

THE IMPACT OF A DECLINING SUPPLY OF DOMESTIC RESERVES
ON NATURAL GAS RATE MAKING

A Thesis
Presented to
the Faculty of the Graduate School
University of Texas at El Paso

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts in Economics

by
Randolph L. Kelley
May 1972

UMI Number: EP00791

UMI[®]

UMI Microform EP00791

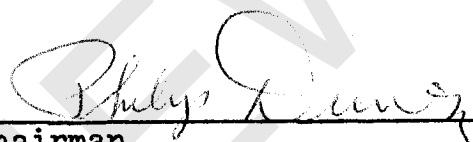
Copyright 2003 by ProQuest Information and Learning Company.

All rights reserved. This microform edition is protected against
unauthorized copying under Title 17, United States Code.

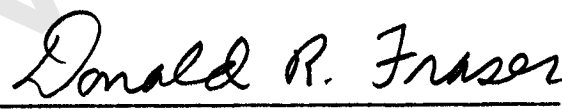
ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

THE IMPACT OF A DECLINING SUPPLY OF DOMESTIC RESERVES
ON NATURAL GAS RATE MAKING

APPROVED:


Chairman


Reader


Reader

APPROVED:


Dean, Graduate School

TABLE OF CONTENTS

	Page
LIST OF TABLES	vi
LIST OF FIGURES.	vii
Chapter	
1. INTRODUCTION	1
BACKGROUND	2
OBJECTIVE.	8
SCOPE.	9
2. ENERGY RESOURCES IN THE UNITED STATES. . . .	15
SIGNIFICANCE OF ENERGY	15
SUPPLY OF ENERGY RESOURCES AVAILABLE TO THE UNITED STATES	18
Coal	20
Liquified Natural Gas.	24
Electricity.	25
Substitute Natural Gas	31
Nuclear Energy	32
SUMMARY.	35
3. NATURAL GAS RESOURCES IN THE UNITED STATES .	39
SUPPLY OF NATURAL GAS.	40
THEORETICAL FRAMEWORK OF GAS SUPPLY. . . .	41
THE SHORTAGE OF NATURAL GAS RESERVES . . .	45
SUMMARY.	52
4. DEMAND FOR NATURAL GAS	55
THE MARKET DEMAND FOR NATURAL GAS.	58

Chapter	Page
INTRA-INDUSTRY DEMAND FOR NATURAL GAS . . .	65
SUMMARY	68
5. THE SIGNIFICANCE OF A STABLE GAS SUPPLY IN NATURAL GAS RATE MAKING	72
NATURAL GAS RATE MAKING ON THE ASSUMPTION OF A STABLE GAS SUPPLY	73
CURRENT RATE FORMS USED TO PRICE NATURAL GAS SERVICE	78
THE COST OF SERVICE APPROACH TO RATE MAKING	85
THE VALUE OF SERVICE APPROACH TO RATE MAKING	93
DIFFERENTIAL RATES RESULTING FROM VARIATIONS IN DEMAND FACTORS	96
SUMMARY	103
6. FACTORS THAT INFLUENCE NATURAL GAS PRODUCTION AND AFFECT DECLINING SUPPLIES .	110
TECHNOLOGICAL AND ECONOMIC FACTORS INFLUENCING THE PRODUCTION OF NATURAL GAS	111
REGULATORY FACTORS INFLUENCING THE PRODUCTION OF NATURAL GAS	128
SUMMARY	132
7. FACTORS THAT INFLUENCE NATURAL GAS TRANSMISSION AND AFFECT RATE MAKING PROCEDURES	137
TECHNOLOGICAL AND COST FACTORS INFLUENCING NATURAL GAS TRANSMISSION . .	138
RATE MAKING FACTORS INFLUENCING NATURAL GAS TRANSMISSION	152
SUMMARY.	161
8. DEMAND AND COST FACTORS THAT INFLUENCE NATURAL GAS DISTRIBUTION	165
SUMMARY.	172

Chapter	Page
9. IMPLICATIONS OF CURRENT REGULATORY POLICIES IN A DECLINING SUPPLY INDUSTRY	176
EARLY PRECEDENTS INVOLVING END-USE PRIORITIES	176
CURRENT REGULATORY PROBLEMS INVOLVING END-USE PRIORITIES	179
SUMMARY.	188
10. SUMMARY AND CONCLUSIONS.	190
SUMMARY.	190
CONCLUSIONS.	196
RECOMMENDATIONS FOR FURTHER STUDY.	202
BIBLIOGRAPHY	204
APPENDIX	212

LIST OF TABLES

Table	Page
1. Energy and Natural Gas Consumption in the United States	17
2. Energy Structure of the United States During Selected Years Between 1950 and 1990.	21
3. Fuel Sources for Electric Power Generation in the United States for 1970 and Estimated for the Years 1980 and 1990.	30
4. Current Estimates of Ultimate Discoverable Reserves of Natural Gas in the United States.	49
5. Potential Supplies of Natural Gas in the United States as of 12-31-70. . .	50
6. Industrial Consumption of Natural Gas in the United States by Industry Classification, 1945-1970.	62
7. Distribution of Natural Gas Service by General End-Use Classification for Various Years Between 1945 and 1970. . .	91
8. Underground Natural Gas Storage Facilities in the United States	100
9. Average Supply Prices of Natural Gas Marketed in the United States During Various Years	112
10. New-Field Wildcat Activity in the United States for Various Years Between 1945 and 1970.	114
11. Drilling Operations and Expenditures, By Type of Well, 1968 and 1969	116
12. Average Cost Per Foot by Type of Well, By Depth Classes, 1968 and 1969.	135

LIST OF FIGURES

Figure		Page
1.	Historical Energy Structure of the United States.	3
2.	Conversion and End-Use Distribution of Secondary Electric Energy from Primary Energy Inputs.	26
3.	Energy Requirements for Electric Generation by Sources of Primary Fuels Estimated to 1990.	29
4.	The Energy Supply Structure in the United States for 1970 and Estimated for 1980	36
5.	Supply Structure of Natural Gas in the United States Estimated to 1985.	46
6.	Supply and Demand Structure for Natural Gas in the United States	57
7.	Demand for Natural Gas in the United States Estimated to 1985.	70
8.	Typical Demand-Commodity Rate at Different Consumption Levels	79
9.	Typical Straight Line, Block and Step Rates	81
10.	Forms of Natural Gas Service from a Common Point of Supply	88
11.	Natural Gas Service Maintenance Function Under Conditions of Stable and Declining Gas Supply	108
12.	Production Development Cost.	119
13.	Production Development Costs for a Given Reservoir Producing a Given Volume over Differing Time Periods	122
14.	Production Development Costs for Producing Different Volumes from Different Reservoirs over a Given Period of Time	123

Figure		Page
15.	Natural Gas Transmission Production Function.	144
16.	Long Run Natural Gas Transmission Production Function.	146
17.	Natural Gas Transmission Cost Structure. .	149
18.	Natural Gas Transmission Price Discrimination	154
19.	Natural Gas Transmission Maximum Field Offer Price Function . . .	158
20.	Natural Gas Transmission Maximum Field Offer Price with Gathering Facilities.	160

Chapter 1

INTRODUCTION

The market relationship between supply and demand for natural gas in the United States is suddenly in disequilibrium. The proven supplies of domestic reserves are declining while demand requirements continue to increase each year.

Regulatory controls used in the past seem ineffective in restoring stability to the natural gas market. The Federal Power Commission cannot act independently to discourage demand throughout the economy nor stimulate supply in the fields. The many factors that determine and reinforce demand lie beyond the statutory limits of the Commission's jurisdiction. Natural gas supply has inherent technological restraints that cannot be altered by governmental decree.

The structural arrangement of the natural gas industry, its markets, and the regulatory agencies will pass through a period of readjustment. Rate making processes will be forced to adapt to those factors influencing demand and supply that are beyond their control. The industry and the regulatory agencies will be socially obligated to reappraise former values and priorities regarding classes of service. Natural gas has become a valuable energy commodity but is still a non-renewable natural resource.

BACKGROUND

The natural gas industry has developed over the past 70 years to its present capabilities of providing 31% of the nation's total energy requirement. America, in its youth, depended mostly upon wood (73%) and later on coal for its primary energy needs. After the turn of the century, industry, production, and mechanization continued to gain momentum and require greater and more efficient forms of energy. Due to this rapidly advancing technology, petroleum and natural gas soon began displacing the harder fuels. (See Figure 1). During that era of growth, billions of dollars were invested in plants, pipelines, and other ancillary facilities. Employment within the industry grew as new markets were penetrated and revenues increased. Volumes of testimony and "benchmark" precedents have followed the many cases heard before the Federal Power Commission and the courts.

Natural gas and oil have supplied 76% of the total primary energy consumed in the United States. Electric utilities have consumed 24% of the total primary energy produced to generate electricity, which in turn represents 8% of the total energy output.¹ These basic relationships are now changing. The supply lives of primary energies are uncertain, and governmental pressures are being exerted on

¹National Energy Forum Report, Energy Policy Issues for the United States during the Seventies (Cambridge: Arthur D. Little, Inc., July, 1971), pp. 1-5.

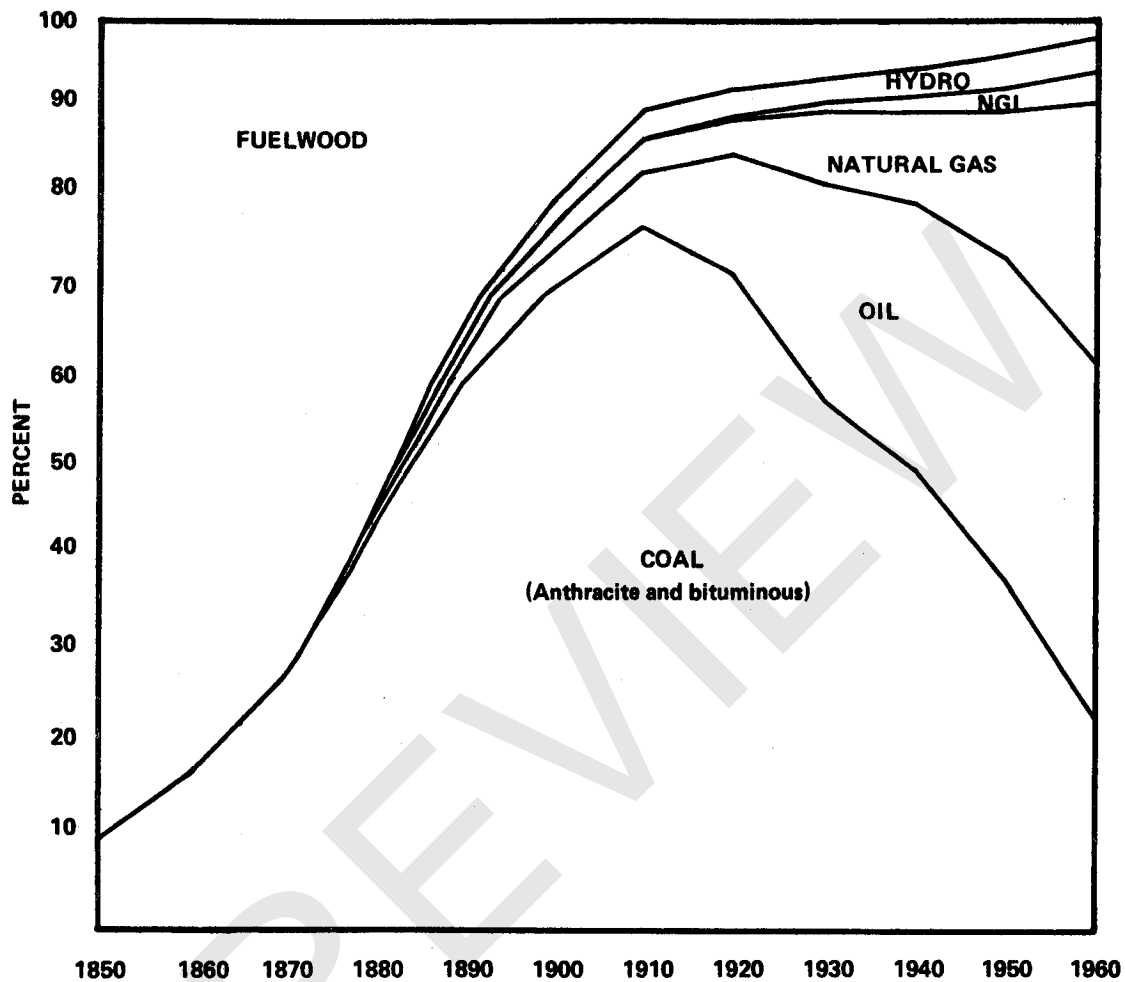


FIGURE 1

HISTORICAL ENERGY STRUCTURE OF THE UNITED STATES

Source: Hans H. Landsberg, et al., "Resources In Americas Future," Publication for Resources for the Future, Inc. (Baltimore: Johns Hopkins Press, 1963), p. 16.

suppliers of secondary energies to protect the environment. There are new competitors on the horizon that will alter the energy structure even further, i.e., nuclear generated electric power, gasified oil and coal. For the most part, natural gas is the most critical component in the total process of energy-conversion-consumption.

Most studies have indicated that during the 1950's was the decade where the natural gas industry experienced its most rapid growth. This was a result of the rapid displacement of coal and oil by natural gas in the residential market for heating and cooking, and in the industrial market for processing and electric power generation. Some attribute this growth to the active promotion of natural gas as an energy commodity by the three elements of industry--producers, transporters, and distributors. The new energy demands for lighting, heating, and power become more evident and have induced the industry to actively search for new markets and absorb existing markets.

The increases in the use of natural gas were accompanied by new methods of production, using improved technology to find the in-place gas and transport it to the market. At first, the gas was only available to those areas adjacent to the fields where it was produced. But with the advent of high-pressure pipelines, natural gas was then able to be transported through interstate commerce. At that time, regulation of business was primarily focused on railroads. By 1938, Congress passed the Natural Gas Act in recognition

of the need for control over the price and quality of service associated with the interstate movement of natural gas. The Act placed those parts of the industry directly involved in "sales for resale" in interstate commerce under the jurisdiction of the Federal Power Commission, which had been formed in 1920. Excluded from the Act were producers, distributors, and all oil and coal producers. The latter group continues to remain non-regulated.

The value of natural gas as both an energy commodity and as a service is evidenced by the intense Federal Power Commission regulation of the industry. The Commission has attempted to control the availability and prices of a very essential although scarce energy used in all phases of economic activity. It has been well established that natural gas is a wasting natural resource that cannot be replaced under any state of the art.² However, in the early years of regulation, the natural gas contribution to total energy was comparatively small and was consequently low priced. The years that followed witnessed the FPC adoption of the "cheap energy" philosophy which is still evident today. That is especially evident in light of the "area price" concepts of producer regulation.³

²"Where Will We Get the Energy?," The New Republic (July 11, 1970), p. 17.

³The area price concept was developed in the early 1960's when the Commission ruled it could set producer rates by geographical area rather than firm by firm. The concept was started with the Permian area rate cases.

The advancing technology improved energy utilization, making natural gas and other energy forms more interchangeable. This, of course, stimulated demand and made gas a valuable yet low-cost commodity. This condition was quite stable up through the middle 1960's. In 1968 the Commission announced that, for the first time in the nation's history, the production of natural gas exceeded the additions to the supply of reserves.⁴ That situation became worse in 1969, and to an even greater degree in 1970.

In a period of four years (between the 1964 Permian area rate case and 1968), the producers who search for, find, and make available the gas to the pipelines had virtually shut down their drilling rigs. Exploration and development (E & D) activities had declined, while the demand for the gas was accelerating at an annual rate of 6.9%.⁵ The natural gas reserves were declining, while the inactive producers were claiming the natural gas prices at the well were set much too low for them to incur the risk associated with E & D.

The demand for natural gas is increasing every year and pipelines are being more and more unable to meet the market requirements due to inadequate supplies. The demand is increasing at all levels of consumption. Regular growth in

⁴Statistics for Interstate Natural Gas Pipeline Companies 1968 (Washington: Federal Power Commission, 1969).

⁵Arthur J. Warner, "Natural Gas," Mineral Facts and Problems, U. S. Department of Interior, Bureau of Mines (Washington: Government Printing Office, 1970), p. 111.

population and industrialization naturally contribute a large share. However, the growing awareness of society of the need to preserve their natural physical environment from energy pollutants and emissions (heat and particulate) has suddenly shifted the emphasis to natural gas.⁶ That makes the existing acute inability of the industry to meet its demand requirements even worse.

The warnings were first given in the early 1960's that the artificially low field price then in existence would lead ultimately to a shortage of natural gas. Whether or not the natural gas shortage was caused by the field price policy is not subject to objective verification. The mere fact that the shortage does exist is sufficient to explain the impact it will have on the industry and the rate making process.

Currently, under Presidential directive, a "National Energy Survey" is being formulated. The objective of the study is to examine the energy shortage, its implications, and to propose all possible solutions that can alleviate the ultimate reallocation of the energy resources.⁷ The reallocation will apply to supply as well as demand. Currently both are taking place to a degree through peak demand apportionment initiated by pipelines who are giving service

⁶The physical and chemical characteristics of natural gas are such that there is neither particulate nor gaseous pollution emitted at point of consumption.

⁷Statement by F. Norman Woodruff, Chairman of the National Energy Forum, personal interview, El Paso, Texas, January 14, 1972.

priority to households when they are confronted with the inadequate gas supplies. Because the fuel and energy resources of the United States are finite and bounded by two oceans and two countries, current attitudes and public policies toward production, imports and end-use priorities for natural gas will, in all certainty, be the foundation from which a total energy policy will be built. The momentum now evident is being felt by the general public, the industrial users, the regulatory commissions, and the national planners. Energy consumption, economic activity, and energy regulation proceed parri pasu. That relationship therefore determines the framework within which this study will be conducted.

OBJECTIVE

The domestic reserves of natural gas supplies are rapidly diminishing. This study will develop and explain how the importance of this phenomenon effects the many varied natural gas demand factors and ultimately the rate making process. Various theories of market equilibrium, rate making, and production optimization will be applied to interpret empirical data. It is essential, therefore, that the natural gas industry be evaluated as a part of the entire energy structure and by each of its component functions. The rate making process will be carefully developed for each function of the industry to analyze how the declining supplies will effect natural gas rate making.

SCOPE

Because of the extreme complexity of the "cause and effect" relationship between the supply of natural gas and its utilization, the flow of demand from the source at the reservoir to the ultimate use at the burner must be handled a step at a time. This means the significance of energy in general, including natural gas, must be established simultaneously with its availability.

That argument will be explored in the analysis which concentrates mostly on the supply of natural gas and defines the important implications of its shortage. A basic overview of the energy industry will initially be developed by identifying the particular energy flows, forms, and the primary implications associated with "cheap energy." A subsequent analysis will be necessary to define and understand how the demand for natural gas and the underlying factors which can be related to the rate making process.

The relationship between natural gas supply and rate making is the crux of this investigation. Therefore, the various aspects of the rate making process will be examined in terms of the current rate forms which have been previously based on a stable (non-declining) supply of natural gas. The concepts of various current rate designs for the particular type of service will be examined in detail to gain a better understanding of how those rates will be effected by the declining supplies of natural gas. The importance of relating

rate making to gas supply is evidenced by the frequency that the natural gas rate making process has been a major topic at academic symposiums, as well as the countless Commission hearings, conducted over the past years. The only differences in rates should be reflected by the true differences in cost of providing the service because natural gas is a relatively homogeneous energy commodity. But this is not so. Under normal conditions of adequate supply (stable), various concepts of promotional rates have existed. That school of thought is now pressured by the "end-use" doctrine where value (rate) of the commodity (gas) is determined by reflecting both its social value and social cost.

The rate making discussion will also be directed through a brief evaluation of the cost and value of service doctrines to an appraisal of differential (discriminatory) rates which are explained by the concepts of marginal cost pricing. The importance of defining the marginal cost concept is evident when it is later proven that marginal cost in reverse (due to volume fall off) can be as discriminating to rate payers as rates that do not reflect marginal costs at all. Many writers have felt quite strongly for many years that the value of the gas should be its marginal cost, even if it is not compensatory for the firm.

The natural gas industry is made up of three distinct functions. The production, transmission, and distribution functions will be evaluated individually to determine how the changes in their respective demand and cost factors caused

by the declining gas supply will effect the overall rate making process. Several writers have devoted a great deal of effort in describing the economic environment of natural gas producers in terms of why there is actually a gas shortage and what needs to be done to correct it. They feel quite strongly that the Commission should reevaluate their price determination policy on well head gas. Studies have been reported in several of the most recent technical publications that have attempted to determine the field price of gas that will bring forth the needed quantities. Their success was minimal.⁸

Aside from the field price, the limited future supplies of gas that producers will have available for sale to the pipelines for further resale to both distributors and direct users will definitely create changes in the demand factors and the resulting rate making procedures. The separate analysis of the production element emphasizes the theoretical framework of their activity and relates their cost structures to the high risks associated with exploration and development.

It is essential then to develop the theoretical structure of the pipeline function by showing the particular effects that can be expected to occur when it is unable to meet its market demands. Currently, not because of limited

⁸J. David Khazzoom, "The FPC staff's Geometric Model of Natural Gas Supply in the United States," The Bell Journal of Economics and Management Science, Vol. 2, No. 2 (Spring, 1971), p. 51.

facility capacity, the major pipelines are asking the Commission's permission to apportion limited available gas supplies to highest priority users first. The impact of the curtailment does not merely terminate with the service. When an electric generating plant (lowest priority) is curtailed, for example, it must still continue to generate electricity. Without gas, it must turn to oil or coal as a substitute fuel, but coal is environmentally undesirable. This leaves the pipeline, the distributor, and the Commission in a quandary without an immediate answer.

The distributor as well as the pipeline must make the necessary adjustments within their structural parameters to adapt to the probable inadequate supply. The distribution function must then be described by relating the supply restraints and problems to its demand factors and rate making procedures.

Natural gas regulation and overall public policy will play an important role in determining how the United States will meet its energy needs. Anticipated imports of huge quantities of gas (Canadian gas, LNG) at prices higher than any domestic source of supply will certainly have an impact on future domestic and international policy. The future energy policies that do occur will depend on the past regulatory precedents and the current decisions handed down from both of the courts and the Commission. The most important policy question facing the Commission and the industry today is how to allocate the scarce gas supplies among the several

end-users whose demand continues to increase.

The analysis will be summarized explaining just how the current decline in domestic natural gas reserves will cause changes to take place in both the natural gas market and within the industry, i.e., the influences exerted by the many demand factors on the natural gas rate making process. Until the producers are induced to search for the new deposits of the deeper gas, pipelines and distributors are going to be faced with deficient domestic supplies which will effect their cost structures and impair their ability to meet peak market demands. The non-availability of the gas will force certain users to substitute other forms of high cost energy for gas--such as oil, Canadian gas, liquified natural gas, gasified coal, and synthetic natural gas.

However, how extensive this substitution will be will depend on the resulting costs of the gas and the resulting effects on the environment due to using those fuels such as coal, that are heavy pollutants. As volumes fall off, cost functions of each component of industry will shift upwardly, which will cause both the costs and prices of domestic natural gas to increase. Somewhere in the process, new high-priced fuels (gasified coal, LNG, and nuclear energy) will become feasible primarily because of their availability. In short, the users of energy will be forced to spend vast sums of capital to adapt to the new fuels, or at least make fuels like coal and oil more adaptable to the environment.

Social costs and benefits of the natural gas supply must then be weighed by the policy makers. Hopefully, a national energy policy will determine how the nation will procure the needed natural gas supplies and how much the gas will cost in real terms of maintaining an adequate supply for all future needs.

PREVIEW

Chapter 2

ENERGY RESOURCES IN THE UNITED STATES

Within the past three to four years, several observations have been made concerning the supply life of energy resources in the United States. Authoritative studies have indicated reserves of domestic oil and gas are dangerously low; coal supplies, although vast, are limited by technological factors; and availability of nuclear energy is still more potential than actual. The extent that electric energy will be able to take up the slack depends on how fast the state of the art of secondary energy can advance. Imports of oil and gas create political conflicts. Fundamentally, the nation is running out of energy. More importantly, though, the United States is running out of cheap energy.¹

SIGNIFICANCE OF ENERGY

As the production processes in technologically advanced societies become more and more sophisticated, their needs for energy become greater. Within the structure of the energy industry, those substructures performing the supply function must be able to respond to the needs of the economy almost instantaneously. If this response is weak, the transformation

¹George Weber, "Petroleum Industry and the Energy Crunch," Oil and Gas Journal (November 15, 1971), p. 121.