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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE ECONOMIC IMPACT OF AIR QUALITY REGULATIONS ON THE ELECTRIC POWER AND COAL INDUSTRIES IN OKLAHOMA

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

BY

LUVONIA J. CASPERSON

Norman, Oklahoma

1974

THE ECONOMIC IMPACT OF AIR QUALITY REGULATIONS ON THE ELECTRIC POWER AND COAL INDUSTRIES IN OKLAHOMA

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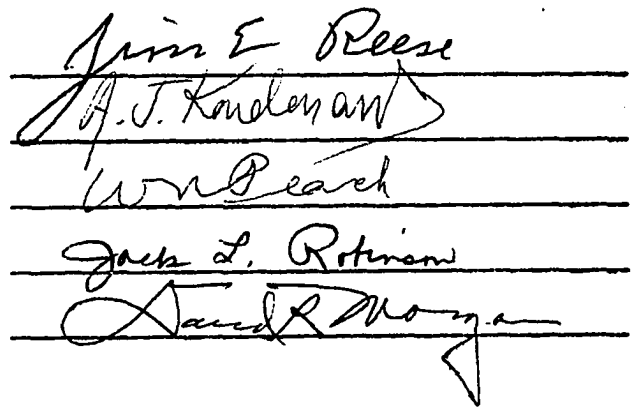

DISSERTATION COMMITTEE

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TABLE OF CONTENTS

		Page
LIST OF TABLES		vi
LIST OF ILLUSTRATIONS		viii
Chapter		
I.	PURPOSE OF THE STUDY	1
II.	AIR QUALITY LEGISLATION	18
III.	EXTENT OF THE PROBLEM IN OKLAHOMA	30
IV.	ELECTRIC POWER INDUSTRY	61
V.	COAL AS AN ENERGY SOURCE	93
VI.	A SUMMARY OF THE EFFECT OF AIR POLLUTION REGULATIONS ON THE ELECTRIC POWER AND COAL INDUSTRIES IN OKLAHOMA	120
VII.	SUMMARY AND CONCLUSIONS	142
APPENDIX A		152
APPENDIX B		155
BIBLIOGRAPHY		160
GLOSSARY		169

LIST OF TABLES

Table		Page
I.	Energy Consumption by Sector in the United States, 1971 Actual, with Projections to the Year 2000	4
II.	Original National Ambient Air Quality Standards Established Pursuant to the Clean Air Amendments of 1970	23
III.	Oklahoma Ambient Air Quality Standards Established by The Oklahoma Air Pollution Council on February 16, 1971	25
IV.	Demand and Supply of Oil in the United States, 1970 Actual - 1985 Projection	41
V.	Use of Energy by Aggregate Markets in the United States, 1970 Actual - 1985 Projection	62
VI.	Kilowatt Generation by Major Electric Power Producers in Oklahoma, 1966-1973 Actual, 1974-1990 Projection	63
VII.	Oklahoma Gas and Electric Company, Customers, Sales, Revenues and Total Electric Power for the Years 1968-1971.	67
VIII.	Public Service Company of Oklahoma, Customers, Sales, Revenues and Total Electric Power for the Years 1968-1971.	68
IX.	Planned Expansion of the Electric Power Industry in Oklahoma, 1974-1984	69
X.	Increase in Electric Bills for Selected Cities in the United States, Fall 1973 - Spring 1974	87
XI.	Projected Impact of Rate Increases on Customers of Oklahoma Public Service Company, 1974	87

Table		Page
XII.	Coal Production and Reserves for Selected Countries, 1970	93
XIII.	Production, Average Value, and Reserves of Coal by State, 1971	95
XIV.	Oklahoma Coal Industry, 1972	98
XV.	Mines Comprising the Oklahoma Coal Industry, June 10, 1974	100
XVI.	Oklahoma Coal Industry - Mines, Production and Employment, 1952-1972	102
XVII.	Average Sulfur Content of Coal by Electric Utilities by Districts in the United States, 1971	104

LIST OF ILLUSTRATIONS

Figure		Page
I.	Oklahoma Air Sampling Network	28
II.	Oklahoma Air Quality Control Regions	31
III.	Projected Number of Episode-Days in Five Years in the United States	33
IV.	Oklahoma Source Emissions Greater Than 25 Tons Per Year	37

THE ECONOMIC IMPACT OF AIR QUALITY REGULATIONS ON THE ELECTRIC POWER AND COAL INDUSTRIES IN OKLAHOMA

CHAPTER I

PURPOSE OF THE STUDY

The purpose of this dissertation is to review The Federal Clean Air Amendments of 1970, the Oklahoma Clean Air Act, effective July 1, 1971, and legislation passed pursuant thereto, in order to determine the impact of these events on a vital industry in Oklahoma. The aim is to examine the evidence concerning the amount and kind of air pollution presently emitted by the electric power industry in Oklahoma and to examine the alternative ways this industry can comply with the laws in both the long-run and the short-run. The thesis will also examine the effect of one of these alternatives on the coal industry which has been an important Oklahoma industry for more than 75 years.

Pollutants emitted by the national electric power industry utilizing the traditional fuel will be examined as well as the pertinent air quality standards. Records will be examined to determine the amount and kind of air pollution presently emitted by the electric power industry in Oklahoma. If there is a relatively small amount, the study will concentrate on the problems that will arise when the primary fuel becomes unavailable or increases in cost.

As compared with other sectors of the economy where competition is allowed to regulate the market, the electric utilities are regulated by the Corporation Commission in Oklahoma. Therefore, if additional costs are incurred by the electric power generating companies, the way in which these increased costs will be passed on to the final consumer is an administrative one. The study will examine the evidence in existence to try to determine if additional costs are expected and if so, how these changes in costs will affect the rate structure.

The Federal Power Commission (FPC) requires that expansion plans be filed 10 years in advance of new construction as well as requiring the annual reporting of data regarding reliability and adequacy of service.[1] The industry is capital intensive and requires a long lead time for construction of new facilities. In addition to state regulations, the electric power industry in Oklahoma is subject to the regulation of the FPC. Therefore, this study will concentrate on the ensuing 10 year period which, for the purpose of this analysis, will be defined as the short-run. In the long-run, arbitrarily defined herein as more than 10 years, we would expect the market to combine technology, increased efficiency and prices in such a fashion as to equate energy

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[1]The Federal Power Commission, The 1970 National Power Survey, U. S. Government Printing Office, Washington, D. C., 1971, Part I, p. 1-2-10.

demand with energy supply in the environment desired. At least the traditional market system is supposed to work this way. A "natural monoply" that is regulated should approximate this theoretical market system.

An effort will be made to determine what it will cost the electric power industry in Oklahoma to comply with the relevant ambient air quality standards, and then to translate these increased costs into the price the consumer pays for electricity. Attention will be called to the fact that there is a pressing need to balance the costs of cleaner air with the benefits derived therefrom. This problem is difficult. The determination of these costs will be only a step toward definitive cost-benefit analysis. When achieved, cost-benefit analysis will aid the regulatory bodies, the industry and the consumer in balancing the costs of a cleaner environment with the resultant benefits.

The problem is critical and the answer appears to lie in achieving and maintaining the proper balance between energy needs and environmental values which can only be done efficiently by looking at the facts, by recognizing that this is a long-range problem and that the nation and state can have clean air and adequate electricity simultaneously. These facts are two major components of the quality of the human environment and should be viewed from a factual standpoint.

Nationwide, the electric power utilities are the second largest consumer of primary energy and are presently the fastest growing market. See Table I.

TABLE I

ENERGY CONSUMPTION BY SECTOR IN THE UNITED STATES, 1971 ACTUAL, WITH PROJECTIONS TO THE YEAR 2000

(In Trillions of BTUs)

Sector	1971	1975	1980	1985	2000
Household & Commercial..	14,281	15,935	17,500	18,960	21,920
Industrial.....	20,294	22,850	24,840	27,520	39,300
Transportation.....	16,971	19,070	22,840	27,090	42,610
Electrical Generation...	17,443	22,410	29,970	40,390	80,380
Synthetic Gas.....	-	-	870	2,670	7,690
Total.....	68,989	80,265	96,020	116,630	191,900

Source: U. S. Energy Through 2000, p. 4.

In addition, the principal source of energy for the generation of electric power is coal. Because of the energy crisis, the Federal Power Commission on December 6, 1973,[2] urged all systems to maximize the use of coal for electric generating capacity.

Coal is one of Oklahoma's more valuable resources. What will be the effect of air pollution regulations on this industry? If more coal is consumed to produce

[2]The Wall Street Journal, March 25, 1974, p. 3.

electricity, to preserve the environment low-sulfur coal must be used, coal must be converted to gas or fuel oil, or a "scrubber"[3] device must be used to scrub the flue gas before emitting it into the atmosphere. Present evidence indicates that the principal source of sulfur oxides in the air comes from the burning of high-sulfur coal. A controversy now rages over the technological feasibility of flue gas scrubbing.

The power industry generally maintains that present scrubbing technology is "unproven". On the other hand, the Environmental Protection Agency (EPA) requires the use of these devices as the "best available technology". Thus, the EPA contends that feasible technology is available to meet air quality standards utilizing high-sulfur coal. Most of the steam coal in Oklahoma that is used for generating electricity is of a high-sulfur content.

President Nixon proposed through the Energy Office that certain major fuel-burning sources including electric utilities

---

[3]A scrubber is a device installed in the flue to clean the pollutants from the waste gas before emitting the flue gas into the atmosphere. Limestone/lime scrubbing is the most popular scrubber, however at least 4 other methods are presently on the market. See Scrubber in the Glossary.

convert to coal. Should this occur, the EPA could temporarily suspend the air pollution standards for sulfur oxides. Compared to low-sulfur coal, the high-sulfur coal of Oklahoma would become cheaper if air pollution devices were not required. However the quality of the nation's air could be expected to deteriorate significantly. As will be shown in subsequent chapters, expansion plans of the major Oklahoma electric power generating companies contain provisions to use low-sulfur western coal for fuel in lieu of installing scrubbers in the short-run. Because the time focus of this paper is the short-run, the economic aspects of scrubbers will not be examined here.

In summary, the first objective of this work is to determine the air quality regulations that apply to both existing and proposed plants that comprise the electric power industry in Oklahoma; second, to determine the economic costs of complying with the present regulations using present plants, equipment and fuels; and third, to ascertain the availability of present fuels for continued use and for expansion of the electric industry. If the evidence indicates present fuel will not be available to meet the projected demand, an effort will be made to determine some of the alternative fuels that might be available in both the short-run and the long-run. If it appears that coal will be a feasible

option, the study will ascertain the pollutants emitted and discuss the approximate costs and alternative ways to meet the air quality standards. In addition, this paper will examine the economic impact on the Oklahoma coal industry of an increased use of coal as a fuel for electric power generation during the next decade. Further, an effort will be made to ascertain how these additional costs incurred in complying with federal and state air quality regulations will affect the rate structure of the Oklahoma electric power industry. Finally, the findings will be summarized and conclusions drawn based on the evidence examined.

SCOPE AND VALUE OF STUDY

This study is based on a survey of the pertinent legislation, personal attendance at legislative hearings, a survey of the literature, more than 30 personal interviews, and an examination of records and reports. It will also use the 1970 Federal Power Survey. A complete set of this Survey was provided by Mr. Donald L. Martin, Regional Engineer for the Fort Worth, Texas Office of the Federal Power Commission. Mr. Robert V. Blanche, Chief of Air Quality Service for the Oklahoma State Department of health, provided access to the State of Oklahoma Air Quality Control Implementation Plan of October 16, 1972 at his office in Oklahoma City. A copy of the Oklahoma Clean Air Act and Air Pollution

Control Regulations published by the Oklahoma State Department of Health on July 1, 1973, was also available.

Minutes of meetings of the Air Pollution Council, the Oklahoma State Board of Health and records of the Corporation Commission were made available by the respective agencies. Staff Memoranda were also furnished.

The Final Report to the Ozarks Regional Commission by the Oklahoma Geological Survey of July 10, 1974, entitled Investigation of the Coal Reserves in the Ozarks Section of Oklahoma and Their Potential Uses by S. A. Friedman was examined. The two volume Final Report of Oklahoma Energy Council entitled Energy in Oklahoma, dated February 1, 1974, has provided a valuable reference. A report entitled The States and The Energy Crisis, June 22, 1973, available from the Southern Interstate Nuclear Board, was examined. It is a comprehensive catalogue containing the action taken by each State of the United States with regard to the energy crisis of 1973. In addition, the Report outlines major areas of concern. It gives the action taken by the different states on energy conservation, the development of land use planning and electric power siting, prevention of delays in licenses, permits and other matters.

As mentioned earlier, The Clean Air Amendments of 1970 was followed in Oklahoma by The Oklahoma Clean Air Act and

Implementation Plan. During the 3 year period, 1971-74, the author attended more than 20 Air Pollution Council meetings of the State Board of Health. In addition, the writer attended two meetings of the Oklahoma Corporation Commission during this period.

Much cooperation has been received from the Oklahoma Chapter for the Coalition for Clean Air which has more than 700 members in the state. The author was honored by being elected to serve on the Governing Council for the 1974-75 year. As a result of cooperation with this group, the writer has experienced television, newspaper and radio exposure as a discussant on the air pollution problems of the region.

An important interview concerning the economic aspects of air pollution regulations was conducted with Dr. Fred H. Abel, Chief of the Economic Analysis Branch of the Office of Research for the United States Environmental Protection Agency, in his office in Washington, D. C. on May 17, 1973. Dr. Abel pointed out some of the problems and interrelationships involved in controlling air pollution and stressed the importance of economic analysis and cost-benefit analysis in decision making. He noted that there are costs and benefits incurred at the individual level, at the firm level, at the industry level, at the community level, at the state level, and at the national level. In addition, Dr. Abel

discussed the multiplier effects of new legislation; the use of retrofitting equipment; the installation of new equipment, or the closing of marginal plants that cannot pay the costs incurred by meeting air quality standards. Dr. Abel stressed that in a new field like this, it is important to ascertain all costs so that the parties can respond creatively, efficiently, responsibly and equitably.

On May 22, 1973, the writer was given a complete tour of the facilities of the Air Pollution Control Division of the Environmental Health Services of the Oklahoma State Department of Health. This tour was conducted by Mr. Robert V. Blanche, Director of the Division. His assistance and that of his staff have been valuable. More than a dozen personal interviews and conferences were conducted with the personnel of this facility which is responsible for seeing that the state meets the state and federal ambient air quality standards within the prescribed statutory time period. Many papers and reports were made available for inspection by officials of the State Health Department. In addition, three trips were made to Dallas, Texas, for the purpose of interviewing regional Environmental Protection Agency representatives.

To complement the interviews with the federal, regional and local Environmental Protection Agency personnel, several interviews were conducted with the representatives of the

major electric power generating companies in Oklahoma. Both companies made available reports, records and other data for inspection. Much of the data furnished was still in preliminary form and in this case the up-to-date estimates of company engineers were used. Without this valuable assistance, a study of this type would not be as useful and might not have been possible from published data alone.

As mentioned earlier, the production of coal is important to the state's economy. In order to get a better understanding of the industry, personal interviews were conducted with representatives of each firm in the coal industry in Oklahoma during June 1974. More than 2000 miles were driven and several on-the-scene mine inspections were made.

As previously stated, decisions concerning costs and rates in the electric power industry in Oklahoma are not subject to the market forces of supply and demand but are determined by the Oklahoma Corporation Commission. Given the demand for electricity, the increased costs incurred for air pollution control devices and present increasing demand for alternative energy sources, the Corporation Commission of Oklahoma is faced with difficult decisions. Without adequate electricity the state's economy can be expected to falter and its citizens can expect brownouts and blackouts. Therefore the Commission must insure that

the utility companies earn enough to provide adequate electricity while at the same time seeing to it that consumers are treated fairly. A petition for an increase in rates and restructuring thereof by a major electric power producer came before the Corporation Commission in early 1974.[4]

It will be shown later that the principal energy source for the growth of the electric power industry in Oklahoma during the next decade will be coal. It will also be shown that much of the available coal has a sulfur content that is too high to meet present air quality standards without further treatment to remove pollutants.

Some air quality standards were relaxed temporarily during the "energy crunch" of 1973. However, Russell Train, then administrator of the Environmental Protection Agency, said that:

> We're not relaxing health standards, we're making temporary adjustments.[5]

From the evidence available, it does not appear that The Clean Air Amendments of 1970 will be abandoned. However, if the Act is repealed or modified, this study will still fill a gap in the existing literature as the following survey will indicate.

---

[4]Cause No. 24969, The Corporation Commission of Oklahoma.

[5]"Environment in an Energy Crisis," Business Week, December 15, 1973, p. 53.

SURVEY OF THE LITERATURE

Most economic literature on air pollution deals with the relative effectiveness of such air pollution control techniques as effluent charges, subsidies and regulations such as The United States Clean Air Amendments of 1970 and the Oklahoma Clean Air Act and Implementation Plan. The analysis in this paper deals only with the current law of the land as enacted and does not discuss the question of decreasing air pollution by other methods.[6]

Although the title suggests some overlap, none was found in a 1973 University of Oklahoma dissertation by William Woodrow Talley II entitled Manergy: An Energy Management Model of the United States For The Prediction of Energy Demand, Resource Consumption, Environmental Effects, The Assessment of New Technology, and Energy Resource Alternatives. The above dissertation develops a computerized, systems-analysis model of the economy of the United States and ". . . . was designed for use as a management tool for assessing the consequences of resource and fuel alternatives,

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[6]For examples of other methods see William David Montgomery, III, "Market Systems for the Control of Pollution," (unpublished Ph.D. dissertation, Harvard University, 1971). James T. Bennett and Mary A. Holman, "Economic Analysis and Noise Pollution: A Survey of the State of the Art," in Akron Business and Economic Review (Winter 1972), p. 21-30. Wassily Leontief, "Environmental Repercussions and the Economic Structure: An Input-Output Approach," The Review of Economics and Statistics (August, 1970) p. 262-271.

environmental controls, and technological advances . . . . to the year 2100."[7] The model developed predicts airborne emissions will decrease initially because of "more stringent emission standards for automobiles and electrical power generation stations."[8] Nevertheless, Talley assumes constant airborne emissions per unit of output after 1980 and that air pollution will increase as energy demand increases. The author admits this characteristic of his model and says that: "It is doubtful whether the United States could tolerate the magnitude of emissions projected for 2040 and beyond."[9]

No study was found that parallels this one for either the state or the nation. The first hand information collected by the author through personal interviews and on the site inspection of coal mines and electric power facilities has not been duplicated by any other investigator. Furthermore, there is no other study of the unique relationship between coal and electric power in Oklahoma.

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[7]William Woodrow Talley II, Manergy: An Energy Management Model of the United States For the Prediction of Energy Demand, Resource Consumption, Environmental Effects, The Assessment of New Technology, and Energy Resource Alternatives, (unpublished Ph.D. dissertation, University of Oklahoma, 1973). p. iii.

[8]Ibid., p. 145.

[9]Ibid., p. 145.

OUTLINE OF THE FOLLOWING CHAPTERS

Chapter II discusses the rationale for the passage of The Clean Air Amendments of 1970 and outlines the federal and state regulations established pursuant thereto.

Chapter III examines the air pollution problem of Oklahoma in detail. The present situation is analyzed to determine the amount of air pollution and the danger of an episode. The analysis then evaluates energy sources available for the growth and development of the electric power industry. Air pollutants traditionally associated with the production of electricity are discussed. National and state data are both examined.

Chapter IV briefly discusses the electric power industry nationwide and describes the Oklahoma electric power industry in more detail. Because air quality standards have added a new component to most electric power production, several studies will be analyzed to determine the approximate costs of meeting these standards. The results of a study done by the author on the Oklahoma Electric Power Industry will be given. A finding of this study is that both major electric power producers in the state plan to join much of the nation in utilizing coal as the major fuel for expansion of the industry in the short-run.

One producer plans to construct new generating equipment so that coal can be utilized in the long-run if it is economically feasible.

Chapter V deals with the Oklahoma coal industry. This chapter gives the present composition of the industry. The trend as shown by the number of mines, total employment of the industry and total coal production during the last 2 decades are discussed. In addition, the present estimated reserves and the sulfur content of Oklahoma coal are given. Projections will be made concerning the growth of the industry. Then the effects of this potential change in the industry on the state's economy will be analyzed. In addition, the potential role of coal gasification is discussed.

Chapter VI provides a synthesis of the evidence examined. It discusses the current controversy over ambient air quality standards and the energy crisis. The costs of meeting present air quality regulations by the electric power industry in Oklahoma will be examined. Ultimately these cost changes are expected to be translated into rate changes. Therefore, the literature will be researched to ascertain the expected elasticity of demand.

In view of the air quality legislation and the energy crisis, the fuels that are available for the generation

of electric power in the short-run will be examined. The fuel chosen by the electric power industry in the short-run is coal. The impact of this decision on Oklahoma's coal industry will be reviewed.

Chapter VII gives the summary and conclusions of the study.

This paper deals with areas of vital concern to the state and nation. A new development has occurred in the history of the United States in that Congress has passed a law, which when implemented by the states, sets forth ambient air quality standards that will be difficult to achieve within the allotted time period, given the current state of the arts.

CHAPTER II

AIR QUALITY LEGISLATION

NEED FOR LEGISLATION

The Clean Air Amendments of 1970 represent an awareness by the Congress that this country faces a severe air pollution problem. The U. S. House of Representatives Report No. 91-1146 in considering the Clean Air Amendments of 1970 (sometimes hereinafter referred to as the Act), states:

> . . . . that the purpose of the legislation is to speed up, expand and intensify the war against air pollution in the United States with a view to assuring that the air we breathe throughout the nation is wholesome once again.[1]

Senator Edmund Muskie, principal author of the Act, said that:

> We must design our environmental health standards so as to assure protection of the health of all the people . . . . and we must not allow those standards to be compromised because they are difficult to achieve, or because of cost.[2]

Air pollution is the presence of unwanted material in the air in sufficient amount and under such circumstances

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[1] U. S. Code Congressional and Administrative News Vol. 3, 91st Congress, Second Session, 1971, p. 5356.

[2] Business Week, "Commentary/Environment," November 3, 1973, p. 35.

as to interfere significantly with comfort, health, or welfare of persons, or with the full use and enjoyment of property. Air pollution is not a new phenomenon but the air has great absorptive capabilities and as long as it can absorb the pollutants pumped into it, there is little notice of the problem. Now, however, with over 1/2 of the population living on 1 per cent of the land the air has become overburdened with pollutants. The problem is multiplied by the fact that most of our industry is also concentrated in this small area.

Much of the literature on the economics of environmental quality assumes that the problem of air quality is a common property resource problem. However in common property resource problems the economic welfare is increased by the exploitation of a fixed resource. It does not appear that this is true with environmental pollution problems.[3] Negative returns can be generated in the form of vegetation damage; decreased mental and physical human performances; and increased death rates from emphysema, influenza, lung cancer and heart ailments. Other results are decreased visibility, eye irritation and climate changes.

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[3]Robert H. Haveman, "Common Property, Congestion, and Environmental Pollution," The Quarterly Journal of Economics, LXXXVII (May, 1973), p. 278-87.

[4]Lester B. Lave, "The Economic Costs of Air Pollution," The Economics of Environmental Problems. Edited by Frank C. Emerson, Michigan Business Papers. Number 58. University of Michigan. Winter, 1972, p. 19-37.

In short, air pollution seriously affects practically everything that comes in contact with it. If full costs are not assigned to production, including pollution costs, then the net economic surplus is negative.

THE CLEAN AIR AMENDMENTS OF 1970

In its passage of the Clean Air Amendments of 1970, Congress apparently concluded that in the case of air pollution the net economic surplus was negative. The Act required the establishment of two levels of air quality - a national primary ambient air quality standard (relating directly to public health and safety) and a national secondary ambient air quality (relating to public welfare). Congress declared that:

> . . . . the Administrator . . . . shall publish proposed regulations prescribing a national primary ambient air quality standard and a national secondary ambient air quality standard for each air pollutant for which air quality criteria have been issued, and . . . .[5]

---

[5]Clean Air Amendments of 1970 - P. L. 91-604 - December 31, 1970, Sec. 109, p. 10.

The major pollutants for which standards were set are:

1. Carbon Monoxide which accounts for 47 per cent of the present air pollution.
2. Sulfur oxides which account for 15 per cent.
3. Hydrocarbons which account for 15 per cent.
4. Particulates which account for 15 per cent.
5. Nitrogen oxides which account for 10 per cent.

In addition standards were set for photochemical oxidants which are not emitted directly but are formed when nitrogen oxides and hydrocarbons in sufficient quantities are exposed to sunlight. The standards set for these pollutants are given in Table II. There were 280 million tons of these pollutants emitted in the United States in 1969.[6]

The Act also called for appropriations of $1.1 billion through 1973. Of this total, $350 million was designated for research on fuels and low emission standards, while another $650 million was set aside for grants to state and local authorities. As mentioned in Chapter I, The Clean Air Amendments of 1970 is the most significant legislation with regard to air pollution ever enacted and adds a new dimension to production.

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[6]First Annual Report of the Council on Environmental Quality, U. S. Government Printing Office, Washington, D. C., 1970, p. 71.

The Environmental Protection Agency estimates the annual toll of air pollution on health, vegetation, materials and property values to be more than $16 billion annually, excluding esthetic values and the cost of discomfort. On a per capita basis, this results in a charge of about $80.[7] However, this paper makes no attempt to assess the benefits expected to be derived from compliance with the Act.

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[7]Second Annual Report of the President's Council on Environmental Quality. U. S. Government Printing Office, Washington, D. C., August 1971, p. 106.

TABLE II

ORIGINAL NATIONAL AMBIENT AIR QUALITY STANDARDS ESTABLISHED PURSUANT TO THE CLEAN AIR AMENDMENTS OF 1970

(All measurements are expressed in micrograms per cubic meter (ug/m^3.) (Equivalent measurements in parts per million (ppm) are given for the gaseous pollutants.)

Pollutant	Primary	Secondary
Particulate Matter		
Annual Geometric mean	75	60
Maximum 24-hour concentration*	260	150
Sulfur Oxides		
Annual Arithmetic mean	80 (0.03ppm)	60(0.02ppm)
Maximum 24-hour concentration*	365 (0.14ppm)	260(0.1ppm)
Maximum 3-hour concentration*		1,300(0.5ppm)
Carbon Monoxide		
Maximum 8-hour concentration*	10 (9.0ppm)	same as primary
Maximum 1-hour concentration*	40(35.0ppm)	
Photochemical Oxidants		
Maximum 1-hour concentration*	160 (0.08ppm)	same as primary
Hydrocarbons		
Maximum 3-hour (6-9am) concentration*	160 (0.24ppm)	same as primary
Nitrogen Oxides		
Annual arithmetic mean	100 (0.05ppm)	same as primary

*Not to be exceeded more than once a year.

Source: The Clean Air Amendments of 1970 - P. L. 91-604.

STATE RESPONSIBILITY UNDER THE CLEAN AIR ACT

The Clean Air Act of 1970 assigned to each state the "primary responsibility for assuring air quality within its entire geographic area," but required each state to have an implementation plan for achieving and maintaining the national ambient air quality standards by 1975.

Each state was left free to establish stricter air standards for all or part of its territory. If a state failed to act, Section 108 (c) (2) of the Act states:

> If a State does not file a letter of intent or does not have a plan which meets the requirements . . . ., the Secretary may, after reasonable notice, publish proposed regulations setting forth a plan which would be applicable to such State. If, within 30 days after publication, the State has not adopted the plan prepared by the Secretary or has not filed a petition for public hearings on such proposed plan, then the Secretary shall promulgate such plan which thereupon becomes applicable to such State.[8]

The Oklahoma Air Implementation Plan was submitted to the Environmental Protection Agency on January 28, 1972, and after initial rejection of portions of the plan, it was approved completely on June 21, 1972, by the Administrator of the Environmental Protection Agency. Table III gives the standards set.

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[8]U. S. Code Congressional and Administrative News Vol. 3, 91st Congress, Second Session, 1971, p. 5356.

TABLE III

OKLAHOMA AMBIENT AIR QUALITY STANDARDS ESTABLISHED BY THE OKLAHOMA AIR POLLUTION COUNCIL ON FEBRUARY 16, 1971

(All measurements are expressed in micrograms per cubic meter (ug/m^3.) Equivalent measurements in parts per million (ppm) are given for the gaseous pollutants.)

Pollutant	Primary	Secondary
Particulate Matter		
Annual Geometric Mean	75	60
Maximum 24-hour concentration*	260	150
Sulfur Oxides		
Annual Arithmetic Mean	80 (0.03ppm)	60(0.02ppm)
Maximum 24-hour concentration*	365 (0.14ppm)	260(0.1ppm)
Maximum 3-hour concentration*		1,300(0.5ppm)
Carbon Monoxide		
Maximum 8-hour concentration*	10 (9.0ppm)	same as primary
Maximum 1-hour concentration*	40(35.0ppm)	
Photochemical Oxidants		
Maximum 1-hour concentration*	160 (0.08ppm)	same as primary
Hydrocarbons		
Maximum 3-hour (6-9am) concentration*	160 (0.24ppm)	same as primary
Nitrogen Oxides		
Annual Arithmetic Mean	100 (0.05ppm)	same as primary

*Not to be exceeded more than once a year.

Source: Air Pollution Control Division, Oklahoma State Department of Health.

If the state fails to enforce its plan and these standards are not met, the federal agency may assess a penalty of up to $10,000 for each day during which any person or firm contributes to pollution or fails to take the required action to abate the pollutant.

OKLAHOMA CLEAN AIR STANDARDS

The basic state legislation in Oklahoma for air quality is the Oklahoma Clean Air Act, Title 63 O.S. 1971, Sections 2001 - 2003, and Title 75 O.S. 1971, Sections 301 - 325. These regulations authorize the adoption of standards, the investigation of alleged violations and provide a procedure for the adoption of state-wide air pollution regulations.

Responsibility for air quality maintenance is vested in the Environmental Protection Agency, the Oklahoma State Department of Health and the Air Pollution Council of Oklahoma. The Environmental Protection Agency represents the federal government whose responsibility is to insure that the provisions of the federal regulations are met. At the local level, the administration of the State Act is the responsibility of the Air Pollution Control Division of the State Health Department, in cooperation with the local health officials of city, county, city-county, or district health departments.

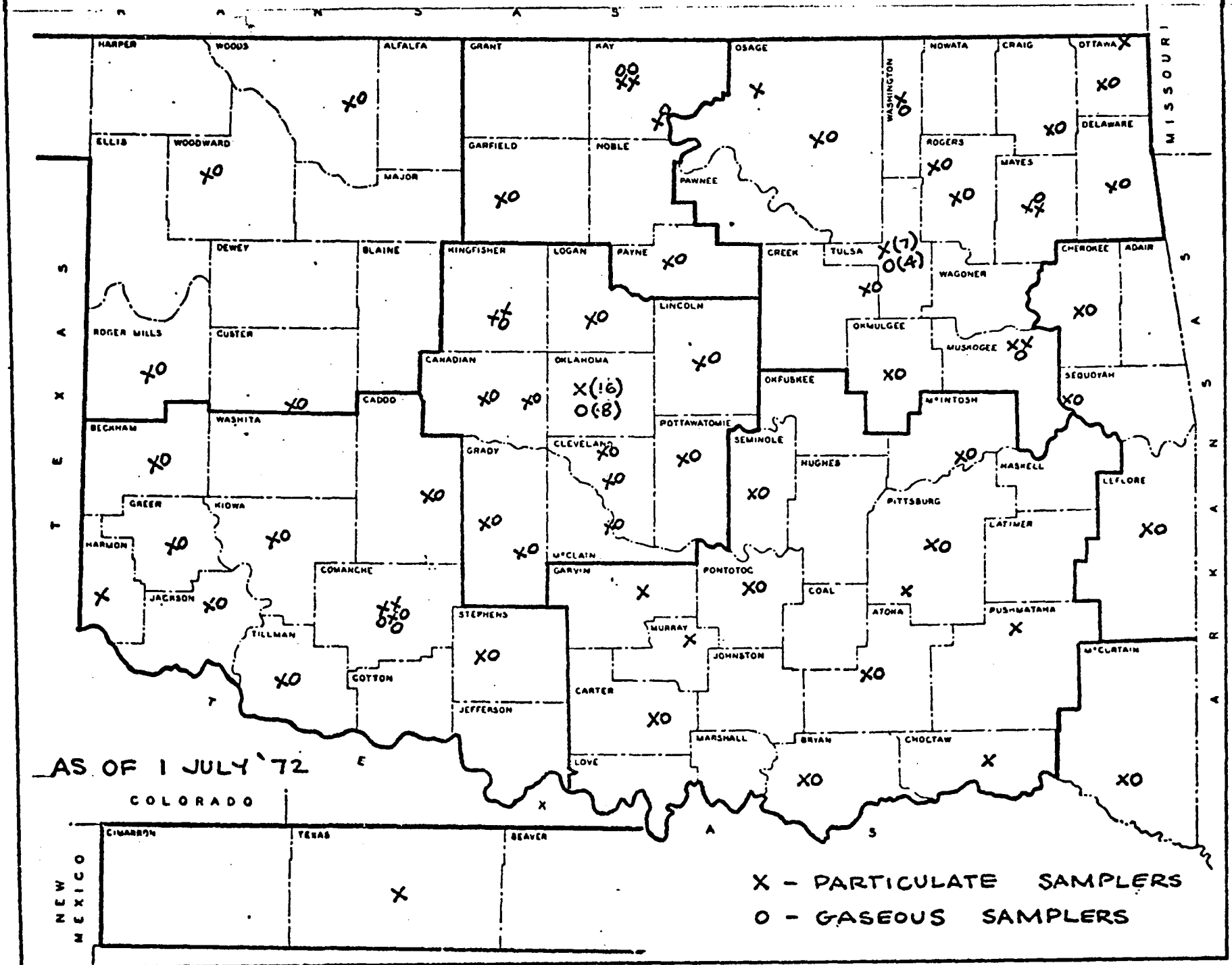
Rule making authority for adopting state regulations is vested in both the State Board of Health and the Air Pollution Council. The Air Pollution Council is a seven member panel of representatives of industry, agriculture, higher education, petroleum production, engineering, transportation, and municipal government. It is appointed by the Governor, with the advice and consent of the State Senate.

The Air Pollution Council has the authority to conduct public hearings and prepare regulations for submission to the State Board of Health. Following adoption of a regulation by the Council, the Board of Health must adopt the text of the regulation or reject it. Neither body can adopt a regulation without the concurrence of the other. Thus the Air Pollution Council has the power to initiate and propose regulations while the State Board of Health has a veto power (but not power to amend) over regulations proposed by the Council.

Many public hearings have been held for the purpose of developing and adopting Air Pollution Control Regulations for the State of Oklahoma. The rules and regulations adopted by the Air Pollution Council and the State Board of Health have enabled Oklahoma to develop the air quality control implementation plan necessary for state participation in the federal air pollution programs.

Figure I

OKLAHOMA AIR SAMPLING NETWORK



As of February 28, 1973, the Air Pollution Control Division of the State Board of Health maintained 101 air monitoring stations containing 234 air sampling units. During the 8 month period between July 1, 1972, and February 28, 1973, 36,808 samples were taken revealing the present quality of Oklahoma's air. Figure I shows the Oklahoma Air Sampling Network.

Also during this period 205 major emission sources were evaluated. Of these sources 154 were in compliance, 13 were closed, 23 were granted a variance to operate under an approved compliance schedule, 10 were operating under an enforcement order to comply by a certain date and 5 were given an order of non-compliance. In addition, during this same period the Air Pollution Control Division of the State Health Department participated in 665 conferences, made 413 inspections, investigated 349 complaints, reviewed 44 applications for construction permits and 9 applications for operating permits.[9]

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[9]Robert V. Blanche, private interview, Oklahoma City, Oklahoma, May 22, 1973.

CHAPTER III

EXTENT OF THE PROBLEM IN OKLAHOMA

INTRODUCTION

Interest in air pollution as a regional problem has stimulated research into geographical and climatological factors that are important to the transportation and diffusion of air pollutants.

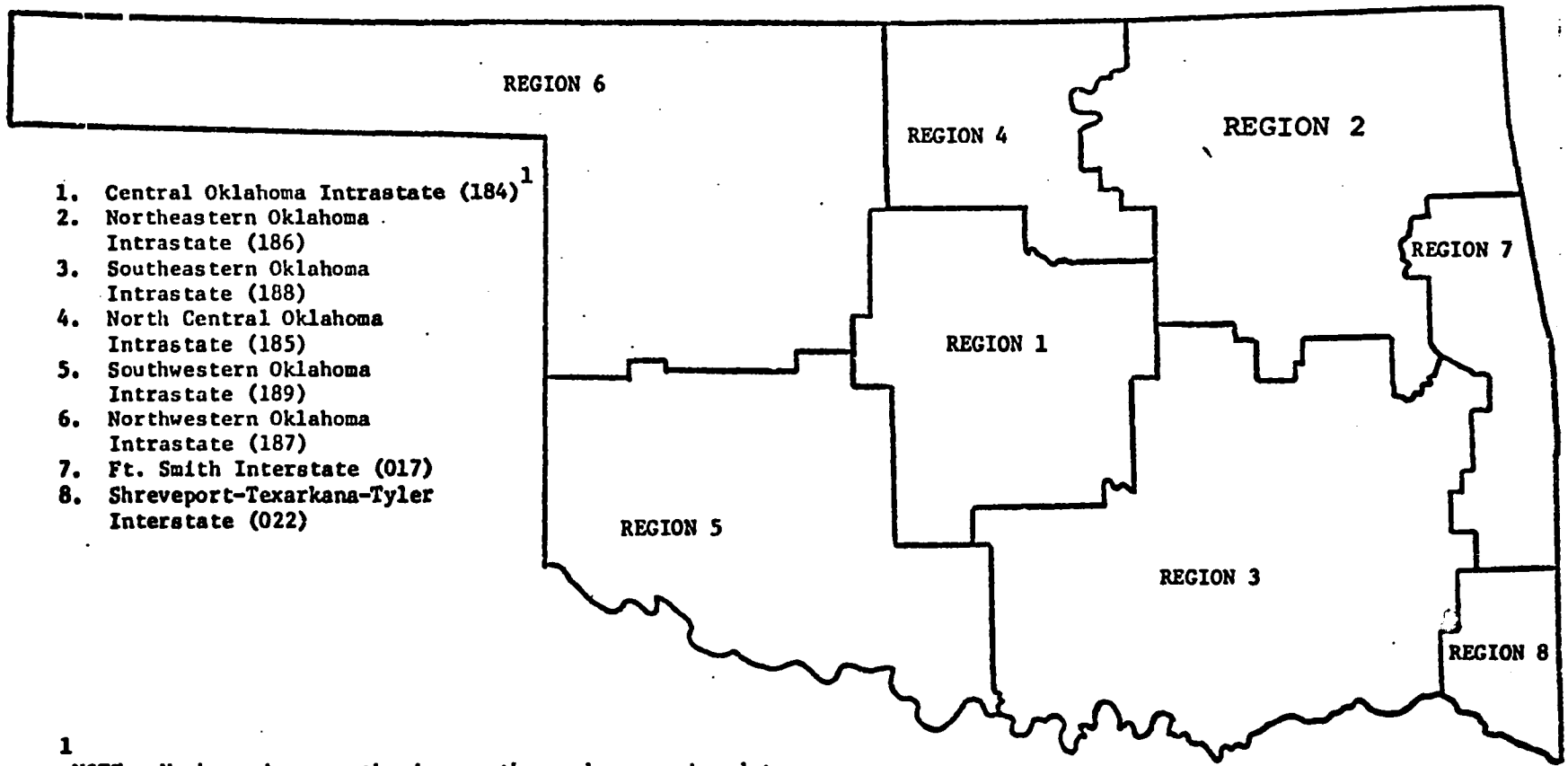
Oklahoma is a south central state in the United States, has a total area of 68,782 square miles and is the eighteenth largest state in land area in the United States. The entire country is divided into air quality regions and The Environmental Protection Agency in cooperation with state officials divided the state into eight pollution control regions (six of which are intra-state and two of which are interstate). Figure II is a map of the Oklahoma Air Quality Control Regions. Geographical and meteorological conditions are major factors affecting the short-term regional effects from air pollution.

METEOROLOGY

Several authors have studied the urban air pollution potential from a meteorological viewpoint. These studies give some indication of the probability of a stagnant meteorological condition which might result in an air

Figure . II

OKLAHOMA AIR QUALITY CONTROL REGIONS



[1] NOTE: Numbers in parenthesis are the numbers assigned to these regions by the U.S. Environmental Protection Agency as part of a system numbering all regions in the United States..

Source: Oklahoma State Department of Health, Air Pollution Control Division.

pollution episode in Oklahoma. One such study was done for the Environmental Protection Agency by George C. Holzworth, a meteorologist on loan from the National Oceanic and Atmospheric Administration, U. S. Department of Commerce.[1] This study was based on regular surface observations and upper air measurements of temperature and wind during the five year period 1960 - 1964, inclusive, at 62 National Weather Stations throughout the 48 contiguous states in the United States. This study indicates that the geographical and meteorological features of Oklahoma are very favorable for the diffusion of air pollutants. Rapid diffusion is a factor which reduces the danger of air inversions or episodes for extended periods of time.

In this study, annual and seasonal maps of mean morning and afternoon mixing heights and wind speeds are given, and much of Oklahoma is projected to have 0 episodes lasting 0 days. In relation to the rest of the country, other sections of Oklahoma are expected to have minimum danger of episodes. Figure III shows these projections.

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[1]George C. Holzworth, Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, Environmental Protection Agency. Office of Air Programs Publication No. AP-101, Raleigh, North Carolina.

FIGURE III

PROJECTED NUMBER OF EPISODE-DAYS IN FIVE YEARS IN THE UNITED STATES

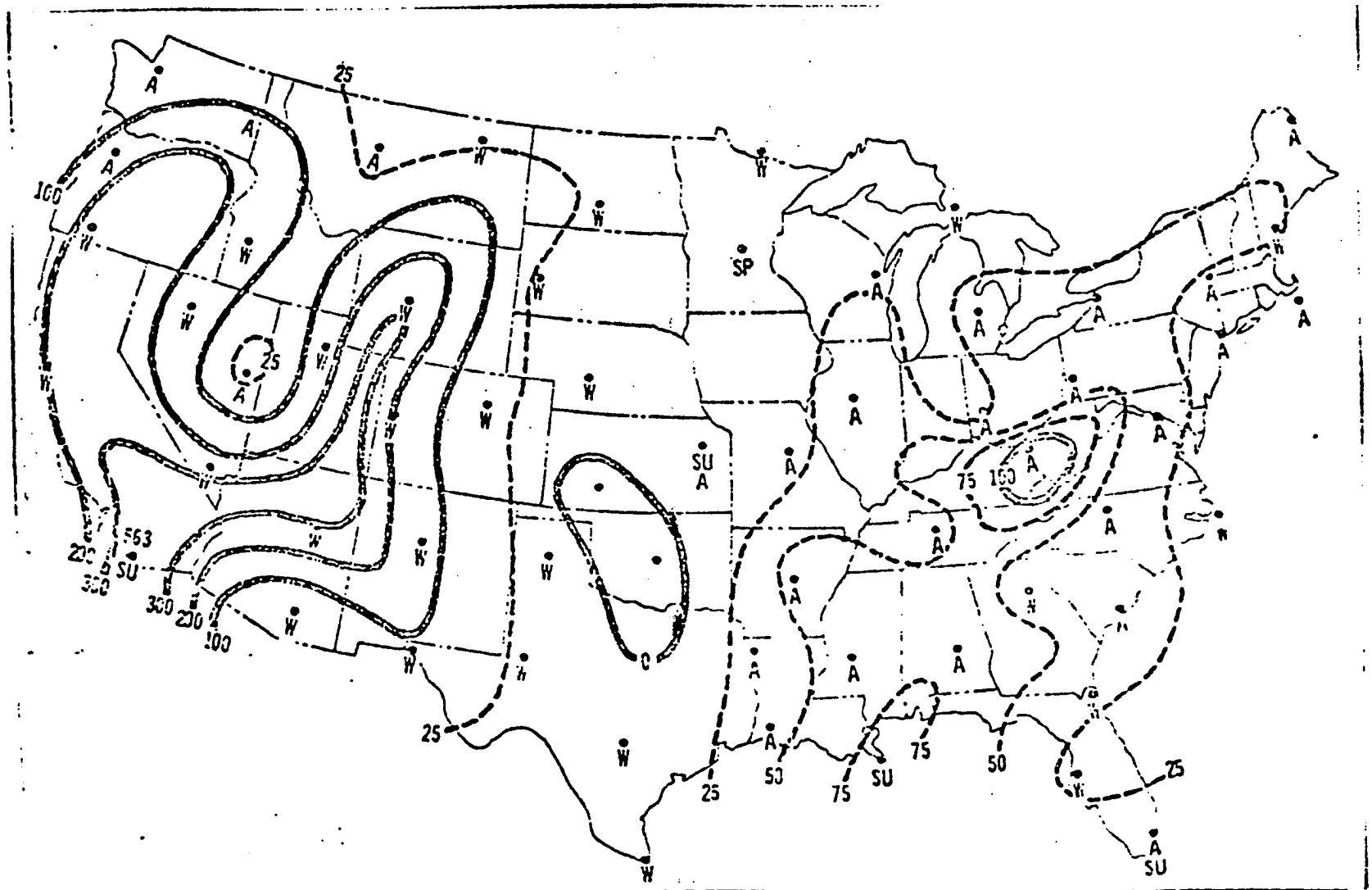

Figure III. Total number of episode-days of limited dispersion in 5 years; season in which most episode-days occurred at each station indicated as W (winter), SU (summer), SP (spring), or A (autumn).

Source: George C. Holzworth, Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, Environmental Protection Agency. Office of Air Programs Publication No. AP-101, Raleigh, North Carolina.

Of course there is no guarantee that episodal conditions will not occur in Oklahoma. Indeed Holzworth cautions that: "Thus, in terms of the concepts used in this study, the meteorological potential is anything but simple and is summarized only briefly."[2] Therefore, the Air Quality Control Implementation Plan for the state contains an emergency episode plan to protect the inhabitants of Oklahoma from short-term exposures to harmful levels of air contaminants.[3]

Most regions in Oklahoma enjoy superior air quality and this gives Oklahoma a comparative advantage over states with lower quality air. The Chambers of Commerce throughout the state have capitalized on this fact in their efforts to attract new industry to Oklahoma. Nevertheless, there were 2.08 million tons of particulates, sulfur oxides, hydrocarbons, nitrogen oxides and carbon monoxide emitted into Oklahoma's atmosphere in 1972.[4] Further research into the air pollution problem revealed 205 sources of air pollution in the state each of which

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[2]Ibid., p. 23.

[3]State of Oklahoma Air Quality Control Implementation Plan. October 16, 1972, p. 6-17 through 6-29.

[4]Oklahoma State Department of Health, Air Pollution Control Division. Compiled from State Emissions by Source Category.

emits 25 tons or more of the above named pollutants annually. These sources are shown in Figure IV. With limited resources, it was obvious that all of the 205 sources could not be investigated. Therefore, this study will be limited to the electric power industry.

The reason for selecting electric power plants is that they are the third largest source of air pollution in the United States and account for about one-fourth of the particulates and one-half of the sulfur oxides emitted.[5]

In addition, while the aggregate demand for energy was increasing at a compound rate of 4.3 per cent annually during the 1960's, aggregate demand for energy in the form of electricity was increasing at the rate of 7.3 per cent annually. In the United States employment increased annually by 1,500,000 workers during this period.[6]

National demand for electricity has doubled in the past decade and the Federal Power Commission

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[5]Improving the Quality of Life, A Study of the Economics of Pollution Control. The Chase Manhattan Bank, New York, 1972, p. 6.

[6]Otto Henry Zinke, "Energy in the Near Term," issued June 21, 1973, by the Arkansas Energy Study, supported by The Ford Foundation.

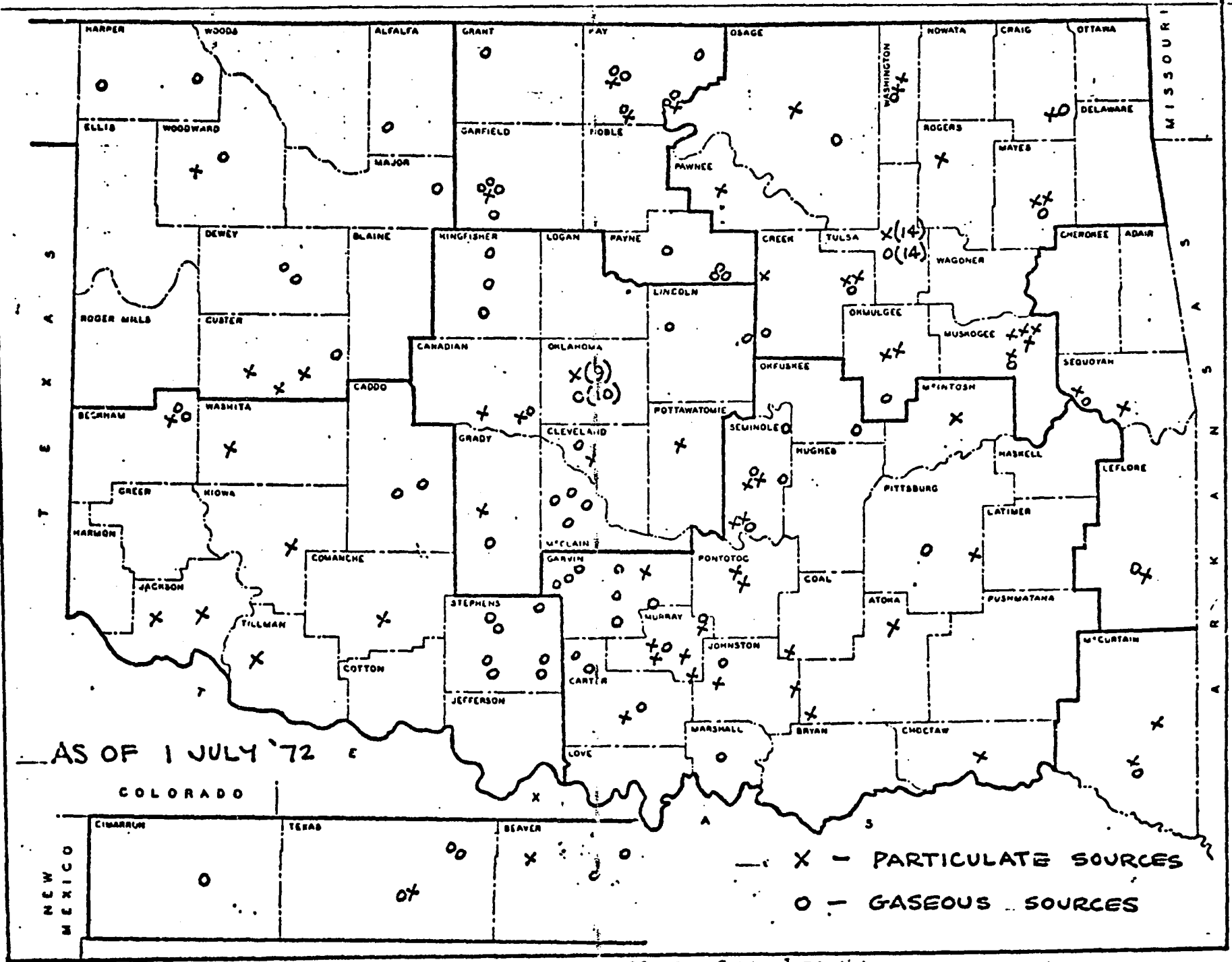
expects this growth to continue. If this forecast is correct, the pollution problem will become even greater.

An investigation showed that the electric power industry nationwide was presently experiencing difficulties in meeting the present air pollution standards. It will be even more difficult to meet the air quality compliance schedule and the costs of pollution control in the future. Oklahoma is working hard to become an industrialized state and while the exact relationship between energy use and economic growth has varied, the U. S. on the average uses more energy for each dollar of Gross National Product than other nations. An economy does not usually grow without a growth in energy and this energy must be translated into useable energy in adequate amounts and in compliance with the laws of the land.

When the Oklahoma State Implementation Plan for achieving state and federal ambient air quality was developed, an emission inventory was made for major sources. As indicated earlier, 205 major sources were found, but electric power plants were not found to be major polluters. The primary reason for this fact was that major electric utilities in Oklahoma changed their fuel to natural gas about 1945, although most units are still able to use fuel oil. As long as power generating

FIGURE IV

OKLAHOMA SOURCE EMISSIONS GREATER THAN 25 TONS PER YEAR



...of Health, Air Pollution Control Division.

facilities can be fueled with hydropower, natural gas, or low sulfur fuel oil there will be little difficulty in meeting air quality standards in the United States or in Oklahoma. The present culprit is coal containing large amounts of sulfur. More than 65 per cent of the coal produced in the United States is consumed in the production of electricity, and practically all of the coal burned in power plants contains more than 1 per cent sulfur. It is this combination of factors that make electric power plants major polluters in other sections of the country.

At the present time in the United States there are 5 major sources of primary energy--coal, petroleum, natural gas, nuclear power and hydropower. With the exception of nuclear power, the present sources of energy in Oklahoma are the same as for the nation. These sources of energy have alternative uses. Therefore, if one energy source is in short supply, it is true that often another source can be substituted. In addition, the evidence indicates that it is reasonable to expect that developing technology will change the above list. Thus, some of the alternative sources of energy for electric power generation will be examined in both the long-run and the short-run to determine whether or not these alternatives

are feasible for Oklahoma. As explained earlier, the short-run period shall be the next 10 years and the long-run shall be any time period exceeding the next 10 years. Again, the emphasis here is on the short tun.

SHORT-RUN AND LONG-RUN ALTERNATIVE ENERGY SOURCES IN OKLAHOMA

Efficiency in Planning and Use

If we are to examine the energy alternatives available to the electric power industries within the legal framework of air pollution regulations, we should also take a look at the possibility of more efficient planning and better use of the available resources.

The Southern Interstate Nuclear Board recently prepared a summary of each state's energy activity at the request of the Southern Governors' Conference Staff Advisory Committee. It is of particular interest that a number of states require a state role in siting electrical generating facilities. The governors of the various states see a need for state governments to take a more active role in the solution of the energy problem in all of its aspects; supply, demand and pollution control. When an overall approach is taken, some of the alleged energy shortages appear in a different light.[7]

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[7]The States and the Energy Crisis, Southern Interstate Nuclear Board, Atlanta, Georgia, August 9, 1973, p. 473.

One-fifth of the nation's energy is used for heating and cooling and one-fourth is used for transportation. The evidence shows that for every degree cooler a house is kept, the energy consumed is about 5 per cent less. The San Diego Utility Company reports the cost of insulating an "average size" home in the San Diego climate zone is about $300. Over 25 years the savings on heating and cooling this insulated home are estimated to be about $1800.[8]

Properly maintained automobiles increase mileage per gallon of gasoline by about 15 per cent, and a reduction of speed from 70 miles per hour to 50 miles per hour increases mileage by another 15 per cent. In addition, estimates indicate that small cars used in lieu of large cars use 260 gallons of gasoline less annually.[9]

Only one-half of the nation's energy is being used for production.[10] Therefore, it appears that energy conservation is a short-term partial solution to the energy crisis. It also appears that more efficient planning

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[8] "The Making of an Energy Skinflint," in Exxon U. S. A., Vol. XII, No. 3, Third Quarter. Exxon Corporation, Houston, Texas, 1973, p. 17.

[9] Ibid., p. 17.

[10] Ibid., p. 16.

and use of the nation's energy resources may be a long-term partial solution to the energy crisis and may be compatible with continued economic growth, with little significant change in the American life style.

Petroleum

Petroleum was the largest source of primary energy in 1970 and is the only fuel that can supply energy to households, industry, electric utilities, transportation and commercial markets. It presently accounts for 7 per cent of the electricity generated nationwide.[11]

TABLE IV

DEMAND AND SUPPLY OF OIL IN THE UNITED STATES, 1970 ACTUAL - 1985 PROJECTION

	1970	1985	Change
	----Million Barrels Per Day----		
Demand	14.7	30.2	+ 15.5
Domestic Supply	11.6	15.0	+ 3.4
Deficit	3.1	15.2	+ 12.1

Source: Outlook for Energy in the United States to 1985, The Chase Manhattan Bank, New York, June 1972, p. 44.

[11] U. S. Energy, A Summary Review, U. S. Department of the Interior, U. S. Government Printing Office, Washington, D. C., January 1972, p. 41.

Oklahoma is fourth in the nation in crude petroleum production, preceded by Texas, Louisiana and California and fifth in known crude reserves following Texas, Alaska, Louisiana and California. Output in the state decreased from 223.6 million barrels in 1970 to 213.3 million barrels in 1971.

In the United States, petroleum consumption was 14.7 million barrels per day in 1970 and demand is expected to increase annually by 4 per cent.[12]

Based upon the above supply and demand discrepancy for oil in the United States, there exists a need for more supplies of oil, decreased demand, increased imports, alternate fuels or some combination of these. Therefore, it does not appear that petroleum is a feasible fuel for expansion of the generation of electric power in the short-run in Oklahoma or the United States.

Nuclear Power

The federal government's 1974 budget contains $772 million for energy research and development, which is 20 per cent above 1973. More than one-half, or $411 million, is allocated to nuclear research and development. Nevertheless, in a study done by The Chase Manhattan Bank it was stated that: ". . . . after a nuclear generating

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[12] Ibid., p. 41.

plant is ordered a 7 to 8 year period is required for construction and other details."[13] This figure appears to be a minimum, for other sources give the average time required to construct a nuclear plant as 10 years.

A group of five utilities called "Snupps", have filed a joint application with the Atomic Energy Commission (AEC) to clear six identical nuclear reactors at once. The normal procedure is for each reactor to be reviewed separately, which takes about 18 months. This proposal is in line with former President Richard M. Nixon's expressed goal of reducing the construction time by 4 years, but the application has not yet been ruled on by the AEC.[14] There are environmental concerns in the form of thermal pollution, possible radiation hazards and other problems involved in the use of nuclear power for electric generation. Nevertheless, nuclear power has been endorsed by local Air Quality officials. However, the time span involved places nuclear plants in Oklahoma in the long-run sphere, as defined herein.

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[13] Outlook for Energy in the United States to 1985, Energy Economics Department, The Chase Manhattan Bank, New York, 1972, p. 48.

[14] The Wall Street Journal, May 2, 1974, p. 16

Other potential sources of fuel for the generation of electricity are solar energy, geothermal energy, wind power, and tidal power. The United States government has budgeted twice the amount spent in 1973 for 1974 to study solar and geothermal energy. Funds to be spent to study solar and geothermal energy total $16 million for 1974.

Solar Energy

Solar energy from the sun is the greatest source of energy known to man and has been used in different forms throughout history. In 212 B. C. Archimedes used the sun's rays with a glass to set fire to the sails of ships of an invading fleet. In the skylab space mission in the United States, solar panels were used to convert sunlight to electricity at a cost of $200 per watt or 2,000 times the "average" cost of generating electricity using conventional methods. Some of the difficulties of solar energy are the diffuse and intermittent ways it reaches the earth. This makes geography a substantial economic factor.

Representative Charles A. Vanik from Ohio has proposed legislation based upon the projections of the Solar Energy Panel of the National Science Foundation and the National Aeronautics and Space Administration that he believes will eventually enable direct energy from the sun to provide 80 per cent of the heating and

cooling needs of all new single story buildings. This time table calls for 10 per cent of the new buildings constructed in 1985, 50 per cent in 2000, and 80 per cent in 2025. Vanik wants funding of $100 million over 10 years and has said, ". . . . the amount needed to develop solar energy is small compared to the alternatives."[15]

With improved technology solar energy may become a feasible fuel for a substantial portion of electric power generation in Oklahoma and the nation, but it does not appear to be technically feasible in the short-run.

Geothermal Energy

Geothermal energy is energy derived from the heat inside the earth and is an automatically renewable source as long as magnatic heat lasts and water supplies are available. It has been used during most of the twentieth century as a source of fuel to produce electricity. The first plant was at Laraderello, Italy, in 1904. Geothermal energy has been used in Reyjkavik, Iceland, a city of about 80,000 persons, for many years, and is relatively pollution free. The U. S. has one electric power plant operating on geothermal energy in Sonoma County, California. It is owned by the Pacific Gas and Electric Company and is

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[15]The Daily Oklahoman, September 25, 1973, p. 12.

known as "The Geysers". It produces electricity for about 4 mills per kwhr. The Interior Department in U. S. Energy, a Summary Review, said that:

> Currently, the only geothermal sites offering possibilities for commercial development are hydro-thermal or hot-spring areas where high-temperature fluids are available at or near the surface. There are approximately 1,200 known thermal springs in the United States, located mostly in the Western States. California, Idaho, and Nevada contain about 200 sites each. There are several hundred additional hot springs in Oregon, Wyoming, Utah, Colorado, Montana, and New Mexico. All of these geothermal fields are associated with hot springs. The potential for sites not associated with hot springs is great and additional exploration could be expected to discover a large number of new hydro-thermal sites.
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> . . . . . .
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> Under favorable conditions, geothermal energy may be locally important to several areas in the Western States; however, it probably will be insignificant as a factor in national power capacity (less than 1 per cent of total) through the year 2000.[16]

Therefore, The Department of the Interior does not forecast an immediate utilization of our geothermal resources. The National Science Foundation is more excited about the prospects and urges a large increase in spending on geothermal research and development. It predicts that with the proper technology, geothermal power could be increased

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[16] U. S. Energy, A Summary Review, The United States Department of the Interior, U. S. Government Printing Office, Washington, D. C., January 1972, p. 33.

to 395,000 megawatts by 2000.[17] This is more than the present electric power generation in the entire United States. However, no evidence was found that indicated geothermal power was feasible for Oklahoma and it is not likely to be significant in the short-run for the nation.

Wind Power

Wind power is a source of energy. In 1850 it provided 14 per cent of the energy for the United States, but it is not significant today in the state or the nation. However in early 1974, Oklahoma State University had under construction a wind electrical generator system. Funds for the project have been allocated from the National Science Foundation and further funds are being sought from electric utilities.[18] Therefore in view of the meteorological conditions discussed earlier and further technical developments, wind power may provide a partial solution for the state in both short-run and long-run periods.

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[17] Exxon, U.S.A. Vol. XII, No. 3, Third Quarter, Exxon Corporation, Houston, Texas, 1973, p. 23.

[18] Energy In Oklahoma, Vol. II. Final Report of Oklahoma Energy Advisory Council, February 1, 1974, p. 134.

Tidal Power

Tidal energy was investigated in the Copper Project in 1921 on Sosliscook Bay, Maine, U.S.A., and Passamaquoddy Bay, New Brunswick, Canada. The project was estimated to cost $75 to $100 million and was not consummated. Because the available market was limited, it was not deemed economically feasible. With increased demand for clean electric power driving costs and prices up, technology may be developed that will enable tidal power to be harnessed at competitive prices. However, it would be a long-run contribution to the energy and environmental problems and does not appear to offer significant promise to the State of Oklahoma.

Hydroelectric Power

Hydroelectric electric power is clean power in that there is no significant air pollution. In 1970, water supplied the energy required to generate 15 per cent of the nation's electric power. The Chase Manhattan Bank estimates that by 1985 water will be responsible for generating only 8 per cent of the nation's electricity. There are now 11 hydroelectric projects in Oklahoma, with an additional unit under construction at Webbers Falls. In addition, there are 23 potential projects that have been evaluated but not constructed because expected annual costs exceeded expected annual revenues or because of

scenic beauty. It is the opinion of the Oklahoma Energy Advisory Council that ". . . . additional conventional hydropower in Oklahoma is limited."[19]

Therefore it appears that electricity generated by hydroelectric power will not increase significantly in Oklahoma in the short-run as defined herein.

Natural Gas

Natural gas furnished one-third of the energy requirements for the United States in 1970 and one-fourth of the fuel for steam-electric plants. In 1971 the production of natural gas in this country exceeded new discoveries, thereby causing natural gas reserves to continue the downward trend begun in 1967. Proved reserves in the 50 states fell from 290.7 trillion cubic feet in 1970 to 278.8 trillion cubic feet in 1971 for an overall decline of 4.1 per cent.[20]

Oklahoma ranked third in the United States in 1971 in the production of natural gas, with production increasing by 5.6 per cent. However reserves fell from 10.6 cubic feet of reserve for each cubic foot produced to 9.3 cubic feet

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[19]Energy in Oklahoma, Vol. II. Final Report of Oklahoma Energy Advisory Council, February 1, 1974, p. 51.

[20]Minerals Yearbook, 1971, United States Department of the Interior, U. S. Government Printing Office, Washington, D. C., 1973, p. 770.

of reserve for each cubic foot produced, for a decline of 7.3 per cent.[21] The Minerals Yearbook states:

> Meanwhile the inability to obtain additional gas supplies has compelled the transmission companies to notify distributors that the pipelines would be unable to supply any increased quantity of gas beyond what is specified in existing contracts. . . . . Action curtailing gas use has been taken in 26 states, of which 12 are located along the eastern seaboard and 9 are in the midwest.[22]

Therefore it appears that natural gas will not be available to meet the increased demand of Oklahoma electric power generating companies. The problems of obtaining natural gas in sufficient quantities prompted a major company in Oklahoma to contract for construction of a coal-fired generating plant in Muskogee. The plant is scheduled for 1975 completion and the owner has contracted to transport for fuel coal from Wyoming by rail. Another major company has been granted a petition by the Corporation Commission of Oklahoma to construct a nuclear fueled plant. This same company is constructing a new coal-fired plant which will also be fueled by western coal. One of the major power generating companies is negotiating with an Oklahoma producer for coal and has made other inquiries regarding

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[21] Ibid., p. 573-574.

[22] Ibid., p. 763.

leasing coal reserves for its own use. Long-run plans are to construct a new electric power generating plant at Hartshorne, Oklahoma, utilizing Oklahoma coal.

If natural gas is not available in sufficient quantities, Oklahoma electric power companies must plan on using a less clean and less desirable fuel for new plants. In so doing local utilities will be faced with problems in complying with pertinent air quality regulations. Let us now examine this problem.

SELECTED ELECTRIC POWER POLLUTANTS

The major pollutants emitted by the electric power industry are particulates, nitrogen oxides, and sulfur oxides, all of which have primary and secondary ambient air quality standards set by federal and state regulations.

Particulate Matter[23]

Particulates can exist as solid matter, liquid droplets, or gas. Conclusions found in the federal criteria document are that adverse health effects occur when the annual geometric mean for particulate matter reaches 80 micrograms per cubic meter.

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[23] A Citizen's Guide to Clean Air, Conservation Foundation, Washington, D. C. under contract with U. S. Environmental Protection Agency, 1972, p. 84-85.

Sulfur Oxides[24]

The major source of sulfur oxides is fuel combustion. Sulfur is found in coal and fuel oil. When these fuels are burned, sulfur joins with oxygen in the air to form gaseous oxides of sulfur, including dioxide (SO_2). Conclusions in the federal criteria document are that increased mortality occurs when the annual geometric mean is as high as 115 micrograms per cubic meter. Adverse effects can be detected when SO_x pollution exceeds certain levels for short periods of time and are especially evident in the case of sulfur dioxide. Levels of 300 micrograms per cubic meter of SO_2 for three or four days have been associated with a variety of adverse health effects.

Nitrogen Oxides[25]

The major source of nitrogen oxides is fuel combustion. Nitrogen gas comprises about 80 per cent of normal air. At high temperatures it can combine with the oxygen in the air to form several different gaseous compounds, collectively called the oxides of nitrogen (NO_x). Nitric oxide (NO) and nitrogen dioxide (NO2) are the two most important.

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[24] Ibid., p. 84.

[25] Ibid., p. 87.

Oxides of nitrogen can cause serious injury to vegetation, including the bleaching or death of plant tissues, the loss of leaves, and a reduced growth rate. A study by Ray Thompson at the University of California indicates that if pollutants were filtered out of the air at Riverside, California, the yield of grapes would increase by as much as 60 per cent, oranges by 50 per cent and lemons by 30 per cent. A similar study at the U. S. Agricultural Station at Beltsville, Maryland, showed growth suppression reduced tobacco yields by 20 to 40 per cent.[26]

Certain pollutants of this group are known to be toxic. In experimental animals exposure to NO_x lowers the resistance to such diseases as pneumonia and unfluenza and the same may occur in man. Exposure to high levels causes humans to suffer lung irritations and potential damage. Exposure of people to lower levels has been associated with increased respiratory disease.

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[26]G. Christian Hill, "Bitter Harvest - Air Pollution Damage to Crops Increases; Experts Disagree on What - If Anything - To Do About It," The Wall Street Journal, July 19, 1972, p. 24.

In addition, oxides of nitrogen, in the presence of sunlight, can react with hydrocarbons to form photochemical oxidants.[27]

A higher incidence of chronic bronchitis has been found in children living in areas where daily averages of NO_2 varied from 118 to 156 ug/m^3 (0.062 to 0.083 ppm) and where nitrate salts in the air were also at elevated levels. Adverse effects on plants have been observed when NO_2 levels exceed 470 ug/m^3 (0.25 ppm) for several months. Corrosion and damage to electrical equipment has occurred when elevated levels of nitrate salts occur and NO_x levels of 124 to 158 ug/m^3 or (0.11 ppm) in the morning hours may be associated, under certain conditions, with the production later in the day of photochemical oxidant levels harmful to human health.[28]

NATIONAL AMBIENT AIR QUALITY STANDARDS FOR SELECTED POLLUTANTS

Table II on page 23 gave the primary and secondary ambient air quality standards set by the Environmental

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[27]Photochemical oxidants are not emitted directly. Nitrogen oxides and hydrocarbons are stimulated by sunlight to form a family of irritants and a brown haze known as "smog". It was discovered and identified between 1950-1953 by Dr. Arie Haagen-Smit of the California Institute of Technology.

[28]A Citizen's Guide to Clean Air, Conservation Foundation, Washington, D. C. under contract with U. S. Environmental Protection Agency, 1972, p. 84.

Protection Agency pursuant to The Clean Air Amendments of 1970. The major pollutants produced by electric generating plants burning coal are particulates, nitrogen oxides and sulfur oxides.

In addition to the federal ambient air quality standards, The Clean Air Amendments of 1970 directed the Administrator to set federal emission standards for new stationary sources. Pursuant to Section III of said Act, standards were set and the standards relating to new steam generators are applicable to this study.

Small quantities of some pollutants are more dangerous than tons of other pollutants and the Act points out that research is continuing to determine harmful levels of different pollutants. It holds that:

> (2) With respect to any air pollutant for which air quality criteria are issued after the date of enactment of the Clean Air Amendments of 1970, the Administrator shall publish, simultaneously with the issuance of such criteria and information, proposed national primary and secondary ambient air quality standards for any such pollutant.[29]

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[29] The Clean Air Amendments of 1970 - P. L. 91-604, December 31, 1970, Sec. 109, p. 10.

On April 6, 1973, the Environmental Protection Agency set standards for beryllium and mercury. These standards are:

> BERYLLIUM - 10 grams per day for any 30-day average (Based on not exceeding an ambient concentration of 0.01 for any 30-day average).
>
> MERCURY - 2300 grams per day (Based on protecting against an average daily ambient concentration of 1 ug/m^3).[30]

Coal burning electric power generating plants emit beryllium and mercury as well as other trace elements including lead, manganese, selenium, vanaduim, chronium, nickel, arsenic, cadmium, flourine and boron.

OKLAHOMA AMBIENT AIR QUALITY STANDARDS FOR SELECTED POLLUTANTS

Table III on page 25 gave the primary and secondary ambient air quality standards for the pollutants set by the State of Oklahoma in its aforesaid Air Quality Control Implementation Plan.

The pertinent Regulations in The Oklahoma Clean Air Act for electric power generating companies in Oklahoma are Regulations 6, 16 and 18 and Proposed Regulation 19, pertaining to particulates, sulfur oxides, nitrogen oxides and hazardous air pollutants, respectively.

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[30]Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants", in Vol. 38, No. 66, Part II. Federal Register, April 1973, p. 8820-8850.

Oklahoma air quality officials think that in order to maintain the superior quality of Oklahoma air and to insure adequate air space to allow for growth and development, existing air pollution sources, including electric power plants, should not be and are not allowed under the Air Pollution Control Regulations published July 1, 1973, to exceed 2 times the secondary standards given in Table III on page 25. For example, the original secondary standard for sulfur oxides was an annual arithmetic mean of 60 micrograms per cubic meter (ug/m^3) but it does not apply if the property or land is controlled by the party responsible for the emissions from the point of emission to the point of concentration.

This fact led to more stringent requirements for selected new facilities including power generating plants. The stated purpose of this tough regulation is to control emissions of pollutants from stationary sources in order to prevent the Oklahoma air quality standard from being exceeded and insure that degradation of the present level of air quality in Oklahoma does not occur.

Regulation 3, as amended, of The Oklahoma Clean Air Act defines new installations:

> New Installations (Source or Equipment) - an air contaminant source which is not in being on the effective date of these regulations and any existing source which is altered, replaced, or rebuilt after the effective date of the regulations such that the amount of air contaminants emissions is increased.[31]

Under this regulation, if a production unit in Oklahoma is an existing source of sulfur oxide or nitrogen oxide as of July 21, 1970, it can continue to operate. However many plants operate under an interruptible fuel contract whereby the supplier can furnish another fuel if the primary fuel is not available. Because of increased demands for fuels, many plants are being supplied with a less desirable fuel, i.e., one that emits more pollutants. For example, if a plant were constructed to burn natural gas and low-sulfur fuel oil and must be modified to burn high-sulfur fuel oil and coal, then the plant will become subject to the more stringent pollution requirements of new sources. For this reason, Oklahoma power officials object particularly to Regulation No. 16, which applies to sulfur oxides. For example, the minutes of the Public Hearing of the Air Pollution Council Meeting held on July 23, 1973, reveal:

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[31]Regulation 3, as amended, pursuant to The Oklahoma Clean Air Act, Title 75 O.S. 1971, Sections 301 - 325. Oklahoma State Department of Health Bulletin No. 0550.

IX. Proposed Revisions to Regulation No. 16:

> Mr. Jim Pollard, Oklahoma Gas & Electric Company, spoke to Council on proposed changes to Regulation No. 16 presented at a previous public hearing. He then introduced Mr. Ronald T. Wall of Brown & Root, Inc., Houston, Texas. Mr. Wall then presented to Council excerpts of a report entitled "Oklahoma Gas and Electric Company Cost Comparisons for Emission Control 500 MW Steam Turbine Generation Unit." A copy of this report is on file with these minutes at the Division Office. Mr. Duane Stratton, OG&E, and Mr. George Gibbons, also made comments regarding the Brown & Root, Inc. Report. Mr. James Parmley, Public Service Company of Oklahoma, spoke to Council urging them to reconsider proposed Regulation No. 16 making it no more restrictive than EPA regulations. Public Service Company does not think that the citizens of Oklahoma can afford anything more restrictive. Mr. M. K. Hutton, Kerr-McGee Corp., Oklahoma City, spoke to Council reinforcing Mr. Parmley's remarks regarding citizen cost.[32]

As noted, the Environmental Protection Agency has set recent standards for beryllium and mercury. Proposed Regulation 19 will set standards for these pollutants as well as other hazardous air contaminants for Oklahoma. The Air Pollution Control Division Staff for the State of Oklahoma in a memorandum to the Air Pollution Control, dated September 5, 1973, said that . . . .

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[32] Public Hearing and Minutes of the Oklahoma Air Pollution Council Meeting held in Pryor, Oklahoma, on July 23, 1973, on file in the office of said Council, p. 3.

> The evidence developed for the promulgation of these standards will probably have great credence toward requiring a valid evaluation on the impact of any source of these pollutants on the environment.[33]

They urge that careful consideration be given to requiring a thorough evaluation on the potential for these two pollutants in Oklahoma.

Therefore, in view of the importance of the electric power industry to the state's growth and development, and the present insufficient quantities of natural gas available for fuel, it appears that the Oklahoma electric power generating industry is another important industry that will experience difficulty in complying with The Clean Air Amendments of 1970. The kilowatt-hour sales for a major Oklahoma electric power producer rose 19.2 per cent for fiscal year 1973. At the present time a continuation of a similar growth pattern of the Oklahoma power industry will necessitate additional costs to meet ambient air quality standards. This growth, together with the attendant costs and possible restructuring of rates, deserves study.

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[33]Memorandum of 9/5/73, State of Oklahoma, Air Pollution Control Division Staff.

CHAPTER IV

ELECTRIC POWER INDUSTRY

INTRODUCTION

Increased demand for energy is world wide. Outside the United States the per capita consumption of energy has doubled within the last 30 years and electric power consumption has doubled in the past decade. Forecasts for the United States are for continued increased demand for energy at an annual 4 per cent growth rate between 1970 and 2000. This growth rate is less than the rest of the world, but at this rate, energy demand in this country would increase by three times from 68,810 trillion BTUs consumed in 1970 to 191,556 trillion BTUs demanded in 2000.[1] As already indicated, the forecasts of the demand for electric power are even greater and show an increase in the United States from 1,614 billion kilowatt hours in the year 2000, an anticipated increase of approximately 600 per cent.[2] In support of these forecasts The Chase

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[1] U. S. Energy, A Summary Review. U. S. Department of the Interior, U. S. Government Printing Office, Washington, D. C., January 1972, p. v.

[2] U. S. Energy Thru 2000. U. S. Department of the Interior, U. S. Government Printing Office, Washington, D. C., January 1972, p. 19.

Manhattan Bank predicts that the electric utilities will increase their share of the total energy market during the next decade. See Table V.

TABLE V

USE OF ENERGY BY AGGREGATE MARKETS IN THE UNITED STATES, 1970 ACTUAL - 1985 PROJECTION

	1970	1985
Energy Market	Per Cent of Total	Per Cent of Total
Industrial	32	26
Electric Utilities	25	37
Transportation	24	21
Residential	14	11
Commercial	5	5
Total	100	100

Source: Outlook for Energy in the United States to 1985, Energy Economics Division, The Chase Manhattan Bank, (New York, N. Y.) p. 8-25.

ELECTRIC POWER INDUSTRY IN OKLAHOMA

Forecasts for Oklahoma reflect the same trend with kilowatt hours produced projected to increase from 20,947,214,780 in 1970 to 106,468,233,700 in 1990 or approximately a 5-fold increase. Table VI gives the current and projected electric power production for the state's two largest producers as well as total data for the state.

TABLE VI

KILOWATT GENERATION BY MAJOR
PRODUCERS IN OKLAHOMA, 1966-1973
ACTUAL, 1974-1990 PROJECTION

Year	Oklahoma Gas & Electric Company	Public Service Company of Oklahoma	State Totals
1966	7,303,994,500	5,171,234,600	14,011,179,100
1967	7,999,170,600	5,231,600,400	14,996,902,230
1968	8,096,555,200	5,677,118,400	16,449,512,170
1969	9,361,369,800	6,215,490,000	18,798,842,330
1970	10,472,133,900	7,279,952,700	20,947,214,780
1971	11,257,257,100	7,837,105,400	22,523,525,230
1972	12,659,692,200	8,724,439,600	25,125,055,080
1973	13,163,000,000	9,260,400,000	27,663,694,000
1974	14,623,000,000	10,537,880,000	29,695,113,700
1975	16,099,000,000	11,623,930,000	32,528,163,700
1976	17,726,000,000	12,112,340,000	34,921,573,700
1977	19,434,000,000	13,377,760,000	38,197,993,700
1978	21,335,000,000	14,208,680,000	41,190,913,700
1979	23,347,000,000	15,621,760,000	44,907,993,700
1980	25,582,000,000	16,541,480,000	48,451,713,700
1981	27,857,000,000	18,195,410,000	52,795,643,700
1982	30,400,000,000	19,747,640,000	57,361,873,700
1983	32,800,000,000	21,800,000,000	62,317,233,700
1984	35,400,000,000	23,618,000,000	67,287,233,700
1985	38,300,000,000	25,442,000,000	72,593,233,700
1986	41,500,000,000	27,330,000,000	78,441,233,700
1987	44,900,000,000	29,793,000,000	84,983,233,700
1988	48,200,000,000	32,242,000,000	91,480,233,700
1989	52,200,000,000	34,703,000,000	98,764,233,700
1990	56,300,000,000	37,402,000,000	106,468,233,700

Source: Energy in Oklahoma, Vol. II, p. 60.

Structure of the Industry

The electric power industry is composed of 4 distinct segments--the private or investor-owned companies, the Federal agencies, non-Federal public agencies and cooperatives. Most systems serving large metropolitan areas are vertically integrated, they generate the electricity, transmit and distribute it. Many of the municipal and cooperative systems provide distribution services only and purchase all the electricity used while others generate a portion and purchase a portion.

There are two major electric power generating companies in Oklahoma. As of December 31, 1973, Oklahoma Gas and Electric Company served 489,739 customers in 267 cities and towns. It also sold electric power wholesale to 19 communities and 5 rural cooperatives. As of the same date, Public Service Company of Oklahoma served 340,092 customers in 231 cities and towns. It sold electric power wholesale to 6 municipalities.

Both Oklahoma Gas and Electric Company and Public Service Company of Oklahoma are investor-owned. These two companies supplied 22,423,400,000 kilowatt hours of electricity in 1973 or approximately 81 per cent of the total output of the state industry. Total state production for the year was 27,663,694,000 kilowatt hours with

O.G.&E. supplying 13,163,000,000 kilowatt hours and P.S.C. supplying 9,260,400,000 kilowatt hours.[3]

Other suppliers are the Grand River Dam Authority, supplying about 5.6 per cent of the output; Southwest Power Administration, supplying roughly 7.6 per cent of the output; and Western Farmers Electric Cooperative, supplying approximately 5.7 per cent of the state's output. In addition, approximately 15 municipalities generate part or all of their electricity for sale to their own customers. This is a slight decrease from 1956 when 17 systems generated all the electricity required for their cities.[4] However, in 1973, the above mentioned Oklahoma Gas and Electric Company, Public Service Company of Oklahoma, Grand River Dam Authority, Southwest Power Administration and Western Farmers Electric Cooperative supplied approximately 97 per cent of the total output of the state.[5] As mentioned earlier, Oklahoma Gas and

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[3]Energy Advisory Council to the State of Oklahoma, Energy in Oklahoma, Vol II, February 1974, p. 60.

[4]Stanley Allen Self, Municipal Electric Utility Systems in Oklahoma, unpublished Ph.D. dissertation, University of Oklahoma, 1958, p. 64-67.

[5]Energy Advisory Council to the State of Oklahoma, Energy in Oklahoma, Vol II, February 1974, p. 49.

Electric Company and Public Service Company of Oklahoma generated about 81 per cent of the state's electricity in 1973. Therefore, this analysis will be limited to these two companies.

Table VII shows customers, sales, revenues and electric power generated and purchased for the years 1968-1971 for Oklahoma Gas and Electric Company. Table VIII shows customers, sales, revenues and electric power generated and purchased for the years 1968-1971 for the Public Service Company of Oklahoma.

TABLE VII

OKLAHOMA GAS AND ELECTRIC COMPANY
CUSTOMERS, SALES, REVENUES AND TOTAL
ELECTRIC POWER FOR THE YEARS 1968-1971

	1968	1969	1970	1971
Customers:				
Residential	355,763	364,475	376,600	391,774
Commercial and industrial	47,571	47,898	48,558	49,311
Other	5,833	6,201	6,252	5,064
Total	409,167	418,574	431,410	446,149
K.w.h. Sales:				
Residential	1,951,942,000	2,337,765,000	2,680,572,000	2,890,764,000
Commercial and industrial	3,414,119,000	3,710,680,000	4,071,071,000	4,402,212,000
Other	2,333,457,000	2,801,856,000	3,124,078,000	3,432,737,000
Total	7,699,518,000	8,850,301,000	9,875,721,000	10,725,713,000
Revenues				
Residential	$ 47,218,273	$ 54,595,617	$ 61,085,195	$ 65,449,432
Commercial and industrial	50,260,677	54,480,917	59,055,749	63,689,158
Other	16,293,423	20,520,129	23,428,860	26,891,017
Total	$ 113,772,373	$ 129,596,663	$ 143,569,804	$ 156,029,607
Steam k.w.h. generated	7,924,087,000	8,987,440,000	10,149,518,000	10,865,716,000
Other k.w.h. generated	172,468,200	373,929,800	322,615,900	391,541,100
K.w.h. purchased & interchanged	333,882,900	350,625,600	362,632,800	355,637,400
Total k.w.h. generated, purchased & interchanged	8,430,438,100	9,711,995,400	10,834,766,700	11,612,894,500

Source: Compiled from Reports to Federal Power Commission.

TABLE VIII

PUBLIC SERVICE COMPANY OF OKLAHOMA
CUSTOMERS, SALES, REVENUES AND TOTAL
ELECTRIC POWER FOR THE YEARS 1968-1971

	1968	1969	1970	1971
Customers:				
Residential	257,471	264,277	274,439	278,649
Commercial and industrial	35,399	35,935	36,634	37,053
Other	945	982	1,010	1,013
Total	293,815	301,794	312,083	316,715
Sales, k.w.h:				
Residential	1,432,857,000	1,705,370,000	1,929,820,000	2,015,429
Commercial and industrial	2,787,365,000	2,958,753,000	3,052,213,000	3,286,907
Other	1,582,093,000	4,362,473,000	4,249,755,000	4,263,901
Total	5,802,315,000	7,026,546,000	9,231,788,000	9,566,237
Revenues:				
Residential	$ 36,228,000	$ 41,679,000	$ 46,142,000	$ 48,266,956
Commercial and industrial	40,514,000	43,044,000	41,795,000	48,051,268
Other	10,148,000	12,937,000	22,750,000	24,894,366
Total	$ 87,160,000	$ 97,660,000	$ 113,687,000	$ 121,212,590
K.w.h. generated (net)	6,004,870,000	7,355,899,000	9,602,404,700	9,969,682,400
K.w.h. purchased (net)	281,787,000	271,919,000	441,655,103	400,352,820
Total	6,286,657,000	7,627,818,000	10,044,059,803	10,370,035,220

Source: Compiled from Reports to Federal Power Commission.

Eleven of the proposed new generating plants in the state are expected to be completed within the next decade for an increase in the total generating capacity of 6,300 megawatts. The details of this expected expansion of the state's electric power industry are shown in Table IX.

TABLE IX

PLANNED EXPANSION OF THE ELECTRIC POWER INDUSTRY IN OKLAHOMA, 1974-1984[6]

Rated Capacity MW	Location	Utility	Fuel	Year To Be Completed
450	Tulsa	PSC	Natural Gas	1974
240	Lawton	PSC	Natural Gas	1974
550	Seminole	OG&E	Residual Oil	1974
450	Tulsa	PSC	Natural Gas	1976
515	Muskogee	OG&E	Coal	1977
515	Muskogee	OG&E	Coal	1978
350	Hartshorne	PSC	Coal	1979
515	Morrison	OG&E	Coal	1979
515	Morrison	OG&E	Coal	1980
1,100	Inola	PSC	Nuclear	1982
1,100	Inola	PSC	Nuclear	1984

Source: Energy in Oklahoma, Vol. II, p. 59.

[6]Since writing the above, new information indicates that Public Service Company plans a 440 megawatt plant at Hartshorne, Oklahoma to be fueled with Oklahoma coal and Oklahoma Gas and Electric Company plans a 440 megawatt plant at Konawa, Oklahoma which will use fuel oil. These are expected to be completed after 1984.

It is noteworthy that after 1976 none of the proposed plants expect to utilize natural gas for fuel.

It appears that nuclear power will be a source of energy in the state by 1982, but in the short-run as defined herein, coal will be the major steam generating fuel for new plants within the state. In other words, Oklahoma has now joined most of the nation using coal as a fuel in new electric power plants. Now, using the announced plans of the major Oklahoma companies for the next decade, let us try to determine what it will cost these companies to comply with the relevant federal and state air quality regulations.

COSTS OF COMPLIANCE WITH AIR QUALITY STANDARDS FOR SELECTED POLLUTANTS

Coal fueled electric power plants are experiencing difficulty in meeting air quality standards. As shown in Chapter III, the major pollutants emitted by these plants are sulfur oxides, particulates, nitrogen oxides as well as other hazardous elements created by the burning of coal. Thus, coal must be consumed in such a way that its use will not violate The Clean Air Amendments of 1970 and the laws of the state where it is used. This compliance will be expensive and these costs must be borne by someone.

It appears that compliance with pertinent legislation can be achieved in some cases for some pollutants by utilizing higher stacks, installing electrostatic precipitators, burning low-sulfur fuels, installing sulfur oxide removal equipment, utilizing intermittent source emission control or some combination of these methods. In other words the pollutants may be removed from the fuel before it is burned; may be removed from the flue gases after burning and before being emitted into the atmosphere; low-sulfur fuel may be utilized; or the fuel may be burned in such a manner that the air will not become overburdened with pollutants.

Separate studies done by the Environmental Protection Agency, the National Economic Research Associates, Inc.; a joint effort by Anthony J. Tarquin, Jack A. Dowdy, and Howard G. Applegate; the Tennessee Valley Authority; and interviews by the writer with the major electric power generating companies in Oklahoma will be discussed.[7] However, it must be pointed out that the choice of one of the alternative ways to comply with relevant standards is a complex process that involves a multitude of interrelationships. For example, the fuel chosen will depend on the fuel producer's selling price, on transportation costs, user's handling costs, conversion efficiency, and the expected cost of compliance with air quality regulations.

Relatively few facts are known about these interactions and figures on costs are, at best, estimates. Mr. James G. Harlow, Jr., President of Oklahoma Gas and Electric Company, Oklahoma's largest electric power generating company, agreed that the problem was complex when he said that:

> The Clean Air Amendments of 1970 made illegal the historical and major source of energy for the generation of electric power, thereby changing the complexion of the entire industry.[8]

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[7]Oklahoma Electric Power Industry, Interviews with Selected Firms, July 1974. To maintain the private nature of these interviews, these sources will not be further identified.

[8]James G. Harlow, Jr., President, Oklahoma Gas and Electric Company, personal interview, Oklahoma City, Oklahoma, July 10, 1974.

New plants are generally more efficient than old plants in converting fuel to electricity and cost estimates indicate that installing air pollution control devices in new plants is cheaper than retrofitting old facilities. However, the large capital investment in existing plants and equipment makes a change to all new plants impractical. For most plants in the nation, retrofitting will be required in order to comply with present air quality regulations. Oklahoma is fortunate that most of the electric power generating plants now burn natural gas and are not experiencing serious air pollution problems. Therefore, at the present time retrofitting to comply with air quality regulations is not a problem in Oklahoma.

Because of the energy crisis, the relative abundance of coal, and the substitutibility of energy sources, it is conceivable that some electric power plants may be required to retrofit their facilities so that coal can be used as the fuel. However, it appears that existing gas-fired boilers in Oklahoma cannot be converted to burn coal. Should coal be the only fuel available, it would apparently take 3 years or longer to construct new boilers. In the words of an industry representative ready for retirement after serving the industry since his teenage years . . . . "The lights

would go out in Oklahoma if we were required to burn coal immediately."[9]

Source emission regulations may become more stringent in the future. Therefore, when new plants are built, comparative costs suggest strongly that they utilize the best available technology in an effort to avoid possible retrofitting costs at a later date. It appears that most of the planned, new coal-fired plants in Oklahoma will use boilers designed to burn coal, natural gas or fuel oil. The extent to which high polluting fuel will be substituted for fuel which emits fewer pollutants per BTU generated depends upon the availability of the fuels and upon the cross-elasticity of demand between fuels including the additional costs of removing the pollutants from each fuel.

The expected costs of controlling nitrogen oxides, sulfur oxides and particulates will be discussed next.

Nitrogen Oxides

Nitrogen oxides may be controlled by the design of the boiler and may present few cost problems. However, little work has been done in this area and additional studies

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[9]James G. Parmley, Chief, Environmental Affairs, Public Service Company of Oklahoma, personal interview, Tulsa, Oklahoma, July 9, 1974.

are required.[10] The Tarquin study says that it cannot estimate the costs of controlling nitrogen oxides in new plants and that it would probably be impossible to change the boilers on old equipment sufficiently to comply with air pollution regulations.[11]

The National Economic Associates study says that: "Comparatively little work has been done to date on the parameters governing NO_X formation in combustion, and even less on means of avoiding NO_X production."[12]

An official of a local electric power generating facility says that nitrogen oxides can be reduced 50 per cent by relatively minor modification on a super-critical boiler burning natural gas. The super-critical boiler is designed so that the liquid enters as water, is heated to about 3200° Fahrenheit and emerges as steam on a once-through basis. This official did not consider the increased

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[10] Emissions from Coal-Fired Power Plants, A Comprehensive Summary. U. S. Department of Health, Education and Welfare, U. S. Government Printing Office, 1967, p. 16.

[11] Anthony J. Tarquin, Jack A. Dowdy, and Howard G. Applegate, "Costs of Air Pollution Controls In the Power Industry," in Public Utilities Fortnightly, March 29, 1973, p. 42.

[12] The Economic Impact of Pollution Control, a Summary of Recent Studies, Prepared for the Council on Environmental Quality, U. S. Government Printing Office, March, 1972, p. 102.

costs incurred in controlling nitrogen oxides to be significant. It appears that standard boilers can be converted so that nitrogen oxide emissions are reduced by making the boiler larger and reducing the flame. However, the local power company spokesman pointed out that this is considered to be a less efficient method of generating electricity.

Nitrogen oxides are one pollutant considered by an Oklahoma utility to be more difficult to control in natural gas boilers than in coal-fired boilers. A spokesman for this utility said that his engineering department estimated that it would cost an additional $135,000 (1974 dollars) to modify the proposed boiler design in a new coal-fired, 450 megawatt plant to meet present federal and state nitrogen oxide standards. The other major utility in the state agreed that nitrogen oxides could be effectively controlled by oversized boilers and estimated the incremental costs at $1 per kilowatt, for a total cost of approximately $450,000 for a 450 megawatt plant. It was the opinion of the spokesman for the latter utility that the efficiency would not change appreciably.

Particulates

It appears that particulate matter emitted by the generation of electric power can be controlled by an electrostatic precipitator. This technology has been

available for about two decades. Efficienty is quite good. Ten years ago most precipitators were designed with a 90 per cent efficiency level or less. Surveys indicated that more efficient electrostatic precipitators were needed to meet ambient air quality standards. Efficiency now is in the 98 to 99.5 per cent range. Sixty utilities in the United States had under construction, between 1968 and 1972, 35,900 megawatts of new fossil-fueled electric power generating capacity. With the exception of two units located in remote areas, all of the coal-burning units had electrostatic precipitators installed.[13]

The higher the efficiency of an electrostatic precipitator, the greater the cost. The Federal Power Commission estimates that on a 500 to 800 megawatt plant, a precipitator of 95 per cent efficiency may cost between $800 and $1,200 per megawatt while on the same size plant, a precipitator with 99 per cent efficiency may cost more than $2,500 per megawatt. In addition, if precipitators are added to existing plants, this installed cost may amount to more than 10 times the above amounts.[14]

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[13]Federal Power Commission, The 1970 National Power Survey, Part IV, U. S. Government Printing Office, Washington, D. C., p. IV-1-21.

[14]Ibid., Part I, p. 1-11-15.

The Tarquin study mentioned earlier states that the "average" electric power residential consumer uses about 6,000 kilowatt-hours annually. This "average" residential consumer would have to pay about an additional $2.24 annually to cover the costs of controlling particulates.[15] No date is given for the period under study.

The study is based on questionnaires. Originally 77 questionnaires were sent to electric power companies in the United States and Canada. After 3 months, 27 responses had been received. The questionnaire was revised and sent to 106 electric power companies selected in these same two countries. After two months, there were 66 responses. The article reports that the responses could be grouped into 4 categories:

1. Those companies that did not answer because the questionnaire was too complicated;

2. Those from companies which did not have air pollution problems because they burned fuel oil or natural gas;

3. Those questionnaires which contained some information but not enough for the study; and

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[15]Anthony J. Tarquin, Jack A. Dowdy, and Howard G. Applegate, "Costs of Air Pollution Controls In the Power Industry," in Public Utilities Fortnightly, March 29, 1973, p. 40.

4. Those which provided the information requested. In addition, it was stated that one company replied the information sought was of a confidential nature.[16]

The number of responses were small, totalling only 50.8 per cent for both questionnaires. In addition, the study does not indicate in any way how many or what per cent of the companies contacted were in category 4. These two facts indicate the study may be of questionable value.

A major Oklahoma utility indicated its supplier has quoted the installed costs of electrostatic precipitators of more than 99.5 per cent efficiency at $25 to $35 per kilowatt in 1974. This amounts to about $15 million for a 450 megawatt plant. This figure is for new coal-fired construction because, as mentioned before, there are few problems when natural gas is utilized for the generation of electric power.

The other major electric generating company in Oklahoma calculated the costs for installing similar electrostatic precipitators in a new, coal-fired 450 megawatt plant in 1974 dollars to be more than $32 million. This $32 million cost is an incremental cost over and above the costs of a gas-fired generating unit of the same size. This estimate is more than $70 per kilowatt. In addition, it is estimated

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[16]Ibid., p. 42.

that operating costs for this electrostatic precipitator will amount to $1,327,852 annually. It appears that the costs calculated here cover the increased investment costs incurred by constructing a coal-fired unit instead of a gas-fired unit.[17]

Sulfur Oxides

It is also true that it is cheaper to control sulfur oxide emissions in new plants than in retrofitted older plants. EPA requires installation of wet limestone scrubbers to scrub the flue gas for removal of sulfur oxides on coal and oil-fired plants. As given by EPA, existing facilities will be brought up to standards by the following schedule:

Year	Per Cent
1972	5
1973	10
1974	35
1975	40
1976	10

EPA estimates investment costs for wet limestone scrubbers to be $30 per kilowatt for new or existing facilities.

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[17]Nevertheless, this $30 million incremental figure for compliance with air quality standards was quoted in a private interview by an official of Southwestern Electric Power Company in Shreveport, Louisiana, August 17, 1974.

A study prepared by the National Economic Research Associates, Inc., for EPA believes this $30 figure is an underestimate for new facilities and that retrofitting will be at least two times more expensive than the cost of installing this device on new equipment. Therefore, the NERA estimate for retrofitting is more than $60 per kilowatt. The National Economic Research Associates study estimates that by 1976 the costs of installing scrubbers to control sulfur oxides and provide the required cooling towers will amount to about 7 per cent of the current average electric power revenue nationwide.[18]

Based on one reply, the above cited study by Tarquin, et. al., supports the study done by National Economic Research Associates, Inc. and shows that sulfur oxides can be controlled in new plants for about $35 per kilowatt while retrofitting costs will run from $45 to $60 per kilowatt.[19]

However, the Tennessee Valley Authority and much of the electric power industry, do not agree that the scrubbing

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[18]The Economic Impact of Pollution Control, a Summary of Recent Studies, Prepared for the Council on Environmental Quality, U. S. Government Printing Office, March, 1972, p. 99.

[19]Tarquin, Dowdy and Applegate, "Costs of Air Pollution Controls In the Power Industry," in Public Utilities Fortnightly, March 29, 1973, p. 42.

technology exists for meeting SO_2 standards at coal-fired electric power plants. In addition, TVA estimates that even if a technologically feasible SO_2 removal system should become available, the installation of these systems would require a capital cost of more than $1 billion. This cost, amortized over the remaining life of existing coal-fired plants (an average of 20 years) plus maintenance and operation costs would account for more than a $200 million annual cost or 31.25 per cent of the annual 1972 revenues, amounting to $640 million.[20] In addition, there are waste disposal problems with scrubber devices that have not been solved.

The Oklahoma electric utility industry does not believe that flue gas scrubbers are technically feasible. Both major companies plan to utilize low-sulfur western coal in order to comply with air quality standards in the state. However, one utility stated it was building the physical plant so that when scrubbers become technologically and economically feasible, they can be added to the facility without the additional expense required by retrofitting.

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[20]Emo D. Porro, "Intermittent Power Plant Emission Limitation for Control of Ambient SO2 Concentrations," in Proceedings Industrial and Power Plant Environmental Impact Symposium held in Dallas, Texas, July 25, 1973, Systems, Science and Soft Ware, La Jolla, Calif., p. 7.

Since the use of low-sulfur coal is an unproven fuel for electric power generation in Oklahoma, neither major company could give cost estimates. In addition to fuel costs, there are other problems fraught with actual and potential costs in the form of transportation, availability of railroad cars, labor, waste disposal and others. Technology proven under a particular set of circumstances is not always applicable in another environment.

One company estimated that even though flue gas scrubbers were not considered to be technically feasible they could be obtained for an additional cost of $90 to $100 per kilowatt. The costs of new plants using coal or nuclear fuel will be 3 to 5 times greater than the capital costs of present plants using natural gas. Cost estimates given by the two major utilities were $100 per kilowatt for gas-fueled boilers, $500 per kilowatt for nuclear boilers, and $300 per kilowatt for coal-fired boilers utilizing electrostatic precipitators to control particulates, but without flue gas scrubbers designed to control sulfur oxides. If these costs are good estimates, based upon present expansion plans, electricity will become more expensive in Oklahoma.

Intermittent Source Emission Control

Intermittent source emission control is not maximum source control but is an effort to achieve ambient air standards at all times at ground level in order to avoid inversions and episodal conditions. A basic premise of intermittent source emission control is optimum utilization of the wind and the weather to prevent the overburdening of the air with pollutants. To do so requires that pollutant levels be forecast in advance. The major components of Intermittent Emission Control are:

1. Meteorological Forecasting.
2. Pollutant Forecasting, Ground Level Concentrations, utilizing the meteorological data and the anticipated emissions from sources to be controlled.
3. A Continuous Air Monitoring Network to verify forecasts and to measure the effectiveness of efforts to control pollutant emissions.
4. Emission Control designed so that pollutants can be reduced before and during critical meteorological conditions so that applicable air quality standards are not violated.[21]

Emission controls include reducing or modifying plant operations, changing fuel so that low polluting fuel will be utilized during the crisis stage, or some combination of these two. TVA conducted a non-continuous SO_2 emission

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[21] Ibid., p. 4-5.

limitation for two of its plants from September 1969 through November 30, 1972. There were 41 days during which the generating load was reduced and the 3-hour average for SO_2 was exceeded 2 times in 21 months as compared to 10 times in the previous 21-month period during which intermittent source emission controls were not used. In addition, during the period when controls were operative, the 24-hour average ceiling for SO_2 was not exceeded, whereas it was exceeded 8 times during the previous period. It is estimated that SO_2 emissions were decreased 50 per cent by utilizing emission limitation in this area.

> The results at TVA indicate that intermittent controls for SO_2 emissions can be used at large coal-fired power plants as an effective method for meeting required ambient SO_2 standards.[22]

According to Emo D. Porro, Intermittent Source Emission Control can control the ground level ambient air quality with little danger of episodes in many cities at one-sixth of source emission costs.[23]

However the Environmental Protection Agency has not found Intermittent Control Systems acceptable for maintaining national ambient air quality standards. It was stated that:

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[22] Ibid., p. 7.

[23] Ibid., p. 2.

> . . . . Experience with systems employing intermittent process curtailment indicates that, although air quality is improved, violations of ambient air quality still occur. Additional experience with these systems may, in specific cases, improve this reliability.[24]

EFFECT ON RATES OF AIR QUALITY LEGISLATION IN OKLAHOMA

As noted, existing electric generating companies in Oklahoma do not face serious pollution problems in complying with the air quality standards so long as they can obtain natural gas or low sulfur fuel oil. They are faced with increases in costs as fuel prices rise because of increased demand or decreased supply referred to elsewhere in this paper as the "energy crisis." These increases in fuel costs can be passed on to the consumer with a minimum two month lag. This mechanism for automatic adjustments because of fuel cost changes has received the approval of the Corporation Commission in Oklahoma and this is the rule rather than the exception for the remainder of the electric generating facilities in the United States.

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[24]Norman E. Thomas, Air Programs Division, U. S. Environmental Protection Agency, "Keynote Address at the Industrial and Power Plant Environmental Impact Symposium," in Systems, Science and Software, Proceedings Industrial and Power Plant Environmental Symposium held in Dallas, Texas, July 25, 1973, La Jolla, California, p. 8.

TABLE X

INCREASE IN ELECTRIC BILLS FOR SELECTED CITIES IN THE UNITED STATES, FALL 1973 - SPRING 1974

City	Per Cent Increase	City	Per Cent Increase
Atlanta, Ga.	27	New Orleans, La.	13
Barre, Vt.	26	New York, N. Y.	35
Jacksonville, Fla.	90	Portland, Ore.	10
Las Vegas, Nev.	25	San Francisco, Calif.	15
Minneapolis, Minn.	10	Tucson, Ariz.	10

Source: Data taken from "The Bills are Electrifying," Newsweek, April 8, 1974, p. 63.

In addition to increased fuel costs, the Public Service Company of Oklahoma filed a petition on August 31, 1973, seeking a restructuring of its rate schedule and an increase in revenues of $9.2 million primarily because of inflationary pressures and the need for capital expansion. The company anticipated that the greater share of the increase would be borne by the largest users.

TABLE XI

PROJECTED IMPACT OF RATE INCREASES ON CUSTOMERS OF OKLAHOMA PUBLIC SERVICE COMPANY, 1974

Consumer	Per Cent Increase
Residential	5.94
General Service	6.17
Industrial	7.40

Source: Records of Corporation Commission of Oklahoma, Cause No. 24969.

The proposal that industrial users of electricity bear the largest increase appears to be the trend nation-wide. However, economic analysis indicates that much of this cost increase will ultimately be borne by the final consumer.

Hearings on the request of Public Service Company of Oklahoma for an increase in rates and a restructuring thereof were held. On April 15, 1974, an order was handed down in which a rate increase was rejected but a restructuring of rates was ordered to be done in such a way that total revenue to the company would be unchanged. Another hearing was held on May 15, 1974, and this matter is still pending before the Commission.[25] The company brought out in its testimony at the hearing that it needs higher rates as its costs have increased for interest charges, capital expenditures, equipment, pollution control and other necessary costs. Therefore, the rate restructuring ordered is a preliminary step and is expected to be the basis from which adjustments will be made.

Testimony also showed that rate increases allowed for increased fuel costs had been excessive because over the years electric power generating plants had become more

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[25]Since the above was written, PSC has withdrawn its petition, but stated a larger increase in rates will be requested soon from the Corporation Commission.

efficient. Thus companies could produce a kwh of electricity with fewer BTUs of fuel. The company in effect was receiving a bonus as fuel increases were passed on to the consumer. The Corporation Commission's rate engineer working with the Public Service Company of Oklahoma has worked out a formula to insure that in the future the fuel cost adjustment will be based on the actual heat rate produced.[26] It is estimated that the failure to make this adjustment for increased efficiency cost the average residential consumer $1.00 annually during the period of increasing fuel costs.

Ideally, the goals of efficiency and equity require that air pollution costs be identified so that costs do not exceed the benefits received. If this could be done, then the most efficient method of compliance with the air quality laws could be chosen and each consumer could pay his fair share. However, as previously mentioned, establishing and maintaining ambient air quality standards is a new area and there is no historical basis upon which to establish costs. In many areas the technology is not proven. Then there are other costs involved in complying with The Clean Air Amendments of 1970 and the subsequent

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[26]Earl A. Hamilton, Public Utility Engineer, Gas, Electric and Water Department, for the Oklahoma Corporation Commission, Personal Interview, Oklahoma City, Oklahoma, April 14, 1974.

regulations that tend to become absorbed in the normal course of business and are difficult to identify. Some of these costs arise from the establishment of Environmental Departments, the decreased efficiency resulting from changes in boiler design and the costs of monitoring the air quality. In addition, one Oklahoma electric power utility has been required to spend $100,000 to evaluate the effects of transmitting nuclear generated electricity. Another Oklahoma electric power generating company has invested about $11 million in more than 450 railroad cars in order to transport the low sulfur fuel it plans to use.[27] The removal of waste materials including sulfur, particulates and ash also present some unsolved problems. For example, if planned ash bins constructed according to the best engineering advice available do not work under present circumstances, a new technology must be devised to accomplish the job. In this case the costs of using unproven technology would readily translate into kilowatt-hour prices before the fact.

Because of the present supply-demand relationships for primary energy sources and the difficulties being experienced by the electric power industry in trying to

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[27]It was learned in a personal interview in Shreveport, Louisiana, on August 17, 1974, with an official of a power company in a neighboring state that other companies in neighboring states were also purchasing railroad cars. This utility had placed a $5 million order for railroad cars to haul coal from Wyoming.

comply with air quality standards, the majority of the industry requested that EPA standards be relaxed. However, the Supreme Court on March 29, 1974, refused to overturn anti-pollution standards for new coal-fired electric utility plants. In this case, the Edison Electric Institute, composed of 193 power companies supplying 77 per cent of the Nation's electric service, argued that the restrictions would "jeopardize unnecessarily the capability of the electric utility industry to construct and thereafter operate additional generating facilities which must be completed if the electric utility industry is to be in a position to supply the nation with its energy needs." The Court did not agree and held that the Environmental Protection Agency's rules were reasonable.[28] This decision reinforces the need to ascertain and assign the relevant costs of compliance with the present air quality standards so that the goals of efficiency and equity can ultimately be achieved.

As stated, it appears that coal will be the major source of fuel for electric power generation in the

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[28]Essex Chemical Corporation v. Ruckelshaus, 480 F. 2d. 427 (1973).

short-run in the United States and for new plants in Oklahoma. It also appears that air quality standards will likely remain in effect for the period under study. An analysis of the role coal is expected to play in these circumstances and the economic effect of this role on the Oklahoma coal industry and on the economy of the state is examined next.

CHAPTER V

COAL AS AN ENERGY SOURCE

INTRODUCTION

Coal supplied 18 per cent of the primary energy in the United States in 1971. This country has 16 per cent of the estimated world reserves which are disbursed over a wide geographical area. In 1970, Russia was the number one producer of coal followed closely by the United States with China third.

TABLE XII

COAL PRODUCTION AND RESERVES, FOR SELECTED COUNTRIES, 1970

(In million short tons.)

Country	Reserves	Production
United States	1,559,695	613
Australia	222,983	82
China	1,114,122	398
South Africa	79,711	60
England	17,081	159
Russia	6,091,838	688
Other Countries	625,993	1,287
Total	9,619,585	3,287

Source: United States - United States Geographical Survey Bulletin 1275, 1967.

Rest of World - World Power Conference Survey of Energy Resources, 1968.

At present rates of usage, there is enough coal in the world to last approximately 3000 years and enough coal in the United States to last a minimum of 250 years. The U. S. Department of Interior states that the recoverable reserves of anthracite, bituminous, sub-bituminous and lignite in the U. S., under present economic and technological conditions, are between 200 and 390 billion tons.[1] In contrast, the Chase Manhattan Bank states that the total potential coal reserves in the United States are in the neighborhood of 800 billion tons, enough to last about 1500 years at the current rate of usage.[2] Certainly the evidence indicates that the deposits of coal are adequate to meet the increasing demand for energy at least in the foreseeable future.

Table XIII gives the production, average value per ton and coal reserves by state in the United States for 1971.

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[1]First Annual Report of the Secretary of the Interior Under the Minerals and Mining Act of 1970, U. S. Government Printing Office, Washington, D. C., p. 58, Appendix I.

[2]John G. Winger, et. al. Outlook for Energy in the United States to 1985, The Chase Manhattan Bank, June, 1972, p. 46.

TABLE XIII

PRODUCTION,[1] AVERAGE VALUE,[2] AND RESERVES[1] OF COAL BY STATE, 1971

State	Production	Average Value	Reserves
Alabama	18	$ 8.15	13,440
Alaska	1	8.18	130,085
Arizona	1	NA	--
Arkansas	--	10.30	2,418
Colorado	5	6.34	80,681
Georgia	--	--	18
Illinois	58	5.46	139,372
Indiana	21	5.18	34,665
Iowa	1	4.66	6,513
Kansas	1	5.72	18,678
Kentucky	119	6.49	65,330
Maryland	2	6.25	1,164
Michigan	--	--	205
Missouri	4	4.87	23,339
Montana	7	1.82	221,697
New Mexico	8	3.26	61,457
North Carolina	--	--	110
North Dakota	6	1.91	350,654
Ohio	51	5.24	41,574
Oklahoma	2	6.72	3,291
Oregon	--	--	42
Pennsylvania	73	8.52	69,472
South Dakota	--	--	2,031
Tennessee	9	6.40	2,606
Texas	--	--	12,914
Utah	5	7.37	32,224
Virginia	31	8.32	9,827
Washington	1	6.72	6,183
West Virginia	118	9.54	101,152
Wyoming	8	3.39	120,686
Other States	--	--	4,721
Total	552	$ 7.07	1,556,549

NA Not Available

[1]In million short tons.

[2]Per ton f.o.b. mines.

Source: Minerals Yearbook, 1971, U. S. Government Printing Office, Washington, D. C., 1973, p. 330, 371.

As previously stated, fossil fuel in the form of coal appears to be adequate to meet forecasted demand. A concern here is the fact that coal is burned to produce more than one-half of the electricity consumed in the United States. This coal that is burned to generate electricity produces one-third of the present air pollution. From the evidence examined in the preceding chapter, these percentages appear likely to increase over the next decade. Sulfur contained in the coal and released as sulfur oxides when the fuel is burned is of major importance insofar as air quality regulations are concerned. More than 90 per cent of the coal presently burned in electric power generating plants has a sulfur content of one per cent or more. Therefore, removing enough sulfur to meet the ambient air quality standards creates an economic and technological problem.

Coal production has been an important industry in Oklahoma for more than 75 years but the steam coal exceeds present allowable sulfur standards. Therefore, this paper will first determine the present status of the coal industry in the state and then evaluate the effects on the Industry of The Clean Air Amendments of 1970 and legislation passed pursuant thereto. The effect of the expected growth of the electric power industry and the present shortage of

clean alternative fuels on the coal industry in the short-run will be examined. Finally, a forecast of the state-wide economic impact of an expanding coal industry will be made.

The Oklahoma Coal Industry

Coal has been mined commercially in Oklahoma since 1880.[3] The state produces bituminous coal which is used for steam generation, principally by electric utilities in other states. A higher quality coal, suitable for coking purposes, is also produced and is marketed inter-state, intrastate and internationally. Although the early mines were underground, about 97 per cent of the industry's output in 1972 came from surface or strip mines. Table XIV describes the Oklahoma Coal Industry of 1972, the last year for which published figures are available.

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[3] Oklahoma Department of Mines, 1972 Annual Report, p. 25.

TABLE XIV

OKLAHOMA COAL INDUSTRY, 1972

No. Counties	7
No. Companies	13
No. Mines	16
Underground	2
Surface	14
No. Men Employed	546
Total Days Worked	2,999
Total Man Days Worked	132,715
Total Man Hours Worked	1,061,720
Average Days Worked Per Company	231
Average Days Worked Per Mine	187
Total Underground Tonnage	84,900
Total Surface Tonnage	2,445,311
Total Tonnage Produced	2,530,211
Estimated Market Value	$17,900,000.00

Source: Compiled from the Oklahoma Department of Mines, Annual Report 1972, p. 18, and Minerals Yearbook, 1971, U. S. Government Printing Office, Washington, D. C., 1973, p. 330-331.

As of June 10, 1974, there were no underground mines operating in Oklahoma although Kerr-McGee maintains an inactive shaft mine in Haskell County. On this date, the industry was composed of 14 strip mines operated by 13 firms. Table XV lists the mines that comprised the Oklahoma Coal Industry, as of June 10, 1974.

Cumulative production through 1973 was roughly 200 million short tons.[4] In 1972, Oklahoma ranked nineteenth among the states in coal production and produced 0.5 per cent of the coal in the United States.

Recoverable reserves in 1972 were estimated to be 1.5 billion tons.[5] However, the preliminary report of an extensive analysis of Oklahoma's coal resources under preparation by the Oklahoma Geological Survey for the Ozarks Regional Commission to be released in 1974 indicates that this figure is a low estimate. It now appears that more than 2 billion tons of recoverable reserves are

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[4]Sam A. Friedman, "Oklahoma," in 1973 Keystone Coal Industry Manual, p. 518.

[5]Energy In Oklahoma, Final Report of Oklahoma Energy Advisory Council, February 1, 1974, p. 109.

TABLE XV

MINES COMPRISING THE OKLAHOMA COAL INDUSTRY
JUNE 10, 1974

Company	Nearest Town	County
Bill's Coal Co.	Welch	Craig
Briartown Coal Co.	Whitefield	Haskell
Garland Coal & Mining Co.	Stigler	Haskell
Great National Coal Co.	McCurtain	Haskell
Green Country Mine	Blocker	Pittsburg
Kerr-McGee Corp.	Stigler	Haskell
Lone Star Steel Co.	McCurtain	Haskell
Leon's Coal Co.	Welch	Craig
McNabb Coal Co.	Claremore	Rogers
Okar Energy Co.	Poteau	Leflore
Peabody Coal Co.	Chelsea	Rogers
Peabody Coal Co.	Vinita	Craig
Sierra Coal Corp.	Porum	Muskogee
United Coal Corp.	Inola	Rogers

Source: Oklahoma Department of Mines and Personal Interviews.

available.[6] According to the most up-to-date information, Oklahoma has enough coal at the present rate of production to last more than 700 years.

However, for several decades, the Oklahoma coal industry has been a "sick" industry. In 1913, there were 9,044 workers employed in mines. Maximum production occurred in 1920 when 4,849,288 short tons were produced by 161 mines. Since that time, production has declined but has remained within a range of from 800,000 to 2,500,000 tons. In most years, Oklahoma production has been about 2 million tons. Table XVI illustrates the lackluster performance of this industry during the past two decades.

The electric power industry in Oklahoma can comply with the air quality standards without treatment of flue gases by burning fuel with 0.8 per cent sulfur or less. Other states have similar legislation, but allow from 0.5 to 2.0 per cent sulfur content in fuels. As pointed out in Chapter V, the control of sulfur oxides through the

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[6]Since writing the above, the Report has been released and has been examined. It shows 2.3 billion tons of net recoverable reserves. S. A. Friedman, Principal Investigator, An Investigation of the Coal Reserves in the Ozarks Section of Oklahoma and their Potential Uses. Oklahoma Geological Survey, Norman, Oklahoma, July 10, 1974, p. 1.

TABLE XVI

OKLAHOMA COAL INDUSTRY - MINES, PRODUCTION AND EMPLOYMENT, 1952 - 1972

Year	No. of Mines	No. of Men	Total Tons Produced
1952	70	1,749	2,161,326
1953	61	1,560	2,296,834
1954	61	1,517	1,870,335
1955	59	1,326	1,906,281
1956	48	1,417	2,052,299
1957	45	1,078	1,944,766
1958	35	998	1,865,540
1959	36	853	1,696,530
1960	36	927	1,490,937
1961	47	841	1,081,701
1962	37	605	1,052,725
1963	33	464	1,011,945
1964	38	283	1,038,979
1965	34	269	963,566
1966	28	221	841,983
1967	25	211	825,255
1968	24	271	1,105,242
1969	17	371	1,837,367
1970	17	552	2,442,464
1971	17	578	2,233,493
1972	16	546	2,530,211

Source: Oklahoma Department of Mines, Annual Report 1972, p. 22.

cleaning of flue gases is expensive and presents some technological problems at the present time. Table XVII gives the average sulfur content of coal burned by electric utilities in 1971.

The average weighted sulfur content of Oklahoma coal produced in 1971 was 2.6 per cent and exceeds the maximum sulfur content allowed for fuels that can be burned without scrubbing. Thus, it is at a comparative disadvantage when compared to low-sulfur coal. As shown in Table XVII there are adequate reserves of western coal. This coal is found in beds 70 to 80 feet deep, can be mined cheaply and will meet air quality standards with no further treatment of the flue gases. However, much of it contains large quantities of ash which does require treatment. The electric power industry in the United States in 1970 spent $71.3 million for air quality control. This pollution abatement control expense amounts to about 0.58 mills per kwh and represents an 11.5 per cent increase over the amount spent in 1969. Most of this expense was for the collection and disposal of ash.[7]

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[7] Steam-Electric Plant Air and Water Quality Control Data For 1970, Federal Power Commission, U. S. Government Printing Office, Washington, D. C., July 1973, p. xi.

TABLE XVII

AVERAGE SULFUR CONTENT OF COAL USED BY ELECTRIC UTILITIES BY DISTRICTS IN THE UNITED STATES, 1971

(In thousand short tons.)

District	Quantity	Per Cent Average Sulfur Content
Eastern Pennsylvania	18,661	2.3
Western Pennsylvania	5,272	2.3
Northern West Virginia	10,172	2.7
Ohio	29,899	3.4
Michigan	--	--
Panhandle	2,155	3.1
Southern Numbered 1	504	.7
Southern Numbered 2	16,486	1.2
West Kentucky	33,706	4.0
Illinois	33,685	3.4
Indiana	13,343	3.3
Iowa	672	3.6
Southeastern	7,022	1.7
Arkansas-Oklahoma	--	--
Southwestern	7,527	3.8
Northern Colorado	431	.4
Southern Colorado	2,247	.6
New Mexico	8,278	.7
Wyoming	7,316	.7
Utah	608	.5
North-South Dakota	3,576	.8
Montana	6,843	.8
Alaska and Washington	620	.1
Total United States	209,023	2.7

Source: Minerals Yearbook, 1971, Government Printing Office, Washington, D. C., p. 372.

An analysis of low-sulfur coal mined in Wyoming and contracted for delivery by an Oklahoma utility shows an average ash content of 5 per cent. On this basis, a 550 megawatt plant will generate about 150,000 tons of ash annually. The most efficient siting of electric power plants is to locate four plants on the same site. Thus four 550 megawatt plants will generate 600,000 tons of ash annually. If the bins are cleaned at the end of a five-year period,as planned, they will contain 3 million tons of ash. The utility states that markets are being explored but if none are found, the company plans to bury the ash and cover it with grass. Thus the consumption of western coal will create a substantial by-product which will constitute a disposal problem. Despite this fact, the utility in question considers the use of Wyoming coal its most feasible option in new generating plants for compliance with air quality standards.

As previously stated, air quality regulations require a reduction in the amount of sulfur oxides emitted. Economic analysis would lead one to infer that these regulations would decrease the demand for high-sulfur coal. However, this has not been the case. Despite the fact that Oklahoma steam coal cannot be used raw and still comply with air quality standards, it possesses a highly desirable

quality. It has a BTU content averaging about 13,000 per ton, whereas the low-sulfur, plentiful western coal has a BTU content of about 7,000 per ton. Therefore, the use of western coal will mean that approximately twice as much coal will have to be mined, transported and fired in order to produce the same number of BTUs as an average ton of Oklahoma steam coal.

To ascertain the economic effect of air quality legislation on the Oklahoma coal industry, the author personally interviewed a member of each firm in a position to produce coal during June 1974. See the Appendix for a copy of the questionnaire.

OKLAHOMA COAL INDUSTRY QUESTIONNAIRE

Question 1 is confidential. Question 2 asks whether the company sells coal to electric power generating companies inside or outside of Oklahoma. No Oklahoma coal was being sold to Oklahoma electric utilities during June 1974, although 65 per cent of the firms in the industry were selling coal out-of-state to be used for electric power generation.

Question 3 asks:

3. What is the average sulfur content of your coal production?

   a. Raw?
   b. Cleaned?

The sulfur content for raw steam coal ranged from 2.86 to 4.0 per cent with a modal value of 3.5 per cent sulfur content. Only 35 per cent of the producers cleaned their coal. Of those producers cleaning coal, the mean value of the sulfur content was 2.8 per cent.

Question 4a seeks to ascertain the effect of the Clean Air Legislation on the coal miner's operations. Thirty-five per cent of the producers felt that the legislation had indirectly decreased their sales. Forty-three per cent of those interviewed stated that their operations had not been affected by the Clean Air Act and the remaining 22 per cent replied that perhaps ambient air quality regulations had decreased sales. However, most of the producers pointed out the difficulty of separating the effects of the restraints imposed on the sulfur content of coal burned by electric utilities and the effects of the general shortages of fuels in the United States during late 1973 and 1974.

Question 5 asks the producers whether or not they expect air quality legislation to have any effect on future sales or production. The answers received were similar to the answers received for Question 4. Approximately 50 per cent of those interviewed saw no effect and the remainder saw a possible decline in sales because of ambient air quality legislation. A relatively new producer,

whose sulfur content was 2.86 per cent, saw sales increasing dramatically if air pollution regulations were less stringent. Another owner-operator who has been producing in the state for many years and whose sulfur content is 4.0 per cent, saw no effect of present or future air pollution regulations on his operations. He is presently planning a five-fold increase in operations in the same seam of coal.

Question 6 asks if the "energy crisis" has had an effect on demand. Eighty-five per cent of the producers reported that the energy crisis had increased demand and sales. The major reason given for the increased demand was the scarcity of other fuels. Established markets needed additional fuel and companies repeatedly reported that such new additional markets as cement plants, paper companies and chemical manufacturers sought energy in coal form. One company with long-term coal contracts reported selling cleanings from coking coal to a local concern for combustion purposes at a free market price greater than the price received for the premium coal under contract. One producer, with several decades of experience in Oklahoma, sees the present market disequilibrium, with the demand for Oklahoma coal greater than the supply, as the industry's "honeymoon". The remaining 15 per cent of the industry were producing under long-term contracts and reported they had not experienced an increase in demand. All of the coal producers who supply

coal for power companies reported that present demand exceeds supply. One producer who sells to power companies and ships by rail, truck and barge had shipments going out on all three on the day interviewed. In addition, this company had already sold all of its stockpile reserves and had in hand a standing offer from a utility in Missouri for all the coal that could be shipped. Further discussion with the producers revealed that as more desirable clean fuels became scarce, expensive or unavailable, electric companies are indeed switching to low-sulfur, low-heating western coals that are relatively inexpensive and comply with the ambient air quality standards without further treatment. However, the demand for Oklahoma coal has increased rather than decreased. One reason for this is that as more companies switch to coal they use high quality, high-sulfur, expensive Oklahoma coal in combination with the lower quality, cheaper western coal to increase the heating value and still comply with the air pollution standards. This process is known as blending. Several producers stated that many of their customers in Arkansas, Iowa, Nebraska, Missouri and Ohio had power plants that were already designed for high volatile fuel and using low volatile, high ash coal exclusively would present significant problems.

Question 7 reads:

7. a. If the demand for electricity doubles in 10 years, will your demand for coal increase?

   b. In your opinion, will your company's sales increase?

   c. By how much?

One hundred per cent of those interviewed stated that if the demand for electricity doubled within a decade, their demand for coal would increase. Eighty per cent of the industry forecasted their ability to increase production to meet demand, whereas 20 per cent were not sure they could meet the increased demand because of difficulty in obtaining equipment, the cost of equipment or the expected short life of their mine.

Question 8 asks the producer to project the role of Oklahoma coal as a fuel for electric power generation for the next 5 year period, the next 10 year period and the next 20 year period. Seventy per cent of the industry see the average growth rate for coal to be used for electric power generation during the next 5 years at 100 per cent for the 5 year period, while 90 per cent forecast an average total growth rate of 310 per cent for the next 10 years. By 1984, 70 per cent of the industry see a stabilization of the demand for coal as a fuel for electric power generation as nuclear, solar and other technologies become economically feasible, while 30 per cent see a continued growth in the market for coal.

Question 9 asks: Can you expand production at present prices? More than 90 per cent of the state's producers replied in the affirmative. A mine that is not expanding in Oklahoma is expanding in the same seam in Kansas. Individual mines reported production could be increased from 25 per cent to 500 per cent with two mines reporting 25 per cent, four mines reporting 50 per cent, one mine projecting a 100 per cent increase at present prices and a large mine estimating a 400-500 per cent increase, all at present prices. Question 9b was an effort to ascertain if production could not be expanded at present prices, why not? The response was because of shortages and high prices of equipment.

Question 10 deals with anticipated costs over the next 5 years. Sixty per cent of the producers cited increases in equipment cost as the expected major cost increase. Cost increases here were expected to be in the neighborhood of 15 per cent annually. New mining equipment and replacement parts are in short supply. Major machinery delivery dates are quoted several years in advance. A minor replacement item such as a steel cable or a dozer bucket may take as long as 38 weeks from purchase to

delivery date. Prices are quoted as of the date of delivery. Wages, repairs and reclamation costs were also of concern as well as general inflationary pressures. Thirty per cent of the producers saw inflation costs adding 40 per cent to their total costs by the end of the next 5 year period, or approximately by 1980.

Question 11 deals with coal gasification for the state and the nation. The conversion of coal to oil or gas is a means of changing the form of coal. There are several advantages. For example, some undesirable components of the coal can be eliminated to make it more acceptable environmentally, and the gas or oil can be transported easier and cheaper. In addition, this new form of coal could service an expanded market and could help alleviate the petroleum shortage which would lessen our dependence on foreign oil imports. The 1974 federal budget included $129 million for research and development on fossil fuels, with $120 million earmarked for coal projects. The emphasis was on transforming coal to different, more environmentally acceptable fuels, such as oil and gas. For example, the Bureau of Mines has a technique for converting coal with 3 per cent sulfur content to fuel oil with 0.3 per cent sulfur. Studies are also being made of the feasibility of underground gasification of coal.

Two promising gasification processes are the Synthane and Hydrone processes. The design for a pilot plant for the Synthane process has been completed and plans have been made to construct a pilot plant which can process 70 tons of coal daily into a pipeline-quality gas. However, the Hydrone Process requires no pretreatment of coal and uses less process hydrogen. Therefore, it offers some advantage over other advanced coal gasification processes.[8] The Bureau of Mines and other organizations are testing several other systems which can change the form of coal. In Oklahoma, the state is supporting a $300,000 contract to study the feasibility of establishing a coal gasification project using low-grade coal in a nuclear reactor.

In June 1974, 93 per cent of Oklahoma coal producers forecast a role in the energy picture for coal gasification in the United States. However, only 35 per cent of this group see gasification becoming feasible for Oklahoma, 50 per cent are doubtful that it will become feasible while the remaining 15 per cent, composed of two of the state's more experienced operators, predict that gasification of

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[8]The Minerals Yearbook, 1971, U. S. Government Printing Office, Washington, D. C., 1973, p. 573.

coal will not occur in Oklahoma. The consensus of the 65 per cent who were negative is that Oklahoma coal is very expensive to mine compared to western coals. There are large deposits of low-cost lignite in North Dakota and vast deposits of sub-bituminous coal in Wyoming and New Mexico that are available for gasification at a cost lower than the cost of Oklahoma coal.

As the transformation of coal into other forms of energy becomes feasible, particular consideration should be given to existing transportation routes. If plants can be built near adequate, proven coal reserves where existing pipelines can be used for transporting the finished product, the necessity for new transportation facilities will be obviated, which will reduce costs. However, it does not appear that this is the case with much of the western coal.

The crux of the coal gasification processes is economic. Producers using coal for fuel will find the project economically feasible if the cost of manufacturing and transporting the synthetic fuel is less than the costs of using high-sulfur coal, including the transportation costs and the removal of the sulfur, fly ash and other pollutants from the flue gas.

Question 12 reads:

12. Based on your experience, do you see the Oklahoma coal industry growing during the next decade?

a. If so, how much?

The modal value for the anticipated growth of the Oklahoma coal industry for the next decade was approximately 300 per cent while the mean value was approximately 310 per cent. One producer saw no significant change in the industry during the next decade, but significantly no producer saw a decline. The Oklahoma Energy Advisory Council predicts an increase in state usage of coal from less than 1 per cent of total energy requirements in 1973 to 28 million tons or 27 per cent of the state's energy needs by 1990.[9] The Council forecasts a state demand of approximately 16 million tons of coal by 1984.[10]

Our study shows that the coal industry itself predicts production of about 8 million tons by 1984. This growth should provide an additional 1100 jobs in the coal mining industry. Based upon a conservative multiplier of 1.5 the total additional employment could amount to 1,650. State coal miners are well paid with a union mine operator

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[9]Energy Advisory Council to the State of Oklahoma, Energy in Oklahoma, Vol. I, February 1, 1974, p. 13-14.

[10]Ibid., Vol. II, Figure 1-5, p. 5.

reporting his lowest wage to be $6.48 per hour, and a non-union producer citing an average wage rate of $5.40 per hour. Based on 1,061,720 man-hours worked in 1972, man-hours worked in 1984 would be 3,185,160. At an average wage of $6.00 per hour, 1984 wages in the industry would be $19,110,960, an increase of $15,740,640.

A stimulus to the industry is the fact that Oklahoma has no coal severance tax and its reclamation laws are not as stringent as some states. Previously, with regulated prices for competing fuels, coal producers report they did not earn a sufficient return to allow for reclamation. Now, with one exception, Oklahoma producers point with pride to their reclamation efforts. It is now economically feasible to reclaim land because of better equipment and higher prices for coal. One producer restores the land according to the owner's desire by planting or sprigging the grass or planting a combination of grasses as directed. Another operator pointed out that restored land was not left in "as good as before" condition but "better than before". The relatively low-cost water transportation of the McClellan-Kerr Arkansas River Navigation System is another asset to the industry. In its first year of operation, the canal handled 18 per cent of the state's coal output.

However, there are potential bottlenecks which may hinder expansion. Pursuant to a Treaty, the United States government purchased the coal under 377,000 acres of Indian lands in the southeastern part of Oklahoma in 1947 for $8.5 million, or about $20 per acre. It now appears that much of the state's coal is located in these segregated lands. There are presently about 60 leases in effect, with 2 operative mines. Leases are made for an initial 20 year period and can be renewed at the lessee's option. A lease unit expires in the fall of 1974 and it is expected that the government will offer competitive leases on new lands at this time. If this is not the case, the failure is expected to retard the growth of the industry.

Although transporting coal is a major source of revenue for the railroad industry, it does not appear that adequate cars are available in sufficient number to service the coal industry at its present level of operations. There is a degree of hope in the fact that some expansion is occurring. Norfolk and Western Railway, for example, has ordered 2,000 coal hopper cars with an average capacity of 100 tons. This represents an investment of $35.6 million and all units should be in service by 1976.[11]

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[11] Coal Mining and Processing, McClean-Hunter Publishing Corp., June 1974, p. 16.

Another difficulty is that coal freight rates are rising and appear to be discriminatory.[12]

> For example, Pittsburg & Midway's shipping rates in 1967 for slack coal were $4.13 per ton. Now they are at $7.25 per ton with a surcharge of $2.50 per ton on top of that. Others are similar. But these rates do not apply as stated to other shippers who contribute far less to the RR's overall net income.[13]

A possible supplementary form of coal transportation is a coal-slurry pipeline. Senator Henry M. Jackson has endorsed this method of transporting coal as being uncomplicated, silent, safe and practically invisible. A coal-slurry pipeline is presently proposed to bring western coal to the Oklahoma-Arkansas area.

Long-term contracts for coal at a fixed price present a major problem during periods of rapidly increasing costs. The mines in Oklahoma operating under long-term contracts are experiencing cost-push conditions. A large coal producer indicated his mine had operated at a loss during the months of March, April and May, 1974 because of long-term contracts. Under these contracts the revenue generated is not enough to replace and repair equipment and expand production.

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[12]J. Wes Blakely, "The Western Scene," Coal Mining and Processing, June 1974, p. 42.

[13]Ibid., p. 42. The author does not state, but it is assumed that these rates are comparable, and are average rates, or rates based from point to point.

SUMMARY

As mentioned earlier, an analysis of the evidence procured by this study indicates an expansion of approximately 300 per cent in the state's coal industry could occur during the next decade. Conceivably, production could increase to 8 million tons annually by 1984 and ultimately create more than 1600 new jobs. Growth of this magnitude would provide a strong stimulus to the state's economy. However, in order to attain this massive growth, it appears that the industry must expand in the southeastern part of the state.

CHAPTER VI

A SUMMARY OF THE EFFECT OF AIR POLLUTION REGULATIONS ON THE ELECTRIC POWER AND COAL INDUSTRIES IN OKLAHOMA

INTRODUCTION

The purpose of this chapter is to put the evidence obtained in perspective. As noted in Chapter III, the standards set by The Clean Air Amendments of 1970 are subject to change. In the opinion of an Oklahoma power company official, the changing of air quality standards is the greatest problem the electric power industry faces in its effort to comply with ambient air quality standards. Because of the large amounts of capital investment required in the electric power industry and the necessity for long-range planning and financing, more stringent anti-pollution standards pose additional economic and technological problems. Likewise, a temporary relaxation of air quality standards does not necessarily mean that more energy will be immediately forthcoming.

PRIMARY ENERGY SOURCES AND AIR QUALITY STANDARDS

It appears that there was no clear understanding of the effects of The Clean Air Act on the demand for and

the supply of primary energy at the time of enactment. For example, ambient air quality standards were set for sulfur oxides. These standards could be met by the electric power industry by burning low-sulfur fuel or installing scrubbers to scrub the flue gas. As shown in Chapter IV, the Environmental Protection Agency requires that existing power plants install wet limestone scrubbers on a fixed schedule. Scrubbers are expensive and, in general, the electric power industry considers the scrubber an unproven and unworkable technology. Because Oklahoma electric power plants presently burn natural gas and do not anticipate using scrubbers in the short-run as defined herein, the technological debate on scrubbers is left to other studies. Oklahoma electric power companies expect to comply with sulfur oxide standards in new plants by burning low-sulfur coal.

According to state electric power representatives, state coal producers and state air quality officials, the passage of The Clean Air Amendments of 1970 caused the coal-burning electric power generating companies to scramble in an effort to obtain clean fuels such as natural gas and low-sulfur fuel oil in order to meet the ambient air quality standards without installing scrubbers. The Federal Power Commission reports that oil deliveries to

steam-electric plants were up 25.5 per cent in August 1973 over August 1972. This was despite an increase in the price from 57.2 cents per million BTU to 77.1 cents per million BTU. In addition, August 1973 deliveries were up 3.3 million barrels over July 1973.[1]

THE ENERGY CRISIS AND THE ELECTRIC POWER INDUSTRY

On November 29, 1973, the Federal Power Commission declared there was a nation-wide fuel emergency and the conservation of petroleum and natural gas by electric utilities was necessary.[2] The Commission requested an overall reduction in electric power generation of 10 per cent and stated that the reduced use of petroleum and natural gas for electric power generation was an appropriate objective. There was recognition that fuel shortages would be distributed unevenly. The coastal regions are the largest users of petroleum resources and the southwest region is the largest user of natural gas for the generation of electric power. The Commission urged that all

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[1]"Monthly Report of Cost and Quality of Fuels for Steam-Electric Plant." EPC Form No. 423 for August 1973, Prepared by the Bureau of Power, Federal Power Commission, Washington, D. C., April 1974, p. 1.

[2]Order 496; Docket No. RM-74-7. Federal Register Vol. 38, No. 234, December 6, 1973.

systems maximize the use of coal for electric generating capacity.

On December 4, 1973, the President of the United States issued Executive Order 11748 creating the Federal Energy Office in an effort to deal with the increased demand for the clean fuels of natural gas and fuel oil and the decreased supply of petroleum products aggravated by the embargo on exports of petroleum by many petroleum exporting countries.[3] The President thus launched the country on Project Independence designed to make the United States self-sufficient in energy by 1980. Executive Secretary William E. Simon of the Federal Energy Office, said that:

> Much of this increase will be reflected in a demand for oil, which has grown, in part, because there has been a shift away from coal to oil, and, in part, because of the inability to obtain natural gas, which is another substitute. . . . . We are pressing forward to switch 26 utility plants from oil to coal.[4]

We will now examine the fuel and air pollution problems faced by major Oklahoma power producers.

A CASE STUDY OF TWO MAJOR OKLAHOMA POWER COMPANIES

In July 1974, the two companies supplying 82 per cent of Oklahoma's electric power were personally interviewed.

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[3]Federal Register, Vol. 38, December 6, 1973, p. 33575-6.

[4]Presidential Documents: Richard Nixon, Volume 9 - Number 49, p. 1389-1390.

A copy of the questionnaire used is found in the Appendix.

Question 1 is confidential. Question 2 deals with any differences that exist between state and federal ambient air quality standards which affect the electric power business. The state has a more stringent regulation for sulfur oxides than the federal government. The regulation was originally scheduled to go into effect in 1975. Hearings have been held and Oklahoma appears to be in the final stages of changing this regulation so that federal and local standards for sulfur oxides will be the same. Chapter IV discussed this controversy.

Question 3 was given a negative answer, but was qualified. It was reported there was no difficulty in meeting present federal and state air quality standards for pollutants emitted by existing plants as long as natural gas remains available. Question 3a established that natural gas was the present primary fuel for the generation of electric power. The answers to Question 3b which sought to determine the secondary fuel for existing plants indicated some of the problems the local electric power companies face. Both companies use fuel oil as a standby emergency fuel, however one company pointed out that fuel oil could not presently be purchased. A site inspection

of a state power generating station revealed a large storage tank. It was explained this tank is used to store fuel oil as emergency standby fuel and many gallons have been loaned to other companies during the present shortage. One company pointed out that fuel oil was not really a secondary fuel but was an emergency standby fuel. According to officials for the local air quality organization and the power companies, technical problems apparently develop with soot if fuel oil is used to generate electricity in the boilers now used for natural gas. The need for constant availability of fuel is crucial since electricity cannot be stored and must be generated when it is used.

Question 3c deals with the costs incurred by state power companies in complying with state and federal ambient air quality standards utilizing planned fuel in existing plants for an average 550 megawatt plant and also the cost per kilowatt. The companies stated there were monitoring costs involved, but they were considered insignificant.

Question 4 reads: Are you experiencing difficulty in obtaining your primary fuel? The companies appear to be in a similar situation but each interpreted the question differently. One company gave a qualified yes answer. This answer was based on present reserves of natural gas amounting to approximately 9 years and it was pointed out

that the company should have reserves of 20 years to be comfortable. The other electric power utility reported that more natural gas was bought than was used in fiscal 1973 and, based on current useage, the company presently has a 10 year supply.

In response to Question 4a, regarding anticipated difficulty in obtaining the present primary fuel, one company responded that in addition to the difficulty incurred in making new contracts, prices have increased tremendously. For example, this utility has gas under old contracts at prices as low as 15 cents per/thousand/cubic/feet while contracts negotiated for new gas is at prices up to 85 cents per/thousand/cubic/feet. The other utility reported it plans to use coal as fuel in new plants to conserve its gas supply.

Question 5 concentrates on the possibility of changing fuel in existing Oklahoma electric power plants. One company reported if it were forced to change fuel by legislative mandate, it would have to burn fuel oil because its boilers were designed for natural gas and fuel oil. The other major company reported fuel oil was not presently available, and its boilers were not designed to burn fuel oil except on an emergency basis; therefore, it would not be feasible to change fuel in existing plants.

Both companies agreed on a negative answer to Question 5a (1) which inquired if they planned to use Oklahoma coal as a fuel in existing electric power plants. The reason given was that in order to burn coal, it would be necessary to build new boilers. Under ideal conditions, the time required for constructing new boilers was estimated to be approximately 5 years. Questions 5b, c, d, e and f probed pollution problems and costs if the electric power firms should be required to use other fuels in existing plants. Given the answers received to Question 5 above, these questions are not considered relevant.

Question 6 asked each of the companies interviewed to project its growth rate for 5 years, 10 years and 20 years. The unanimous answer was a growth rate of about 10.5 per cent annually or a doubling of capacity within 8 to 10 years. One company expected to see a similar growth rate continue for Oklahoma and the southwestern part of the United States beyond 1994. A more cautious attitude was taken by the other major producer of electricity in the state. The spokesman for that company stated that while it was impossible to project future growth 2 decades in advance at this point, it was concievable the growth rate would taper off or stabilize after 1994.

Question 7a asks what fuels the electric utility company plans to use for future expansion. The spokesman for one of the companies stated he has signed a 30 year contract for western coal for two units now under construction. He also stated that this coal is expected to enable the utility to comply with the sulfur oxide air quality regulations without installing scrubbers. The boilers for all presently planned plants to be constructed by this company will be built so that coal, fuel oil or natural gas can be utilized. The secondary or standby fuel will be stockpiled coal.

The other major Oklahoma electric power company views the situation somewhat differently. In answer to Question 7, it expects to use both coal and nuclear power as fuel for new plants. Auxiliary fuel for start-ups will be fuel oil or gas, whichever one is available. Secondary or standby fuel will be stockpiled coal. This company is also doing extensive research with a major Oklahoma city to determine the feasibility of utilizing that city's garbage as a supplementary fuel source in a new plant.

The answers received in response to Question 7c were similar. This question asked: Do you plan to use Oklahoma coal? Representatives of both companies replied in the negative. It was reported that one company had

attempted in vain to secure a contract for Oklahoma coal. Both companies cited the comparatively high costs of Oklahoma coal and the relatively high sulfur content which would, in their opinion, require blending with low-sulfur coals. As noted earlier, the major electric power companies do not consider flue gas scrubbing proven technology and this stance is in opposition to the position taken by the Environmental Protection Agency. However, plants to be constructed in Oklahoma utilizing coal as a fuel will have built-in space for less extensive and, therefore, less expensive retrofitting costs should it become necessary to install scrubbers at a later date. Both companies expressed a desire to use some Oklahoma coal in the future.[5]

Question 7d asked if the utility anticipated air pollution problems using the aforesaid fuels in new plants. Both companies stated that the plants would be designed to comply with the present state and federal ambient air quality regulations.

> Question 7e reads: What would be your estimate of the total costs to your company to comply with the present air quality standards in a new plant.

Since costs have been discussed in Chapter IV, this question will be reviewed only briefly here. Both companies agreed that it was both desirable and necessary to estimate

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[5]As noted in Footnote 6 in Chapter IV, Public Service Company now plans to construct a new facility burning Oklahoma coal. It is expected to be completed after 1984.

the costs required to comply with present air quality standards, however, each company pointed out that it had no historical basis upon which to calculate these costs. Therefore, costs given are best estimates only.

Question 7f asked the electric power company to estimate the average costs for each new kilowatt of capacity to comply with the particulate, sulfur oxide and nitrogen oxide standards. In addition, aggregate costs for an average 550 megawatt plant were sought. Each company declined to answer questions concerning sulfur oxides. Control of nitrogen oxides was estimated by one company to be about $1.00 per kilowatt. The other company estimated average plant capital costs to be about $138,000 for the redesign of boilers to control nitrogen oxides or about $0.30 per kilowatt. A difference also existed in the estimates obtained for the control of particulate matter. One company estimated the cost of installed electrostatic precipitators to control particulates at $25 to $35 per kilowatt. At this rate the capital investment to control particulates on a 550 megawatt plant will be more than $19 million. The other company estimated the investment cost of installed electrostatic precipitators at $38.5 million for a 550 megawatt plant, or about $70 per kilowatt. As previously stated, this is an

area where costs are not clearly defined. Further study is recommended in this area.

Question 7g (1) asks how much the additional costs incurred to comply with current federal and state ambient air quality standards will add to the average residential consumer's monthly bill. The only answer received was from a producer constructing a new coal-fired plant. After checking with his company's engineers, the best estimate was about $28 to $30 annually, or roughly $2 to $2.50 monthly for this one plant and referred to particulates only. However, all customers in the same classification pay the same rate. Since the majority of electricity in Oklahoma is generated by natural gas, consumers are not expected to feel a great impact from the particulate control device in the immediate future. The greatest cost increase appears to be in investment costs. Coal-fired electric power generating costs, without scrubbers, are 3 times the cost of the same size gas-fired units. Nuclear generating plants will require an investment of about 5 times the investment of a gas-fired unit. In addition, funds for nuclear plants are committed during a 10 year period before any revenue is generated.

Question 7g reads: In your opinion, how will these increases (in costs resulting from air pollution control)

be passed on, i.e., what effect will it have on your rate structure? Both companies stated an appreciable change in the rate structure was not anticipated since the rates of each company are said to be based on the cost of supplying energy to each class of customer. Chapter IV discussed some proposed rate structure changes before The Corporation Commission of Oklahoma. Because of increased costs, both companies stated that rates must be increased.

Question 8 relates indirectly to former President Nixon's Operation Independence. The question reads:

8. There is some speculation that because of the "Energy Crisis" all fossil fueled electric power generating plants may be required to switch to coal.

   a. Do you see this occurring?

Spokesmen for both companies thought that it was possible that plants that were designed to burn coal and switched to natural gas or oil in order to meet ambient air quality standards could be required to return to coal as the primary fuel. Certainly, they agreed, new plants can be required to burn coal. An official of one of the local electric power generating companies noted that the passage of The Clean Air Amendments of 1970 discouraged investment in the coal industry because the Act made the burning of traditionally used steam-coal illegal. It was also pointed

out that temporary waivers of air quality standards would not be sufficient to attract the investment required to stimulate the coal industry to the extent needed to alleviate the energy shortage. Long-term commitments are required to obtain the financing necessary to open and operate mines.

THE ENERGY CRISIS AND THE CLEAN AIR AMENDMENTS OF 1970

Will the energy crisis modify the effects of the Clean Air Act of 1970? The evidence is conflicting.

As mentioned earlier, Ex-President Richard M. Nixon proposed to make the country self-sufficient in energy and was willing to sacrifice some air quality to do so. He proposed the installation of taller stacks to allow wider dispersion of pollutants. Under certain meterological conditions, the stacks might not be needed. He also wanted to close plants temporarily when pollution levels become high.[6] Intermittent control methodology was discussed in Chapter IV.

Environmental and economic factors contribute to the quality of life. B. R. Dorsey, Chairman of the Board of Gulf Oil Corporation, believes that energy demands are not incompatible with environmental goals. In an

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[6]The Wall Street Journal, March 25, 1974, p. 3.

address to the Graduate School of Business of the University of Pittsburgh on August 3, 1973, he said:

> . . . . I firmly believe that there can be harmony between environmental quality and adequate energy consumption. . . . . The argument that energy and environmental quality are incompatible is not valid and should not persist. The benefits of both are desired and can be achieved.[7]

A third school of thought believes that even a temporary relaxation of the air pollution standards should not be allowed. Dr. Betram Carnow, Professor of Occupational and Environmental Medicine, University of Illinois School of Public Health, speaking at a National Academy of Sciences symposium said:

> . . . . deaths from influenza, bronchitis, and pneumonia among white males nearly doubled in Chicago during a nine-day period of high sulfur dioxide and particulate levels.[8]

His conclusion is that sulfur compounds are "disease and death accelerators even at levels considered safe and used to set standards".[9]

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[7]B. R. Dorsey, "Managing the Nation's Energy," Pittsburgh Business Review, University of Pittsburgh Graduate School of Business, September-October, 1973, p. 1-3.

[8]Business Week, "Commentary/Environment," November 3, 1973, p. 36.

[9]Ibid., p. 36.

The National Academy of Sciences is conducting a year long study at the request of the Senate to develop data concerning the amount of pollution and the effects of that pollution. In addition, information is being gathered and evaluated by the Environmental Protection Agency's Community Health Environmental Surveillance system. Business Week argues that:

> For now, the primary, health-released standards should remain intact pending the results of the NAS study. To deal with the expected fuel crunch this winter, the EPA may have to grant temporary extensions of deadlines, especially for the secondary standards. But the agency should continue to apply the best-available medical data and get on with the job of purging dangerous pollutants from the nation's air.[10]

Certainly with ambient air quality standards set, a new factor has been added to business planning, and the economic problems resulting from air pollution control are complex. With the increased use of coal in Oklahoma, local air quality officials are concerned with the effects of the increased amounts of sulfur oxides that will be emitted. Concern was expressed for the potential adverse health effects on Oklahoma's citizens as well as property damage and degradation of Oklahoma air. Comparatively speaking, the high quality of most of the air within the state is a useful economic asset for attracting new industry to the state. A local representative of the Air Pollution

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[10]Ibid., p. 36.

Department, State Board of Health, estimates that Oklahoma stands today where California stood 15 years ago in regard to air quality.[11]

SYNTHESIS OF COSTS

From the evidence examined, it appears that electric power generating companies are faced with increased costs for fuel, other operating expenses, air pollution equipment and the costs for the new plants and equipment required to meet the increased demand for electric power. For example, a representative of one of the electric power companies reported that his company was borrowing money at today's interest rates to pay off old bonds that carried an interest coupon at 4 per cent. In summary, the electric power companies in Oklahoma are faced with 1974 inflationary rates for wages, equipment, and money as well as the costs of maintaining an acceptable air quality. In most cases, increased costs are passed on to the consumer. The amount of the increases and the effect on particular rates will be determined by the Corporation Commission of Oklahoma.

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[11]John W. Gallion, Chief of the Technical Section, Air Pollution Control Division, Oklahoma State Department of Health, Personal Interview, Oklahoma City, Oklahoma, July 30, 1973.

On July 25, 1974, three national utilities announced capital spending cancellations. General Public Utilities Corporation of Pennsylvania announced a 25 per cent cut in its 1974-76 construction budget, amounting to $400 million. Virginia Electric & Power Company deferred a capital expenditure of $100 million for 1974. Public Service of Colorado reduced its 1974 construction budget by $65 million. All companies:

> . . . . blamed inflation and the inability to raise capital for the cutbacks and warned that they would need increased rates to maintain earnings and avoid further cuts.[12]

ELASTICITY OF DEMAND FOR ELECTRICITY

Elasticity of demand measures the responsiveness of the quantity demanded to a change in price and the coefficient of elasticity is calculated according to the formula:

$$\text{Elasticity Coefficient} = - \frac{\text{Per Cent Change in Quantity}}{\text{Per Cent Change in Price}}$$

If the calculated elasticity coefficient is greater than 1, the demand is elastic. If the coefficient is less than 1, the demand is inelastic and for a coefficient of 1, demand is unitary.

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[12] The Wall Street Journal, July 25, 1974, p. 5.

Several studies have been made to determine the elasticity of demand for electricity, but further studies need to be made in this area. A study prepared by National Economic Research Associates, Inc. said that:

> . . . . Several studies have been made of the elasticity of demand. We had occasion within the past two years to review them critically and concluded . . . . none of the studies could be considered to have yielded a satisfactory measurement. We assume for the purpose of this report that the demand for electricity is relatively inelastic . . . .[13]

F. M. Fisher has done the most comprehensive study found on the elasticity of demand for electricity. This study relates electricity price to the number of electrical appliances in the household and Fisher concluded that the demand for electricity was inelastic in the short-run.[14]

Further studies were made by Fisher to identify those factors that influence the rate of growth of the stock of appliances in the home. The factors that were considered included:

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[13]Electric Power Generators, in The Economic Impact of Pollution Control, Prepared by National Economic Research Associates, Inc. for the Council on Environmental Quality, Department of Commerce, and Environmental Protection Agency, U. S. Government Printing Office, Washington, D. C., March 1972, p. 97.

[14]Franklin M. Fisher, A Study in Econometrics: The Demand for Electricity In The United States. Amsterdam: North Holland Publishing Company, 1962, p. 3-10.

1. Changes in population.
2. Changes in the number of wired households per capita.
3. Number of marriages.
4. Changes in long-range income.
5. Current income.
6. Price of appliances.
7. Price of substitutes.
8. Price of electricity.
9. Kilowatt hours consumed per hour of average use.
10. Price of gas.[15]

In general, the net changes in the stock of appliances in the home were influenced by changes in long-run income, changes in population and changes in the number of wired households per capita. The price of electricity and the price of appliances seem to have little or no effect.[16] Fisher's analysis of long and short term demand is based on data gathered from 47 states and the results reflect total demand characteristics of all residential plus some commercial consumers.

However, another study was found that indicates the finding of price inelasticity for the demand of electrical energy needs to be qualified. When the demand analysis is considered on a regional basis, the results seem to apply only to states roughly east of the Rockies, and north of the Mason-Dixon line. In the other states, there appears to

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[15] Ibid., p. 5.

[16] Ibid., p. 5.

be a relationship between electrical rates and demand, particularly in the case of large appliances such as water heaters, ranges, space heaters and air conditioners.[17]

An explanation for the price elasticity in the southwestern states can be explained by economic considerations. The southwest is generally considered economically "younger" than other states. In addition, the household in the southwest is usually able to compare energy costs between electricity and alternate sources of energy such as gas. This competition has a significant influence on high energy usage items such as water heaters and ranges.

This relatively higher price elasticity of electricity in the southwestern states is supported by the experience of TVA. During the thirties, the Tennessee Valley Authority drastically cut rates and found that the demand for electricity was far more elastic than had been expected. Many people during this period argued that TVA should become a yardstick for rates. However, the results of the TVA were possible because of the time and place. Fisher's studies indicate that as areas grow and mature economically, the demand elasticity decreases and energy pricing becomes a much less significant factor.

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[17]Damodar Giyarati, "Demand for Electricity and Natural Gas," Public Utilities Fortnightly, Vol. 83, No. 3, January 30, 1969, p. 19.

FORECASTED GROWTH OF THE OKLAHOMA COAL INDUSTRY

Coal is an energy source that exists in an adequate supply over a wide geographical area. The evidence examined shows that it will be utilized extensively in the United States and in Oklahoma as a fuel for the generation of electric power in the short-run. With more funds channeled to coal research and development, technological developments can be expected to occur which could make coal more environmentally acceptable. In addition, technological advances are usually accompanied by cost reductions. Preliminary discussions with knowledgeable parties in the state indicate that such a technological break-through is expected for flue gas scrubbers. If this occurs, coal will become more competitive as an alternate source of clean energy. Also, as discussed in Chapter V, it appears that coal gasification nationwide may become feasible in the short-run.

The Oklahoma coal industry was discussed at length in the previous chapter. As indicated there, it is the opinion of the Oklahoma coal industry that output will increase by more than 300 per cent by 1984.

CHAPTER VII

SUMMARY AND CONCLUSIONS

This research was designed to investigate the economic impact of The Clean Air Amendments of 1970 and subsequent ambient air quality regulations issued to date on the electric power and coal industries in Oklahoma.

The Federal Clean Air Act came under scrutiny because the legislation reflected an awareness by Congress that the atmosphere is not a free good. State legislation was passed pursuant to the Federal legislation. Studies have been presented that indicate harmful effects occur when sufficient quantities of pollutants are released into the air. Therefore, there are costs associated with these externalities. The Federal Act attempts, by regulatory methods, to insure that the polluters internalize these costs. Thus, a new dollar cost is added to the other costs already incurred by business.

Congress felt the evidence showed that benefits would accrue to the nation by reducing the level of certain air pollutants. As stated in Chapter II, EPA studies show the costs of air pollution to be in excess of $16 billion annually. Several other studies have been made

in an attempt to quantify the benefits obtained by reducing air pollution. This study made no such effort.

The primary concern here has been to determine the effect of the air quality legislation on the Oklahoma electric power industry. In addition, the study has focused on the costs of compliance with present air quality standards and the economic effects, in the short-run, on the electric power and coal industries in Oklahoma.

The electric power industry was chosen because it is an important industry. Traditionally, a close relationship has existed between the amount of energy consumed and the dollar value of the Gross National Product. In addition to its economic importance, as previously stated, the electric power industry is the third largest source of air pollution in the United States. However, at the present time, electric power plants are not major polluters in Oklahoma because the primary source of energy for generating electricity is natural gas. Nevertheless, evidence has been presented that shows in the short-run, previously defined as the period of 1974-1984, inclusive, Oklahoma electric utilities plan to utilize coal as the primary fuel for expansion.

As the study progressed, it became clear that electric power generating firms burning natural gas were in an

enviable position. Not only are such plants not major air polluters, but, in addition, the average nominal price per kilowatt-hour has undergone a substantial decline. The average price per kwhr of electricity sold by the state's two major producers in 1964 was $2.71. By 1973, the price had experienced an actual dollar decline of about 11.5 per cent to $2.29 per average kwhr. By way of comparison, the U. S. Consumer Price Index in March 1974 was 143.1.[1]

In the United States and Oklahoma, the electric power industry is a natural monopoly. Regulation replaces the market mechanism to insure that consumers receive the best possible service at reasonable prices. The Regulatory Agency is also charged with the responsibility of insuring that the stockholders receive a reasonable return on their investment. An equitable return is required so that additional investment will be forthcoming for the continued growth of the industry. In addition, funds must be provided for the air pollution control devices required by law.

The coal industry was investigated because nationwide coal is presently the major fuel for the generation

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[1]Based upon 1967 dollars (1967=100).

of electric power. Coal is also responsible for much of the air pollution produced by the generation of electricity. In addition, coal is an important natural resource in Oklahoma and is one of the state's oldest industries. The evidence examined shows that the use of coal as an alternate fuel for the generation of electric power is expected to increase tremendously in the short-run. The Oklahoma coal industry was surveyed to determine the economic effects of this projected increased demand for coal on this state industry. In addition, the economic effects of this anticipated change in the coal industry were examined for state-wide economic implications.

To summarize, the following findings are given.

1. Primary and secondary ambient air quality standards have been set pursuant to both federal and state regulations for certain air pollutants. The major pollutants emitted by the electric power industry are sulfur oxides, nitrogen oxides and particulates.
2. The electric power industry in Oklahoma is not presently a major polluter. However, it is expected to experience problems in complying

with the ambient air quality standards during the period under consideration.

3. The electric power industry in Oklahoma will utilize coal as its primary fuel in new plants constructed during the period 1974-1984, inclusive. It is this use of coal that will present the major problems to be encountered in the compliance with the ambient air quality standards.
4. Air quality standards and source emission controls can be changed by Federal or state regulatory agencies. This instability of air quality regulations makes it more difficult for the electric power companies to map compliance programs.
5. The price of electricity has experienced a secular decline. The evidence examined indicates that this decline may be over. It has been shown that additional costs will be incurred by the compliance with ambient air quality standards. In addition, the electric power industry in Oklahoma expects to double its electrical generating capacity during the next decade.

It will require financing for this expansion. The industry is also experiencing inflationary pressures particularly in the area of wages, fuel, repairs, new equipment prices and interest charges.

6. The evidence available was insufficient to determine how these increased charges will be passed on to the consumer. Changes in rates will be determined by The Corporation Commission of Oklahoma.
7. The present study provides cost data on the methods and costs of controlling particulates, nitrogen oxides and sulfur oxides in the electric power industry.
8. Since the electric power industry is a publicly regulated industry, the ascertainment of cost data is of prime importance. Only when costs are available can the Regulatory Agency act efficiently and equitably. This study has added to the available knowledge on the costs to be incurred by the addition of the air pollution control mechanisms which are required on electric power generating equipment in Oklahoma.

9. There are enough coal reserves in the world to last approximately 3000 years. While Oklahoma presently produces only about 0.5 per cent of the nation's output, coal is an old, important industry in the state. Since the sulfur content of much of the state's steam coal is too high to comply with federal and state Clean Air regulations without further cleaning, these regulations might be expected to cause a decline in the Oklahoma coal industry. However, this decline is not anticipated.
10. The Oklahoma coal industry predicts that the total tonnage of coal produced will increase by about 310 per cent from 1973 to 1984. Production is forecast to be about 8 million tons in 1984.
11. This growth of the coal industry is expected to stimulate the state's economy. It appears that total additional employment will increase by approximately 1,650 jobs. This study indicates that wages earned by the coal miners in Oklahoma in 1984 may be greater than the value of all the coal produced by the state in 1972.
12. Because Oklahoma does not have the vast quantities of coal reserves in thick seams that are

present in other states, the consensus of the coal industry is that coal gasification in Oklahoma does not appear to be feasible.

In summary, compliance by the electric utilities of Oklahoma with federal and state ambient air quality standards will be expensive for new electric power generating facilities. In Oklahoma, the Corporation Commission regulates the electric power industry. The Commission has an unusually difficult task in the present situation. As stated in Conclusion 5, the generating capacity of the electric power industry is expected to more than double within the next decade. Because natural gas is not available for long-term contracts, present plans of the industry are to construct coal and nuclear-fueled generating plants. Investment costs for coal-fired plants are approximately $300 per kwh and investment costs for nuclear-fueled plants are approximately $500 per kwh. In addition, air pollution devices must be installed for coal-fired plants.[2] In contrast, natural gas-fired electric power generating plants require an investment cost of only about $100 per kwh and the costs incurred for air pollution devices are

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[2]Other environmental safeguards are required for nuclear-powered plants. However, they have not been examined in this study because they will not be important during the period here examined.

relatively insignificant. Thus it appears that the electric power consumer in Oklahoma cannot escape an increase in electric power rates. However, these planned increased capital expenditures by the electric power industry could insure adequate power for industrial expansion while protecting the generally superior quality of Oklahoma's air resources. Equity and efficiency for both the Oklahoma electric power stockholder and the Oklahoma electric power consumer are the responsibility of The Corporation Commission in Oklahoma.

The primary fuel for the growth of the electric power industry in the short-run will be coal. Despite the fact that much of the state's steam coal has a sulfur content which is too high for compliance with air quality standards without scrubbing, it has other desirable qualities. The growth of the Oklahoma coal industry during the next decade is expected to be an impressive source of economic growth for the state.

APPENDIXES

APPENDIX A

QUESTIONNAIRE USED FOR PERSONAL INTERVIEWS FOR SELECTED COAL COMPANIES IN OKLAHOMA, JUNE 1974.

PERSONAL INTERVIEW FOR SELECTED
COAL COMPANIES IN OKLAHOMA:
JUNE 1974

1. Date:

   Company:

   Address:

   Name:

   Title:

2. Do you sell coal to companies that use it for electric power generation?

   a. In Oklahoma
   b. Outside Oklahoma

3. What is the average sulfur content of your coal production?

   a. Raw
   b. Cleaned

4. (a) Has the Clean Air Act had any effect on your Operations?

   (1) If so, has it decreased your sales?

   or

   (2) Increased your sales?

5. In the future, do you expect air quality legislation to have any effect on your sales or production?

   a. If so, in which direction?

6. Has the "energy crisis" changed your demand?

   a. If so, in what direction?
   b. For what reason?

7. (a) If the demand for electricity doubles in 10 years, will your demand for coal increase?

   (b) In your opinion, will your company's sales increase?

   (c) By how much?

8. What role do you see for Oklahoma coal as a fuel for electric power generation?

   (a) 5 years.

   (b) 10 years.

   (c) 20 years.

9. Can you expand production at present prices?

   (a) If so, how much?

   (b) If not, why not?

10. What increased costs do you anticipate in the next 5 years?

11. In your opinion, is there a role for coal gasification?

   (a) In the United States?

   (b) In Oklahoma?

12. Based on your experience, do you see the Oklahoma coal industry growing during the next decade?

   (a) If so, by how much?

APPENDIX B

QUESTIONNAIRE USED FOR PERSONAL INTERVIEWS FOR SELECTED ELECTRIC POWER COMPANIES IN OKLAHOMA, JULY 1974.

PERSONAL INTERVIEW FOR SELECTED
ELECTRIC GENERATING COMPANIES
IN OKLAHOMA: JULY 1974

1. Date:

   Company:

   Address:

   Name:

   Title:

2. Is there a difference between state and federal air quality standards?

   a. If so, which are more stringent?

   b. In your opinion, why?

3. Are you having difficulty in meeting the present federal and state air quality standards for pollutants emitted in existing plants?

   a. What is your primary fuel for existing plants?

   b. Secondary fuel for existing plants?

   c. What is your estimate of the costs of complying with present federal and state air quality regulations using planned fuel for existing plants?

      (1) 550 megawatt plant.

      (2) kwh.

4. Are you experiencing difficulty in obtaining your primary fuel?

   a. Do you anticipate difficulty in obtaining your primary fuel?

5. If you change fuel for existing plants -

   a. What would you use?

      (1) Why?

      (2) Do you plan to use Oklahoma coal?

         (a) Why?

         (b) Why not?

   b. Would you have problems with pollution?

   c. What would be your estimate of the total costs to your company to comply with the present federal and state air quality standards?

   d. What would be your estimate of the additional costs to comply with the air quality standards per
      550 megawatt plant - particulates
      sulfur oxides
      nitrogen oxides
      kwh - particulates
      sulfur oxides
      nitrogen oxides

   e. In your opinion, how much would these additional costs add to price of an average kwh?

      (1) Average monthly bill?

   f. In your opinion, how will these increases be passed on, i.e., what effect will it have on your rate structure?

      (1) Industrial.

      (2) Residential.

      (3) Commercial.

      (4) Other (employees).

6. What is your projected growth rate?

   a. 5 years.

   b. 10 years.

   c. 20 years.

7. What fuel do you expect to use in new plants?

   a. Primary.

   b. Secondary.

   c. Do you plan to use Oklahoma coal?

      (1) Why?

      (2) Why not?

   d. Do you anticipate problems with pollution using these fuels?

   e. What would be your estimate of the total costs to your company to comply with the present air quality standards in a new plant?

   f. What would be your estimate of the additional costs to comply with the air quality standards per
      550 megawatt plant - particulates
      sulfur oxides
      nitrogen oxides
      kwh - particulates
      sulfur oxides
      nitrogen oxides

   g. In your opinion, how much would these additional costs add to prices of an average kwh?

      (1) Average monthly bill?

   h. In your opinion, how will these increases be passed on, i.e., what effect will it have on your rate structure.

(1) Industrial.

(2) Residential.

(3) Commercial.

(4) Other (employees).

8. There is some speculation that because of the "energy crisis" all fossil fueled electric power generating plants may be required to switch to coal.

   a. Do you see this occurring?

   b. If it does occur, in your opinion, what will be the result in:

      (1) Air quality.

      (2) Costs.

      (3) Generating capacity.

SOURCES

PERSONAL INTERVIEWS AND QUESTIONNAIRES WERE AN INTEGRAL PART OF THIS RESEARCH, PARTICULARLY WITH REGARD TO THE ELECTRIC POWER AND COAL INDUSTRIES. THEREFORE, THESE INTERVIEWS ARE LISTED FIRST IN THE BIBLIOGRAPHY.

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GLOSSARY

The following glossary is not intended to be comprehensive or highly technical. It includes several specific terms which are useful in the literature on air pollution problems and abatement.

Air quality criteria: The levels of pollution and lengths of exposure at which, based on currently available scientific information, specific adverse effects on health and welfare are known to occur. These are delineated by EPA in "criteria documents".

Ambient Air: The unconfined space occupied by the atmosphere; i.e., outdoor air.

Ambient air quality standard: A limit on the amount of a given pollutant which will be permitted in the ambient air:

--primary standard--a limit for a given pollutant that, according to the Act, is to be set by EPA at a level stringent enough to protect the public health.
--secondary standard--a limit for a given pollutant that, according to the Act, is to be set by EPA at a level stringent enough to protect the public welfare.

Anti-degradation clause: A provision in air quality standards that prohibits deterioration of air quality in areas where the pollution levels are presently below those allowed by the standards.

Background level: Amounts of pollutants present in the ambient air due to natural sources. Examples: marsh gases, pollen.

BTU (British Thermal Unit): The amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit. Also used as a measure by which to compare energy available in various fuels.

Control techniques: Methods, equipment and devices applicable to the prevention and control of air pollutants at their sources, such as process changes, flue gas stack devices, stack height requirements, fuel use limitations, plant location rules, and so on. They are described in EPA's control-techniques documents.

Electrostatic precipitator: A device that uses electrical (rather than mechanical or chemical) attraction to collect particulates for measurement, analysis or control.

Emergency episode: An air pollution incident in a given area caused by a concentration of atmospheric pollution reacting to meteorological conditions (e.g., an extensive inversion) that results in a significant increase in illnesses or deaths.

Emission inventory: A list of air pollutants emitted into the atmosphere in a given area in amounts (usually tons) per day, by type of source.

Emission standard: The maximum amount of pollutant that is permitted to be discharged from a single source.

Fossil fuels: Coal, oil, and natural gas; so-called because they are the remains of ancient plant and animal life.

Hazardous air pollutant: Defined by the Act as a pollutant which, in EPA's judgment, "may cause, or contribute to, an increase in mortality or in serious irreversible, or incapacitating reversible, illness." These pollutants include asbestos, beryllium, cadmium, and mercury.

Implementation plan: A state blueprint of the steps that will be taken to ensure attainment of an air quality standard within a specified time period.

Inversion: The phenomenon in which a layer of cool air is trapped by a layer of warmer air above it so that the bottom layer cannot rise.

Kilowatt: Measures the production capacity or capability of electric generators.

Kilowatt-hour (kwhr): The amount of energy equal to one kilowatt in one hour; equivalent to 3,412 BTUs. Used to measure the amount of electricity generated and the amount consumed.

Margin of safety: The difference between an allowable level for a given pollutant and a criteria level at which adverse effects have been noted, assuming that the allowable level is numerically lower.

Megawatt: Measures the productive capacity of electric generators: 1000 kilowatts = 1 megawatt.

Micrograms per cubic meter (ug/m^3): A weight per unit volume measurement. Micro is a prefix meaning 1/1,000,000.

Monitoring: Sampling by local, state, and regional agencies as part of a surveillance system for measuring pollutants present in the atmosphere or pollutants emitted from an individual point source, e.g., a factory stack.

Parts per million (ppm): A volume unit of measurement; the number of parts of a given substance in a million parts of air.

Point source: A stationary source that emits a given pollutant in amounts above specified levels (such as 25 tons per year).

Scrubber: A device that uses a spray to remove aerosol and gaseous pollutants from an air stream; used for both measurement and control of pollution.

Standard of performance: An emission limitation imposed on a particular category of pollution sources, either by EPA or by a state. Limitations may take the form of emission standards or of requirements for specific operating procedures.

Surveillance system: A required part of implementation plans, established to monitor all aspects of progress toward attainment of air quality standards and to identify potential episodes of high pollutant concentrations in time to take preventive action. Also, the ambient monitoring network.

Variance: Sanction granted by a governing body for delay or exception in the application of a given law, ordinance, or regulation.