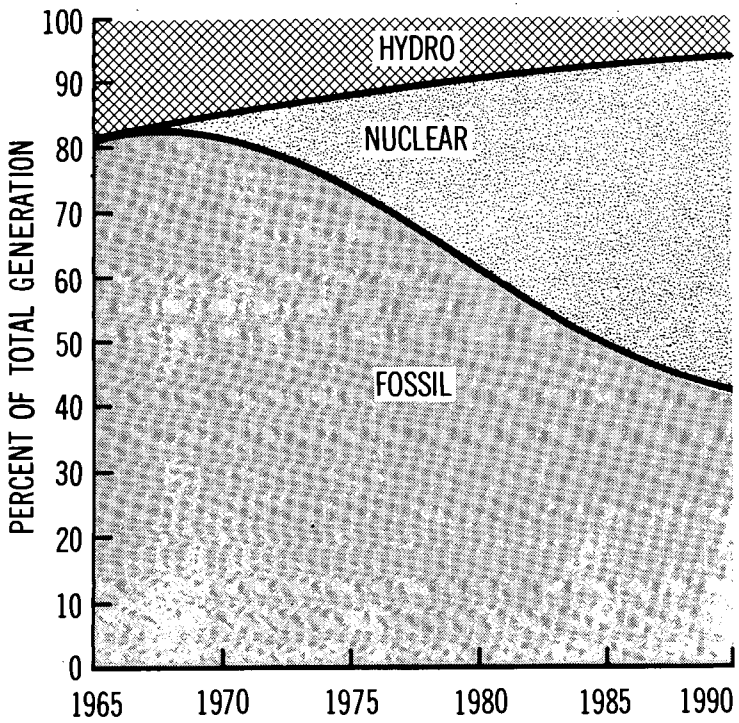

Figure 3

ESTIMATED ANNUAL ELECTRIC UTILITY GENERATION BY PRIMARY ENERGY SOURCES

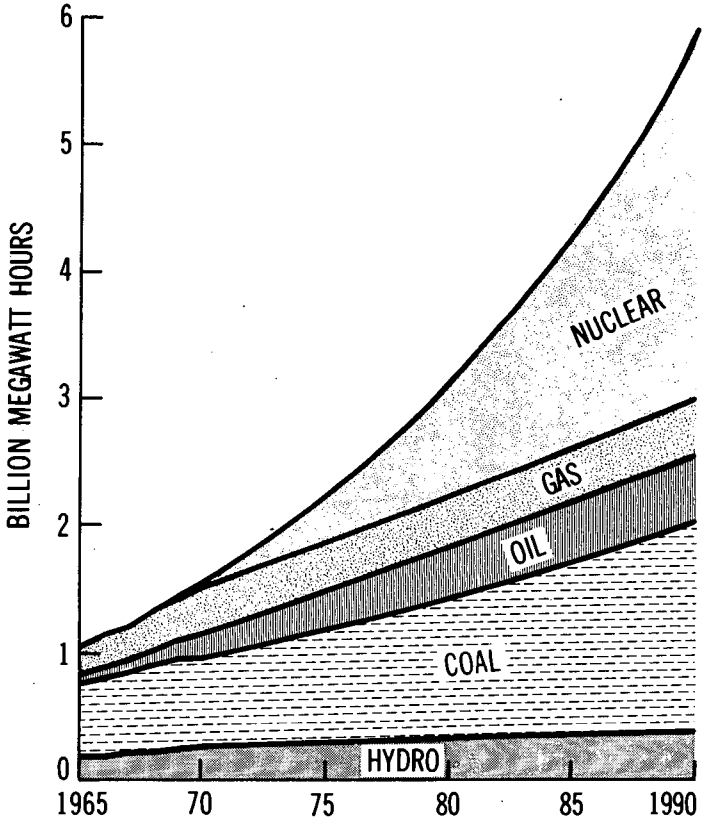

Figure 4

ESTIMATED ANNUAL FOSSIL FUEL REQUIREMENTS FOR ELECTRIC UTILITY GENERATION

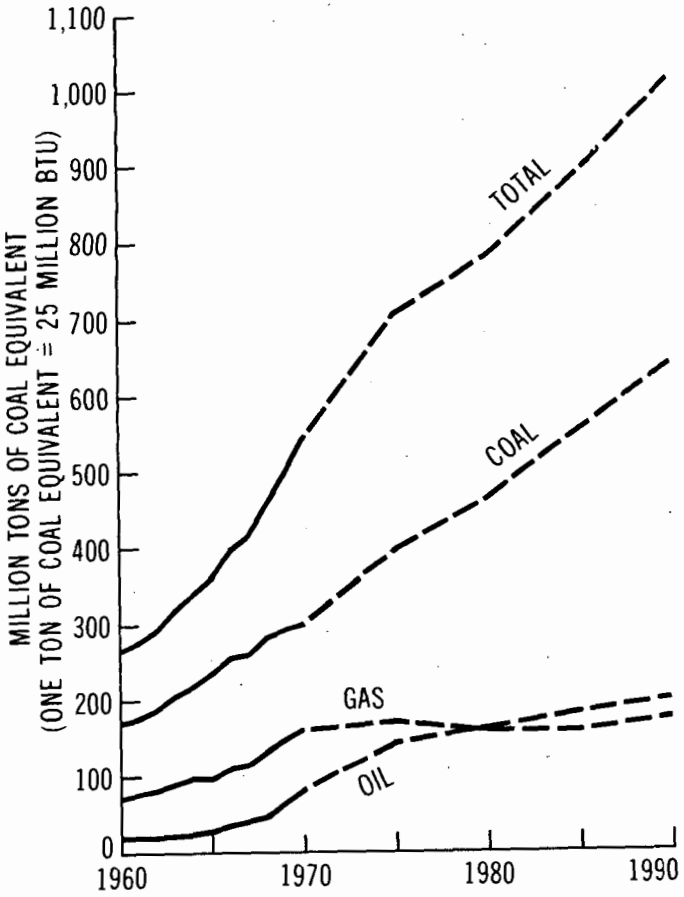

Figure 5

DISTRIBUTION OF SULFUR CONTENT OF COAL BURNED BY ELECTRIC UTILITIES (1969)

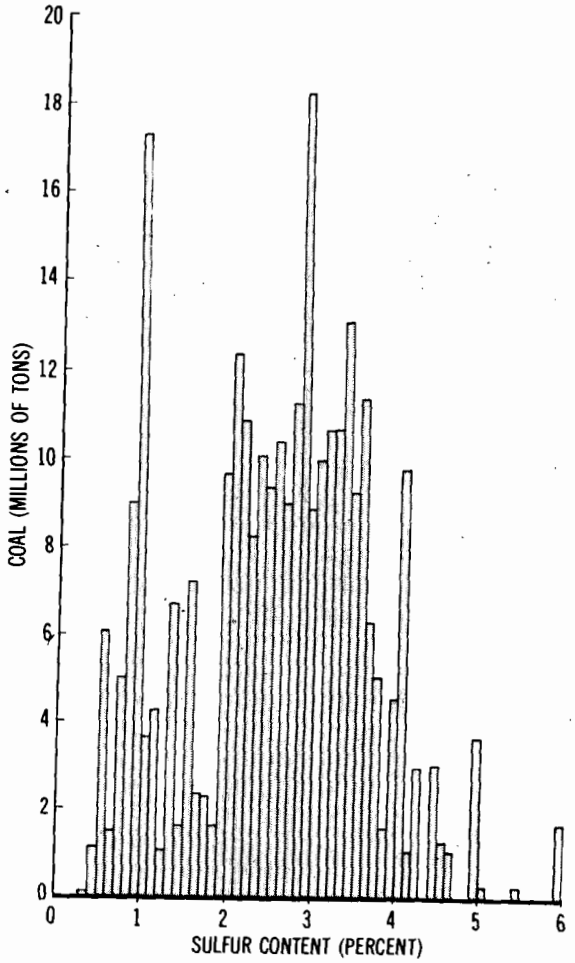

Figure 6

DISTRIBUTION OF SULFUR CONTENT OF OIL BURNED BY ELECTRIC UTILITIES (1969)

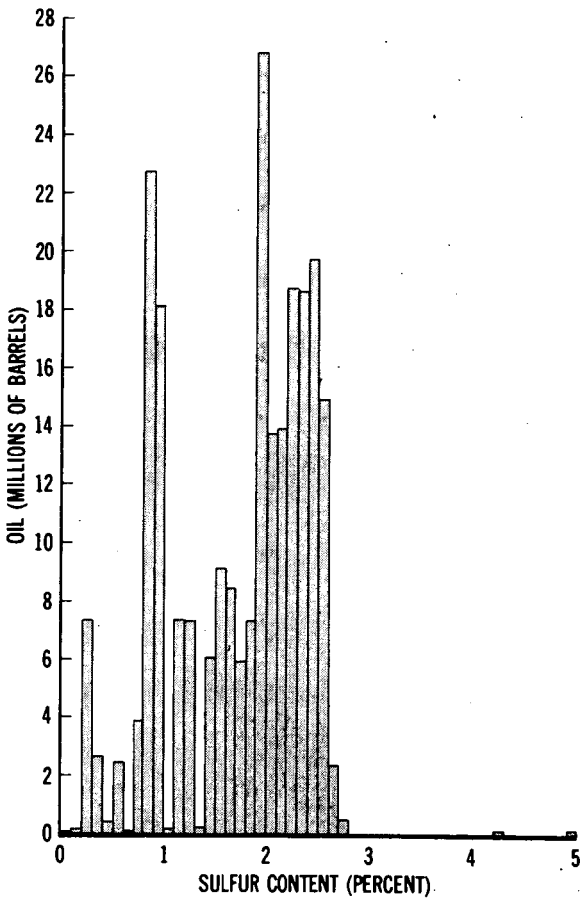

Figure 7