

AN ABSTRACT OF THE THESIS OF

Melvin M. Vuk for the degree Doctor of Philosophy

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Title: THE ROLE AND POLICY IMPLICATIONS OF SELECTED EXTERNAL

FACTORS AS APPLIED TO THE DEVELOPMENTAL PATTERNS OF FIVE

WYOMING FUELS

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Abstract approved: Thomas J. Maresh

The developmental patterns of five fuel resources located within the state of Wyoming are examined through time and in relation to several factors external to the location of the fuels. An historic description and inventory of the five fuels: petroleum; natural gas; oil shale; coal; uranium are presented. External factors including governmental activities; economic and technological conditions as well as socio-environmental factors are portrayed as having cyclical impacts upon the developmental and utilization patterns of Wyoming's fuels. Emphasis is particularly placed upon the ever increasing impact of societal concerns regarding environmental aspects of governmental and economic/technological activities. The external factors are examined in terms of their total impact on Wyoming's role as a regional and national supplier of fuel.

Spatial aspects of the fuel resources in terms of their acquisition, transportation facilities and market areas are examined through time using various descriptive and quantitative measures. Policy implications for the successful implementation of federal energy development programs are discussed and evaluated in relation to an investigation of the aforementioned external factors, spatial considerations, and constraints. The author posits that the implications for policy decisions concerning energy on a national level are magnified at either a regional or state level. The solutions to environmental, economic and social problems as well as the traditional technological difficulties of mining which are found in Wyoming may be a microcosm of solutions which could be implemented on a national scale.

Wyoming has traditionally been an exporter of its fuel resources, and the state's economy has generally been reactive to the national and political environment. The state has now begun to assume a role of leadership in energy resource development. Assuming an ever greater role as a regional and national supplier of fuels, Wyoming's future role may become more prominent in national energy affairs.

The Role and Policy Implications of Selected External Factors  
as Applied to the Developmental Patterns of  
Five Wyoming Fuels

by

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Typed by Cynthia Vuk for Melvin Marvin Vuk

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M.M.V.

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THE ROLE AND POLICY IMPLICATIONS OF SELECTED EXTERNAL FACTORS

AS APPLIED TO THE DEVELOPMENTAL PATTERNS

OF FIVE WYOMING FUELS

I INTRODUCTION

At this point in the history of the United States some national priorities concerned with particular aspects of the "national welfare" seem to be in direct conflict with a traditional national goal - economic growth. Societal progress in this country has long been equated with economic expansion and growth, with one indicator being the production and consumption of energy. Some areas of our national life which are intricately tied to producing a traditional "good" seem to be entirely antithetical in promoting certain portions of the "national welfare." For example, how does one reconcile the conflict in priorities which, on the one hand, emphasizes the reduction of sulfur dioxide levels in our urban areas and on the other, fulfills the growing demand for electrical energy in those urban areas? The conflict cannot be wholly solved by relocating the power generating sites nor by greatly reducing the nation's growing dependence upon electrical energy.

One of the most rapidly changing factors of American society has been a growth in population which has doubled about every 40 years. At the same time the demand for electric energy has

been doubling about every ten years. In 1968 electric energy accounted for about 30 percent of all energy consumed in the United States and by the year 2000 that proportion is expected to increase to at least 60 percent.<sup>1</sup> It now seems apparent that the interplay of power production and environmental quality standards will be of considerable consequence in the future. This of course assumes as Holcomb notes that, "...it is generally agreed that our society would demand the power, that it would be produced, and that changes in the technology of power production and waste disposal would be made in attempts to control pollution."<sup>2</sup> Given the aforementioned requirements for pollution control and the accompanying increasing demand for electric power a new set of alternatives will have to be developed in order to accomplish the twin goals of more power and less pollution. New methods of power generation utilizing fluidized bed boilers, MHD (coal-gas fired) and nuclear breeder reactors may eventually be able to provide enormous quantities of power with few or none of the attendant pollution problems associated with current methods of power production. However, in the immediate future of perhaps the next thirty to thirty-five years, more traditional methods utilizing fossil fuels will continue to be the primary source of electric power generation. In order to provide more power and reduce pollution while utilizing

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<sup>1</sup>M. Steinberg, J. Powell, and B. Manowitz, The Western Coal Deposits: A National Source of Power, Report BNL50187, (Upton, New York: Brookhaven National Laboratory, 1969), p. 1.

<sup>2</sup>Robert W. Holcomb, "Power Generation: The Next 30 Years," Science 167 (January 9, 1970): pp. 159-60.

thermal plants burning fossil fuels, interim plans and solutions are being sought which would include increased combustion efficiencies; treatment of fuel to eliminate contaminants such as sulfur at the furnace or stack site; utilization of fuels with low sulfur levels; relocations of power generating facilities to areas other than urban areas; development of a national power grid utilizing EHV transmission lines and exclusive use of mine-mouth power plants.

#### The Interrelationship of Society and Fuels

The types of fuels considered, the demand for them, and the ways they are utilized are a reflection of the society which utilizes those energy resources. Quantity and the types of energy sources are two important factors which should be included in any energy resource plan, but another important factor which should be considered is the spatial aspect of both energy source areas and energy consumption areas. Fuel sources, to meet the energy demands of society, are developed in particular places often in response to certain combinations of technological or societal as well as geologic or economic circumstances. The changing spatial context of resources is also a reflection of Christenson's statement that, "The geological elements of the world do not become resources until people make them so. Thus an essential ingredient of economic development is a set of cultural values which motivate human action."<sup>3</sup> Further, the spatial context in which some energy sources are viewed is due, in part, to seemingly unrelated societal decisions. For example, decisions regarding the quality of air Americans breathe, in the most general

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<sup>3</sup>C.L. Christenson, Economic Redevelopment In Bituminous Coal, (Cambridge: Harvard University Press, 1962), p. 1.

sense, will have a considerable influence upon the types of fuels utilized in the future. Concomitantly, technological capabilities along with social and political processes will be extremely influential in determining the future development and utilization of energy resources in the United States.

### Wyoming As A Fuel Source

One area of the United States which is beginning to take on greater significance in the quest for more electric power and cleaner power plants is the Rocky Mountain region. As previously mentioned, one of the immediate alternatives to the problem of excessive amounts of sulfur released into the atmosphere is the utilization of low-sulfur fuels such as natural gas or low-sulfur coal. Coal is by far the more abundant of the two fuels even though only a small fraction of the coal reserves in the United States is considered low-sulfur grade (those with less than 1 percent sulfur content). However, of those, "Over 80 percent of the total 23.5 billion tons of low-sulfur subbituminous coal is in the Rocky Mountain and Northern Great Plains provinces, with almost 70 percent (13.4 billion tons) in Wyoming."<sup>4</sup>

Already unit trains carrying low-sulfur subbituminous coal from Wyoming to power plants in Wisconsin and Illinois make it possible for heretofore underutilized Wyoming coal resources to be competitive with Midwestern coal. Largely because of much

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<sup>4</sup>U.S., Department of the Interior, Bureau of Mines, Strippable Reserves of Bituminous Coal and Lignite in the United States, (Washington, D.C.: Government Printing Office, 1971), p. 21.

stricter regulations of sulfur emissions low sulfur coal can now be transported over a thousand miles and also compete favorably with fuels such as natural gas and petroleum.

Since 1868, when coal was mined for the locomotives of the Union Pacific Railroad, fuel production has been a very important factor in Wyoming's economy. In 1970 Wyoming ranked in the top ten states nationally in the production of petroleum, natural gas, coal, and uranium. In terms of uranium reserves Wyoming ranks first in the United States and also ranks first in tonnage of both mapped and unmapped coal reserves.<sup>5</sup> Recently decisions on both national and state levels regarding the quality of air Americans breath has stimulated a re-examination of fossil fuels. Assuming that Wyoming has both short and long run potentials as a fuel reservoir, one should be concerned with the location and utilization patterns of those fuels.

#### Examples of External Factors

Additionally important are the factors or forces which play a part in shaping those spatial patterns. An example of a factor which is not directly related to the site or situation characteristics of Wyoming fuels has been the Arab oil embargo. As the result of certain political and economic reactions to the embargo, some traditional constraints to development of fuels in particular locations have been altered. The announcement of Project Independence did not

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<sup>5</sup>University of Wyoming, Division of Business And Economic Research, College of Commerce And Industry, Wyoming: Comprehensive Economic Studies To Facilitate Development Through Planning, (Laramie: University Press, 1970), p. 8.

in itself create new fuel sources; but given the shortage of fuels and an officially announced policy of domestic self-sufficiency in fuel production, such factors as proximity to markets and transportation costs were viewed as somewhat less important than availability.

Even now technology which may have a deleterious effect on our environment is also making it possible for us to utilize its methodologies and tools to correct as well as monitor the changes in our physical environment. However, one element is basic not only to the eventual solution of the energy/environment conflict, but also in defining the areas of conflict that have often been relegated to a background position. Spatial factors are critical elements which must be considered in understanding any energy problem. Time constraints are more easily comprehended than spatial constraints, yet the latter are as important. Additionally, the interaction between areas does not take place in a vacuum but within the political and cultural milieu at both regional and national scales. It does little good to consider how energy demands are to be met in the future if no assessment is made of the optimum choices available now. To do this requires such basic steps as an inventory of energy sources as they exist in finite space; the recognition and measurement of the movement of energy resources both within and outside of a given region.

#### Scope and Limitations of the Study

The limitation of the study area to the political state of Wyoming is viewed as a convenience in obtaining and working with data. Functionally, as one might expect, there is a great deal of

interaction between political units, and a state as sparsely populated as Wyoming probably has more external economic ties than internal ones. However, the study is also concerned with the changing role the state of Wyoming has played over time at both a regional and national level. It is postulated that the cyclical nature of the state's production of fuel resources has been determined largely by external factors. Only recently have the vast reserves of subbituminous coal located within the state been considered important enough, in economic terms, to be exploited by eastern consumers.

#### Previous Work in Energy Geography

Gerald Manners, in his pioneering work on energy geography, pointed out the great interdependence of a variety of factors which influence not only why but where energy is produced.<sup>6</sup> Manners, for the most part, worked at the international and national scale where data were more abundant and reliable than one would find at a regional or state level. His basic emphasis was the interrelationships between markets, transportation, and politics although he emphasized that a variety of factors played their part in creating the geography of energy. Indeed, as Manners pointed out, development of a nation is heavily dependent upon energy, which was characterized as "...serving as a catalyst, as well as an essential ingredient, its role in economic growth is both qualitative as well as quantitative."<sup>7</sup>

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<sup>6</sup>Gerald Manners, The Geography of Energy, (Chicago: Aldine Publishing Company, 1967).

<sup>7</sup>Manners, op. cit., p. 15.

Recognizing the importance of energy development and utilization on a national level, Nathaniel B. Guyol<sup>8</sup> brought further refinements to the geography of energy. Using the Netherlands as a case study, Guyol utilized a form of energy accounting which, in a rudimentary sense, was similar to an input-output economic analysis.

With the exception of approximately one half dozen unpublished dissertations written on energy geography,<sup>9</sup> which focused solely upon electric energy, most of the literature on the subject of energy geography has been limited. In general United States energy data have been collected, analyzed and disseminated by various agencies of the federal government, most notably the U.S. Department of the Interior; the Federal Power Commission; and the Atomic Energy

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<sup>8</sup>Nathaniel B. Guyol, Energy In The Perspective of Geography, (Englewood Cliffs, New Jersey: Prentice-Hall, 1971).

<sup>9</sup>For example, Martha E. Church, "Spatial Organization Of Electrical Territories In Massachusetts" (unpublished Ph.D. thesis, Department of Geography, University of Chicago, 1960); Harold A. Classen, "A Geographic Study Of Power Development In The Niobara Basin, With Emphasis On Hydroelectric Power" (unpublished Ph.D. thesis, Department of Geography, University of Nebraska, 1955); Jordan A. Hodgkins, "Regional Energy Potentials of Conventional Non-Renewable Energy Sources In The Soviet Union" (unpublished Ph.D. thesis, Department of Geography, Syracuse University, 1959); Warren D. Kress, "The Geography of Electric Power In Minnesota" (unpublished Ph.D. thesis, Department of Geography, University of Minnesota, 1962); Ronald A. Larson, "Geographic Patterns Of Energy Consumption In Tasmania" (unpublished Ph.D. thesis, Department of Geography, University of Illinois, 1968); Hollis Reid Wagstaff Jr., "The Geography Of The Michigan Electric Power Industry" (unpublished Ph.D. thesis, Department of Geography, University of Michigan, 1967).

Commission. Consequently, the spatial aspects of energy resources utilized in this country are most often not an integral part of either the data or the subsequent studies or reports issued by those energy-oriented agencies. Almost all analytical work is done at a national level though apparently the value of state or regional level efforts are recognized as very worthwhile inputs.

In explaining some of the limitations of a national energy model developed in 1968 by the U.S. Bureau of Mines, the authors conceded that

It is recognized, however, that the quality of national forecasts would be greatly improved if prior analysis and projections were made at the State and regional levels. Such analysis has been limited in part by the difficulty of obtaining detailed, reliable energy data by State and region on a standardized basis.<sup>10</sup>

It is at this scale, where the dichotomy of a paucity of data and the relevance of state data for national analysis exists, that this study is oriented.

#### The Problem

Basic to a study of fuels, yet often lacking in many studies by the aforementioned national agencies, are the patterns of energy development. Assuming that the political and social milieu of the United States has changed greatly in the last 50 years this study is oriented toward an attempt to examine how the spatial patterns of energy development on a state level have changed in

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<sup>10</sup>W.E. Morrison and Charles L. Readling, An Energy Model For The United States, Featuring Energy Balances For The Years 1947 to 1965 And Projections And Forecasts To The Years 1980 and 2000, (Washington, D.C.: Government Printing Office, 1968), p. 51.

concert with changing external factors. An historic description and inventory of five basic fuels in their geographic setting within the state of Wyoming are presented. A combination of chronological development and current production and distribution patterns at a state level may offer valuable inputs to future fuel development plans at a national level as well.

The state of Wyoming is an excellent case study in that it is extremely well endowed with fuels which have had great impacts upon the economic development of the United States. Perhaps to a greater degree than any other state in the nation, Wyoming possesses an abundance of all five fuels which now appear to be vital to our national future. The author has chosen four broad categories of "external" factors against which he examines the development in both temporal and spatial terms of the five fuels found in Wyoming; 1. petroleum; 2. natural gas; 3. oil shale; 4. coal; 5. uranium.

The author believes that a significant degree of insight into explaining present spatial patterns can be gained by tugging on the thread of historical fact which is woven throughout the present patterns of fuel development. The one unifying methodology then becomes one of an historical economic geography, with a variety of other tools used to more fully analyze the five fuel resource base of Wyoming. Because of the number of fuels examined and their variety, no one methodological approach was used for all. Generally an historical theme is found in an examination of each fuel, but in some cases quantitative analysis provided a better tool for examination and in others a descriptive or purely historical

recounting accomplished the task. Thus it is that more quantitative exposition and statistical data are presented in portions of the study concerned with coal and uranium than petroleum or oil shale.

The study is divided into nine chapters. The second chapter presents an historical overview of the five fuels and their development whereas the third through seventh define then examine the variety of relationships between the external factors and the various fuel industries. The eighth chapter deals with the spatial considerations of the fuels. Such elements as spatial constraints, fuel movements, the changes in markets, and new technology are investigated. Finally, the external factors are evaluated in terms of their impact on the role Wyoming is assuming as a regional and national supplier of fuels.

## II A BRIEF HISTORICAL OVERVIEW OF FIVE WYOMING FUELS

### Petroleum

Although the first oil well in Wyoming was drilled southwest of Lander in 1884, the state's most famous and greatest long-run producing field is located approximately fifty miles north of Casper. The Salt Creek field first came into production in 1889 and by 1900 a small refinery located in Casper was distilling a good quality lubricating oil.<sup>1</sup> By 1903 a syndicate composed of two Parisians and three Londoners had invested in the Salt Creek field and, with the addition of Dutch interests to the "Wyoming Syndicate", the first gusher was brought in by October, 1908, at a depth of 1050 feet. Two years later the Wyoming Syndicate had declared bankruptcy and was acquired by another foreign dominated company, Franco-American Wyoming Oil. At approximately the same time investors from Colorado Springs, Colorado, who had gained their wealth in the Cripple Creek goldfield, formed the Midwest Oil Company which absorbed the Franco-American company and almost immediately built a six inch pipeline from its 560 acre lease to a refinery the company constructed outside of Casper, Wyoming. More significantly perhaps:

They persuaded the Chicago and Northwestern Railroad to convert its locomotives to oil burners in return for the

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<sup>1</sup>U.S. Department of the Interior, U.S. Geological Survey, Mineral Resources Of The United States, 1901 (Washington, D.C.: Government Printing Office, 1901), p. 572.

opportunity to haul gasoline and kerosene eastward. Marketing arrangements were worked out with the Standard Oil Company of Indiana.<sup>2</sup>

### Early Development Pattern

Thus at an early stage in the development of the petroleum industry in Wyoming, external market links were being formed between at least one oil field and areas outside the state. Another important feature which is still characteristic of the petroleum industry in Wyoming was the early affiliation with large oil companies and their access to national markets.

In the early developmental days of the petroleum industry about a half dozen areas of the state (Fig. 1) were considered leading petroleum producers. Figure 2 indicates the slight significance of Wyoming in national petroleum production. In 1910 Wyoming production was almost too small to be measurable on a national scale. Yet, in less than a decade there were five refineries operating in the state, prompting Governor Houx to boast in 1917 that

A minor industry in the state in 1912, the oil business in 1917 has become second in importance of Wyoming's industrial activities ranking below agriculture only and representing a gross business only four per cent less than that of agriculture.<sup>3</sup>

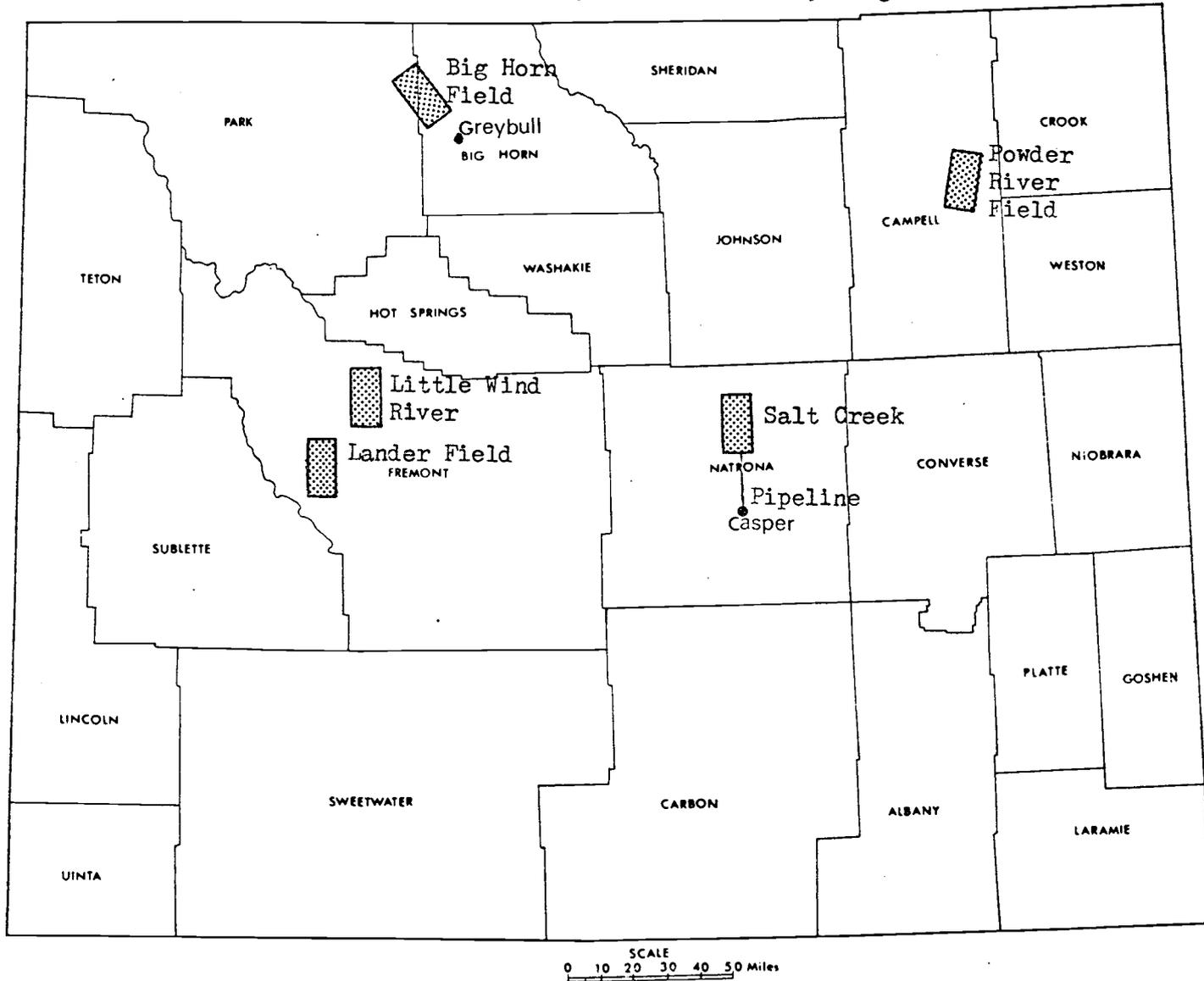
Within three years Standard Oil of Indiana had moved into the state through its acquisition of Midwest Oil Company and by 1921 had become the dominant oil producing company in Wyoming. The degree

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<sup>2</sup>Taft A. Larson, History of Wyoming, (Lincoln: University of Nebraska Press, 1965), pp. 338-9.

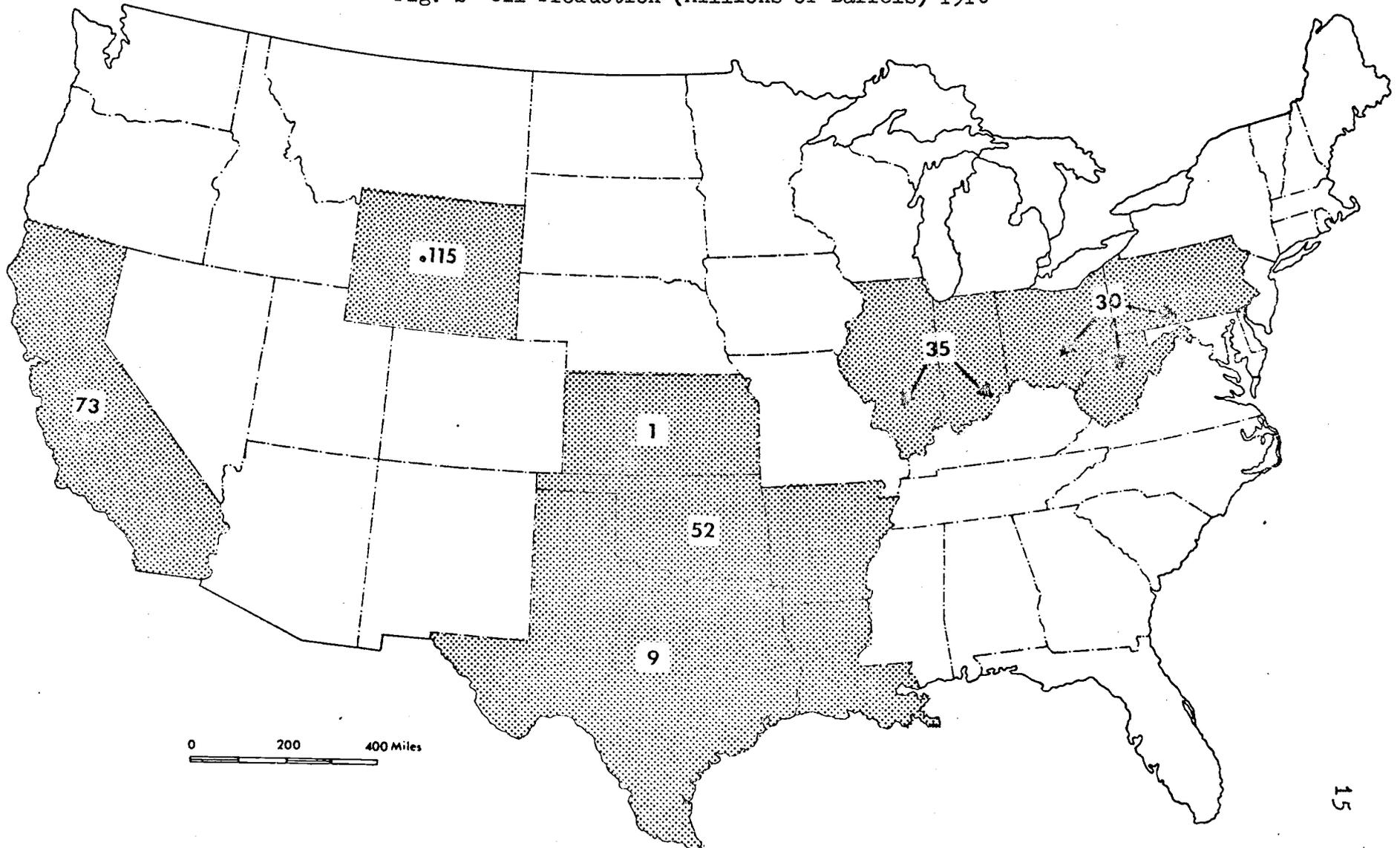
<sup>3</sup>Ibid., p. 397.

Fig. 1 Early Producing Oil Fields of Wyoming



Locations found on Energy Resources Map of Wyoming.

Fig. 2 Oil Production (Millions of Barrels) 1910



Source: Energy in the United States, p. 44.

of rapid early growth of the industry in Wyoming was indicated by the growing number of producing wells, from 169 in 1911 to 1,450 in 1921. The average rate of production for the Wyoming wells in 1921 was 443.3 barrels per day, compared to a U.S. average of only 4.9 barrels per day.<sup>4</sup>

Wyoming ranked sixth in petroleum production in the nation by 1921, however prices fluctuated wildly. For example, the average price for the years 1919-1921 for a 42 gallon barrel of crude oil from three representative Wyoming fields reads thusly:

TABLE 1. OIL PRICES FOR THREE WYOMING FIELDS

	Greybull Field	Lander Field	Salt Creek
1919	\$1.88	\$0.92	\$1.53
1920	3.00	1.93	2.65
1921	1.60	0.82	1.16

Source: Interior Department, U.S. Geological Survey, Mineral Resources Of The United States, Vol. II, Nonmetals, (Washington, D.C.: Government Printing Office, 1921), p. 306.

Part of the price fluctuation can be explained by Wyoming's remoteness from large market areas and part by the poorly developed transportation network, especially pipelines. As previously mentioned, in 1911-12 a six-inch pipeline was laid to Casper from the Salt Creek Field; however, by 1923 a trunk line was laid from the Salt Creek and Teapot fields to Freeman, Missouri, a distance of over 700 miles. For the first time Wyoming petroleum was brought into direct competition

<sup>4</sup>U.S. Department of the Interior, U.S. Geological Survey, Mineral Resources Of The United States, 1911; 1921, (Washington, D.C.: Government Printing Office, 1911; 1921), p. 284; p. 308.

with Mid-Continent petroleum. An important factor in the construction of the pipeline was that it was built by Standard Oil Company of Indiana whose concern at the time was to integrate its corporate structure. Indeed, as Johnson pointed out "...pipelines were not built as public transportation facilities but as facilities to reduce the transportation costs of the company that supplied the capital and assumed the risks associated with pipelining..."<sup>5</sup>

#### Governmental Influences on the Petroleum Industry

Early governmental activities with regard to the petroleum industry on both a national and state level were also evident. For example, the provisions of the Leasing Act of 1920 made federal lands available for private leasing with royalties to be paid to the federal government thusly: 10 percent to the general federal treasury; 32.5 percent to the U.S. Reclamation Fund with 37.5 percent of that amount going directly to the state of production. Wyoming's share of the royalty (37.5 percent) was allocated thusly: 50 percent used for public schools; 41 percent for highways and roads and 9 percent used for capital improvements at the University of Wyoming. At the same time the state and counties of Wyoming collected property taxes from petroleum producers on all the crude oil produced on state lands since 1913, and the state also received a portion of the federal royalty accruing to the U.S. Reclamation Fund as a result of leasing public lands.<sup>6</sup> By the 1960's the

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<sup>5</sup>Arthur M. Johnson, Petroleum Pipelines and Public Policy, 1906 - 1959, (Cambridge: Harvard University Press, 1967), p. 463.

<sup>6</sup>Larson, op. cit., p. 431.

petroleum industry was paying over 1/3 of the state's property taxes and in some counties the proportion of property taxes paid was borne heavily by the petroleum industry, such as the nearly 80 percent in Hot Springs County, or 76 percent, 66 percent, and 55 percent in Park, Sublette and Big Horn Counties respectively during the 1963 tax year.<sup>7</sup>

Although the percentage of personal income derived from the production of petroleum and natural gas has generally declined, it is estimated that almost 75 percent of the total income from extractive activities in Wyoming still comes from the production of oil and natural gas. Almost half of the value added by manufacturing in the state by 1970 was from the refining of petroleum products, yet as previously mentioned, less than 25 percent of the total production in the state is refined there.<sup>8</sup>

#### Natural Gas

Wyoming is endowed with a great number of natural gas deposits. These totaled 128 in 1964, but in just five years had increased to 634 fields.<sup>9</sup> Natural gas production is similar in pattern to that of oil. Very few producers are currently Wyoming-based and all gas

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<sup>7</sup>Ibid., pp. 550-4.

<sup>8</sup>University of Wyoming, Division Of Business And Economic Research, College Of Commerce And Industry, Wyoming: Comprehensive Economic Studies To Facilitate Development Through Planning, (Laramie: College Of Commerce And Industry, 1970), p. 8.

<sup>9</sup>American Petroleum Institute, Petroleum Facts & Figures 1971, (Baltimore: Port City Press, 1971), p. 102.

pipeline companies are directed by non-Wyoming interests. In addition to providing consumer gas service to all Wyoming cities of over 5,000 population, these pipelines also carry gas to consumers in North Platte, Nebraska, and cities farther east; to Denver, Colorado; to Salt Lake City, Utah; to cities in the Pacific Northwest; and to Billings, Montana.<sup>10</sup> Corporate control based outside Wyoming and external markets characterize Wyoming's natural gas industry. These two characteristics are also common to the oil industry. In fact, the two forms of petroleum have closely parallel histories because in the early days of oil field development natural gas was often found in conjunction with oil. Thus, as early as 1911 the chief supply of natural gas in Wyoming was from wells in Bighorn County with the chief consumers being in the towns of Basin and Greybull.<sup>11</sup>

Although it is true that the state of Wyoming now has both an internal and an external market for its natural gas, for a considerable number of years the entire production of natural gas was included in the internal consumption totals of statistical surveys. In early years, because there was a lack of a large external market (and transportation facilities to get gas there), much of the gas produced was simply burned at the production site. In other cases the gas was consumed, but in a very irregular manner which was exceedingly difficult to trace. Concerning that subject

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<sup>10</sup>Brown, op. cit., p. 27.

<sup>11</sup>Mineral Resources Of The United States, 1911, op. cit., p. 345.

a U.S. Geological Survey publication's editorial comment complained that,

Many of the large number of operators who are producing natural gas get only a small output from one or a few wells, and it is therefore very difficult - indeed, as to some wells or fields it is impossible - to obtain accurate data even from the producers themselves, for the gas is not measured either by the producer or the user and hence any figures showing production are necessarily estimates. For many small producers the operation of their wells is not their main business but is simply incidental to farming or other work. The gas from such wells is piped into neighboring houses, where it is used without any very clear idea of the quantities required or consumed, and payment is usually made by the month or year, often without any record of the transactions.<sup>12</sup>

In general the development of the natural gas industry in Wyoming was severely restricted by the limited markets which were due, in part, to the limited number of pipelines. As a result, in the 1920's and through the 30's, consumption was mostly internal to the state for such uses as injection into oil fields to maintain production pressure and for local space heating. During the 1930's "natural gas had displaced coal...as the state's major source of heat."<sup>13</sup> Great impetus for natural gas development occurred during World War II and the post-war period. Early estimates of reserves which were classified as recoverable stood at about four trillion cubic feet of natural gas. It soon became evident that the estimate was extremely low, especially when one considers that just one area, the Green River Basin, had estimated recoverable reserves of six trillion cubic feet in 1970. This same region has already

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<sup>12</sup>Mineral Resources Of The United States, 1921, op. cit.,  
p. 345.

<sup>13</sup>Larson, op. cit., p. 551.

produced almost three trillion cubic feet of natural gas and has only reached the 1/3 point of its cumulative production expectation.<sup>14</sup>

In 1969, 173.7 billion cubic feet (bcf) were produced in the Green River Basin and of that total 147.3 bcf were transported out of state. Only 2.5 bcf are used locally and 10.9 bcf are utilized in the Cheyenne area. This situation of natural gas being sold outside the state is not unexpected.

#### The Trona Industry as a Natural Gas Consumer

A major market for natural gas is developing within Wyoming but may be restricted in its development because of direct competition with outside markets for the fuel. Currently about 8 percent of the gas production from the Green River Basin is consumed by the trona<sup>15</sup> (natural soda ash) industry. The industry is composed of three chemical companies (Allied, FMC and Stauffer) which are producing 2.4 million tons of soda ash per year but would like to increase production to 4.5 million tons in 1975. In addition, another company, Texas Gulf Sulfur, is also planning to construct a plant in the area, so that production could be more than doubled in just three years. The status of the industry today is summed

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<sup>14</sup>Barlow & Haun, Inc., Natural Gas Resources Green River Basin, Wyoming, (Casper: Barlow & Haun Inc., 1972), p. 2.

<sup>15</sup>Trona; urao. "A natural sodium sequicarbonate  $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$ , and the most important of the natural sodas. White, gray, or yellow with vitreous, glistening luster, contains 41.2 percent  $\text{H}_2\text{O}$  with some impurities. Extensive deposits are found in Wyoming, California, especially Searles Lake, Owens Lake; Hungary; Egypt; Africa; Venezuela. A source of sodium compounds." Source: A Dictionary of Mining, Mineral and related terms, p. 1168.

up thusly:

Soda ash consumption in the U.S. is not increasing very much but Wyoming production is increasing significantly because plants that produce synthetic soda ash in other parts of the country are becoming obsolete and production of natural soda ash from trona is more economical than rebuilding the synthetic plants.<sup>16</sup>

Expansion of the trona industry is contingent upon two factors: additional guaranteed supplies of natural gas which would increase from 14 bcf to between 25 to 40 bcf by 1975; and other fuel sources which can be obtained in adequate amounts at competitive costs in relation to natural gas.

At the present time approximately 83 percent of the gas produced in the Green River Basin is marketed by four companies in Utah, Colorado and the Pacific Northwest. In response to the competition between firm contracts to external markets, and the expansion expectations of the trona companies, petroleum companies have greatly increased their exploration activities for natural gas. In the four year period 1965-69 the average number of wells drilled has been 132 per year but in 1970 it increased to 160 and is now expected to average about 200 wells per year. New reserves have been added to the Green River Basin at a rate of about 210 bcf per year and are expected to rise to about 135 bcf as exploration and drilling activity increases. Table 2 gives an illustration of how attractive natural gas is as a fuel source

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<sup>16</sup>Wyoming Department Of Economic Planning And Development, Soda Ash Production, Fuel Requirements and Natural Gas Supply Green River Basin, Wyoming (Casper: Department Of Economic Planning And Development, 1971), p. 1.

TABLE 2 FUEL COSTS GREEN RIVER BASIN WYOMING TRONA AREA

	1972	1973	1974	1975
<b>#2 Fuel Oil</b>				
Price Per Gallon	11-3/4¢	11-3/4¢	12-3/4¢	13-1/4¢
Transportation	2-1/4¢	2-1/4¢	2-1/2¢	2-1/2¢
Total Price Per Million BTU's	\$1.08	\$1.14	\$1.17	\$1.21
<b>#6 Fuel Oil</b>				
Price Per Gallon	11¢	12¢	13¢	14¢
Transportation	2 1/2¢	2-3/4¢	2-3/4¢	2-3/4¢
Total Price Per Million BTU's	\$0.89	\$0.97	\$1.04	\$1.11
<b>LPG</b>				
Price Per Gallon	8 1/2¢	9¢	9 1/2¢	10¢
Transportation	2¢	2¢	2¢	2¢
Amortization of Storage	1/2¢	1/2¢	1/2¢	1/2¢
Total Price Per Million BTU's	\$1.20	\$1.25	\$1.31	\$1.36
<b>Coal</b>				
Price Per Million BTU's	36-1/2¢	37-1/2¢	38-1/2¢	39-1/2¢
Transportation & Handling	3-1/2¢	3-1/2¢	3-1/2¢	3-1/2¢
Amortization of Capital Costs	12¢	12¢	12¢	12¢
Total Price Per Million BTU's	52¢	53¢	54¢	55¢
<b>Natural Gas</b>				
Total Price Per Million BTU's	26¢	29¢	32¢	36¢

Source: The Trona Industry In Wyoming.

when compared to the costs of alternative fuels. The trona industry has a considerable influence upon the development of natural gas resources in Wyoming. Trona operators can, of course, explore for and develop natural gas deposits independently; they can assist petroleum companies with the expenses involved in increasing natural gas supplies. However, they can also opt for the utilization of a more expensive fuel such as coal, which would reduce the rate of trona production growth. The future importance of natural gas within Wyoming will be strongly influenced by the trona companies' decisions.

#### Oil Shale

Oil shale deposits in Wyoming have been known for over half a century and were utilized on an individual basis by both Indians and pioneers in southwestern Wyoming as a fuel source. A very small oil shale industry was operating in Canada and the Eastern United States as early as 1860 but disappeared when petroleum became plentiful following the Drake oil well in Pennsylvania.<sup>17</sup>

As a matter of record however, it should be noted that the first sales of oil shale and shale oil reported to the United States Geological Survey were made in 1921. The credit of the first commercial transactions belongs to Colorado; 5,000 gallons of shale oil near DeBeque, Garfield County, valued at \$1,000, was sold to mining companies for mineral flotation, and two tons of oil shale valued at \$40, was reported to have been shipped from Rio Blanco County for delivery to chemical

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<sup>17</sup>U.S. Department of the Interior, U.S. Bureau Of Mines, Bulletin 650, Mineral Facts and Problems, 1970, (Washington, D.C.: Government Printing Office, 1970), p. 184.

plants. Also 1,250 gallons of shale oil made near DeBeque was used<sup>18</sup> in the manufacture of 'soap, stock dip, ointment, etc.'....

A recovery of 50 to 60 gallons of shale oil per ton having an average gravity of 24 Baume' (specific gravity 0.909) is reported to have been made.<sup>19</sup>

It is estimated that "The known oil shale deposits in Wyoming contain 430 billion barrels of oil in place in beds 10 or more feet thick containing 10 or more gallons of oil per ton."<sup>20</sup>

The largest oil shale deposits are largely found in the Green River Basin and collectively cover about 6700 square miles in the counties of Sweetwater, Sublette, Uinta, Lincoln and Carbon (see Figure 3).

Today all fuels are so intertwined that a change in the status of one will be reflected to some degree by all others. This is also true of shale oil. Its development depends to a great degree upon the status of other conventional fuel sources. In order to develop a viable oil shale industry, the Department of the Interior began issuing leases for shale oil production in 1974. It was expected that by 1975 about 18 million barrels of shale oil would be produced and in 1980 it was hoped that annual productive capacity

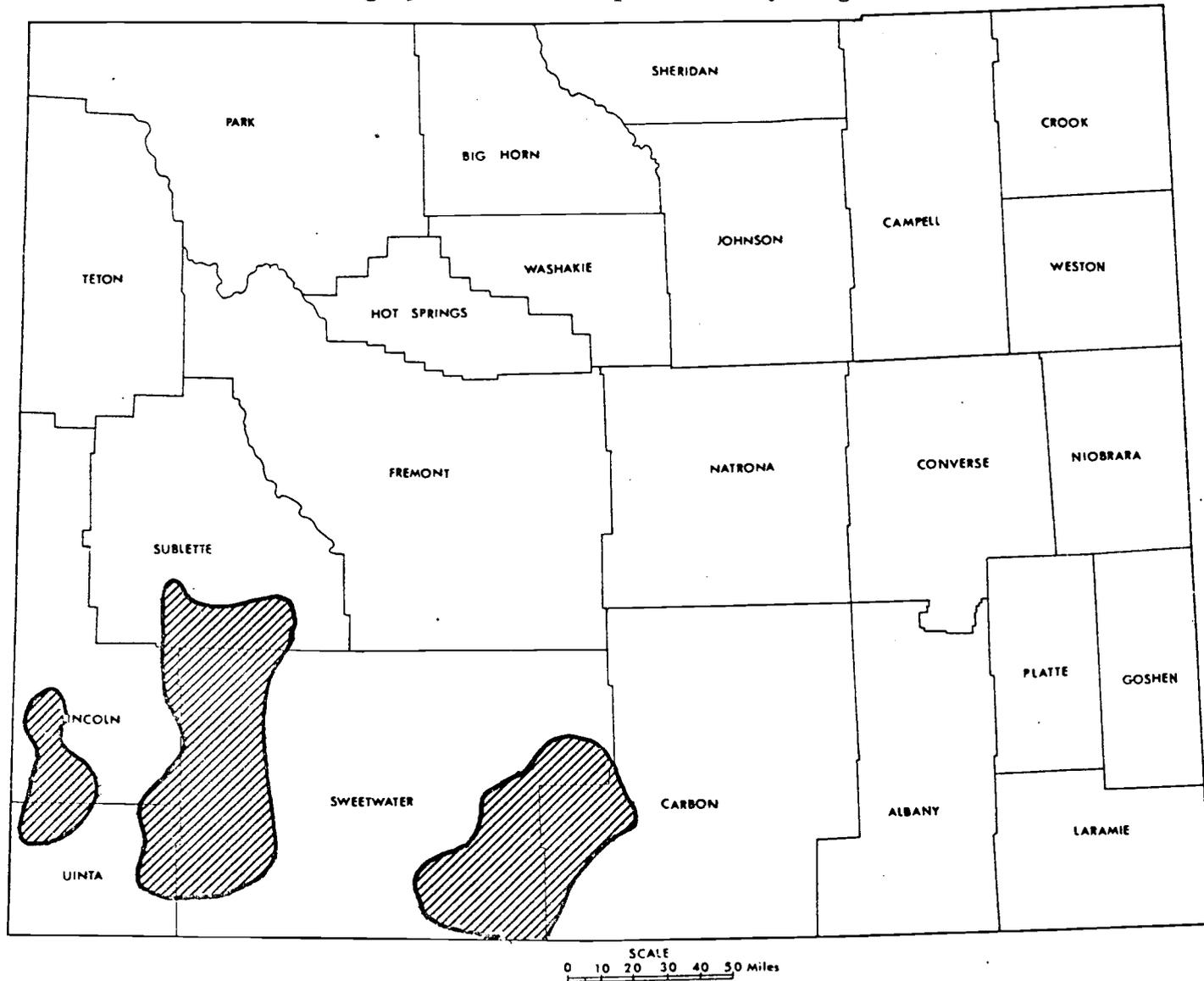
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<sup>18</sup> Mineral Resources Of The United States, 1921, op. cit.,  
p. 323.

<sup>19</sup> Ibid.

<sup>20</sup> Wyoming Oil Shale Environmental Planning Committee, Environ-  
mental And Economic Report On Wyoming Oil Shale (Cheyenne:  
Department Of Economic Planning And Development, 1971), p. 5.

Fig. 3 Oil Shale Deposits in Wyoming



Source: Environmental and Economic Report on Wyoming Oil Shale, p. 6.

would be increased to about 100 million barrels. To date development of the industry has been slowed because of such factors as inadequate technology concerned with mining and retorting oil shales which could produce shale oil at competitive prices; a general lack of water in the area of oil shale deposits; the problem of adverse environmental impact; and a serious shortage of development capital because of current inflation rates.<sup>21</sup> A discussion of some of those external influences which may either encourage or impede further development of Wyoming's oil shale deposits will form the basis of another section of this study.

### Coal

Coal has been produced in Wyoming since 1865, when 800 tons were mined for local consumption. By 1868, 6,925 tons were produced from mines at Carbon, Rock Springs and Almy, near Evanston, and consumed by the locomotives of the Union Pacific Railroad. Indeed, the presence of coal had been an important factor in the Union Pacific's decision to locate in southern Wyoming.<sup>22</sup> In the 1870's mining was carried out by the Wyoming Coal and Mining Company which was controlled by the directors of the Union Pacific Railroad. In 1874 the railroad established its own coal department and in the years 1874-75 about one quarter of all the freight tonnage carried by the Union Pacific

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<sup>21</sup>Federal Power Commission, National Power Survey 1970 (Washington, D.C.: Government Printing Office, 1971), I: pp. 4-20.

<sup>22</sup>Alan Hopwood Grey, "A Railroad Across The Mountains: Choosing The Route Of The Union Pacific Over The Eastern Rockies: (Ph.D. dissertation, University of Wisconsin, 1963), p. 146.

was coal. Coal was so important to the railroad that in 1887 the president of the Union Pacific testified "...that coal mines were the salvation of the Union Pacific; those mines saved it. Otherwise the Union Pacific would not have been worth picking up".<sup>23</sup> Early limits were placed upon the acquisition and development of coal lands by the federal government in the interest of conservation. An 1873 law limited the total acreage of coal lands acquired by an individual to 160 acres and for corporations or associations a maximum of 640 acres was allowed. In addition, values were placed upon such lands in accordance with their location relative to railroads. For example, all coal lands within 15 miles of a railroad could not be purchased for less than \$20 per acre and land more than 15 miles from a railroad could not be purchased for less than \$10 per acre.<sup>24</sup>

In general, coal, along with oil and agriculture, formed the economic underpinning of Wyoming until well into the twentieth century. By 1919, oil had surpassed coal as the most important mineral product in terms of value, and in the 1950's both natural gas and uranium also surpassed coal in importance. As an example of the rapid decline of coal's role in the economic and social life of the state, Sweetwater County, whose county seat is Rock Springs, saw its payroll drop from \$21 million in 1953 to \$14.6 million in 1955. In Carbon County the Hanna mine of the Union

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<sup>23</sup>Larson, op. cit., p. 114.

<sup>24</sup>Ibid., p. 378.

Pacific Coal Company was closed in 1954 and the population dropped from 1,326 to 625 between 1950 and 1960. Coal production reached a peak in 1945 of 9.8 million tons but declined sharply thereafter until only 1.6 million tons were produced in 1958. In 1968 the production figure had again risen to 3.8 million tons. During the twenty-eight years between 1940 and 1968 surface mining operations became overwhelmingly dominant. In 1940 only 0.2 million tons or about 3 percent of coal production in Wyoming was strip-mined coal. In 1968 strip-mine coal accounted for 3.7 million tons and 97 percent of the state's output. Most of the coal is used for electric power generation and one area of reserves, the Powder River Basin, is an exceedingly rich region of low-sulfur subbituminous coal.

At Lake DeSmet, near Buffalo, on the west flank of the Powder River Basin, a coalbed averages more than 100 feet in thickness and locally may be as much as 220 feet; it underlies an area of several square miles and contains a strippable deposit of more than 1 billion tons.<sup>25</sup>

Figure 4 indicates the areas and thicknesses of subbituminous coal within Wyoming. Table 3 gives additional information on the major coal regions currently being mined.

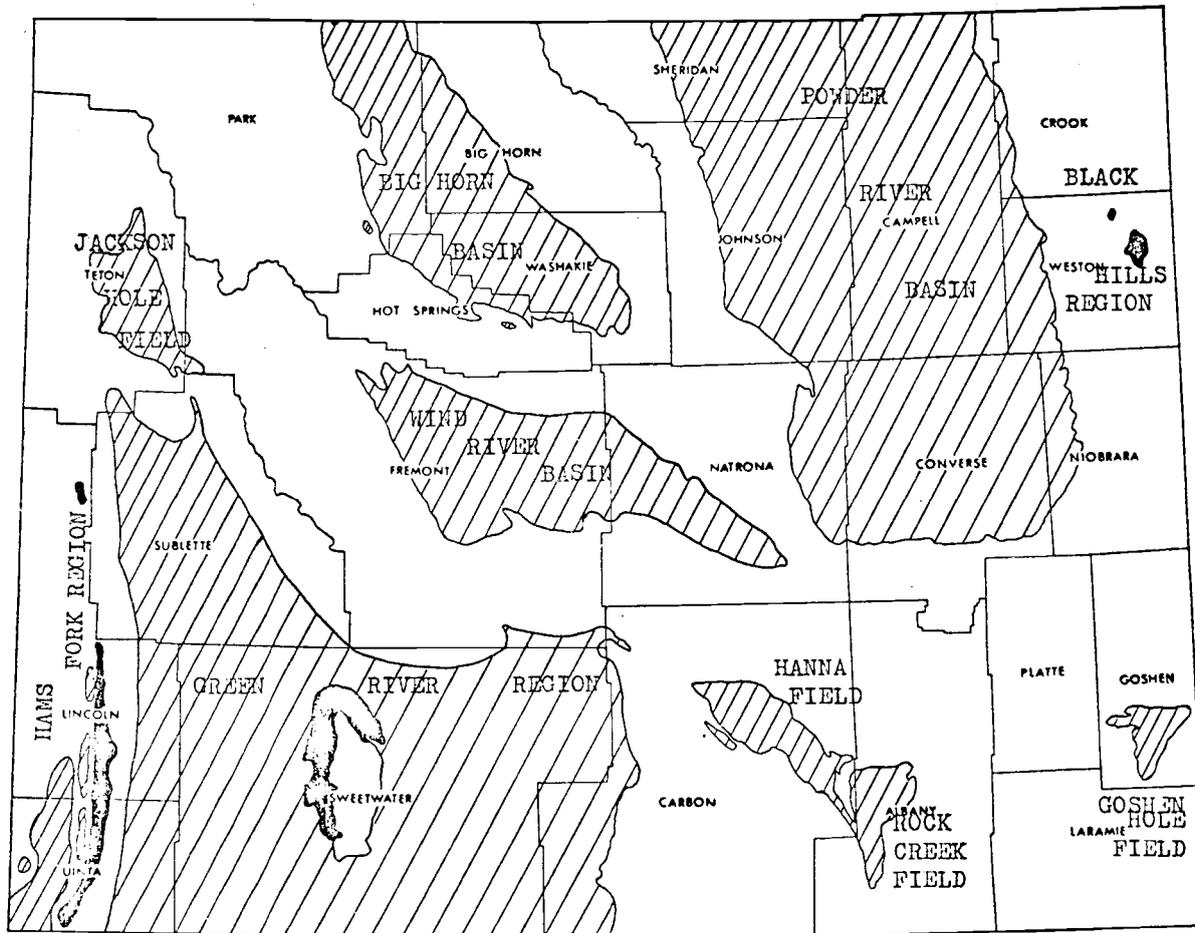
#### Consumers and Producers of Wyoming Coal

As previously mentioned, one of the primary consumers of low-sulfur Wyoming coals is the electrical power industry. In addition to air pollution regulations which have made low-sulfur types of coal more desirable, improvements in the technology of high voltage transmission of electrical power have generally helped the coal

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<sup>25</sup>Strippable Reserves of Bituminous Coal and Lignite in the United States, op. cit., p. 54.

Fig. 4. Wyoming Coal-bearing Areas



BITUMINOUS  
Containing coal beds more  
than 14 inches thick

SCALE  
0 10 20 30 40 50 Miles

SUB-BITUMINOUS  
Containing coal beds more  
than 30 inches thick

Source: Coal Age, May, 1974, p. 99.

TABLE 3 REMAINING STRIPPABLE SUBBITUMINOUS COAL RESOURCES OF WYOMING TO JANUARY 1, 1972

BY COAL-BEARING REGION (MODIFIED FROM U.S. BUR. OF MINES)

Coal-bearing Region	Original Strippable Resources Estimate to Jan. 1, 1968	Production and Mining losses Since Jan. 1, 1968	Remaining strippable resources to Jan. 1, 1972	Remaining Recoverable Strippable Resource(80% recovery)
Powder River Basin	21,262,400,000	15,190,211	21,247,209,789	16,977,767,832
Green River Coal Region	1,151,100,000	34,483	1,151,056,517	920,852,414
Hams Fork Coal Region	1,000,000,000	6,598,403	993,401,597	794,721,278
Hanna Coal Field	313,000,000 <sup>1</sup>	15,132,000 <sup>2</sup>	297,868,000	218,294,400
Bighorn Coal Basin	3,000,000	0 <sup>3</sup>	3,000,000	2,400,000
Total	23,729,500,000	36,955,097	23,692,544,903	18,934,035,924

<sup>1</sup>This approximation is based on Berryhill's 1950, original resources estimates (Glass, 1972 a)

<sup>2</sup>This is strip mine production and mining losses since 1950

<sup>3</sup>Probably very little to no strippable tonnage has been removed

Source: Glass, Gary. Coal Age Western Edition Mid-April 1973, Vol. 78 No. 5, p. 191.

industry. Such technological improvements stimulate "...the development of inaccessible coal reserves and combustion of coal at the mine or at mid-point sites remote from densely populated load centers."<sup>26</sup> So far, more coal is being shipped out of Wyoming for use as a fuel source in distant markets than is being burned to produce electricity within the state. To date only six coal-fired plants are operating within the state and one is under construction (see Figure 5). One of the plants, Pacific Power & Light's 420,000kw Dave Johnston plant (Figure 6) is reported to have one of the most efficient coal mining operations in the country. Approximately 6,000 tons of coal per shift are produced by 35 men, which averages to slightly more than 175 tons per man per day. This compares with a national average for strip-mining of about 35 tons per man per day.<sup>27</sup>

The senior geologist for Pacific Power & Light Company gives a good insight into one reason why relatively few thermal electric plants have been built in Wyoming. The combination of large coal reserves and water have always been important to the power industry, but recently the amount of cooling water has become increasingly important. As he points out

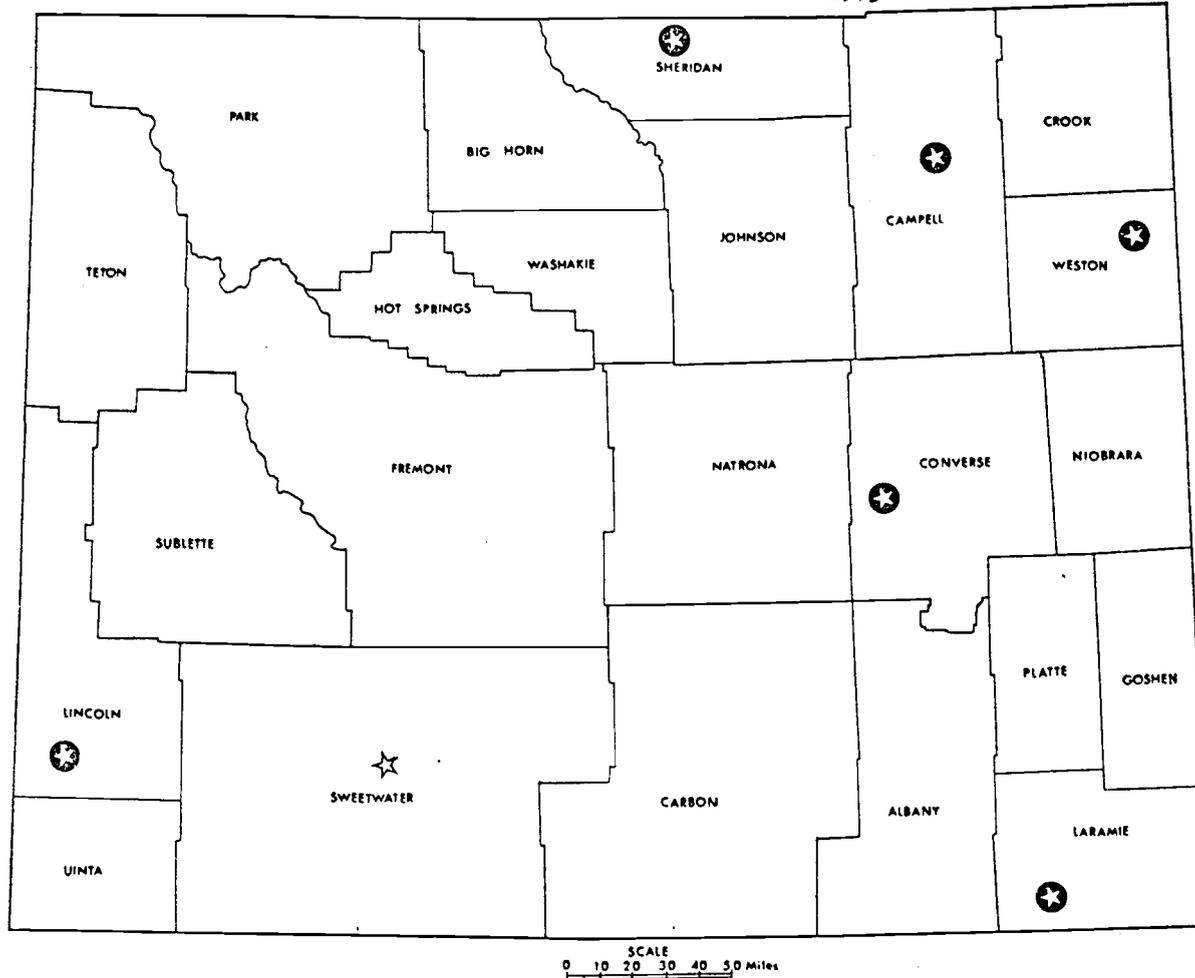
The search for coal starts only in areas where large quantities of water can be continuously available and acquired at reasonable cost. The required quantities of water are about 1250 g.p.m. [gallons per minute] or about 2.5 to 3.0 cubic feet per second

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<sup>26</sup>National Power Survey 1970, op. cit., I: pp. 4-16.

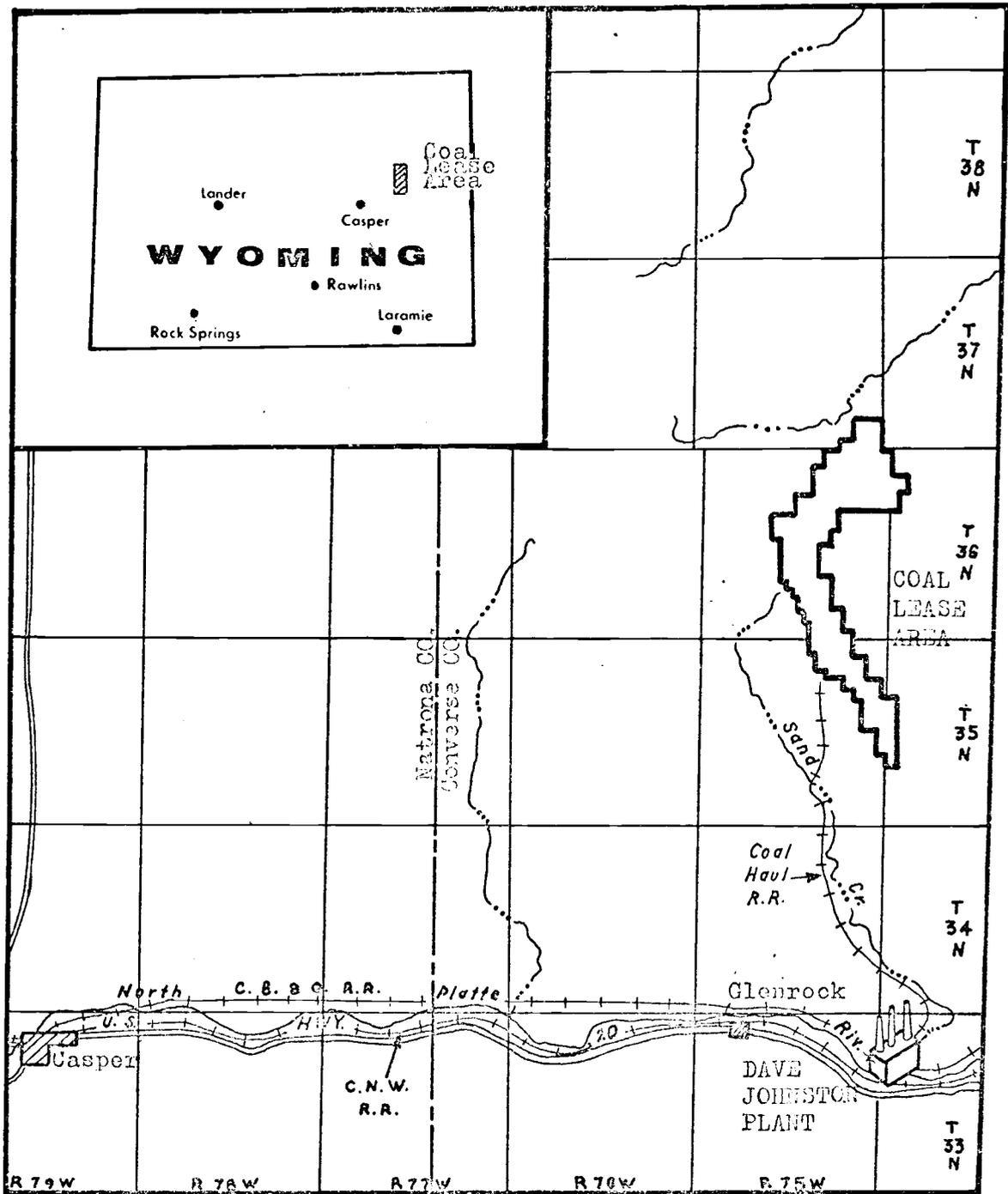
<sup>27</sup>Garth A. Duell, "Pacific Power And Light's Coal Operations, Converse County, Wyoming", Wyoming Geological Association Guidebook, 1969, p. 160.

Fig. 5 Coal Fired Electric Plants 1973



★ Operating      ☆ Under construction  
Source: "Energy Resources Map of Wyoming"

Fig. 6 Index Map Dave Johnston Steam Electric Generating Stations and Coal Operations Locality 34



0 5 10 15 20 Miles

Source: "Pacific Power & Light's Coal Operations Converse County, Wyoming", by Garth A. Duell, Wyoming Geological Assoc. Guidebook - 1969.

per 100,000 kilowatts of power plant capacity. The foregoing quantities are related to the use of evaporative cooling towers as opposed to a once-through condenser cooling water circuit. The power company of today would be unlikely to consider construction of a power plant at a location where expansion to 1,000,000 kilowatts or more was not feasible due to the lack of either economical fuel or water. In general, this calls for recoverable coal in an amount exceeding 100,000,000 tons, depending upon its heating value and the expected power plant capacity factor over its 35 to 40 year life. Also, an amount of consumable water exceeding 25 cubic feet per second (11,000 g.p.m.) must be continuously available for use. It is immediately obvious that other factors must also be considered and among them are proximity to transportation, population, electrical transmission and an area's electrical growth requirements. The coal exploration problem quickly becomes more than simply finding a low-cost fuel supply, but finding such a supply in a region where many other factors of almost equal importance exist.<sup>28</sup>

A typical example of the more common method of utilizing Wyoming's coal, mining it and shipping it to distant markets, is the Arch Mineral Corporation<sup>29</sup> facility near Hanna. Arch opened its second mine near Hanna in late 1972. A 62 cubic yard dragline, the largest in the Rocky Mountain Region, is used to strip-mine the coal which is hauled away in four 100 ton coal trucks. A total of 99 men are employed by the company but only 9 men (working in crews of 3 for 3 eight hour shifts) are required to operate the huge dragline. Current plans are to strip down to a depth of about 150 feet and after that level is reached the company will begin underground mining operations.<sup>30</sup> The coal from the mine is "flood loaded"

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<sup>28</sup>Ibid., pp. 159-60.

<sup>29</sup>Arch is 45 percent owned by Ashland Oil Co. and 45 percent owned by Hunt Industries. The company presently also operates coal mines in Illinois and Alabama. (Mining Congress Journal, Oct. 1971, p. 12).

<sup>30</sup>Wyoming Department Of Economic Planning And Development, Big Wyoming Progress Reports May - June, 1972, p. 6.

at a rate of over 3500 tons per hour into Union Pacific unit trains and shipped to either the Chicago or Kansas City Power and Light Companies. Presently, Union Pacific sends 500-600 cars to Arch's Hanna Mine each week, with each car carrying about 100 tons of coal.

### Uranium

Almost every county in Wyoming has uranium deposits although many of them are too low-grade to be developed. After petroleum, this metal is the most valuable mineral mined in the state. On a national scale Wyoming ranks first in reserves of uranium ore and second to New Mexico in tons of uranium mined per year.

The first uranium deposits were found in 1918 near Lusk in Niobrara County but little other than the report resulted from the discovery. Another uranium find was reported in 1930 in Sweetwater County in the area of the Red Desert, but again there was no exploitation of the ore. The Atomic Energy Commission, established by Congress in 1946, began looking for domestic sources of uranium as it stockpiled atomic bombs and planned other uses for nuclear energy. In 1948 the A.E.C. guaranteed a market for all domestic ore of not less than 0.10 percent grade discovered and developed in the next ten years. Good prices were promised and bonuses were added in some circumstances.<sup>31</sup> In 1949 a prospector searching for fluorides found uranium in Crook County and there is some belief that the find stimulated further exploration and uranium discoveries

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<sup>31</sup>Larson, op. cit., p. 554.

in the northwestern portion of Crook County.<sup>32</sup>

What followed was Wyoming's first uranium "boom" in which thousands of prospectors scoured the state and filed thousands of claims, which in most cases, were not rich enough to be developed. One man however, Neil M. McNeice of Riverton, found an extremely rich deposit of uranium in the Gas Hills of eastern Fremont County and established the Lucky Mc Mine. After McNeice's success in 1953 others became interested in the area of the Gas Hills which "...became a beehive of claimstaking and prospecting activity."<sup>33</sup> The last significant uranium field to be developed was the Shirley Basin in the northeastern corner of Carbon County about midway between Casper and Medicine Bow. Largely because of activity by the Teton Exploration Drilling Company, interest in this area began to develop in 1956. One year later a major discovery was made by the company and the claim staking rush was on. Today it is one of the most important uranium districts in the state with two large mills and five mines operated by Petrotonics Inc., Getty Oil, Kerr McGee and Utah International Inc. (Figure 7).

#### Organizing the Uranium Industry

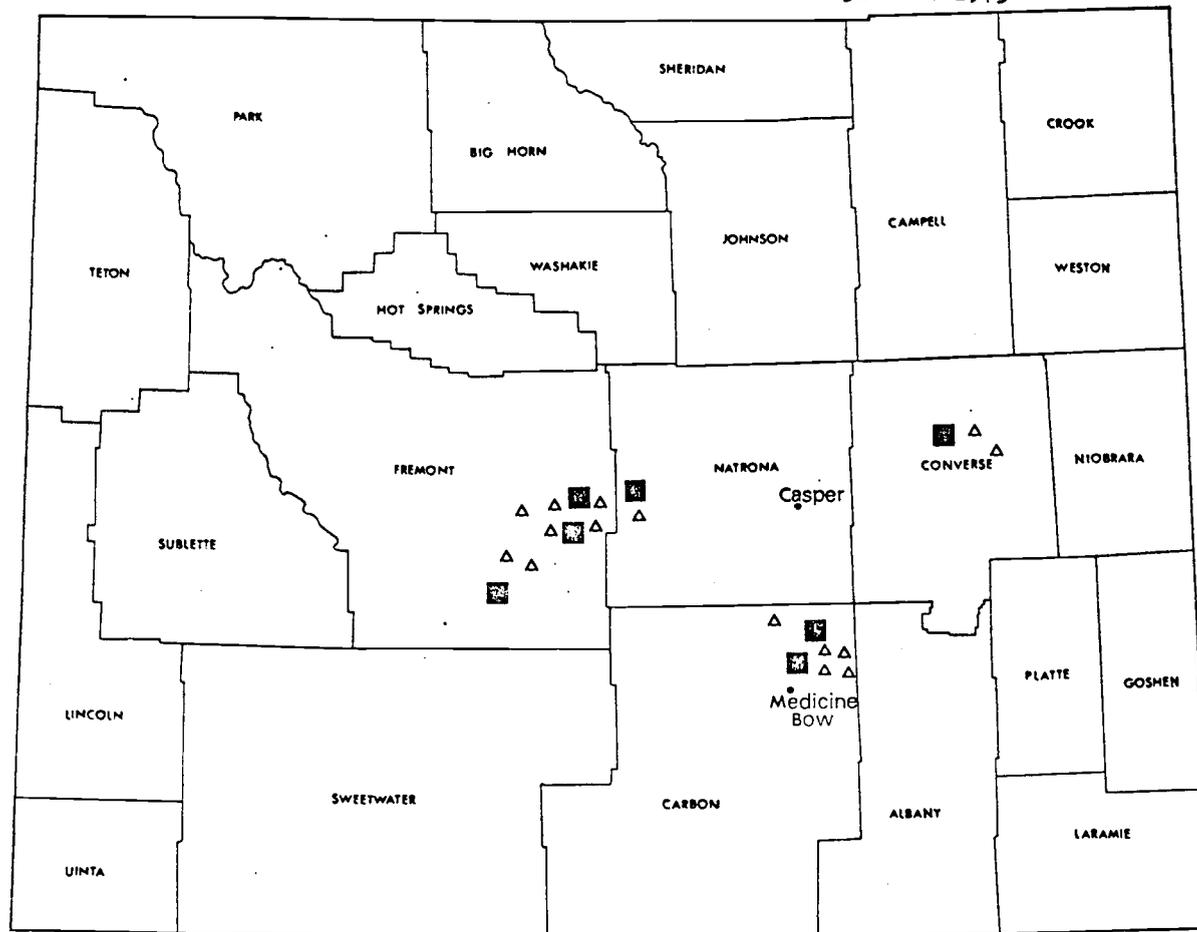
There were many legal as well as physical problems involved with the developing uranium industry in Wyoming. There were conflicts over surface and subsurface rights, and conflicts with oil and mining laws throughout the 1950's and part of the 60's

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<sup>32</sup>Merle E. Crew, "Wyoming Uranium Review", Wyoming Geological Association Guidebook, 1969, p. 169.

<sup>33</sup>Ibid., p. 169.

Fig. 7 Uranium Mill and Mine Locations as of 31 Dec. 1973



■ Uranium Mills

△ Uranium Mines

SCALE  
0 10 20 30 40 50 Miles

Locations found on Energy Resources Map of Wyoming

exemplified thusly:

In January, 1953, Congress validated all uranium claims on oil and gas leases prior to that date. At the same time, the Atomic Energy Commission authorized uranium filings on oil and gas lands. A heavy cloud of doubt remained until Congress passed the Multiple Use Statute of August, 1954, which stipulated that oil exploration should be under the Oil and Gas Leasing Act of 1920, while uranium exploration should be governed by the General Mining Laws. The delay in clarifying exploration laws left the validity of many claims in doubt. Other claims were of doubtful validity because it took the courts several years to clarify proper claim procedures for uranium. Some uranium deposits were classed as lodes, others as placers, and still others as both lodes and placers, depending on whether they lay underground or on the surface. In time, the courts ruled that the problem could be solved by permitting the prospector to stake the same area twice and thus make both lode and placer filings.<sup>34</sup>

As requirements for uranium increased in the private nuclear power industry during the middle and late 1960's the uranium industry experienced a second albeit minor "boom" beginning in 1966. During that period, following a regional trend, increased numbers of claims were made and acreage leased for uranium exploration and production increased greatly. In the period 1966-69 an estimated 5 million acres of land in Wyoming were acquired by the uranium industry and most of that total was located outside of known uranium districts. Table 4 gives a comparison of total acreage held for uranium in the West. Wyoming is second only to New Mexico total acreage but as of 1968 accounted for over 50 percent of the total U.S. drilling footage for uranium discovery.<sup>35</sup>

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<sup>34</sup>Larson, op. cit., p. 58.

<sup>35</sup>Crew, op. cit., pp. 169-70.

TABLE 4. TOTAL ACRES HELD FOR URANIUM

State	Acres 1/1/66	Acres 7/1/68	Acres 1/1/69
Colorado	213,000	1,720,000	1,987,000
Utah	113,000	2,308,000	3,084,000
Texas	34,000	552,000	842,000
Wyoming	226,000	5,164,000	6,941,000
Montana			182,000
Idaho			100,000
Washington			43,000
Oregon			80,000
New Mexico	137,000	6,292,000	7,228,000
California	6,000	528,000	536,000
South Dakota		30,000	30,000
Arizona	2,000	243,000	288,000
	<u>731,000</u>	<u>16,836,000</u>	<u>21,341,000</u>

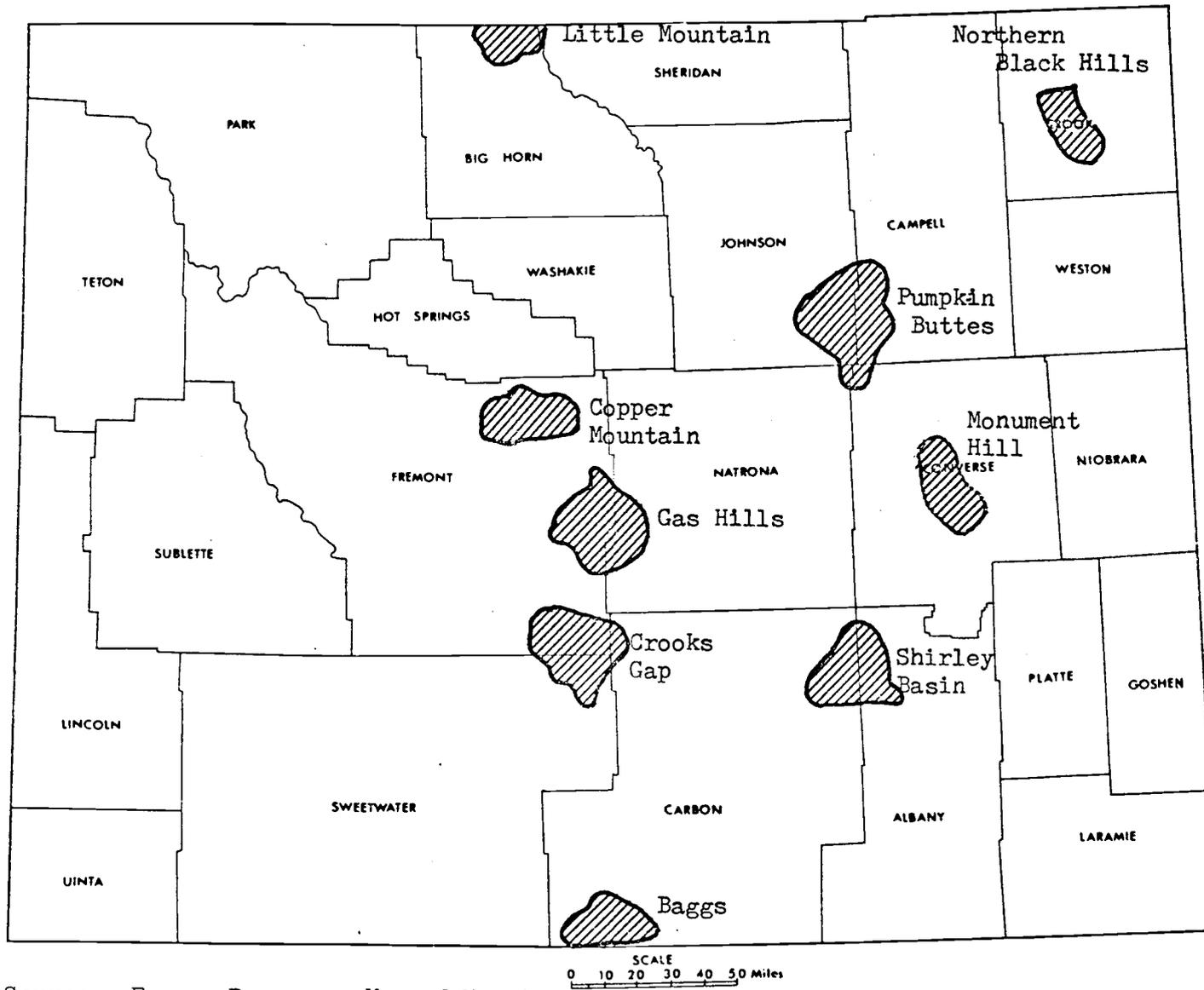
Source: Crew, op. cit., p. 170.

Today the major uranium areas in Wyoming are shown on Figure 8. Lesser areas such as Baggs and Little Mountain have also produced uranium in the past.<sup>36</sup> Underground mining techniques are used mainly in the Crooks Gap, Gas Hills and the Shirley Basin. More common however, is the open pit method of mining which is utilized to depths of over 400 feet. Overburden is usually removed by large scrapers or large power shovels and trucks. When the overburden has been stripped to the ore horizon the actual mining is usually done with a power backhoe and smaller trucks. Front end loaders and conventional power shovels may also be used.<sup>37</sup> Table 5 summarizes total production from the major uranium producing areas of Wyoming.

<sup>36</sup> Wyoming Geological Survey, Energy Resources Map of Wyoming (Laramie: Wyoming Geologic Survey, 1972).

<sup>37</sup> Crew, op. cit., p. 171.

Fig. 8 Major Areas of Uranium Deposits



Source: Energy Resources Map of Wyoming.

TABLE 5. TOTAL PRODUCTION TO 1 JANUARY 1969

Area	Tons of Ore	%U <sub>3</sub> O <sub>8</sub>
Gas Hills	9,235,000	0.224
Shirley Basin	1,715,000	0.271
Crooks Gap	1,530,000	0.240
Monument Hill	477,000	0.185
Pumpkin Buttes	35,000	0.287
Northern Black Hills	720,000	0.219

Source: Crew, op. cit., p. 171.

#### Summary

The history of the five Wyoming fuels considered in this study has been characterized by generally abundant supplies but uneven development patterns. An early start in the production of coal, petroleum and natural gas gave Wyoming at least regional significance as a fuel-producing area. However, the problem of distance to markets and the attendant high cost of transportation became evident even in the nineteenth century. The one clear exception to the pattern was in the development of the uranium industry which was stimulated and supported by the federal government.

An early influx of capital from outside the state for development of Wyoming's fuel resources established a pattern which continues today. Corporations operating on a national scale are still active in the development of all five fuels discussed. Their views, as well as those of both the federal and state governments, of Wyoming's role as a possible national fuelpool have followed a cyclical pattern through time.

### III EXTERNAL FACTORS

External factors are here defined as those factors which are not entirely related to the physical site or properties of a particular fuel but still exert enough of an effect to influence the supply and demand characteristics of the fuel. Factors specified as external also include socio-environmental and to a lesser degree, economic/technological influences, which are also included in the general political environment. Dole<sup>1</sup> delineated the differences between governmental influences and the more encompassing political milieu thusly:

The pulling and hauling that goes on between these varied and often conflicting aims; the maneuvering, the bargaining and the trade-offs that finally materialize over specific issues form the broth in which our mineral policies are steeped, and they often come out with quite a different flavor and smell than the cook intended them to have. Thus policy states what our actions should be; politics determines what they are.<sup>2</sup>

Politics has a reciprocal relationship with society and each to varying degrees, is a reflection of the other. The development and consumption patterns of fuels are influenced by both governmental and societal factors which emerge as the economics of fuel utilization. Decisions regarding the use and production of fuels are made, as

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<sup>1</sup>Hollis M. Dole, Former Assistant Secretary - Mineral Resources U.S. Department of the Interior.

<sup>2</sup>Hollis M. Dole, "Mineral Policy - The Act of the Possible", Mining Congress Journal, June, 1972, p. 43.

Landsberg and Schurr point out, "...within a framework of federal and state laws and regulations that govern many of the conditions of doing business."<sup>3</sup> They further emphasized that

Because of inter-fuel competition and the wide growing area of use in which energy sources are substitutable, the regulations governing one industry react upon the others. Markets for coal, for instance, are sensitive to rules governing the importation of oil, and to the regulation of natural gas prices in the field. Similarly, rail rates granted coal unit trains affect the threshold at which nuclear energy becomes competitive. And, most recently, standards for emission of noxious effluents or gases from combustion are reflected in the greater attractiveness of natural gas as against coal and fuel oil.<sup>4</sup>

#### Governmental Influences - Natural Gas

Some fuels, such as natural gas, are controlled by governmental decisions which affect prices directly, and indirectly determine the exploration and production rates of the industry. Currently the shortage of natural gas is a function, in part, of high demand and low prices in relation to capital investment in the natural gas industry. Demand for this clean-burning fuel has risen rapidly, partly because government has controlled the price of natural gas. The Federal Power Commission regulates the price of all natural gas moving and marketed on an interstate basis (about 60 percent of all natural gas) and generally the Commission has maintained relatively low price ceilings which tended to discourage increased drilling and production levels in the industry. On a national level, the 1945-70 period showed an increase in natural gas

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<sup>3</sup>Hans Landsberg and Sam H. Schurr, Energy in the United States: Sources, Uses and Policy Issues (New York: Random House, 1968), p. 179.

<sup>4</sup>Ibid., p. 180.

production of 7 percent per year, but in 1971 production increases had dropped to only 2.6 percent.<sup>5</sup>

#### Governmental Price Regulation

Since Wyoming's natural gas industry is characterized by both external corporate control and external markets, the pricing policies of the FPC are highly significant in the operation of the industry. The natural gas industry alone was valued at about 6 percent (\$36.3 million) of the state's total mineral output in 1968.<sup>6</sup> By 1969, as a reflection of the growing demand for natural gas, Wyoming marketed natural gas valued at \$44.6 million while production increased 22 percent over 1968. National gas consumption within the state also increased 15 percent in 1969 versus 1968.<sup>7</sup> Meanwhile, the FPC is attempting to stimulate exploration in the industry at the national level by exempting most small gas producers from price ceilings and prodding the large pipelines companies to lend money to gas producers at very low rates of interest. In rethinking its traditional role as regulator of the gas industry (since 1938 when Congress passed the Natural Gas Act), the FPC is currently allowing the price of natural gas to rise gradually over the next two years in order to encourage some industrial

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<sup>5</sup>Gilbert Burck, "The F.P.C. Is Backing Away From The Wellhead", Fortune, November, 1972, p. 111.

<sup>6</sup>U.S. Department of the Interior, U.S. Bureau of Mines, Minerals Yearbook, 1968, 4 vols. (Washington, D.C.: U.S. Government Printing Office, 1970), vol. 3: Area Reports: Domestic, p. 823.

<sup>7</sup>U.S. Department of the Interior, U.S. Bureau of Mines, Minerals Yearbook, 1969, 3 vols. (Washington, D.C.: U.S. Government Printing Office, 1971), vol. 3: Area Reports: Domestic, pp. 330-2.

consumers of natural gas to utilize other fuels. In the meantime the FPC has defined a fair return to producers as whatever it takes to revive exploration and development. Additionally, the price of intrastate gas, whose rates are controlled by the individual states, must be considered in regulating interstate gas prices. Both principles have been approved by the courts. In August, 1972, the FPC adopted a ruling which permitted domestic gas producers to sell new gas to interstate pipelines at prices above the ceiling price in their area. However, there were limits to how far above the ceilings the producers could go; in order to ensure "responsible" pricing, the FPC reserved the right to veto any "deal."<sup>8</sup>

Currently there is a strong movement within the FPC, within Congress, and within the gas industry for total deregulation of natural gas prices. Arguments for deregulation include those which point out that consumers would be willing to pay as much as twice the price of domestically produced gas for foreign liquified gas in order to utilize gas as a fuel. It is argued that in order to keep the flow of foreign gas into the United States within reasonable limits, domestic supply must be expanded and demand reduced.<sup>9</sup> Already the trona industry in Wyoming is facing a problem of expansion which will be largely determined upon the continued abundance of low cost natural gas as a fuel source. If gas prices are allowed to rise in a free market situation, then the industry

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<sup>8</sup>Burck, op. cit., p. 180.

<sup>9</sup>Ibid., p. 186.

might find that alternative fuel sources such as coal will become more economically feasible alternatives. The trona plants even now are equipped with a standby oil supply to augment natural gas which is supplied on an industrial interruptable contract.

Wyoming is representative of the current plight of the natural gas industry nationwide. Some people, like Edwin L. Kennedy,<sup>10</sup> and a growing number of economists (such as M.A. Adelman of M.I.T.) are becoming increasingly critical of governmental presence in the natural gas industry. Since so much of Wyoming's gas moves in interstate markets, federal pricing controls are particularly important and relevant with regard to a solution of satisfying an overly stimulated natural gas market. Speaking as an investment analyst Mr. Kennedy pointed out that a vital issue which must be faced by not only the gas producers but all energy industries will be their ability to provide for their capital needs. Increasingly energy companies are finding it difficult to generate the required funds internally.<sup>11</sup>

Although the comments apply to "energy industries," which include energy users like electric companies as well as fuel suppliers, some comments by Mr. Kennedy can be singled out as representative criticism of governmental influence in the gas industry. Kennedy admitted that, "Government has a vital role in the energy decisions

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<sup>10</sup> Managing director of Lehman Brothers Incorporated, a New York investment banking house.

<sup>11</sup> Edwin L. Kennedy, "Fuel for the Future: The Economics of Energy Supply", Petroleum Today, No. 1 1972, p. 4.

of the future, but it is important that government permit the market place to establish the conditions necessary to assure our energy supply and capital required to accomplish it."<sup>12</sup>

#### General Scope of Government Activities - Natural Gas

Governmental influences both on a federal and state level have been an integral part of both the oil and gas industries in Wyoming almost from their beginnings. Because the gas industry is so broad-based in its social and economic activities, many levels of government and many departments of both local and federal governments have responsibilities which often relate to the natural gas industry. For example, on the federal level, the Federal Power Commission under the Natural Gas Act of 1938 has been granted regulatory powers and responsibilities. The Department of the Interior is currently involved in various programs which include natural and synthetic gas research, resource evaluation, economic analysis of resources, and disposal (leasing) of Federal lands for purposes of enhancing the development of natural gas supplies.<sup>13</sup> In addition, the Justice Department, Department of Health, Education and Welfare and Department of Transportation all play collateral roles as agencies with a distinct impact upon the gas industry. In its role of lessor of public lands, the Department of the Interior has had a profound effect upon both the natural gas and

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<sup>12</sup>Ibid., p. 3.

<sup>13</sup>U.S. Department of the Interior, U.S. Bureau Of Mines Bulletin 650, Mineral Facts and Problems, 1970, (Washington, D.C.: Government Printing Office, 1970), p. 126.

petroleum industries. Beginning with the Oil Land Leasing Act of 1920, The Interior Department, and specifically the Secretary of the Interior, was granted the following powers:

...the Secretary of the Interior is hereby authorized, to prescribe, to grant to any applicant qualified under this Act a prospecting permit, which shall give the exclusive right, for a period not exceeding two years, to prospect for oil or gas upon not to exceed two thousand five hundred and sixty acres of land wherein such deposits belong to the United States and are not within any known geological structure of a producing oil or gas field upon condition that the permitter shall begin drilling operations within six months from the date of permit, drill one or more wells for oil or gas to a depth of not less than five hundred feet each, unless valuable deposits of oil or gas shall be sooner discovered, and shall, within two years from the date of the permit, drill for oil or gas to an aggregate depth of not less than two thousand feet unless valuable deposits of oil or gas shall be sooner discovered.<sup>14</sup>

Additional provisions of the Act (Public Law No. 146 - 66th Congress) provide that a rental of one dollar per acre shall be paid to the federal government each year that the lease is valid (up to twenty years). In addition, a royalty of 5 percent will be paid to the federal government and thereafter a tax of 20 percent on the gross value of all oil or gas produced on the lease land will also be paid to the federal government. Other requirements such as well spacing and conservation practices were included in the act as well as levying a 12½ percent tax on oil and gas produced on federal withdrawal lands (Executive Withdrawal Order issued 27 Sept. 1909) which were occupied prior to 1 July 1919.<sup>15</sup> As

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<sup>14</sup>Gilman G. Udell, Oil Land Leasing Act Of 1920: With Amendments And Other Laws Relating To Mineral Lands, (Washington, D.C.: U.S. Government Printing Office, 1968), p. 9

<sup>15</sup>ibid., pp. 9-14.

time went on approximately 30 amendments to the 1920 Act were incorporated into the federal law system which allowed the Secretary of the Interior to: reinstitute leases which were terminated because rental was not paid on time; provided for competitive bidding for lease lands; allowed for unit operation of gas and oil fields; limited the primary lease term to five years on competitive bids; and to require that the Secretary of the Interior "...report to Congress at the beginning of each regular session all such agreements entered into during the previous year which involve unleased Government lands".<sup>16</sup> In just one limited area, land leasing, governmental influence at the federal level has been a very powerful force in both the petroleum and the natural gas industries nationwide. A more detailed examination of the public land leasing system will be undertaken at a later point.

#### General Scope of Government Activities - Uranium

Other areas of governmental influences on a federal level include the Atomic Energy Commission's activities in the uranium industry. As early as 1948 the AEC began to make major efforts to stimulate new domestic discoveries of uranium and in the 1950's the AEC set a guaranteed price of eight dollars per pound of uranium concentrate ( $U_3O_8$ ) in an attempt to increase exploration. With both a market and price guaranteed many companies began to enter the uranium mining industry by 1952. In Wyoming such firms included Kerr-McGee; Getty Oil; Utah International; Petrotomics

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<sup>16</sup>Public Law 86-705, 86th Congress., 1st session, H.R. 10455, sec. 17(g) (1960).

Company; Union Carbide; Western Nuclear; Federal-American Partners; and Sigma-Teton Mining Ltd. In all, by 1969, a total of about 10.2 million acres of land or one sixth of the total area of the state of Wyoming were held by uranium companies.

In 1958 the AEC ended its purchases of domestic uranium ores produced after November of that year but the agency agreed to honor existing contracts until 1966. However, the days of the guaranteed \$8 per pound price paid by the AEC for  $U_3O_8$  were over. During 1968 the AEC paid an average of \$7.97 per pound of concentrate ( $U_3O_8$ ) and during 1969 and 1970 AEC paid \$1.60 per pound of  $U_3O_8$  plus 85 percent of the allowable production costs during the prior six years subject to a maximum of \$6.70 per pound.<sup>17</sup> The U.S. Bureau of Mines estimated that in 1968 private sales in the uranium industry had prices that ranged between \$5 and \$5.50 per pound which is somewhat below the \$5.50 - \$6.00 per pound rates paid by the AEC on contracted deliveries extended through 1970. A survey of the uranium industry carried out by the AEC in 1968 revealed that uranium producers were hoping that the price for  $U_3O_8$  would rise to about \$7.20 per pound in 1971 then to about \$8.00 per pound by 1974.<sup>18</sup> Such hopes on the part of the uranium industry were not well founded. As an example, the United Nuclear Corporation and the AEC signed an agreement in 1970 by which shipments of uranium concentrate to the AEC would be terminated. The agreement provided

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<sup>17</sup>U.S. Department of the Interior, U.S. Bureau of Mines, Minerals Yearbook, 1968, 4 vols. (Washington, D.C.: U.S. Government Printing Office, 1970), vol. I-II: Metals, Minerals and Fuels, p. 1130.

<sup>18</sup>Ibid.

that the final 896 tons of  $U_3O_8$  would be purchased by the AEC at 72¢ per pound instead of the prior rate of \$6.47 per pound.<sup>19</sup> This example clearly indicates that the helping hand of the AEC as a readily available market has been withdrawn. That the federal government's role in the domestic uranium industry was significant, in economic terms is further illustrated by the AEC's purchase record of  $U_3O_8$  over a period of some 33 years (Table 6). Again, one can readily discern the rapid decline in federal purchases of uranium concentrate after 1968.

Even though the uranium industry has, in effect, become a completely independent and competitive private industry which no longer has either a stable price or market, governmental influence still remains quite strong. The federal presence in the distribution and control of nuclear materials can still be considered a monopoly.

AEC is charged with the control of all fissionable material and any source material used to produce fissionable materials. More explicitly, source material means any material, except special nuclear material, which contains 0.05 percent or more uranium, thorium, or any combination thereof. Unless authorized by a license issued by AEC, no person may transfer, deliver or export any source material after removal from its place of deposit in nature. Application for license is available from AEC and, upon determination of the Atomic Energy Acts of 1946 and 1954, as amended, and of the regulations of AEC, a license will be issued in the form and upon the conditions imposed include the filing of reports and restriction upon the use of source material.<sup>20</sup>

Additionally, such gas stimulation projects as Cassbuggy, Rulison and the proposed Wagonwheel which employ nuclear explosions, are co-sponsored and regulated by the AEC. Even the packaging and

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<sup>19</sup> Mining Congress Journal, "Mining Newsmoth" Mining Congress Journal, April, 1970, p. 22.

<sup>20</sup> Mineral Facts and Problems, 1970, op. cit., p. 231.

TABLE 6 AEC CONCENTRATE PURCHASES BY STATES

In Thousands of Dollars

Calendar Year	Colorado	New Mexico	Utah	Wyoming	Others <sup>1</sup>	Total
1947	966	-	-	-	-	966
1948	1,531	-	-	-	-	1,531
1949	3,063	-	-	-	43	3,106
1950	7,992	-	-	-	1,890	9,882
1951	13,513	-	2,275	-	-	15,788
1952	17,163	-	3,556	-	-	20,719
1953	22,149	-	6,139	-	271	28,559
1954	29,404	-	7,331	-	5,536	42,271
1955	34,341	19,978	12,166	-	-	66,485
1956	40,969	64,633	23,698	-	2,994	132,294
1957	45,105	50,920	57,980	-	12,501	166,506
1958	58,514	66,462	67,374	23,764	17,491	233,605
1959	62,572	112,770	63,853	28,587	19,981	287,763
1960	61,257	125,146	54,641	44,799	18,874	304,717
1961	52,245	123,794	51,376	45,361	17,001	289,777
1962	43,058	110,373	52,174	48,942	13,458	268,005
1963	34,126	85,892	49,348	41,045	14,810	225,221
1964	28,803	75,975	33,007	35,461	16,317	189,563
1965	20,631	73,464	24,164	33,551	15,259	167,069
1966	20,118	70,285	-	31,094	30,276	151,773
1967	13,442	75,147	-	27,275	18,921	134,785
1968	12,514	68,801	-	24,990	11,012	117,317
1969	-	47,150	-	12,531	12,777	72,458
1970	-	7,875	-	6,346	13,814	28,035

Note: Uranium recovered as a byproduct from the processing of phosphates, euxenites, etc., is not included.

1. Data included in "Others" category when only one company is operating in a state for sales to AEC.

Source: AEC Statistical Data of the Uranium Industry.

transportation of radioactive and fissionable materials is regulated by federal agencies. For example, the packaging of radioactive materials for transport is governed by AEC regulations listed in U.S. Code of Federal Regulations, Title 10, Part 71. However, on April 1, 1967, the Department of Transportation (DOT) assumed the overall regulatory responsibilities for shipments by the Coast Guard and the Federal Aviation Agency. The AEC coordinates its regulatory control of radioactive materials with the DOT and the Post Office Department.<sup>21</sup>

#### State Governmental Activities

On a state level government regulation of petroleum and gas fields tends to overlap the federal structure. For example, during the 1969 session of the Wyoming legislature (it meets biannually) a bill was passed which allowed that the State Land Commission could eliminate the requirement that drilling units must be of uniform size and shape. Instead, the Commission must only require that drilling units must conform to a uniform size criteria. Additionally, the Commission was granted the power to restrict or limit oil or gas production from wells which the Commission had previously exempted from well spacing conditions.<sup>22</sup> In addition to the state regulations on unit size, the state of Wyoming, somewhat belatedly, became a member of the Interstate Compact To Conserve Oil And Gas.

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<sup>21</sup>Ibid., p. 232.

<sup>22</sup>Wyoming State Land Office, 33rd Biennial Report 1968-70, (Cheyenne: Wyoming State Land Office, 1970), p. 17.

### Taxes

In the area of taxes levied on mineral and fuel production the state of Wyoming breaks down its tax rates thusly: No corporate income tax; a 1970 state gasoline tax of 7 cents per gallon (which earned the state almost 16.5 million dollars in 1969, while on the federal level the receipts from Wyoming totaled 8.4 million dollars in 1968);<sup>23</sup> 2/5 of one mill per dollar levied on the value at well of oil and gas produced in Wyoming (1966). A property tax is levied in lieu of a corporate income tax in Wyoming and in 1966 that tax was:

State - 4 mills into a general fund; 6 mills into a state school fund.  
 County - 12 mills  
 Cities and towns - 8 mills  
 School Districts - Elementary schools 19 mills maximum; High schools 11 mills maximum; unified school districts 30 mills maximum.

Source: Tax Rates and Debt Limitations in Eight States, 1966.

### Other Non-Governmental Externalities

#### Economic and Technological Factors - Uranium

Economic and technological factors which have influenced the development and utilization of various fuel sources on a national level have also had an ancillary effect upon the fuel industries of Wyoming. In the area of nuclear power, when private and governmental agencies developed a light-water reactor in the early 1960's two factors influenced the growth of uranium mining in the United States in general and in Wyoming in particular. First, with the

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<sup>23</sup>American Petroleum Institute, Petroleum Facts & Figures 1971 (Baltimore: Port City Press, 1971), pp. 473-95.

development of ordinary water as a reactor coolant, nuclear-fired electric plants were able to compete on a cost basis with non-nuclear plants for the first time. Second, as a result of the new developments in reactor technology, the AEC agreed to extend some of its purchase contracts with the uranium mining companies through 1970 when many of the proposed nuclear plants would be coming on stream. The results, in part, were reflected by increased production levels of both uranium ores and concentrates in Wyoming.

### Reactors

The development of the light water reactors was an important technological breakthrough. However, the follow-on step of producing commercial fast-breeder reactors which produce more fuel than they consume has not yet come about. At the present time only an estimated 0.7 percent of  $U^{235}$  is utilized by the light water reactors and the  $U^{235}$  that is left behind must undergo an expensive process of changing it to a usable fuel - plutonium 239. Over ten years ago the AEC had started research on fast breeder reactors and had developed a time table which would place the first reactor of that type in operation by 1976 and its widespread commercial use was expected by 1984. Unfortunately, general cut backs in federal spending have also cut into the AEC's research and development funds so that it now seems doubtful that the commission's original timetable can be met. Private industry's only attempt at developing a fast breeder reactor has not been successful to the point of encouraging private companies taking up further developmental work

without AEC aid.<sup>24</sup> Because of the lack of breeder reactors some electric utility companies are considering alternative power sources.

### Economic and Technological Factors - Coal

#### Unit Trains

Quite apart from thermal electric plants utilizing low sulfur coal, has been the development of such technological innovations as unit trains and integral trains. In order to maximize efficiencies of coal handling a great deal of cooperation between the coal producers, car designers and coal handling and storage equipment supplies was a prerequisite. Although the concept of unit trains is a managerial innovation, it can also be considered a technological innovation in a broad sense because of its total systems scope. The unit train is but one element in a total system approach which requires an economic and technological balance of components within the system and involves a thorough analysis of each individual move before initiation. Such factors as minimum train tonnages, car type, capacity and quantities, loading facilities, unloading facilities and storage must be considered since all affect the scheduling and economic benefits of the unit train operation.<sup>25</sup>

The unit train concept and its level of efficiency, especially in the loading and unloading of coal, has led to transportation

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<sup>24</sup>Business Week, "Nuclear Fuel Runs Scarce," Business Week, March 21, 1970, pp. 84-5.

<sup>25</sup>Mining Informational Services, "Rail Transportation," 1971 Keystone Coal Industry Manual (New York: McGraw-Hill, 1972) p. 140.

rate reductions and the greatly expanded market area for Wyoming coals. Without utilizing unit train operations it is doubtful if Wyoming coals would be sold in Midwestern markets irrespective of their low sulfur content. Two examples help to illustrate the extent to which unit trains are being utilized to move Wyoming coals to Midwest consumers. The Chicago & Northwestern Railroad moved 9.8 million tons of coal from Wyoming in 1971 and unit trains operations made up 5.2 million tons or 52.4 percent of the total. The loading point was Rock Springs, with facilities which can load 9,000 tons per minute; the destination was Oak Creek, Wisconsin; the train cycle was 5 days and coal was moved at a rate of \$7.24 per ton. The second example is the coal moving operation of the Burlington Northern Railroad which moved 60 percent of its coal tonnage (1971 tonnage, 25 million tons) by unit trains. The loading point was Kleenburn, Wyoming (just north of Sheridan) with a loading capacity of 5,000 tons per minute. Some coal was shipped to Kansas City at a rate of \$5.79 while another shipment went to Havana, Ill., at a rate of \$7.42 per ton. Both markets were served by unit trains operating on a seven day turn around cycle.<sup>26</sup> As a comparison, other market areas served by western coals give the following rate structures for their unitized train coal deliveries: The Denver and Rio Grande Western ships coal from Carbondale, Colorado to Kaiser, Calif., for \$6.32 per ton (coking coal) and coal from Salina, Utah, to the port of Los Angeles for either \$5.62 or \$6.25 per ton depending upon the length of the

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<sup>26</sup>ibid., pp. 158-62.

return trip. The Elgin Joliet and Eastern Railway Co., which serves the northeastern Illinois northwestern Indiana area, ships coal from Wingate, New Mexico to Hammond, Indiana for \$10.80 per ton and from Colstrip, Montana to Hammond for \$7.50 per ton.<sup>27</sup> These rates compare to an estimated standard price of \$6.10 per ton for coal as burned utilized by electric utilities companies throughout the United States.<sup>28</sup>

#### Mining and Loading Equipment

Increasingly, larger size mining equipment is being designed and utilized so that mining operations are generally raising their level of efficiency. Numerous advances in coal cleaning have also led to coal preparation equipment designed so that efficiencies of 99 percent or better are attained. Other equipment items such as increased dragline capacities of 100 to 200 yards and larger coal trucks (up to 240 tons) self propelled sackers, and powerful wheel excavators have aided the efficiency levels of coal mining. Larger earth moving equipment, larger drills, and fewer drill holes have aided in reducing strip mining costs. For example, "Blast holes are now drilled up to 15 inches in diameter. New explosives being used are blasting agents primed by metallized slurries and nitro-carbonate slurries packaged in polyethylene cartridges."<sup>29</sup>

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<sup>27</sup>Ibid.

<sup>28</sup>Mineral Facts and Problems, 1970, op. cit., p. 46.

<sup>29</sup>ibid., p. 40.

Most coal mined by strip methods is consumed by the electric utility industry. In a recent testimony the president of the National Coal Association stated that 75 percent of all surface mined coal (nationwide) in 1970 went to the electric utility industry and accounted for a little over 18 percent of all the electricity produced that year.<sup>30</sup> Because so much coal is utilized by electric utilities, the problems the electric companies experience in meeting air quality standards are intimately shared by the coal industry. Many methods of reducing sulfur emissions have been investigated because most of the country's coal resources are high in sulfur content and, as Bagge said, "The development of technology to convert coal to the more environmentally desirable liquid and gaseous forms is now a national priority."<sup>31</sup> Government programs at the federal level have been carried on for a considerable length of time on methods to convert coal into synthetic gas, gasoline and other chemicals as well as an increased emphasis on finding more deposits of low sulfur coals. This area will be discussed in more depth at a later point in this study.

#### Economic and Technological Factors

##### Petroleum and Natural Gas

Although little in the technology of drilling for natural gas has changed in the last 15 years some improvements in drilling

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<sup>30</sup>Statement by Carl E. Bagge before House Committee On Interior And Insular Affairs, 10 April 1972.

<sup>31</sup>U.S., Congress, House, Hearings before The Committee on Interior And Insular Affairs, Fuel And Energy. 92nd Cong., 2nd sess., 1972, p. 237.

techniques have made it possible for the average drilling rig to drill more wells at greater depths.

The greatest advances in the production of natural gas will probably come from the application of nuclear devices to stimulate heretofore uneconomic deposits of natural gas. Nuclear fracturing of gas bearing strata portends greatly increased possibilities for gas production. An estimated 300 trillion cubic feet of natural gas is known to exist in fields in the Rocky Mountain states alone. Such reserves, if economically exploitable, could favorably improve the domestic supply position and defer needs for supplemental alternative sources of gas.<sup>32</sup> Already projects such as Gasbuggy and Rulison which have just been completed have utilized nuclear energy to stimulate natural gas production. Such projects are placed under the general supervision of the Atomic Energy Commission but involve private industry as well. So far there are little data available to assess the cost of the gas produced by this new form of technology. However, the future of gas stimulation by nuclear energy may be somewhat clouded by the apparent increasing opposition on the part of environmental organizations concerned with the application of nuclear detonations in areas of suspected gas deposits.

#### Socio-environmental Factors

In a referendum vote in Sublette County during the 1972 general elections, people of the county rejected Project Wagon Wheel (a proposed experiment to stimulate natural gas by nuclear detonations)

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<sup>32</sup>Ibid., p. 134.

by a margin of 4 to 1. The development firm, El Paso Natural Gas Co., which up to that point had invested about \$8 million in the project denounced the results of the vote by declaring that "...misleading and erroneous information had been circulated prior to the vote." Nevertheless nuclear stimulation experiments in the Pinedale area have been postponed until perhaps 1980.<sup>33</sup> This example is indicative of the growing, increasingly publicized role of social and environmental factors and their influence upon fuel development. For example, the city of Denver recently experienced an extended period of unseasonably cold temperatures which led to difficulties in meeting the demand for heating fuels. As a result of the fuel shortage schools were forced to curtail their operations until adequate supplies of fuel oil were found as a substitute for natural gas which was supplied on an interruptable contract. Spokesmen for the petroleum industry laid the blame for the fuel shortage on the environmentalist groups which, they said, had discouraged continued exploration and expansion of natural gas and fuel oil.

Still another example of the growing influence of environmental considerations involves the nearly completed Jim Bridger power plant located 42 miles northeast of Green River, Wyoming. The \$300 million 1,500 MW plant was scheduled to have its first 500 MW unit in operation by 1974, but concern over the environmental disruption of the plant has led to both litigation by environmentalist

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<sup>33</sup>The Denver Post, 1 December, 1972, p. 24.

groups to halt construction, and an unfavorable federal response to environmental impact statements filed by the owners.<sup>34</sup> It is estimated that when the plant becomes fully operational about 125 acres of coal land will be strip mined each year to supply coal to the furnaces which will utilize 250 tons of coal per hour. Much of the controversy centers around the smoke emitted by the plant and has prompted William D. Ruckelshaus, former head of the EPA, to point out to the Secretary of the Interior that there were areas in which there was a shortage of information on the plant's environmental impact study.

The second draft of an environmental impact statement was also rejected by EPA because, although certain problem areas were identified, no proposed solutions were put forth. Once again a lack of data in the statement was noted by EPA in its comments prepared by the Bureau of Land Management in cooperation with the builders of the plant. Although the plant would have electrostatic precipitators installed which meet all federal and state standards for stack emissions technology, it was admitted that formidable air pollution problems would still exist. Additionally, the BLM admitted that soil erosion problems were certain to become more pronounced during the plant's operation and that a potential existed for a combination of separate environmental effects which could produce an impact that alone each effect could not cause.<sup>35</sup>

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<sup>34</sup>Pacific Power and Light Company 2/3 interest, Idaho Power Company 1/3 interest.

<sup>35</sup>Dick Prouty, "Great Wyoming Changes Seen In Coal Stripping", The Denver Post, 4 June 1972, p. 33.

## Socio-Environmental Factors at the Federal Level

### Legislative Activities

One area in which solutions to environmental and their related social problems have been attempted, is through legislative acts at the national level of government. The Federal Air Quality Act and the Federal Coal Mine Health and Safety Act upon first examination seem to fall clearly into the category of socio-environmental influences. Upon further consideration however, it seems that these two landmark federal laws actually represent combinations of several external influences upon fuel industries.

The Federal Coal Mine Health and Safety Act of 1969, for example, was designed to improve health and safety standards in underground coal mines through a system of inspections, new technology, and penalties for operators who do not meet safety standards. The United States Bureau of Mines has been given the responsibility to enforce the act and has assigned federal mine inspectors (in 1972 they numbered 570 inspectors and 714 field officials) to determine if mine operators were violating the law. The rate of violations has risen steadily from about 38,000 in 1970 to over 50,000 by the autumn of 1972. Federal officials point to the fact that coal mining is becoming safer through the efforts of the inspection program and cite a death rate of .72 miner deaths per million man-hours worked in 1971 compared to a rate of 1.0 deaths per million man-hours worked in 1970, one year after implementation of the Safety Act.<sup>36</sup> If conditions are such, that in the opinion of the

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<sup>36</sup>George Vecsey, "Mine Safety Effort Draws Rising Criticism", New York Times, 19 September 1972, part C, p. 1.

federal inspectors a mine is considered unsafe, the mine can be closed. As of August, 1971, a total of 233 mines across the United States, but mainly concentrated in the eastern portion of the nation, had been closed by enforcement of the Coal Mine Health and Safety Act (U.S. Bureau of Mines data).<sup>37</sup> Most of the closures affected small mines employing only 1 to 20 people, with only three mines in the 51-100 employee category being included in the list.

#### Impact on Wyoming Mines

Wyoming has been only minimally affected by the Health and Safety Act, with only two mine closures reported as of 1971 (and one of those was reopened after a short period) but the Act may be of great importance in the future. Already Energy Development Company is mining coal by underground methods in the Hanna Basin and it is very likely that other companies may also give greater consideration to underground mining in the future as readily available strippable deposits are consumed. The controversy over the implementation of the Mine Safety Act concerns not the social benefits to the miners derived from improved working conditions, but the decline in coal production since the inspections have been carried out. Some critics of the program cite the act for being badly conceived because it does not allow for any distinction between standards applied to large or small mine operators.

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<sup>37</sup>Hollis M. Dole, Former Assistant Secretary of Mineral Resources, U.S. Department of the Interior, to Melving M. Vuk, Washington, D.C.: 20 December 1971, Personal Files of Melvin M. Vuk, Corvallis, Oregon.

As a consequence, many of the small mine operators are actively engaged in fighting the enforcement of the act and have filed suit against the penalty system (requiring fines to be paid by the operators for health and safety violations) aspect of the act. The government for its part is actively attempting to enforce the provisions of the law but at the same time is attempting, as Hollis M. Dole said, to "...reconcile the requirements for mine safety with the need for efficient production."<sup>38</sup> Increased levels of coal production will continue to be an important goal for the industry because most projections for future energy requirements indicate a steady increase in the amount of coal used for power generation.

The Clean Air Act is a second example of an external influence upon the fuel industry which appears to be entirely of the socio-environmental variety yet has had much wider ramifications. As originally enacted in November of 1967, the act was designed to accomplish four goals: (1) To authorize planning grants to Air Pollution Control agencies; (2) expand research provisions relating to fuels and vehicles; (3) provide for interstate air pollution control agencies or commissions, and (4) authorize the establishment of air quality standards.<sup>39</sup> In concept the original act was one oriented toward encouraging state participation in air quality compacts and the establishment of air quality regions and therefore anticipated the cooperation of state governments. The Clean Air

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<sup>38</sup>Ibid., p. 47.

<sup>39</sup>Air Quality Act, 81 U.S.C., sec. 103-106, (1967).

Amendments passed in December of 1970 however, significantly strengthened the federal government's power to enforce clean air provisions and is characterized more by an emphasis upon compliance to federal standards than voluntary cooperation among states. For example, federal funding was made available for the development and implementation of interstate air quality control regions; each state was required to adopt an air quality plan which was at least as stringent as the national standards for air quality and such state plans would have to meet the approval of the Administrator of the Environmental Protection Agency.

Federal penalties include the fine of up to \$50,000 and imprisonment of up to two years for persons who knowingly violate either state or federal standards. In any case, where a state fails to enforce federal standards, the EPA will upon notice, take over the enforcement process from the state. In the case of motor vehicle fuels the federal law:

Prohibits a State from prescribing or enforcing controls or prohibitions respecting any fuel or additive unless they are identical to those prescribed by the Federal Government or unless a State implementation plan includes provision for fuel or additive control and such plan is approved by the Administrator as being necessary for achievement of national air quality standards. Exempts these restrictions from California. Provides for a civil penalty of \$10,000 per day for violations of the provisions relating to fuels and additives.<sup>40</sup>

While the amendments to the 1967 Clean Air Act clearly indicate that the federal government was willing to assume the burden of dealing with increasingly serious environmental degradation

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<sup>40</sup>Clean Air Amendments, 84 U.S.C., sec. 7(a) (1970).

problems, the consequences of that action were demonstrated in other than wholly environmental areas.

In testimony before a House Sub Committee (Flood Control And Internal Development) a spokesman for the coal industry said that the coal industry was particularly affected by the implementation of the Clean Air Act, because the industry does not yet have the technology to comply with the air quality standards. Consequently, the application of the law has forced some electric utilities and industrial consumers to turn to alternate fuels, usually oil.<sup>41</sup>

#### Implications for Wyoming

Shipping fuel out of Wyoming to eastern market areas has created a great deal of agitation and controversy among people in Wyoming. On the one hand, the Clean Air Act was perhaps the key triggering device which led to the export of tremendous amounts of low sulfur coal to markets outside Wyoming. On the other, provisions of the Clean Air Act also make possible the alternative of building more thermal plants in the West.

In December of 1972, in a report issued by the U.S. Department of the Interior, the department strongly suggested that future power plants be constructed near cities needing more electricity, rather than building them in the Southwest. The most critical factor is developing new air-pollution control equipment, and locating highly

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<sup>41</sup>U.S., Congress, House, Statement of Robert V. Price, Assistant to the President, National Coal Association, Hearings before the Subcommittee on Flood Control and Internal Development of the Committee on Public Works. 92nd Congress, 2nd session, 1972, pp. 879-887.

polluting conventional thermal plants in states such as Wyoming is not necessarily the correct course to take in trying to control air pollution.<sup>42</sup> If the courts uphold Interior's plan then it is probable that an expansion of strip mining activities and transportation facilities would take place in a very short time and the estimated forty power plants scheduled for construction in the region will be greatly reduced in number.

The General Philosophic Implications  
of Socio-environmental Factors

The Economic Costs

Examples of environmental factors upon the development and utilization of fuels are usually oriented toward dealing with the general problem of pollution control. In addition to physical changes in the environment, the economic costs of pollution control are becoming increasingly important factors among the social and environmental influences placed upon energy sources.

One problem concerning pollution focuses upon internalizing the cost of pollution controls within the private corporation. Yet the costs to society for pollution control are highly subjective, even for the present. Projecting such societal costs, especially when one considers that a future rate of discount should also be developed, is indeed a most difficult problem. What value can society place, for example, on controlling or eliminating sulfur

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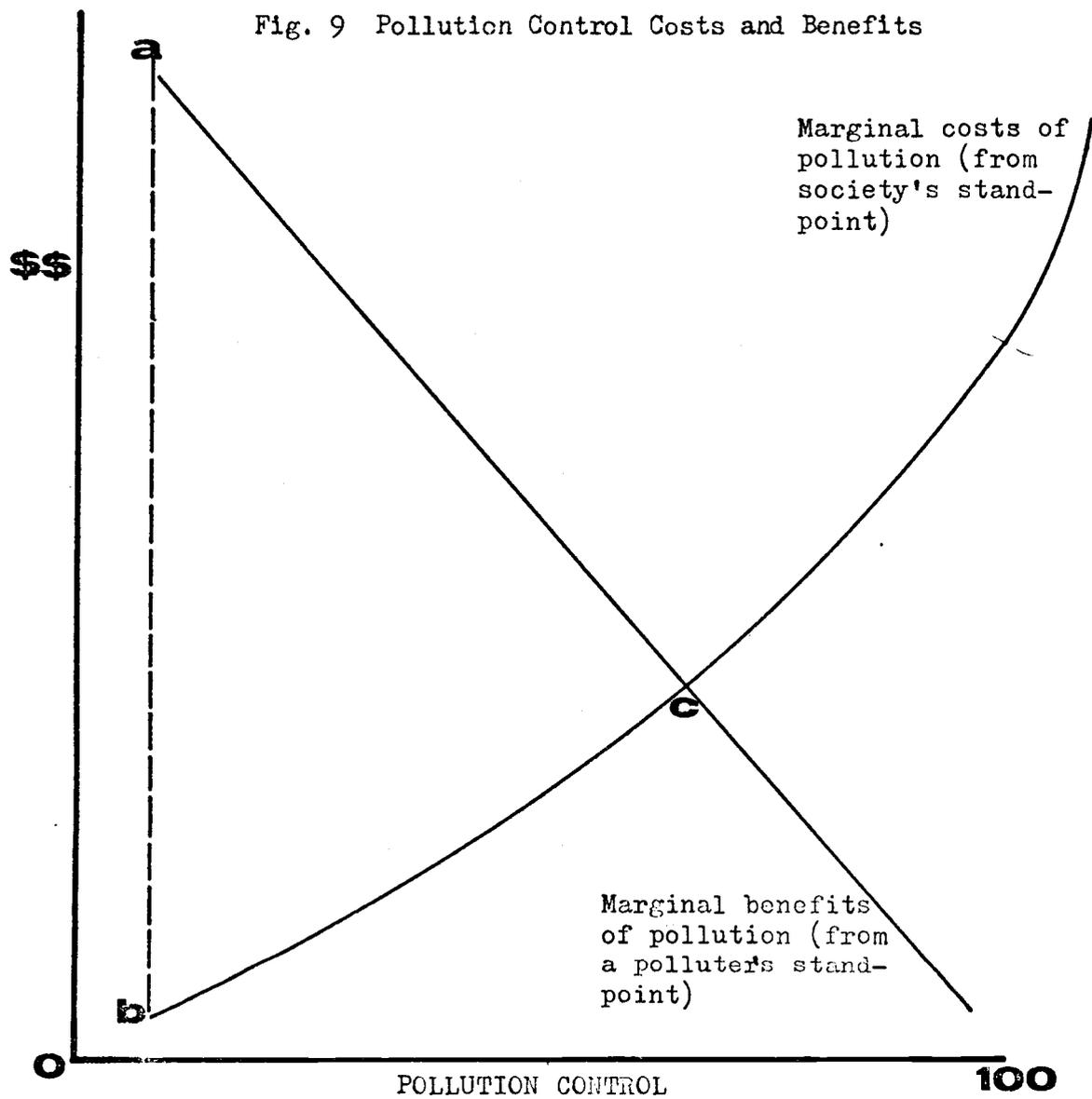
<sup>42</sup>"Moving Coal to Cities Urged", The Denver Post, 19 December 1972, p. 1.

and nitrous oxides from the combustion of fossil fuels in thermal electric plants? It is known that the marginal costs of pollution control will rise dramatically (assuming a given technology) if certain threshold limits are exceeded. For example, it may cost a particular amount of money, perhaps 20 million dollars, to control 98 percent of the particulate materials coming from the smokestack of a thermal electric plant. In order to control the additional 2 percent it may take an additional 20 million dollars, utilizing a given technology. A very simplistic illustration of the dilemma can be sketched as in Figure 9. Dashed line A-B illustrates the disparity between the costs of pollution control from the standpoint of the current society and the declining interest (benefit line) in control on the part of the polluter. Since the marginal costs of pollution control, from society's point of view, increase as the degree of control increases, and the benefits as perceived by the polluter decline, a compromise point (C) may be the best solution. This is especially true with regard to long-term pollution abatement programs which would involve future generations. However, even if a compromise point were agreed upon by both the polluter and society (represented by the government) increased costs would still be incurred and ultimately passed on to society.

#### Decisions in Resource Management

In a sense this discussion also concerns itself with the broader concept of resource practices into which pollution control is included. As Bowden pointed out, those practices can be generally categorized into practices which are: physically possible or not

Fig. 9 Pollution Control Costs and Benefits



physically possible; economically gainful or not economically gainful; socially acceptable or not socially acceptable; legally permissible or not legally permissible. One could modify Bowden's categories into broader ones such as: (1) technology (2) corporate costs (3) societal costs (4) government's response to its constituency. These four categories are interlocking. For example, governmental response to its constituency regarding excessive pollution might be the establishment of an agency such as the Environmental Protection Agency. On the other hand, as Bowden points out, "Decision making, at the individual level, is then greatly dependent upon decisions of group or government levels."<sup>43</sup> Given this reciprocal condition a responsive decision-making apparatus (government) already exists, but with certain serious impediments. At this period in the history of our country we are probably faced with making decisions concerning resource congeries. As Firey observes there are

...two varieties of resource systems...within a set of resource processes. Both are taken as limiting cases. One of them, which we propose to call a resource complex, shows some constancy and stability in the face of changes that are external to itself. The other, ...resource congeries, shows no such stability but varies widely in response to external changes.<sup>44</sup>

It would seem as though the idea of resource congeries is indeed at work in the choice of fuel sources at a national level. In response to external changes in both societal and governmental

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<sup>43</sup> Leonard W. Bowden, Diffusion Of The Decision To Irrigate, University of Chicago Department of Geography Research Paper, no. 97 (Chicago: University of Chicago Press, 1965), p. 3-6.

<sup>44</sup> Walter Firey, Man, Mind, and Land, (Glenco, Illinois: The Free Press, 1960), pp. 36-37.

(responding to its constituency) attitudes concerning air pollution, power companies have turned to relatively low-polluting fuels such as natural gas and low sulfur coal to produce electricity at a time when the demand for energy has reached an all time high. The interesting aspect of the apparent paradoxical situation of increasing energy demand and decreasing choices of fuels to meet that demand is that it hinges upon technology and particularly upon technological assessment.

#### The Philosophic Dilemma

Katz defined technology assessment as a way to optimize the use of technology which can multiply social options. In his view technology assessment can reduce costs and increase benefits through the examination of a variety of options.<sup>45</sup> He suggests that one method of encouraging corporations to incorporate technological assessment into their decision-making process is to internalize those costs and thus the crux of the entire problem of pollution costs and controls is faced. The apparently reciprocal system of decision-making between the individual or private sector of society and the public or governmental sector is relatively unresponsive because:

The externality of the external costs derives neither from the fundamentals of economics nor from the nature of business. It derives from the legal system. If the legal order requires a cost arising from a company's operations to be borne by the

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<sup>45</sup>Milton Katz, "Decision-Making In The Production Of Power", Scientific American, September, 1971, p. 192.

company, the cost is internal. If the legal order requires such a cost to be borne by others, the cost is external. Damage to the environment from pollutants emitted by a power company will be an external and social cost only to the extent provided by the legal system.<sup>46</sup>

Katz goes on to suggest that the legal system can also be used to internalize heretofore external costs through such methods as taxes, damage payments, or subsidies. But, one must still raise a question concerning technology.

Even if the legal system is employed to prod corporations into technological assessment, there would be no particular incentive to develop new technology. Would either corporations or society, for example, be any more willing to pay the increased marginal costs for 100 percent pollution control? If the governmental structure is truly responsive to the desires of its present constituency can it then propose long-term programs which would encourage the development of new technology at greatly increased incremental costs for both present and future societal demands? It appears that the goals of governmental stimulation through technological programs to develop energy production techniques such as coal gasification and liquification or geothermal or solar power production can be attained. However, will the economic costs involved with developing such programs as the fastbreeder reactor or fusion reactors be acceptable to society while oil shale deposits remain untapped in Colorado, Utah, Wyoming and other areas of the West? Do our resource utilization practices follow a continuum over a long-run or are they really point to point, practices such as Fiery's "resource congeries"?

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<sup>46</sup>Ibid., p. 193.

One could end this discussion of the possible roles the fuels of Wyoming may play in the overall energy base of the United States on a very optimistic note by saying that as long as there are fossil fuels in Wyoming, there will be a demand for them. Realistically, however, this may not always be the case, and the conclusion can be a more somber appraisal of our environmental problems by Salter and Van Dyke who say:

...every solution is a new problem, and for the foreseeable future we are going to have to run as fast as we can to balance our budget of problems and solutions. There is the ever present possibility...that we have already passed the point of no return in critical environmental areas. It is difficult for man to perceive exponential processes wherein the acceleration is accelerating. If on the other hand, effective policies and incentives can be devised soon enough to focus technology on these vexing problems, the time scale for finding solutions might also be exponentially foreshortened.<sup>47</sup>

#### Summary

This chapter was organized into three large divisions which serve as an introduction to the kinds of external factors which are later examined in greater detail for each of the five fuels discussed in this study. The first division entitled "External Factors" generally was concerned with governmental activities as they affect each fuel resource. As such it dealt with the scope of governmental activities as they pertain to a particular fuel at both a national and state scale. Additionally, specific governmental actions as they impact on Wyoming fuels were introduced to be further expanded upon in subsequent chapters.

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<sup>47</sup>R.M. Salter and P.T. Van Dyke, The Price Of Fire: The Application Of Modern Technology To The Improvement Of Man's Environment, (Santa Monica, California: The Rand Corporation, 1972), pp. 24-25.

The second large division was entitled: "Other Non-Governmental Externalities," and was further divided into economic and technological factors as well as socio-environmental factors. Those factors were generally confined to the methodology and machinery used to extract and transport the selected fuels. Their impact upon development of the fuel industries, in Wyoming was briefly examined in that section. The socio-environmental division of the chapter introduced the idea of the interface between the governmental, economic and technological and environmental factors. The intent was to introduce the reader to the complexity of a discussion concerned with fuel resource development placed in a realistic setting which included the governmental decisions, the economic conditions, and the technological applications. Environmental concerns of society were portrayed as having an ever-increasing impact upon governmental and economic/technological activities engaged in planning the development and utilization of Wyoming's fuels.

Given that the developmental patterns of fuels on both a national and regional scale are being affected by such socially designed statutes as the Clean Air Act and the Coal Mine Health and Safety Act, an examination of their philosophic implications was also undertaken. Questions concerned with who should pay the costs, what is society dealing with in terms of resource types, and how to solve social-environmental problems within the context of an acceptable lifestyle were raised. Few if any useable answers were provided the reader but it was felt that the questions should be raised before a more detailed examination of individual Wyoming

fuels is undertaken. The interrelationships of the external factors discussed cannot be overemphasized. Individually they are components influencing the development of fuel resources. Collectively they form the mortar binding the fuel development patterns found on Wyoming's landscape.

IV EXTERNAL FACTORS AND THEIR IMPACT UPON THE DEVELOPMENT  
PATTERNS OF THE PETROLEUM INDUSTRY IN WYOMING

Government's Participation in the Petroleum Industry

Prior to the passage of the Leasing Act of February 25, 1920, the right to extract oil and gas from the public domain emanated from the provisions of the Mining Law of May 10, 1872 (17 Stat 91). In the early days it was debated whether oil and gas were minerals subject to location and purchase under the 1872 mining law. However, those doubts were resolved by the Congress in the passage of the Act of February 11, 1897 (29 Stat 526), which authorized the entry and patenting of lands containing petroleum and other mineral oils under the placer mining laws of the United States and validated placer locations for petroleum made prior to February 11, 1897.<sup>1</sup>

The first major change since the Mining Law of 1872 was The Stockraising Homestead Act of December 29, 1916. This act was originally designed to stimulate the development and settlement of the Western U.S. by encouraging agricultural activities and to retain all minerals found on those public lands for the United States. Previously, in July of 1914, certain mineral-bearing lands were allowed to become agricultural land. The Act of 1914 and The Stockraising Homestead Act of 1916 were known as the

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<sup>1</sup>Lewis E. Hoffman, Oil And Gas Leasing On Federal Lands, (Denver: Ray F. Frey Company, 1957), p. 1.

"Separation Acts" and were the first declaration of policy by the Congress of multiple use of lands.

However, the most significant piece of legislation was the Mineral Leasing Act, passed by Congress on 25 February 1920. The purpose of the Act was to

...promote the mining of coal, phosphate, oil, oil shale, gas and sodium by private capital under a permit and leasing system whereby title to the land and unproduced minerals therein would remain in the United States and prospecting and mining would be done under the supervision of the Government, thereby assuring operations under sound conservation principles and the prevention of waste.<sup>2</sup>

Through the years the Mineral Leasing Act of 1920 has been amended over thirty times and greatly broadened in its scope. Presently only those public lands acquired under the Forest Act of 1911 and other acts after 1920 are excluded, along with lands found within incorporated cities, towns and villages. Additionally, lands in national parks and monuments and lands within naval petroleum and oil shale reserves are exempted from the Mineral Leasing Act of 1920. Approximately 34 percent of all land in the United States is now owned by the Federal Government with about 10 percent of that total being under lease to private enterprises exploring for or producing oil or gas. The remaining public lands can be considered as those which constitute additional, albeit potential, oil and gas reserves.<sup>3</sup>

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<sup>2</sup>Ibid., p. 2.

<sup>3</sup>Walter J. Mead, "Federal Public Lands Leasing Policies", Quarterly Of The Colorado School Of Mines, 64 (October 1969): 182 and Lewis E. Hoffman, Oil And Gas Leasing On Federal Lands, (Denver, Ray F. Frey Company, 1957), p. 3.

Recently the issue of compatibility on homesteaded lands has arisen with regard to the multiple use concept. Today agriculturalists own the surface of their lands but not the oil, gas uranium or other subsurface minerals. There are 13 million acres in Wyoming which were patented under the Stockraising and Homestead Act yet those subsurface mineral rights are still held by the federal government. Presently almost 40 million of Wyoming's 62 million acres are under the jurisdiction of the Bureau of Land Management's mineral operations office.

#### Public Land Leasing: Its Practice and Philosophy

By authority of the Mineral Leasing Act of 1920 and the Oil Land Leasing Act of 1920 the federal government entered into the business of leasing lands solely for their mineral contents.

The Oil Land Leasing Act of 1920 clearly states that

...all unappropriated deposits of oil or gas situated within the known geologic structure of a producing oil or gas field and the unentered lands containing the same, not subject to preferential lease, may be leased by the Secretary of the Interior to the highest responsible bidder by competitive bidding under general regulations to qualified applicants in areas not exceeding six hundred and forty acres...<sup>4</sup>

In 1970 an estimated 54.7 percent of Wyoming's land area was under lease for oil and natural gas compared to an overall U.S. average of only 15.1 percent.<sup>5</sup> Additionally, over 2/3 of Wyoming is public land. Under the Stockraising and Homestead Act, public

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<sup>4</sup>Oil Land Leasing Act, 41 Stat. 437 (1921).

<sup>5</sup>American Petroleum Institute, Petroleum Facts & Figures 1971 (Baltimore: Port City Press, 1971), p. 128.

ownership of natural resources was established but the extraction of those resources was given to the private sector of the economy. The federal government's problem became one of trying to accurately establish a market price for those public resources and to determine which buyers should develop the resources. Generally the federal government chooses the following methods of determining both prices and buyers of resources from the public domain: 1. competitive or non-competitive leasing; 2. royalty bidding; 3. bonus bidding; 4. profit sharing.

#### Non-competitive Versus Competitive Leasing Method

Even though competitive bidding for oil and gas leases on public lands has been established by statute, such a procedure will be carried out only in a "known geological structure." Accordingly, all leases not found in known geological structures are issued on a non-competitive basis. As Mead pointed out:

The vast majority of on-shore oil and gas leases are issued non-competitively. In the fiscal year 1967, almost 9 million acres were leased. From 1960 through 1967, oil and gas acreage leased on a competitive basis accounted for less than one percent of the total acreage under lease in 1967.<sup>6</sup>

One technique which is non-competitive in nature is first-come-first-served, which is usually workable where so many leases are granted that their value is very low (in terms of residual value) and the number of interested lessees is therefore small. The other situation, whereby very few leases are made available and the residual values are consequently high because of a great demand, has sometimes led to chaos.

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<sup>6</sup>Mead, op. cit., p. 184.

In order to modify the chaotic conditions found in the first-come-first-served system the federal government has often used the lottery system. Once a month Bureau of Land Management offices hold simultaneous drawings, with the number of offers to lease a tract of land varying anywhere from zero to perhaps more than 2,000. Each person is allowed to make one application and pays a ten dollar application fee. The problems in utilizing such a system are many and the end result can often be a misallocation of resources. Resources are not necessarily allocated to the most efficient users since the winners are determined by chance. From the viewpoint of the public, another problem arises. If the value of the lease exceeds the value of the filing fees on that tract the public can be deprived of a fair value for its resources and the individual who wins the lottery is the sole beneficiary of the system.

Another non-competitive approach in dealing with allocating resources is negotiation between the government and buyers. Using this method there is a great deal of flexibility on the part of both the government and the buyer concerning the terms of the lease. Generally however, the government tries to obtain a minimum level of resource development while the buyer tries to minimize his cost.<sup>7</sup> Although this method has not been widely used in conjunction with developing public resources, the vulnerability of public administrators to "give away" charges is very great. Whenever such officials are involved with attempts to make

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<sup>7</sup>Ibid., p. 185.

optimal resource allocation decisions, questions relating to their integrity are bound to arise. A classic illustration of the pitfalls of this non-competitive method of resource allocation was Teapot Dome.

Competitive bidding greatly aids a government's decision concerning who will get the lease and how much he should pay. Critical elements required for competitive bidding to work are competitors in sufficient numbers to preclude collusion among them and adequate data on the bidders to evaluate the effectiveness of competition for the resources. In a study carried out by Walter S. Mead in Louisiana, it was shown that there was a definite relationship between the number of bidders for a lease and the sale price of the lease. Usually the greater the number of bidders, the higher the price of the lease. As Mead stated "...the number of bids received appears to be an indication not only of degree of competition but also is a reasonably good proxy for the oil industry's estimate of the ultimate productivity of the tract."<sup>8</sup> However, one problem that seems to be rather common in the competitive bidding method of leasing is that, at least in Colorado, less than 1/3 of the leases had three or more bidders. From this situation Mead drew the conclusion that high bids for leases seem to be a function of the number of bidders and that the spread between high and low bids becomes great when the number of bidders increase. These relationships may well indicate that the competitive method of bidding is unreliable when there are few bidders who apparently are uncertain

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<sup>8</sup>Ibid., p. 189.

about the true value of the tract for which they are bidding. This leasing method will be re-examined in more detail in a later portion of this study.

#### Royalty Bidding

When royalty bidding procedures are utilized, potential buyers are requested to frame their bid either in terms of a specific price per unit of the resource (such as barrels or M.C.F.) or some percentage of the value of the resource at a particular point in the production process (such as crude oil, liquified petroleum gasses, or natural gasoline). Normally royalty bidding is limited by a minimum acceptable price and bids may either equal or exceed that stated amount. However, when bidding is based on a royalty and the royalty is high, the resource can be under-utilized. The system is designed so that the buyer agrees to pay for the resource utilized on a unit of production basis even though the cost to society (in terms of environmental impact) may not be related to a unit of production basis. For the oil industry this type of leasing arrangement can seriously hamper efficient resource utilization.

A point must ultimately be reached where costs become relatively high because oil recovery in barrels per day becomes low and marginal revenues no longer exceed marginal costs. Thus the royalty charge takes the form of a marginal cost to the producer but has no real value as far as society is concerned. It can be argued that from the operator's point of view only petroleum which he can pump out at the wellhead has any economic value. Therefore any secondary process which could be undertaken by the operator might be viewed

as a very high and perhaps prohibitive cost.<sup>9</sup>

In an attempt to avert skimming the cream off the lease and therefore leaving large reserves in the ground, a sliding scale of oil royalty rates has been proposed. By this system lower royalty rates would apply as output per day declines during the productive life of an oil field. Hopefully some of the problems of misallocation would be solved along with obtaining a higher share of the profits for the government from highly productive leases. The State of California for example, has adopted the sliding scale of oil royalty rates, but finds that in order to be effective it must be strictly policed. It must be mentioned that under this approach the production rates per well are still under the control of the producer, who could operate in direct conflict with any pro-ration plan designed to maintain a desired price of domestic crude oil. One significant advantage that royalty bidding has over the method known as bonus bidding is that only a minimal amount of capital is required for entry into the lease. A reduction of entry barriers can make for a more competitive and therefore truer value situation. Additionally, in contrast to bonus bidding, royalty bidding is advantageous for the producer in that royalty payments are only paid on tracts where oil fields are discovered and production actually occurs.

#### Bonus Bidding

This approach to leasing public lands requires that the buyer submit a lump sum bid on all the resources found in a particular

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<sup>9</sup>Ibid., p. 204.

tract of public land. The bonus payment, in effect, becomes a fixed cost after it is paid as far as the operator is concerned. Since the payment is not dependent upon output and the operator in theory owns all the resources in the lease tract, he is free to develop the most efficient methods possible of extracting the resources. However, problems characterizing this method of bidding arise almost immediately. The price of the bonus can be very high, depending on the suspected production potential of the tract. This situation encourages joint corporate bidding for such high risk ventures. Bonus payments can and have gone very high and could act as significant barriers to entry for smaller operators.

#### Profit Sharing

When a lease area has a very high degree of uncertainty concerning the presence of oil or gas resources, a relatively rare system of bidding, profit sharing, is employed. Profit sharing bidding requires that a potential buyer bids the percentage of net profits which he, the buyer, would pay to the landowner for the privilege of utilizing his resources. Because the payments are based only upon a percentage of profitability, they will not increase in proportion to the rate of production. Therefore the buyer's marginal unit of production is not affected by lease payments and the buyer may exploit the resource in a more efficient manner than if he were operating on a royalty basis.

Two basic problems arising from the profit sharing method of lease bidding involve efficiency of resource allocation and the conflict

between the seller (government) and the buyer/operator. One problem which develops when the profit share paid to the landlord is high is that there is a tendency on the part of the oil producer to re-invest only a small portion of his excess profits in the oil producing operation. Thus the economic efficiency incentives are often quite low. However, when the operators' main interests are profits from refining, or increased import quota "tickets" he tends to maximize crude oil production regardless of recovery efficiency.

Another problem rises when the landlord (the government) interferes with the management techniques employed by the operator. Because payments to the landlord are a function of profits the operator often has a tendency to increase his overhead and operating costs, at least on paper. In response, in order to protect his interests, the landlord may want to carefully supervise the management practices of the operator.

Some of the more obvious advantages of the system are that the landlord, the government, is protected from seeing great windfall profits accrue to the operator who has taken very little risk. The buyer/operator is protected in that, unlike a bonus bidding system, no payments are made when there is no net profit derived from the lease. Barriers to entry on the part of potential operators bidding on the tracts are also lower via profit sharing than by bonus bidding and payments to the landlord are not required until after a profit has been obtained from the operation.

### Summary

The preceding discussion was intended to serve the purpose of introducing the reader to the types of federal public lands leasing policies which are most commonly used today. The leasing systems are not limited to petroleum but apply to most mineral leases on public land. No attempt has been made to argue strongly for the adoption of one leasing method over another, but based upon the work Mead has done some general comments can be made. It seems that the public interest is best served when, as nearly as possible, a competitive bidding situation exists. This might suggest that the large oil companies in particular be discouraged from using joint bidding in attempting to obtain a lease on public land. In order to insure a competitive situation all firms who could bid separately should be required to do so. Exactly what number of bidders is required to insure an adequate level of competition is not readily determinable but certainly it would exceed the two bidder situation which is so often encountered. A later discussion concerning coal leasing will re-examine these points.

As Mead intimates, a royalty bidding system with a fixed royalty payment until production declines, might be the best method of leasing in the Rocky Mountain area. When productivity of a well or coal field reaches a point where marginal costs including royalty payments start to exceed marginal revenues then perhaps the royalty payments should automatically fall to zero. The purpose of this economic "trigger" would be to encourage efficient utilization of the petroleum resources which could be foregone if the marginal

costs are too great. At this point in time the most important considerations concerning petroleum resources on public lands should be efficient allocation and utilization. Therefore the minimization of resource misallocation should really be the criteria upon which to judge the public lands leasing policies of the federal government.

#### Quotas - Their Development and Impact

In 1946 foreign crude made up about 5 percent of the total crude oil supply used by firms in the United States; by 1958 the percentage had risen to more than 12. During the same period imports of refined fuel oils grew from three to over seven percent. Part of the explanation of why imports continued to grow is related to certain governmental decisions which affected domestic crude oil prices.

During the immediate post war period it was felt by many state regulatory agencies that stripper well<sup>10</sup> operators and other marginal operators should be encouraged to stay in business in order to stimulate new drilling activity. Then, as now, drilling costs were increasing steadily and it was hoped that, by maintaining large numbers of operators, new domestic activity in oil exploration and development could be generated. What actually occurred was an ever widening disparity between the prices of domestically produced crude and easily obtainable foreign crude oils. The growing price differential plus the practice of placing prorationing restrictions

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<sup>10</sup>A nearly depleted well whose income barely exceeds operating cost of production.

on some non-stripper wells tended to encourage some of the larger petroleum companies to depend to an ever increasing degree upon their own cheaper sources of crude outside the United States. The practice created increased pressures on prices of domestic refined products and led, as some think, to a rift in the petroleum industry between those who wanted more imported crude and those who opposed a growing reliance upon foreign sources.

Imports were symptomatic of a basic change in the supply structure of the domestic industry. In total, American petroleum firms changed their status from net exporters to net importers of petroleum. In order to cope with what was then viewed as a strategic overreliance on imported crude oil, the federal government proposed a program of voluntary controls on imports during a three year period from 1955 through 1958. The program failed. In March of 1959 President Eisenhower imposed a system of mandatory controls administered by the Interior Department. Under the regulations adopted, imports into the United States (except the West Coast) were limited to 9 percent of the Bureau of Mines estimate of the domestic demand for petroleum products, excluding residual fuel oils. Import quotas based upon prior estimates of demand were given to the oil companies in May and December of 1959 and at six month intervals.<sup>11</sup>

That the import quota system was established with an eye toward national security considerations seems clear. In the statement

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<sup>11</sup>Harold F. Williamson et al., The American Petroleum Industry, (Evanston: Northwestern University Press, 1963), p. 818.

accompanying the Proclamation exempting overland imports, President Eisenhower alluded to a hemispheric concept of petroleum supplies. A portion of the Proclamation was reported thusly:

In proclaiming mandatory oil controls on March 10, the President pointed out our joint defense interests with Canada and other Western Hemisphere countries within the larger sphere of free world security. In recognition of this fact, conversations will continue with Venezuela and other Western Hemisphere countries looking toward a coordinated approach to the oil problem as it relates to defense and to the interests of all producer countries.<sup>12</sup>

The oil import quota program remained essentially intact with a few minor exceptions until the spring of 1973 when President Nixon eliminated oil import quotas in an effort to ease a fuel shortage situation. Under the new system oil importers could bring in oil up to the maximum allowable amount in the 1959 act, but no tariffs would have to be paid. According to Nixon's plan the tariff-free imports would be gradually eliminated over a seven year period and replaced with a fee system. In order to encourage the construction of new refineries in the United States, they would receive a partial exemption from the fees. In addition to a dismantlement of the 14 year old quota system President Nixon asked Congress to deregulate price controls on new natural gas supplies by the Federal Power Commission.<sup>13</sup>

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<sup>12</sup>Wallace E. Lovejoy, "Oil Import Policies As They Relate To National Security", Quarterly Of The Colorado School Of Mines 64 (October, 1969): pp. 165-6.

<sup>13</sup>The Denver Post, 12 April 1973, p. 15.

### Depletion Allowances

Two types of federal tax provisions are of particular usefulness to producers of petroleum and natural gas. One is known as the intangible writeoff and the other is the much more widely known depletion allowance. Intangible writeoff provisions allow the operators to deduct as expenses such intangible costs as drilling and development costs or allow the option of capitalizing such costs and then recovering them through depreciation deductions. "Intangible expenses are generally understood within the industry to be expenditures for items not having salvage value. The intangible writeoff is available for all operators, whether a small independent operator or large integrated oil company."<sup>14</sup>

The other federal tax provision, the depletion allowance, began in 1926. It has allowed producers of oil and gas to receive equitable treatment in relation to other mineral industries by permitting them to deduct an allowance for the depletion of the resource. The rate of depletion allowance changed from  $27\frac{1}{2}$  percent to 22 percent in 1970. The allowance is calculated upon one of two bases. One method allows cost depletion, which assures tax free return of the original capital investment in property by amortizing part of that cost each year in proportion to the year's production. Another method allows the operator to deduct for each property whichever is the lesser: 22 percent of the property's gross income or 50 percent of the net income from the property,

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<sup>14</sup>U.S. Department of the Interior, U.S. Bureau Of Mines, Bulletin 650, Mineral Facts and Problems, 1970, (Washington, D.C.: Government Printing Office, 1970), p. 165.

computed without any allowance for depletion. The theoretical basis for the depletion allowance was to create an incentive for the exploration and discovery of new petroleum and natural gas reserves.<sup>15</sup>

#### State Government's Control of Petroleum Development

At the state level of government various programs have been adopted to monitor the exploitation of petroleum resources and to insure both reasonable development patterns and income flows from such development. That the state government of Wyoming has long been mindful of controlling its own<sup>16</sup> fuel resources was clearly indicated as early as August of 1951 when the Wyoming Oil and Gas Conservation Commission was established. Through the years the Commission had functioned within the guidelines of its original set of rules and regulations until 1971 when some of the Commission's powers were expanded. Recently the Commission has exercised enough power to restrict petroleum production for any reason in order to promote conservation measures. Some of the Commission's powers to limit or even curtail production proved to be so odious to the INEXCO Oil Company, that the company filed suit in District Court in an attempt to overturn the production restriction powers granted to the Commission by the 41st Session of the Wyoming Legislature in 1971.<sup>17</sup>

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<sup>15</sup>Ibid.

<sup>16</sup>The state of Wyoming itself also retains ownership of sections 16 and 36 from each surveyed township.

<sup>17</sup>John Edward Norman, "The Wyoming Petroleum Landman: A Comparative Study Examining Members Of The Wyoming Association Of Petroleum Landmen And Comparing Them To Another Study Made Of Members Of The American Association Of Petroleum Landmen": (M.B.A. Thesis, University of Denver, 1972), p. 83.

The District Court ruled against INEXCO whereupon the company appealed to the Supreme Court of Wyoming. The Supreme Court upheld the District Court's ruling and judged that the Commission could and should restrict the company's production rates because it was wastefully flaring natural gas at its Hilight Jayson petroleum field.<sup>18</sup>

The 42nd Wyoming Legislature (1974), perhaps spurred by the successful defense of state control of its resources, passed legislation creating a 3 percent excise tax on certain mineral resources. Included under the provisions of the bill were petroleum, natural gas, coal, trona and oil shale. The bill was tied to a constitutional amendment which was presented to the electorate during the 1974 general election. The constitutional amendment provided for a  $1\frac{1}{2}$  percent mineral excise tax which would be used to establish a permanent mineral trust fund for Wyoming. The amendment was passed by over a two to one margin. Under provisions of the amendment the legislature can now loan money in the Permanent Wyoming Mineral Trust Fund to political subdivisions of the state. Exemptions to the tax would be stripper oil wells with average daily production of less than ten barrels. However, such wells are still taxed a 1 percent severance tax.<sup>19</sup>

#### The Interface of Federal and State Governmental Controls

At the Federal level of government, numerous controls, regulations and statutes have been enacted which have had either a direct

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<sup>18</sup>Pacific Reporter, vol. 490 par. 2d.

<sup>19</sup>The Denver Post, 12 February 1974, p. 13.

or indirect influence upon fuel resources, and especially the petroleum resources of Wyoming. At a minimum, eight federal agencies<sup>20</sup> are directly involved in the petroleum industry and range from the Interstate Commerce Commission's regulation of oil pipelines to the Office of the President's enforcement of the Connally Hot Oil Act.<sup>21</sup> Generally speaking, federal statutes deal with either the leasing of public lands for petroleum development or the regulation of petroleum's transportation. However, one federal office, the Environmental Protection Agency, is particularly involved with the environmental aspects of the petroleum industry.

The express purpose of the Environmental Protection Agency was to control and prevent pollution on a systematic basis:

Reorganization Plan 3 of 1970 transferred to EPA a variety of research, monitoring, standard-setting and enforcement activities related to pollution abatement and control which, when properly integrated, will provide for the treatment of the environment as a single interrelated system. Complementary to these activities is the Agency's coordination and support of research and antipollution activities carried out by State and local governments, private and public groups, individuals, and educational institutions. EPA will also reinforce efforts among other Federal agencies with respect to the impact of their operations on the environment.<sup>22</sup>

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<sup>20</sup>Interstate Commerce Commission (pipelines); Federal Power Commission (gas prices and pipelines); Environmental Protection Agency; Department of the Interior, Office of Oil and Gas; Bureau of Land Management (leasing); Bureau of Mines (Oil Shale fuels); Office of the President; Bureau of Indian Affairs (Leases and subsurface storage).

<sup>21</sup>Public Law No. 14 74th Congress 22 February 1935. An act which authorized the federal government (Department of the Interior) to formulate and enforce measures which would restrict the importation and interstate shipment of "hot" or contraband oil.

<sup>22</sup>U.S., Congress, House, Compilation Of Federal Laws Relating To Fuel And Energy Resources, Prepared for use of the Committee On Interior And Insular Affairs, 92nd Cong., 2nd sess., 1972.

Paragraph 1857h Definitions in the General Provisions of Chapter 15B 42 U.S. Code states:

All language referring to effects on welfare includes, but is not limited to, effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being.<sup>23</sup>

There is no comprehensive national energy policy at this time and the provisions of the National Environmental Policy Act are very broad-based. Therefore, EPA is often looked at as a possible coordinating agency concerned with the environmental consequences of developing fuel resources, even if those resources fall under the responsibility of another federal agency.

The establishment of the Federal Energy Office<sup>24</sup> in April of 1973 (Executive Order 11712) has changed the presence of the federal government in the petroleum industry greatly. With the creation of this office the Executive Branch of the federal government has not only assumed a greater role in determining environmental standards concerning the utilization of petroleum fuels, but the FEO has had a profound impact upon the day-to-day activities of the industry as well. This is particularly evident in the open ended powers granted in sections 3C-1 and 3C-6 of the Executive Order respectively. Section 3C-1 calls for the Director of the Federal Energy Office to "assure the development of comprehensive plans and programs to insure

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<sup>23</sup>Ibid., p. 482.

<sup>24</sup>Later changed to the Federal Energy Agency in August 1974. P.L. 93-275.

the availability of adequate and dependable supplies of energy." Additionally the Director is supposed to view the FEO as "...a clearing house for the prompt consideration of energy problems brought to his attention by Federal departments and agencies and by other public and private entities, organizations, agencies or individuals..." (Executive Order 11712). With its power to dictate refinery runs, set wholesale prices and to allocate supplies, the FEO has emerged as perhaps the single most influential and effective branch of government at the federal level involved with the petroleum industry. Though nominally operating at a national level the FEO has had a significant impact upon state petroleum facilities as well. As of this writing it is still exceedingly difficult to discern how profound the effects of the FEO's guidance and regulations have been upon Wyoming's petroleum industry.

### Economic Impacts on the Petroleum Industry

#### Technology Assessment

The current domestic petroleum industry is light years away, in terms of technology, from 19th century conditions when the prime use for petroleum was illumination. Methods of exploration and drilling for petroleum have been characterized as being more evolutionary than revolutionary. Equipment and techniques have aided prospecting methods largely through the implementation of remote seismic sensing equipment, automatic data processing, and advances in marine seismic technology. Major advancements in drilling technology have included more portable drilling rigs, new drill bits, drilling fluids and applied automation systems.

Various elements of technology have been developed to such an extent that the total volume of new oil found for each new wildcat field has remained relatively constant even though geologic opportunities have been reduced in many areas of the United States.<sup>25</sup>

More important perhaps than the mere availability of technology is how it is applied. For example, advances in transportation technology have had a powerful and reciprocal effect upon not only the petroleum industry, but upon the entire spectrum of American society.

#### Transportation and Regional Demand Characteristics

Most crude petroleum and petroleum products are transported by pipeline in the United States. In 1968 almost half of all<sup>26</sup> movement (46.5 percent) was via pipeline with an additional 28 percent moved by truck.<sup>27</sup> Thus the primary thrust of a discussion concerning petroleum movement should focus upon the pipelines. Wyoming crude oil moves to locations as far away as eastern Ohio and to places as near as Montana, Colorado and Utah. The amount is substantial as judged from the more than 117 million barrels of crude oil which were shipped from Wyoming to other states in 1968. Fully 65 percent of the interstate movement of Wyoming crude oil was by pipeline which compares favorably with a 70 percent

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<sup>25</sup>Ibid., p. 151.

<sup>26</sup>Intrastate and interstate movement.

<sup>27</sup>American Petroleum Institute, Petroleum Facts & Figures 1971 (Baltimore: Port City Press, 1971), p. 272.

rate for this mode of transportation on a national scale.<sup>28</sup>

Representative costs in 1969 for crude from Wyoming to Chicago refineries averaged 33¢ per barrel as compared to an average of only 28¢ per barrel moved from west Texas to Chicago. It should be noted that pipeline costs are significantly lower (1.7 - 6.0 mills per ton mile) than either railroad tank car (20 to 70 mills per ton mile) or tank trucks (30 to 50 mills per ton mile.<sup>29</sup>)<sup>30</sup> The transportation cost conditions by mode have probably not changed appreciably in terms of their relative disparities. These costs reflect a long standing characteristic of Wyoming crude oil, namely its remoteness from large market areas like Chicago, although regional markets such as Denver are being supplied by at least two eight inch product pipelines (from refineries in Sinclair and Casper) and one eight inch crude line from western Niobrara County.

#### Non-local Markets

From its earliest beginnings the petroleum industry of Wyoming was oriented toward external and generally non-regional markets as evidenced by the early development of petroleum pipelines to the midwest. The Platte Pipeline, for example, is a sixteen to twenty inch line extending from Worland, Wyoming to Wood River, Illinois

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<sup>28</sup>Ibid., p. 275.

<sup>29</sup>One ton of crude is approximately equal to 6.7 barrels.

<sup>30</sup>Mineral Facts and Problems, 1970, op. cit., p. 166.

and was completed in the early 1950's. Far from being unique, it had been preceded by Standard of Indiana's Stanolind Pipeline completed in the 1920's, which tied the Salt Creek Field to a refinery at Sugar Creek, Missouri and another Standard refinery at Whiting, Indiana.<sup>31</sup> In 1941 approximately 78,000 barrels of petroleum per day were moving out of Wyoming via pipeline, and just nine years later that had been increased to almost 100,000 barrels per day. That Wyoming still exports most of its petroleum outside its immediate boundaries is indicated by the fact that of the 148.1 million barrels produced in 1971 only 16.1 million were consumed within the state. Refinery capacity during that same year (1971) had increased about 23 percent compared to 1968.<sup>32</sup> These data are mentioned because an apparent shift away from wholly extra-regional markets for Wyoming crude might be beginning. Population growth has been substantial in the Rocky Mountain region during the 1960-70 period (being 21 percent overall). During the 1950-60, 1960-70 census intervals, increased refinery capacities averaged 3522 barrels per day 1960-70 as compared to 1525 bbl/day 1950-60.

During the same period (1950-70) petroleum requirements within the Rocky Mountain region seem to be changing, while a reciprocal

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<sup>31</sup> Arthur M. Johnson, The Development of American Petroleum Pipelines: A Study In Private Enterprise And Public Policy, 1862-1906, (Ithaca: Cornell University Press, 1956), p. 134.

<sup>32</sup> U.S. Department of the Interior, United States Energy Fact Sheets 1971 (Washington, D.C.: U.S. Government Printing Office, 1973), pp. 104-5.

shift in petroleum demand has also taken place on a national scale. In 1971 almost 42 percent of all energy consumed in the United States came from petroleum sources. That same year the Rocky Mountain region received  $35\frac{1}{2}$  percent of its total energy needs from petroleum.<sup>33</sup> These aforementioned data tabulations must also be viewed in the light of increased population growth and its corresponding increases in demand both in the Rocky Mountain Region and in the United States. In the case of Wyoming the state's total population of around 340,000 (in 1971) is not likely to increase very much. This assumption is based on Wyoming's demographic pyramid which has lately been characterized by a sizeable reduction in the number of children. Between the 1960 and 1970 census periods the percentage of children from zero to five years old has declined by almost 41 percent.<sup>34</sup>

#### Regional Petroleum Supply Characteristics

Generally speaking, refineries are market-oriented and are therefore found in both greater numbers and greater capacities on the three U.S. coasts and Midwest. Since technological improvements have increased the efficiency levels of refining and transportation (especially pipelines), there has been a greater pull toward the market areas rather than an orientation toward the producing areas. Consequently, refineries located inland, as in the Rocky Mountain

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<sup>33</sup>Ibid., p. 138.

<sup>34</sup>U.S. Department of Commerce, Bureau of the Census, 1970 General Population Characteristics: Wyoming (Washington, D.C.: U.S. Government Printing Office, 1971), pp. 52-55.

region, are generally smaller, older, and less efficient facilities. The gasoline shortage during the summer of 1973, which was particularly acute in the Rocky Mountain region, was due, in part, to application of transportation technology to economic organization in the petroleum industry. This has meant that the distribution system, with particular emphasis upon pipelines, has been focused out of the region and upon large consuming areas such as the Midwest.

This orientation has been reinforced by long-term contracts which call for states like Wyoming to supply crude oil to markets located east of the producing fields. Contractual arrangements coupled with a distribution system within the Rocky Mountain region which is relatively fixed in its capacity has led major petroleum suppliers to allocate the region petroleum products based upon yearly estimates of the demand. The system worked well until an underestimated variable, an overall increase of population in the region, exceeded predictions. With greater demand for gasoline across the United States spurred by new high gas-consuming autos, good summer weather, and vacationers, all the fuel requirements could not be met. Since the Rocky Mountain region had traditionally been a dumping ground for excess petroleum products (and especially gasoline) a significant portion of the product distribution system was composed of independent petroleum dealers.

When the gasoline shortage became evident in the early summer of 1973, the Rocky Mountain region and the populous Front Range corridor in particular, was hard hit because the independent petroleum distributors were denied their usual quotas from the major petroleum

companies. The situation was one of extreme scarcity in the rather small portion of the Rocky Mountain region which is most heavily populated and the one area where the greatest increment of "unplanned" demand had taken place. It is not too improbable to postulate that perhaps the gasoline shortage along the Front Range has its ultimate roots in the efficiency levels attained by refineries in producing high octane gasoline during World War II.

#### Petroleum Technology's Impact at a National Scale

Technology has made it possible to produce more gasoline in greater amounts at greater levels of efficiency, which in turn, has stimulated demand for gasoline by ever increasing numbers of automobile operators. Technology has also allowed the great number of autos found in urban areas to be fed by a rather sophisticated distributional system of pipelines supplying both crude and products to the demand centers. Concomitantly, technology has also been responsible for alleviating some of the deleterious effects of so much petroleum being burned so inefficiently by so many vehicles. Yet, technology is also the reason why ever greater amounts of petroleum are being consumed just as inefficiently by even more vehicles. In an effort to comply with clean air standards, pollution control devices of increasing complexity have been placed on vehicles manufactured and imported into the United States.

The result has been a reduction in certain types of air pollutants and a rather significant increase in the consumption (demand) of petroleum products. The paradoxical situation simply stated is that we must burn more petroleum products in order to

control the amount of pollution caused by their combustion. However, the problem is never solved because more vehicles are produced each year in response to demands for forms of transportation which in most cases cannot be met in any other way. The combustion efficiencies of the engines utilized to burn petroleum are not being improved and indeed some engineers believe that technology cannot economically solve the problem in a reasonably short time.

Much emphasis has been placed upon the transportation sector because almost one quarter of all energy used in the United States in 1970 was consumed by transportation. Of that amount over 55 percent was used by automobiles. Obviously much can be done to improve energy efficiencies and particularly in the area of transportation. An examination of Tables 7 and 8 indicates how the transportation sector of petroleum consumers utilizes petroleum and the levels of efficiency which are obtained. It is also obvious that as population increases a greater demand for energy is almost certain to occur unless bicycles and walking become infinitely more popular forms of transportation than they are today. However, this alternative is not likely to develop because of the impact that energy and specifically petroleum, has had on social organization. It is to the application of technology to social organization that this discussion will now turn

#### Petroleum Technology and the Impact of Environmental Considerations

It is clearly evident that although the transportation sector may be the largest consumer of petroleum, the range of petroleum

TABLE 7. DISTRIBUTION OF ENERGY WITHIN THE TRANSPORTATION SECTOR

	Total energy (percent)		
	1950	1960	1970
<b>Automobiles:</b>			
Urban	20.1	25.1	28.9
Intercity	<u>21.3</u>	<u>27.6</u>	<u>26.4</u>
Total	<u>41.4</u>	<u>52.8</u>	<u>55.3</u>
<b>Trucks:</b>			
Intercity freight	4.6	6.1	5.8
Other uses	<u>11.9</u>	<u>13.8</u>	<u>15.3</u>
Total	<u>16.5</u>	<u>19.9</u>	<u>21.1</u>
<b>Aircraft:</b>			
Freight	.1	.3	.8
Passenger	<u>1.1</u>	<u>3.0</u>	<u>6.7</u>
Total	<u>1.2</u>	<u>3.3</u>	<u>7.5</u>
<b>Railroads:<sup>1</sup></b>			
Freight	25.8	3.7	3.2
Passenger	<u>3.1</u>	<u>.3</u>	<u>.1</u>
Total	<u>28.9</u>	<u>4.0</u>	<u>3.3</u>
<b>Buses:</b>			
Urban	.3	.2	.2
Intercity	<u>.6</u>	<u>.5</u>	<u>.3</u>
Total	<u>.9</u>	<u>.7</u>	<u>.5</u>
Waterways, freight	1.0	1.1	1.0
Pipelines	.7	.9	1.2
Other <sup>2</sup>	<u>9.4</u>	<u>17.4</u>	<u>10.2</u>
Total	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
Total transportation energy consumption (trillion B.t.u.)	<u>8,720</u>	<u>10,880</u>	<u>16,500</u>
Transportation as a percent of total U.S. energy consumption	<u>25.7</u>	<u>24.4</u>	<u>24.5</u>

<sup>1</sup>Energy efficiency of railroads increased dramatically between 1950 and 1960 because of the shift to diesel engines. Hence the values given here for 1950 are based on 3,600 B.t.u. per ton-mile and 8,900 B.t.u. per passenger-mile.

<sup>2</sup>Includes boat passenger traffic, general aviation, pleasure boating, and nonbus urban transport, as well as the effects of historical changes in modal energy efficiencies.

Source: U.S., Congress, House, Hearings Before The Committee on Science and Astronautics, Energy Research & Development. 92nd Cong., 2nd sess., 1972, pp. 508-509.

TABLE 8 ENERGY REQUIREMENTS FOR FREIGHT TRANSPORT

	<u>B.t.u. per ton-mile</u>
Pipeline	450
Waterway	540
Railroad	680
Truck	2,300
Airplane	37,000

## ENERGY REQUIREMENTS FOR PASSENGER TRANSPORT

	<u>B.t.u. per passenger mile</u>
Bicycles	200
Walking	300
Buses	1,200
Railroads	1,700
Automobiles	4,500
Airplanes	9,700

Source: U.S., Congress, House, Hearings Before The Committee on Science and Astronautics, Energy Research & Development. 92nd Cong., 2nd sess., 1972, pp. 508-509.

products utilized by Americans is great. It is difficult to think of the United States functioning without many of the chemicals and chemical products derived from crude oil and natural gas. It is also difficult to imagine the impact a significant decrease in petroleum supply may have upon the standard of living to which Americans have grown accustomed. In short, petroleum as a resource, has so permeated American society that a lack of petroleum or restrictions placed upon its use would very likely have profound societal effects.

Indeed, demand for petroleum has been increasing so rapidly that supply cannot keep pace unless imported petroleum is calculated into the requirements. For example, a conservative estimate of imported petroleum ranges from almost 14 to over 16 million barrels per day in 1985.<sup>35</sup> Even ignoring the adverse effects such imported oil could have upon national security, the problem of petroleum supply would still be serious in other more social-oriented areas. The interdependence of elements in the fuel supply problem may well find their nexus in the area of environmental protection.

#### Electric Power Production

In addition to transportation, the production of electrical energy from petroleum deserves special attention since it is a source of environmental as well as energy problems. Electrical generation is expected to consume a growing portion of national

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<sup>35</sup>Executive Office Of The President, The Potential For Energy Conservation: A Staff Study (Washington, D.C.: Office of Emergency Preparedness, 1972), p.iii.

energy requirements in the future. By the year 2000 it is estimated that about one half of all fossil fuels (with 10 percent constituted by oil and gas) will be used for the generation of electricity. However, in 1970 gas and oil were even then accounting for 36 percent of electric generation, largely because of their low sulfur content relative to coal.<sup>36</sup> Pollution control regulations on both federal and state levels are likely to result in an increase in the demand for environmentally clean fuels and the additional use of energy. As an example, it is estimated that because of air quality legislation such as the Clean Air Act, as much as 1 billion additional barrels of low sulfur oil might have to be imported for use in the generation of electricity by 1975.<sup>37</sup> It now seems apparent that the interplay of power production and environmental quality standards will be of considerable consequence in the future. This of course assumes as Holcomb notes that, "...it[is] generally agreed that our society would demand the power, that it would be produced, and that changes in the technology of power production and waste disposal would be made in attempts to control pollution."<sup>38</sup>

#### Environmental-Energy Trade-offs

An additional element which should be considered in an examination of energy demand and environmental protection measures is the

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<sup>36</sup>Deane N. Morris, Future Energy Demand And Its Effect On The Environment (Santa Monica: The Rand Corporation, 1972), p. 26.

<sup>37</sup>The Potential For Energy Conservation, op. cit., p. 37.

<sup>38</sup>Robert W. Holcomb, "Power Generation: The Next 30 Years", Science, January 1970, p. 159.

energy which must be utilized to restore, maintain or improve the environment. For example "...the energy required for removal of fly ash and particulates from the stack gases of a typical 800 megawatt power plant amounts to 0.1 to 0.2 percent for a precipitator, 1 percent for a baghouse, and 2 to 3 percent for a wet scrubber."<sup>39</sup> To date very little work has been done on determinations of how much additional energy is required, as opposed to the amount of energy saved, by employing environmental improvement techniques such as recycling energy intensive products.

At a time when energy demands are increasing and the choices of fuels which are environmentally acceptable are decreasing petroleum is assuming the role of a "swing" fuel. That swing characteristic is aptly pointed out in the testimony of W.D. Crawford, President of the Edison Electric Institute. Appearing before the Committee On Interior and Insular Affairs, Mr. Crawford stated that while coal's share of the electric generation market has steadily decreased, natural gas and fuel oil consumption has grown to capture 44 percent of the market. The growth or substitution of oil and natural gas has been due in large measure to the environmental protection laws. Regarding the electric industry's use of natural gas, Mr. Crawford said, "Gas is important to our industry not only because of the substantial quantities we utilize but also because it is the cleanest type of fossil fuel available and in some instances is the only possible means of meeting air

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<sup>39</sup>Morris, op. cit., p. 23.

quality standards."<sup>40</sup> Crawford also cautioned that if the quantity of natural gas used by the electric industry is substantially reduced, power output by the generating plants would have to be reduced. Additionally, the substitution of other fuels is not presently utilized.

#### The Costs

Given the problem of fuel substitution in an effort to achieve the air quality standards required by society, the economic costs involved with meeting those standards should be considered. Environmental control expenditures will lead to increased electrical generating costs. It is estimated that "...in the course of the next several decades, electricity prices (in 1968 dollars) will increase by at least 50 percent, while fossil fuel prices may increase 100 percent or more."<sup>41</sup> Even if certain technological improvements such as higher transmission and distribution voltages are made, other elements may intervene which can offset the improvements. For example, rising interest rates, increased construction costs and unforeseen social costs (such as public relations activities) may drive electrical power costs even higher. Table 9 indicates in a general way how environmental control devices are expected to affect the cost of electrical power production.

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<sup>40</sup>U.S., Congress, House, Hearings Before The Committee On Interior And Insular Affairs, Fuel And Energy Resources. 92nd Cong., 2nd sess., 1972, p. 342.

<sup>41</sup>Morris, op. cit., p. 33.

TABLE 9 SUMMARY OF TOTAL INCREASES IN ELECTRIC POWER COSTS  
 REFLECTING ENVIRONMENTAL CONTROL EXPENDITURES<sup>a</sup>  
 (In 1970 mills/kWh)

Environmental Control [sic]	1980	1990	2000
Generation	1.009	1.668	2.008
Transmission	0.500	0.500	0.520
Distribution	0.670	0.680	0.680
Rights-of-way and all other	0.591	0.758	0.848
Total (rounded)	2.800	3.600	4.100

<sup>a</sup>Where appropriate, the estimates represent weighted averages reflecting the assumed mix of nuclear and fossil-fueled plants.

Source: Morris, pg. 33.

In 1970 investments totaling some \$9.3 billion for all U.S. industries were made in pollution control devices and the amount is expected to double by 1975 to almost \$19 billion. In terms of percentage of annual capital expenditures, iron and steel corporations have averaged as much as 10 percent for pollution control systems. Because those companies recognize that their fuel costs are very significant with respect to total profits, their pollution control systems are generally efficient and installed early. Fuel costs are also significant for electric utilities but they have noticeably lower capital expenditures for pollution control systems, about 4 percent. The low percentage of expenditures for pollution control comes from the transportation sector of the economy which expends only 2.6 percent of its earnings.<sup>42</sup>

<sup>42</sup>The Potential For Energy Conservation, op. cit., p. 38.

Both capital investment and institutional policies, such as environmental protection, take a considerable time to implement on either a national or a regional basis. However, a question of institutional perception has considerably slowed down the process. While electric power producers have been acknowledged as public utilities under the control of public agencies, part of the transportation sector has been exempted from public control. Some carriers such as airlines, interstate trucking companies and railroads are regulated, as are utilities, but the private automobile, which is the greatest mover of people in the nation, is treated as a private convenience. As Kneese noted:

Neither the manufacturers nor the owners have, until very recently, been subject to any systematic regulation representing the public interest. Scattered state and federal legislation now exists covering such topics as auto safety, compulsory insurance, and gaseous emissions...This fragmentation of governmental authority, coupled with the enormous economic power of the automotive industry, makes a successful attack on the problem of automobile-caused deterioration in environmental quality difficult.<sup>43</sup>

Thus a very complex yet delicate interplay of governmental statutes and regulations and current levels of technology have combined to create a societal impact of heretofore unmeasured magnitude. Legislation on both national and local levels, often characterized by a public welfare intent, may well be in a "driver" position vis-a'-vis technology which sometimes cannot react quickly enough to perceived environmental requirements. With regard to petroleum resources, their development, utilization and eventual

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<sup>43</sup>Allen V. Kneese, Robert U. Ayres, and Ralph C. D'Arge, Economics and the Environment, A Materials Balance Approach (Washington, D.C.: Resources For The Future, Inc., 1970), p. 28.

replacement by other fuels points out the need for a balance of external factors. A balance between governmental, technological and economic factors is a critical requirement for wise policy concerning what is probably the most important of all "societal" fuels.

### Summary

This chapter has primarily emphasized the breadth and depth of governmental activities in the development and operation of the petroleum industry. The range of federal governmental activity has extended from the leasing of public lands to the allocation of petroleum products at local service stations. Increasingly active has been the Wyoming government, which in its reassessment of the state's mineral endowments, has begun to control the development of all fuel resources. The Wyoming Oil and Gas Conservation Commission has been granted expanded powers of control. The establishment of the Permanent Wyoming Mineral Trust Fund has placed the entire spectrum of mineral development into a different perceptual framework.

With the advent of petroleum technology which can produce petroleum products more efficiently Wyoming assumed a relatively substantial role as a petroleum supplier at a regional and extra regional level. The implications of the great demand for gasoline and other petroleum products by the transportation and electrical generation sectors of the national economy were then examined in light of the lack of environmentally acceptable fuels.

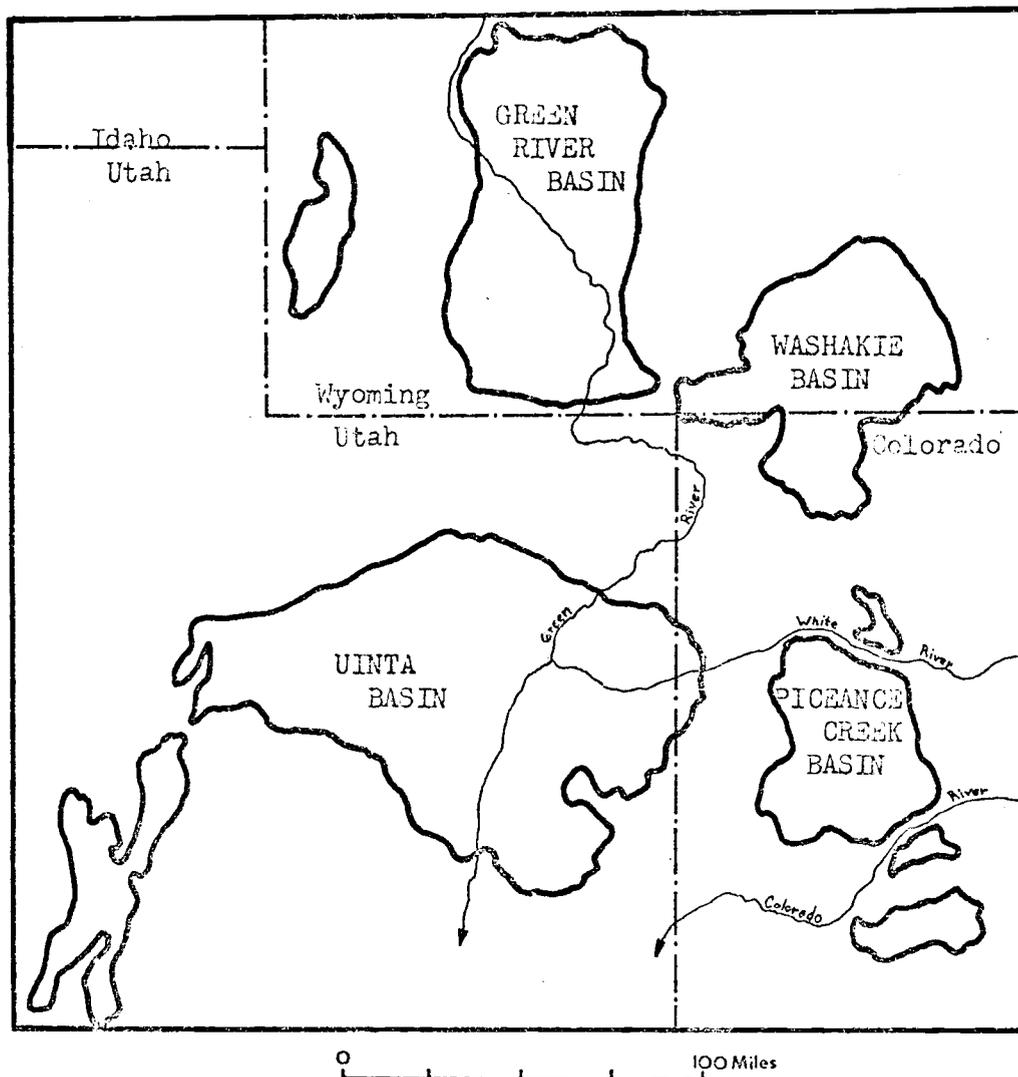
The clash of environmental considerations and the growing demand for petroleum products was presented in this chapter to illustrate that petroleum has now become a basic resource on a national level. The problems of substitution, restrictions, or alterations of petroleum on a national scale affect Wyoming to a considerable degree. Decisions regarding the state's powers to control the development patterns of petroleum within the state must increasingly be made within the context of national and state environmental quality standards. The balance point between increased demand for petroleum and an acceptable environmental standard has not yet been reached at either the national or state level. Such a balance point however seems to be a mutually desirable goal for both federal and state governments.

## V WYOMING'S OIL SHALE POTENTIAL

The oil shale industry in Wyoming, like the remainder of the nation, is in a state of nascence. However, a great amount of government and corporate interest as well as financial stimulation are beginning to make their impacts felt. Largely because of a nation-wide fuel shortage and "Operation Independence," which gives federal executive sanction to the strategy of petroleum self-sufficiency for the United States, the great reserves of petroleum locked in the oil shales of the Rocky Mountain region have taken on greater importance. Interest in oil shale is building rapidly and the potential results are impressive. The states of Wyoming, Colorado and Utah contain oil shale deposits which cover about 16,500 square miles of territory and are estimated to contain two trillion barrels of shale oil. This amount is believed to occur in shale beds limited to 10 feet in thickness with a potential of 10 or more gallons of oil per ton of shale. If heretofore unexplored areas were taken into account, the estimated shale oil content is placed at about four trillion barrels. These potentially rich oil shale deposits are generally located in the Piceance Creek Basin of Colorado, the Uinta Basin of Utah and the Washakie and Green River Basins of Wyoming (see Figure 10).

The oil shale deposits of Wyoming alone are placed at 430 billion barrels of shale oil in beds limited to ten feet in thick-

Fig. 10 Oil Shale Deposits in Colorado, Wyoming, and Utah



Source: Environmental And Economic Report On Wyoming Oil Shale

ness and containing ten or more gallons of oil per ton of rock.<sup>1</sup> In all, about 6700 square miles of Lincoln, Carbon, Sweetwater, Sublette and Uinta counties are underlain by oil shale deposits. Much of oil shale area is exposed at the surface and therefore lends itself to good accessibility for both exploration and development activities.

#### Land Ownership

Most of the oil shale deposits in Wyoming underlie Sweetwater county and at the present time the Federal Government owns over two-thirds (69 percent) of the land in the county. The remaining portion of the county is owned by the state, county, municipalities or private individuals. Since the Union Pacific Railroad passes through the area it owns every other section of land along a twenty mile strip on each side of the railroad right-of-way. Thus, in oil shale development as well as in petroleum and coal resources, there appears to be an inextricable tie between the Federal Government, the Union Pacific Railroad, and the rate and degree of development of the fuel resources of Wyoming. Two of the three currently operating pilot projects for producing shale oil are being carried out on federally owned lands and one on a combination federal, state and railroad owned lands. However, it should be pointed out that on a national scale the Federal Government occupies a very advantageous

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<sup>1</sup>Wyoming Oil Shale Environmental Planning Committee, Environmental And Economic Report On Wyoming Oil Shale (Cheyenne: Department of Economic Planning and Development, 1971), p. 5.

position in that fully 80 percent of the known oil shale reserves are found on federally owned land.<sup>2</sup>

### Shale Oil Extraction Technology

There are several methods of extracting oil from impermeable shale rock but one process, in situ retorting, seems to be the best long run method of extracting oil from the shale. One test site near Rock Springs, Wyoming, has been operated by the U.S. Bureau of Mines to test the feasibility of fracturing the shale and extracting the oil in place (in situ). Using this process a series of wells is drilled through the oil shale deposits, fracturing of the rock is accomplished by chemical explosives, then shale in the central wells is ignited (see Figure 11). The heat produced from the combustion of the oil shale is then forced outward to retort or heat adjacent areas of oil shale. As combustion proceeds, the shale oil and gaseous products are collected and recovered by conventional petroleum recovery techniques. Using the in situ method in beds of oil shale twenty feet thick and overlain by 68 feet of overburden the U.S. Bureau of Mines was producing  $4\frac{1}{2}$  barrels of oil per day at the Wyoming test site in 1969. The site itself is actually made up of one section of federal land with a 187-foot-thick deposit of oil shale under an overburden of 480 feet. The estimated content of the oil in the rock is almost 18 gallons of oil per ton.<sup>3</sup>

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<sup>2</sup>U.S. Department of the Interior, U.S. Bureau Of Mines Bulletin 650, Mineral Facts and Problems, 1970 (Washington, D.C. Government Printing Office, 1970), p. 191.

<sup>3</sup>Environmental And Economic Report On Wyoming Oil Shale, op. cit., pp. 35-36.

Source: Environmental And Economic Report on Wyoming Oil Shale, p. 40.

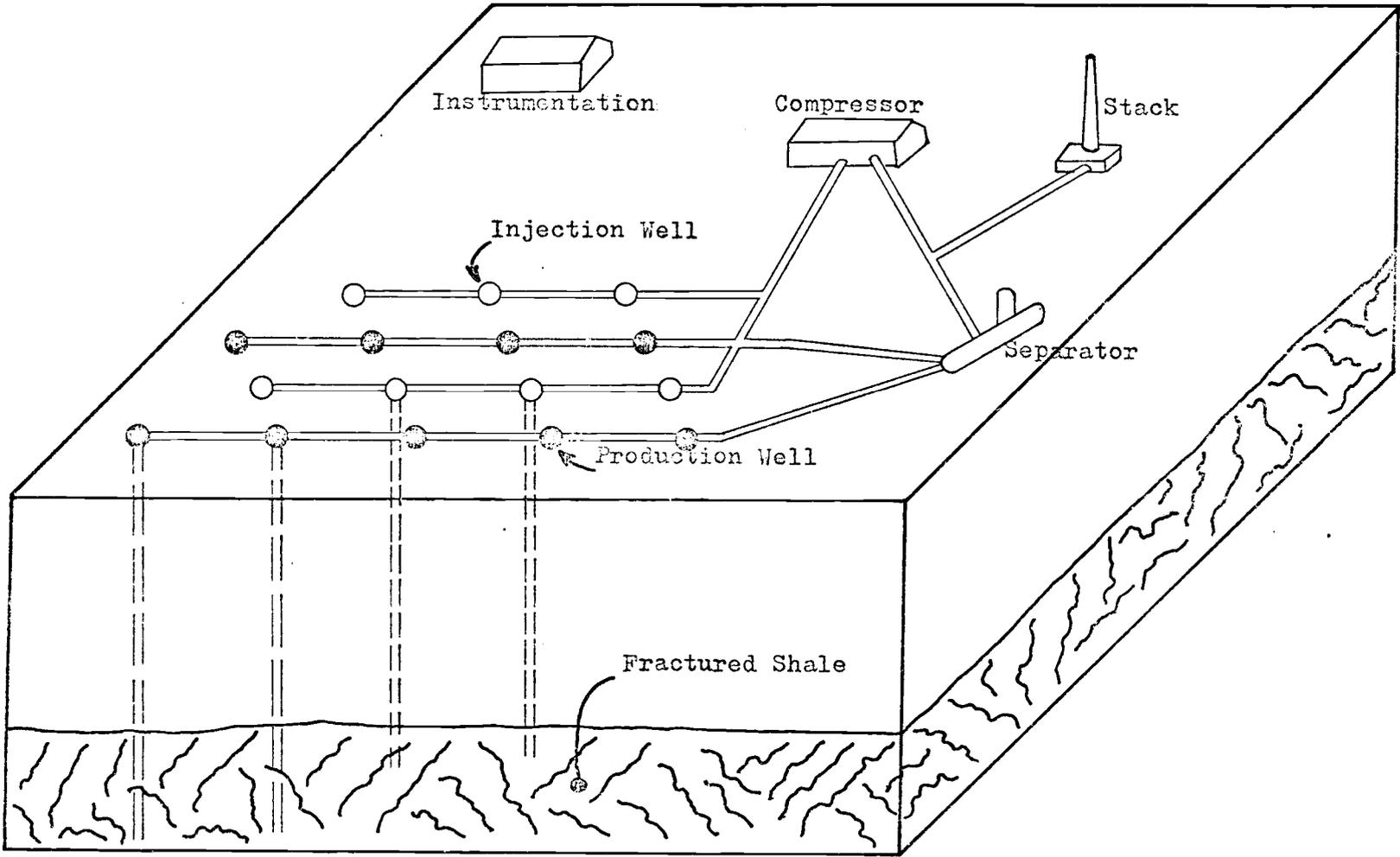


Fig. 11 Schematic Layout for In Situ Processing

During the combustion phase of the operation additional rows of wells can be drilled in order to maintain the retorting process. Used wells, those already burned out, can be plugged or used to recover gaseous vapors and heat as water is pumped into them. In general, a stepwise progression to the retorting process is carried out by drilling additional producing wells. Additional insight into the expected recovery rates and usefulness of this process are provided by the Environmental And Economic Report On Wyoming Oil Shale which describes the test site potential thusly:

To obtain 60,000 barrels of oil per day from the oil shale averaging 17.9 gallons of oil per ton requires the complete retorting of 140,800 tons of shale per day. A retorting and recovery efficiency of 60 percent may be achievable. In this case 234,600 tons of oil shale, or 3.4 million cubic feet, would be retorted each day. Since each block to be processed is 1 mile long by 187 feet thick, the rate of advance of the retorting zone for one block is 3.4 feet per day. At this rate, 29 days would be required to retort the shale block in one direction between adjacent rows of wells,  $4\frac{1}{2}$  years to retort the oil shale in the 1-square-mile area,<sup>4</sup> and 36 years to retort the oil shale in a 5,120 acre lease.

It is assumed that a 60 percent recovery rate of oil from shale rock is possible via the in situ process and with a minimum output of 50,000 barrels of shale oil per day it has been estimated that an investment of 107 million dollars (1968 dollars) and a 500 man labor force would be required to operate such a facility. This estimate is based on a 1969 report "Review and Forecast - Wyoming Mineral Industries" done by the Denver-based Cameron Engineers who were estimating the impact of a 100,000 barrel per day oil shale industry which also utilized open-pit methods of production.<sup>5</sup>

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<sup>4</sup>Ibid., p. 38.

<sup>5</sup>Ibid., p. 42.

### The Federal Government's Role in Oil Shale Development

The Federal government plays an interesting though dichotomous role in its participation in Wyoming's potential oil shale industry. On one hand, it actively encourages and finances research and prototype developments in shale areas, and on the other it actively enforces environmental and sometimes economic restrictions upon the development of this ancillary fuel resource. At the federal level a four-point program was instituted ten years ago to stimulate development by: clearing title to oil shale lands, consolidating them into commercial-sized units, to establish prototype technology in selecting areas and funding research into in situ processes. The primary agency of the federal government involved with developmental activities in the industry has been the Bureau of Land Management which has begun the process of leasing federal lands for private development of shale oil plants. To date the lease sale revenues from the BLM leases in Colorado alone have exceeded 300 million dollars. The Bureau of Mines has also continued to investigate shale fracturing techniques and research into in situ retorting in conjunction with the Atomic Energy Commission.

In a recent letter to U.S. Representative Teno Roncalio (representing Wyoming) which was made public, the then chairman of the AEC, Dr. Dixy Lee Ray, indicated that Atomic Energy Commission funding of oil shale development will be increasing. Of the \$107.6 million earmarked for underground natural gas and oil shale stimulation experiments during the next five years, \$51.4 million will be used for in situ oil shale development. The attractiveness of in situ processing in terms of its reduced adverse impact upon

the environment is well recognized by the AEC, but because of the technological difficulties involved, the federal government assumed that shale oil production via in situ retorting would be rather slow to develop. Therefore the AEC chairman, Dr. Lee, was quoted as saying, "It was expected...that underground research and development by the government could accelerate the development and industry acceptance of an in-situ technology."<sup>6</sup>

As a contrast to the proposed early and rapid development of oil shale industry by the AEC, the Interior Department, in accordance with the National Environmental Policy Act of 1969 and Public Law 91-190, 1 January 1970, required that both federal and state agencies prepare an environmental impact statement on prototype oil shale developments. Restrictions concerning air and water pollution are applied to the oil shale industry in order to comply with Public Law 91-190 which states that the federal government shall "...promote efforts which will prevent or eliminate damage to the environment and troposphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation..."<sup>7</sup>

At the present time it is not known how much environmental protection measures will cost because of the variety of oil shale production techniques which could be employed. However, it seems

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<sup>6</sup>"AEC's Wagon Wheel Test Plan Dormant," The Denver Post, 20 February 1974, p. 2.

<sup>7</sup>National Environmental Policy Act of 1969, Statutes at Large 83, sec. 2, 852 (1970).

assured that commercial developers will have to accept those costs, whatever they may be, as they begin to produce shale oil in significant amounts. Although no shale oil is produced commercially for consumption at this time in Wyoming, past experience in Colorado has shown that there are no particular refining problems involved with shale oil. For example, Union Oil Company, operating a small refinery near Grand Junction, Colorado, had refined and successfully marketed 20,000 barrels of shale oil in 1963.<sup>8</sup>

#### Taxes and Leases

Shale oil, unlike other forms of petroleum, is allowed a depletion allowance of only 15 percent on Federal income tax returns. Since 1969 shale oil has been brought into a more competitive position vis-a-vis petroleum because the petroleum depletion allowance was changed from 27½ percent to 22 percent. The tax exemption is based upon the value of the raw or unprocessed shale oil. Prior to 1969 and the passage of the Tax Reform Act<sup>9</sup> (PL 91-172) oil shale operators were at a distinct disadvantage compared to petroleum producers. The change in the tax laws is thought to have been a stimulus for private commercial producers who have justifiably perceived an improvement in their economic position compared to crude oil producers.

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<sup>8</sup>Mineral Facts and Problems, 1970, op. cit., p. 189.

<sup>9</sup>Commerce Clearing House, Inc., Explanation of Tax Reform Act of 1969 (San Francisco: Commerce Clearing House, Inc., 1970), pp. 176-79.

In order to facilitate the orderly development of the oil shale industry, the federal government was successful in exchanging equally valued parcels of private and Federal lands in order to consolidate shale deposits. It was hoped that such a consolidation process would make oil shale lands more attractive to private commercial development. At the same time the Department of the Interior, Bureau of Land Management, has allowed bids on oil shale leases on public lands with the following restrictions:

No lease hereunder shall exceed five thousand one hundred and twenty acres of land...Leases may be for indeterminate periods, upon such conditions as may be imposed by the Secretary of the Interior, including covenants relative to methods of mining, prevention of waste, and productive development... the lessee shall pay to the United States such royalties as shall be specified in the lease and an annual rental, payable at the beginning of each year, at the rate of 50 cents per acre per annum, \$2560 for the lands included in the lease, the rental paid for any one year to be credited against the royalties accruing for that year; such royalties to be subject to readjustment at the end of each twenty-year period by the Secretary of the Interior. For the purpose of encouraging the production of petroleum products from shales the Secretary may, in his discretion, waive the payment of any royalty and rental during the first five years of any lease.<sup>10</sup>

#### State Government's Activities

As might be expected, the state of Wyoming actively encourages the development of an oil shale industry in the state though it expects that the industry "...will be required to meet all environmental protection standards..."<sup>11</sup> In order to meet such environmental standards it has been suggested that the state establish a

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<sup>10</sup>Mineral Lands Leasing Act, U.S. Code, vol. 30, sec. 241(a) (1960).

<sup>11</sup>Environmental And Economic Report On Wyoming Oil Shale, op. cit., p. 53.

fund which would insure that additional research or technology be carried out by the industry. Under recommendations put forward by the Wyoming Oil Shale Environmental Planning Committee, a levy would be placed on every barrel of shale oil produced in the state and transferred to the fund. In effect the levy functions much like a severance tax.

Additionally the Oil Shale Environmental Planning Committee expressed its concern that the size of the oil shale leases is critical to the industry's development in that relatively small lease parcels would act as constraints rather than incentives to rapid commercialization of oil shale lands. The federal government, as previously mentioned, has already limited oil shale leases to a maximum of 5120 acres and one gets the distinct impression that the state would also encourage oil shale leases sized close to the federal maximum limits. In conjunction with lease size regulations the state of Wyoming has aided the Sweetwater County Planning Commission in the preparation of a comprehensive land use plan and a revision of the county's zoning ordinance. Although Wyoming already has a set of environmental standards which regulate reclamation, air and water quality standards, amendments to these laws sometimes greatly change their impact upon mineral industries.

For example, during the final session of the meeting of the 42nd Wyoming Legislature (1974) an amendment concerning industrial water usage was passed which will have a great impact upon the oil shale industry. After much debate it was agreed that at least a partial moratorium on industrial water appropriation should be

imposed. The law will give the state engineer power to withhold permits for underground water in any Wyoming county if the request is for more than 6,000 acre-feet annually.<sup>12</sup> In 1969 it was estimated that just one open-pit type oil shale facility producing about 50,000 barrels of shale oil per day would consume at a minimum approximately 5000 acre feet of water per year. By 1980 it is expected that the oil shale industry will be using well over 9,000 acre feet of water per year. Thus it seems clear that even though the state of Wyoming is actively engaged, along with the federal government, in encouraging the development of an oil shale industry, legislation such as that previously cited, will probably act as a restriction to rapid development of oil shale deposits. It must be emphasized that the impact of such legislation would have a differential impact on the industry in that the in situ process uses almost no water. The open pit method however, is the most conventional and therefore most readily available technology available to a developing shale oil industry. Therefore early development of oil shale plants in Wyoming may be delayed until more investigative work is done on the in situ retorting method of oil production. In this venture the federal government is clearly the only level of government which can thoroughly carry out the funding and research activities to make this process the most economic and environmentally desirable form of shale oil production.

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<sup>12</sup>"Wyoming Legislature Passes 31 Bills in 18-Day Session", The Denver Post, 13 February 1974, p. 66.

### Economic Factors of Shale Oil Production

Because there is no significant commercial production of shale oil at the present time it is not possible to discern what impact the production of shale oil will have upon the economic structure of the nation or Wyoming. However, a forecast of demand for shale oil by the year 2000 (see Table 10) indicates that most of the oil is expected to be refined as a fuel for vehicles. A 1966 study carried out by the Bureau of Mines on the economics of oil shale development indicated that at least partial refining of the shale oil was expected to be carried out at the mining site then shipped eastward via pipeline where it would be further refined into premium gasoline and other by-product fuels.<sup>13</sup> According to that particular projection shale oil produced in Colorado and shipped to St. Louis could be expected to cost about \$2.70 per barrel to the producing company at a St. Louis refinery location. Overall a return on total investment was computed to be slightly over six percent. Table 11 shows the estimated costs in step-like progression to the St. Louis refinery point. However, the competitive disadvantage of shale oil compared to ordinary domestic crude has changed rapidly during the 1973-74 period. As of February, 1974, prices for Wyoming produced crude oil increased to \$10 per barrel compared to about \$2.50 per barrel in 1973. It is estimated that producers would still be able to sell the crude at no less than \$7.50 per barrel even if federal price restrictions were increased.

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<sup>13</sup>Mineral Facts and Problems, 1970, op. cit., p. 193.

Table 10 CONTINGENCY FORECASTS OF DEMAND FOR SHALE OIL BY END USE, YEAR 2000

End use	Demand in year 2000								
	U.S. demand 1968 <sup>1</sup>	U.S. forecast base 2000	United States				Rest of the world <sup>2</sup>		
			Low (million barrels)	High Million barrels	High Trillion Btu	Low Million barrels	Low Trillion Btu	High Million barrels	High Trillion Btu
<b>Liquid fuels:</b>									
Transportation	.....	.....	.....	890	5,162	NA	NA	NA	NA
Household and commercial.....	.....	.....	.....	270	1,566	NA	NA	NA	NA
Electric utilities	.....	.....	.....	90	522	NA	NA	NA	NA
Industrial	.....	.....	.....	550	3,190	NA	NA	NA	NA
<b>Fuel gas<sup>3</sup></b>									
Transportation	.....	.....	.....	7	41	NA	NA	NA	NA
Household and commercial.....	.....	.....	.....	81	470	NA	NA	NA	NA
Electric utilities	.....	.....	.....	35	203	NA	NA	NA	NA
Industrial	.....	.....	.....	77	446	NA	NA	NA	NA
<b>Total liquid and gaseous fuels..</b>									
Transportation	.....	.....	.....	897	5,203	NA	NA	NA	NA
Household and commercial.....	.....	.....	.....	351	2,036	NA	NA	NA	NA
Electric utilities	.....	.....	.....	125	725	NA	NA	NA	NA
Industrial	.....	.....	.....	627	3,636	NA	NA	NA	NA
<b>Total</b>	.....	.....	.....	2,000 (Median 1,000)	11,600	100	580 (Median 550)	1,000	5,800

NA Not available.

<sup>1</sup>This refers to demand for commercial product and therefore does not reflect the small quantity produced in research and development operations. <sup>2</sup>Estimated 1968 shale oil demand in the rest of the world was 40 million barrels. <sup>3</sup>Quantities for fuel gas are given in millions of barrels of shale oil to be converted to high-Btu gas.

Source: Mineral Facts & Problems, 1970, op. cit., p. 196.

TABLE 11 ESTIMATED CAPITAL REQUIREMENTS AND OPERATING COSTS FOR A COMMERCIAL OIL SHALE INSTALLATION<sup>1</sup>  
(Dollars)

	Mines	Retorting Plant <sup>2</sup>	Colorado refinery	Pipeline to Fort Laramie	Commercial pipeline	St. Louis refinery	Total
Capital investment	34,955,000	46,864,100	65,189,700	10,432,000		28,042,400	185,482,200
Annual operating cost	12,313,000	5,780,000	8,709,300	1,056,300	3,962,500	8,182,400	40,003,500
Cost per ton of shale mined	.56	.26	.40	.05	.18	.37	1.82
Cost per barrel of crude shale oil	.84	.39	.59	.07	.27	.55	2.71

<sup>1</sup>60,000 tons per calendar day, 30-gallon-per ton shale.

<sup>2</sup>Includes crushing and screening and fines-briquetting plants.

Source: Mineral Facts & Problems, 1970, op. cit., p. 196.

When taken in the context of the fuel shortage conditions of 1973-74 the projections made in 1966 on shale oil's competitive position have also changed greatly. Given the rapid increase in price of domestically produced crude oil, shale oil, even with the 15% depletion allowance, appeared to be increasingly attractive for commercial development. The sudden competitive advantage in oil shale as perceived by private developers was probably illustrated by the record-setting bid of \$210 million by an Exxon-Gulf consortium for a 5,000 acre lease in Colorado.

Oil shale is unlike other forms of petroleum in that it has relatively small amounts of naphtha and large quantities of oxygen and hydrogen compounds. It is believed that a very significant by products component would develop in the refining of oil shale, with the two most important by-products being sulfur and ammonia.

The amount of sulfur, for example, that might be obtained by refining 1 million barrels of crude shale oil daily would be approximately 400,000 short tons per year. This would be nearly 4 percent of the 1968 U.S. sulfur demand. The corresponding ammonia production would be approximately 800,000 short tons per year, which would be nearly 7 percent of the 1968 domestic demand.<sup>14</sup>

Thus it seems that shale oil may gain considerable importance in the petrochemical industry. Another by-product of considerable potential importance is the manufacture of synthetic gas from oil shale. Some estimates for such shale gas by the year 2000 range as high as one trillion cubic feet per year.<sup>15</sup> However, it is

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<sup>14</sup>Ibid., p. 191.

<sup>15</sup>Ibid., p. 196.

assumed that whatever the amount of shale-derived gas produced, it would be marketed in the Rocky Mountain Region and the Pacific Coast area through conventional gas pipeline distribution systems.

#### Transportation of Shale Oil

The conventionality of transporting petroleum cannot be applied to shale oils. Unlike most crude oils, shale oils have a high pour point<sup>16</sup> (75-90°F) and high viscosity so that utilizing pipeline transportation systems would not be feasible. Therefore it is expected that at least partial distillation would have to take place at the oil shale production site before it would be sent through the pipeline. It is assumed that the partial refining will have to take place at the production site in order to keep the transportation costs within the 12 percent range of total shale oil costs as described in the 1966 capital requirements projection. That the transportation costs must be held to a minimum is an increasingly important consideration in the development of an oil shale industry which will have to compete with other domestic petroleum sources such as the North Slope deposits.

When the North Slope petroleum is brought to U.S. markets the costs of transportation will be very important to the oil shale industry in that if the costs of production and transportation are maintained at a competitive cost level through the utilization of pipelines, oil shale production and development may be retarded.<sup>17</sup>

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<sup>16</sup>The lowest temperature at which an oil can be poured.

<sup>17</sup>Ibid.

However, as Swager<sup>18</sup> recently pointed out, overall demand for petroleum is increasing rapidly and such an increase will both place increased pressure on any domestic petroleum resource and will alter existing patterns of interregional petroleum flow. If Swager is correct in his hypothesis, the consuming region for shale oil could be changed to a Midwest orientation (and thus face competition from mid-continent petroleum producers) or to be much more localized in its market area (the Rocky Mountain and North Central regions). If such a shift were to take place the market size may be critical in light of the tremendous fixed capital costs involved in establishing an oil shale operation. It seems certain that a combination of political, environmental and economic influences will considerably outweigh mere technological problems in any evaluation of the viability of an oil shale industry in Wyoming.

#### Summary

In the case of oil shale no industry presently exists, therefore this chapter necessarily must deal with the potentialities of this fuel resource. However, factors already in place such as the land ownership patterns and the leasing and taxing policies of the federal and state governments are examined. Like other fuels, the impact of governmental activities is extremely important, but in the case of the shale oil industry governmental decisions may be more critical than most.

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<sup>18</sup>Ronald J. Swager, "Regional Changes In Petroleum Supply, Demand And Flow In The United States: 1966-1980", Occasional Publications Of The Department Of Geography, No. 5, University of Illinois, (April 1973).

The technology required to extract oil from the shale rock is already in existence and the retorting process has been proven to be a feasible technique of producing shale oil. Even a more advanced technology, in situ retorting, has been tested and shows great promise of being the ultimate method of shale oil production. However, governmental incentives in the form of making oil shale leases on public lands available to developers, and tax deductions on production are important external factors bearing on the shale oil industry. Adherence to environmental quality standards at both federal and state levels will also have an impact on the rate of development since shale oil producers will make great demands upon the water and land resources of oil shale areas.

Finally, the potential development of a shale oil industry is probably dependent upon more traditional types of petroleum deposits. The prices of crude petroleum both domestically and world-wide must remain at high levels if shale oil, removed from large market areas, is to remain in a competitive economic position. Transportation costs incurred in moving shale oil to distant markets may prove to be as critical as environmental restrictions placed upon the early development of the shale oil industry.

VI EXTERNAL FACTORS AND THEIR IMPACT UPONTHE DEVELOPMENT PATTERNS OF THE COAL INDUSTRY IN WYOMINGWyoming's Coal Industry: Its State and National Characteristics

Since the First World War the coal industry in Wyoming has been overshadowed economically by the petroleum industry as measured by revenue. During a fifty year period (1920-1970) the coal industry can be characterized as having a fluctuating record of production. For example, in 1920 over 9.5 million tons of coal were produced. That production level was only exceeded during 1945 and 1972.

Technology and social legislation in combination have played key roles in determining the fortunes of the state's coal industry. Low sulfur Wyoming coal is in demand today largely because of its use by electric utilities companies both within and outside the state's borders. The original impetus for the coal industry, as previously mentioned, was provided by the railroads and their desire for a good steam coal. However, with a change in motive technology diesel engines replaced steam driven ones with a resultant decline of both coal production and employment. Even when coal was being mined almost solely for use by railroads it generally left the state in the coal cars and tenders of the four railroad companies which serve Wyoming.

Wyoming as a Supplier of Coal

The export of coal to other areas is not a new distributive pattern for Wyoming coal producers. In 1918 for example, only 8 percent of the coal produced in the state was consumed there.<sup>1</sup> As a point of historical interest and an illustration of the relative importance of petroleum compared to coal in 1918 the following data are presented: in 1918 Wyoming produced slightly more than 1.5 million gallons of gasoline valued at \$268,339 (17 cents per gallon at the refinery). In the same year 9.4 million tons of coal were produced with a value of 22½ million dollars.<sup>2</sup> Fifty-five years later, 125 million barrels of crude oil valued at 386 million dollars were produced compared to 10 million tons of coal valued at 20.2 million dollars.<sup>3</sup>

Another change has been the role of surface compared to subsurface coal mining. As Glass mentioned, 99 percent of 1945's record production came from 44 underground mines, yet only 10 surface mines produced as much coal in 1972. Nearly 85 percent of all the coal mined in Wyoming between 1865 and 1972 has come from underground mines.

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<sup>1</sup>U.S., Department of the Interior, U.S. Geological Survey, Mineral Resources Of The United States, 1918 (Washington, D.C.: Government Printing Office, 1921), pp. 1356-7.

<sup>2</sup>Ibid., pp. 708; 1437.

<sup>3</sup>Annual Report of The Department of Revenue and Taxation Ad Valorem Tax Diversion, State of Wyoming, 1973, by Francis Hellard, State Tax Commissioner (Cheyenne: The Department of Revenue and Taxation, 1973), pp. 18-66.

The shift of coal's economic role is not surprising when viewed in light of the great increase in petroleum consumption by the transportation sector of the economy. The transportation sector has in fact grown over three times as rapidly as population in the United States since 1955.<sup>4</sup> However, even though railroads have transitioned from steam to diesel-electric engines, and almost half of all transportation is accomplished by gasoline-burning automobiles, coal production in Wyoming has increased, largely in response to a rising demand for low-sulfur coal by many electric utility companies who were attempting to meet the air quality criteria of federal air pollution regulations. Yet the increase in Wyoming's coal production came at a time when the number of mines on a national scale was declining.

A significant change which had a significant impact upon the coal producers of Wyoming occurred when the 1970 amendments to the Clean Air Act became law. As a result of the new constraints upon air pollution, electric utility companies looked for low sulfur fuel sources and generally opted for natural gas, low sulfur fuel oil or low sulfur coal. As natural gas supplies dwindled and fuel oil prices rose, low sulfur coal became an increasingly attractive alternative. Because almost 99 percent of the coal found in Wyoming is rated as having less than 1 percent sulfur, an increasing demand for the fuel, especially by out-of-state electric utilities has greatly stimulated the state's coal industry.

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<sup>4</sup> James J. Mutch, Transportation Energy Use In The United States: A Statistical History, 1955-1971, Rand Report R-1391-NSF (Santa Monica: The Rand Corporation, 1973), p.v.

Gillette, Wyoming as a Representative Coal Town

What seems to be the inevitable results of rapidly expanding primary economic activity, the social as well as environmental impacts, have also appeared in Wyoming. The town of Gillette is an example of the impact the exploitation of coal resources is making upon the social and spatial configurations of Wyoming. Its population has grown from under 2200 people in 1950 to almost 7200 in 1970 based primarily upon the oil discoveries in the area during the 1960's. However, when the coal reserves of Gillette are being worked at their peak levels it is estimated that the town's population will grow an additional 25,000 by 1978.<sup>5</sup>

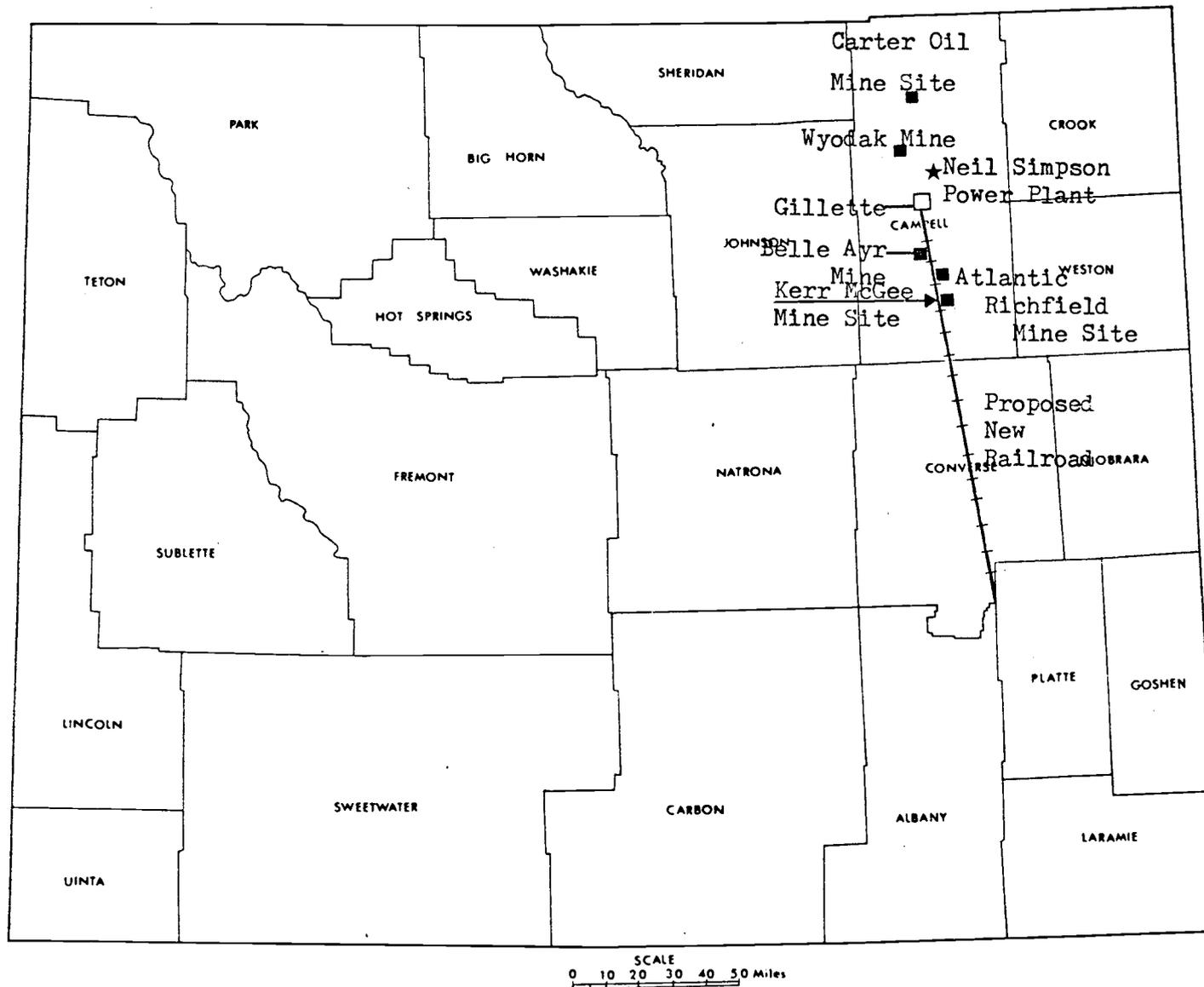
It is believed that more than twenty billion tons of strippable low sulfur coal will be surface mined from over 756,000 acres of land in the surrounding Powder-River Basin. In 1973, 4.4 million tons of coal were mined from the entire basin but by 1985 that is expected to increase to over 60 million tons annually. Currently two coal mines, Wyodak and Amax's Belle Ayr are in operation and the \$134 million Neil Simpson (27.68 MW) electric powerplant is under construction (see Figure 12). At least six new coal mine operations, a new 126 mile rail line, by the Burlington Northern/Chicago and North Western, a coal slurry pipeline from Gillette to Arkansas, and three coal gasification plants are also planned for this coal boom town.<sup>6</sup>

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<sup>5</sup>"Town Scarred by Oil Boom Waits Apprehensively for Mines", New York Times, 11 April 1974, sec. 2, p. M33.

<sup>6</sup>Ibid., pp. M33-36.

Fig. 12 Coal-related Developments in the Eastern Powder River Basin



Source: Coal Age, May, 1974, p. 97.

The point illustrated by the Gillette example is that there is a growing recognition of the great reserves of coal in Wyoming (the Powder Basin alone has almost 95 billion tons) and developmental activities have already begun or are being planned. Both private corporations and federal agencies, fully cognizant of recent fuel problems, especially for electric power producers, have underscored the importance of Wyoming coal for the nation. Indeed, even the state government actively advocates the immediate albeit controlled development of Wyoming's fuel resources, especially coal, as a fulfillment of its duty to the United States.<sup>7</sup>

#### A Profile of Coal Producers in Wyoming .

The Rocky Mountain states which are coal producers have historically been small producers of coal at the national level. Generally speaking, the region has always consumed less coal than it produced and has functioned as an exporter to states such as California, Arizona and Nevada. In 1965 for example, the Rocky Mountain area shipped over two million tons to those coal deficit states. During the same year less than one million tons were sent to the Central U.S. (Minnesota, Iowa, Missouri, North and South Dakota and Nebraska). However since 1969 the generalized pattern of coal movement just described has begun to shift from the west coast consumers to a greater emphasis upon the Central U.S. markets, which are larger and therefore more lucrative.

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<sup>7</sup>Governor Stanley K. Hathaway, speech given during meeting of the Denver Coal Club, Denver, Colorado, October 1974.

At the national level, petroleum companies began acquiring large amounts of coal land during the 1960's. For example, Continental Oil acquired Consolidation Coal Company in 1966 and with that acquisition also gained 11 percent of national coal production as well as over 38 thousand acres of coal lands, much of which is in Wyoming. In all it was estimated that over 20 percent of the coal produced in 1970 was controlled by parent oil corporations. As previously discussed not all coal leases are producing leases for a variety of reasons but Table 12 indicates how many acres may be involved in the nonproductive category.

When the temporary moratorium on public lands coal leasing went into effect in 1971 no fewer than nine oil companies,<sup>8</sup> holding over 78 thousand acres of coal leases on public land in Wyoming filed with the Bureau of Land Management. Additionally, Peabody Coal Company (Kennecott Copper) held over 34 thousand acres of public land coal leases in the state.<sup>9</sup> In terms of total public lands leased by oil companies for coal, data appearing in recent U.S. House hearings indicate that an estimated 2.1 billion tons of coal on 141,000 acres of only 56 public land leases were held as of August 1970. Most of those leases are in the Western United States and many of them are in Wyoming. For example, at that date 73 percent of Kerr-McGee's coal leases (estimated to contain 253

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<sup>8</sup>Sun Oil, Atlantic Richfield, Mobil, Belco Petroleum, Carter Oil, Kerr-McGee, Concho Petroleum, Island Creek (Occidental Petroleum) Consolidation Coal (Continental Oil).

<sup>9</sup>U.S. Department of the Interior, Bureau of Land Management, "Public Land Lease Records - Coal." Cheyenne, 1973. (photocopies).

TABLE 12 NON-PRODUCTIVE COAL PERMITS AND LEASES OF LARGE COAL AND OIL COMPANIES (ON PUBLIC LAND) AS OF AUGUST 1970

<u>COMPANY</u>	<u>ACREAGE</u>	<u>DATE ACQUIRED</u>
*Consolidation Coal (Continental Oil)	38,032.62	1967, 69, 1970
*Peabody Coal Co. (Kennecott Copper)	50,561.81	1967, 68, 1970
North American Coal	4,208.97	1962, 64-66, 1967
*Kerr-McGee Oil	55,677.11	1965, 67, 69, 1970
*Atlantic Richfield	51,000.25	1964, 66-67, 67-68, 1970
*Sun Oil Co.	36,390.98	1968, 69
Gulf Oil Corp.	540.49	1964
*Carter Oil Co. (Exxon Subsidiary)	15,651.51	1963-65
Seneca Oil Co.	6,336.12	1967
*Belco Petroleum Co.	4,551.46	1970

\*Have leases in Wyoming.

Source: House Hearing, 92nd Congress, 2nd Session, Aug. 1, 2, 3, 8, 9, 10, 11, 1972 pg. 1045.

million tons) and 44 percent of Atlantic Richfield leases (643 million tons) were located in Wyoming while 100 percent of Sun Oil's holdings were also located in the state.<sup>10</sup>

A discussion of the corporate structure of companies, either mining or holding coal leases would not be complete if the degree of diversity found in the so-called energy industries were not pointed out. Table 13 which appeared in U.S. House Hearings On Fuel Shortages indicates in a general format how great such diversity has become. The data are presented here to illustrate that all of the five fuels found in Wyoming and surveyed in this dissertation are involved in the operations of at least some of the twenty-five largest petroleum companies. Although the Arab oil embargo has since occurred and the petroleum companies' assets and profits have increased greatly since 1969/70 the data are still of interest in that they indicate that diversity has been both widespread and well developed before the events of late 1973.

#### Recent Coal Company Activities

In 1974 16 companies were engaged in the production of coal within Wyoming (see Figure 13). The Amax Coal Co. (a subsidiary of American Metal Climax) currently is strip mining a seventy foot thick coal seam (Wyodak seam) in Campbell County near Gillette. Its Belle Ayr mine supplies one million tons of coal (7640 to 8640 per pound) to the 350,000KW Comanche Power Plant near Pueblo, Colorado. Amax signed a twenty year contract to supply the plant with coal

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<sup>10</sup>Ibid.

TABLE 13 DIVERSIFICATION OF THE ENERGY INDUSTRIES BY THE 25 LARGEST  
PETROLEUM COMPANIES RANKED BY ASSETS, AS OF EARLY 1970

Petroleum Company	1969 Assets (Thousands)	ENERGY Rank	ENERGY		INDUSTRY	
			Gas	Oil Shale	Coal	Uranium
Standard Oil (New Jersey)	\$17,537,951	1	+	+	+	+
Texaco	9,281,573	2	+	+	+	+
Gulf Oil Corp.	8,104,824	3	+	+	+	+
Mobil Oil	7,162,994	4	+	+	+	+
Standard Oil of Calif.	6,145,875	5	+	+	0	0
Standard Oil of Indiana	5,150,677	6	+	+	0	0
Shell	4,356,222	7	+	+	+	+
Atlantic Richfield	4,235,425	8	+	+	+	+
Phillips Petroleum	3,102,280	9	+	+	0	+
Continental Oil	2,896,616	10	+	+	+	+
Sun Oil	2,528,211	11	+	+	+	+
Union Oil of Calif.	2,476,414	12	+	+	0	+
Occidental Oil <sup>1</sup>	2,213,506	13	+	+	+	0
Cities Service	2,065,600	14	+	+	0	+
Getty Oil <sup>2</sup>	1,859,024	15	+	+	0	+
Standard Oil, Ohio <sup>3</sup>	1,553,591	16	+	+	+	+
Pennzoil United, Inc.	1,356,832	17	+	0	0	+
Signal Oil <sup>4</sup>	1,258,611	18	+	0	0	0
Marathon Oil	1,221,288	19	+	+	0	0
Amerada-Hess	982,157	20	+	0	0	+
Ashland Oil	846,412	21	+	+	+	+
Kerr-McGee	667,940	22	+	0	+	+
Superior Oil	494,025	23	+	+	0	0
Coastal States Gas Producing <sup>5</sup>	490,190	24	+	0	0	0
Murphy Oil	343,914	25	+	0	0	0

<sup>1</sup>Includes Hooker Chemical Co.

<sup>2</sup>Includes Skelly and Tidewater

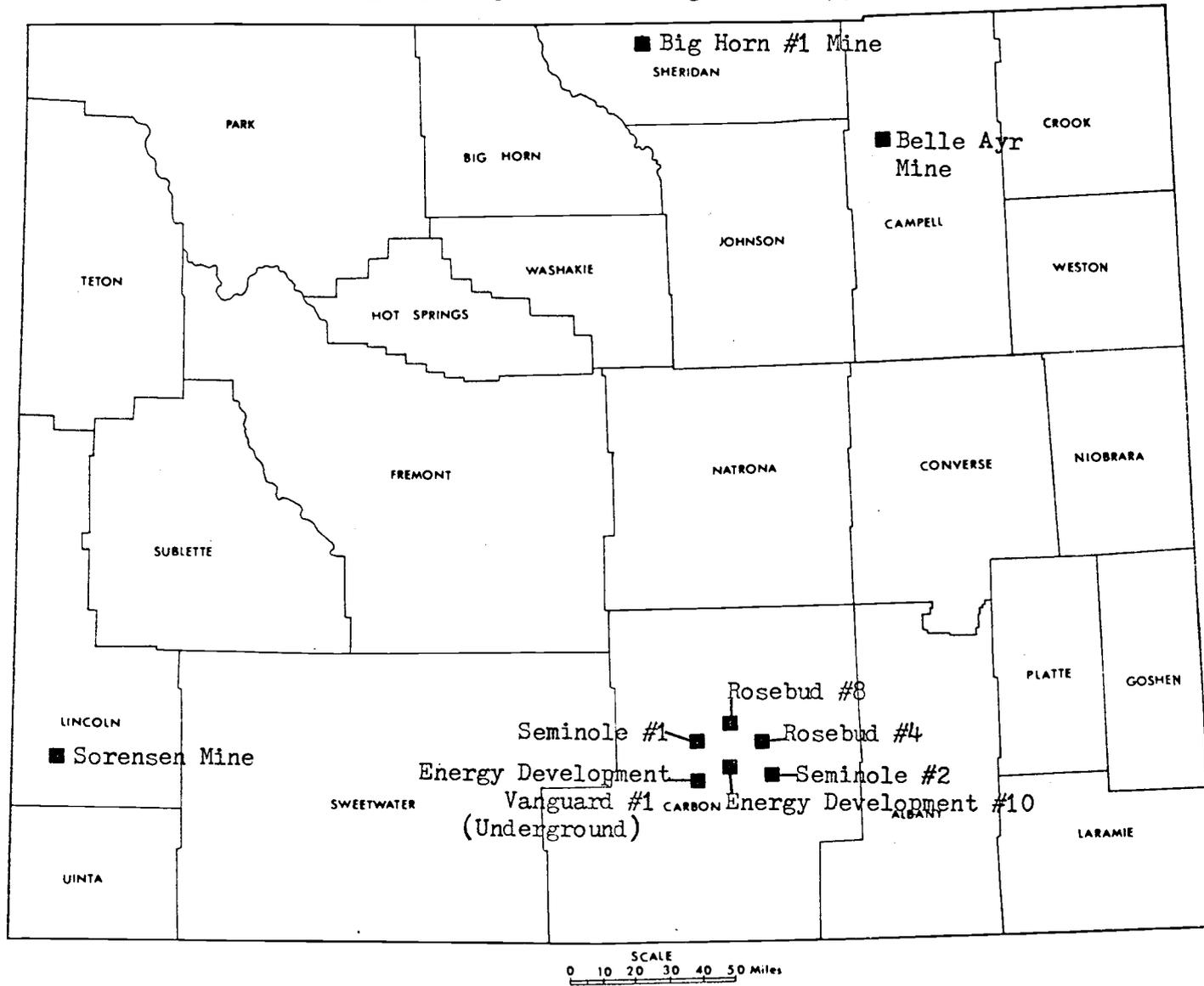
<sup>3</sup>Includes reported British Petroleum assets

<sup>4</sup>As of June 30, 1969

<sup>5</sup>As of Sept. 30, 1969

Source: U.S. House Hearings on Energy Shortages 92nd Congress  
2nd Session Aug. 1,2,3,8,9,10,11, 1972 Table 12, p. 1065.

Fig. 13 Major coal mining sites 1974



Locations found on Energy Resources Map of Wyoming.

that is shipped via unit train from the mine. A new 25 year contract was also recently signed with Southwest Electric Power Company to supply the first coal-fired electric plant in Texas located in the northeastern part of the state at Avinger. Haulage will be by unit train which will, at 1483 miles, make it the longest unit train route in the United States. It is estimated that at the Belle Ayr site alone the company has coal reserves of about 300-400 million tons. Already contracts with the Public Service Company of Colorado, contracts to supply additional coal-fired electric plants in Texas and Arkansas as well as companies operating in the Ohio River Valley have been signed and deliveries are expected to begin as early as 1978.

#### Coal Producer Characteristics

The largest producer of coal in Wyoming as of 1974 is the Arch Mineral Corporation (Ashland Oil Co. and Hunt Enterprises) which produces about 5 million tons of coal per year from its two strip mines in the Hanna Coal Field. The company mines a relatively high heat value (10,000 BTU/lb) coal which is shipped via unit train to Chicago, Kansas City, Milwaukee and Sioux City. Each of the two mines has its own unit-train loading dock which greatly facilitates coal handling.

As the name implies the Big Horn Coal Company strip mines coal in the Big Horn Basin. The company, which is a subsidiary of Peter Kiewit Sons, Inc., mines a 44 foot thick coal seam near Sheridan and ships its (9300 BTU/lb) coal to Kansas City, to South Dakota and to North Dakota. Another Peter Kiewit subsidiary,

Rosebud Coal Sales, operates in the Hanna Basin shipping its  $1\frac{1}{2}$  million tons per year to Nebraska, Colorado, Iowa and Illinois.

Energy Development Company, which is a subsidiary of Iowa Public Service Company mines coal both by surface and underground methods in the Hanna Basin. The heat value of the coal is 10,806 BTU/lb which is shipped by unit train to Sioux City, Iowa, at a combined rate (deep and surface mines) of about one million tons per year.

The Kemmerer Coal Company surface mines seams which range from 6 to 118 feet thick and generally have a heat value of 9671 BTU/lb. One mine, the Sorensen, has the sole function of providing Utah Power & Light's Naughton Power Plant (710 MW) at Kemmerer with  $2\frac{1}{2}$  million tons of coal per year. In the next several years the production rate is expected to double when the plant is expanded to 1570 MW.

#### Planned Activities

Increased coal production is expected in the near future. Carter Oil (a subsidiary of EXXON) will start shipping coal from a surface north of Gillette in 1976. The shipments will be by unit train to power plants in Indiana and Michigan as well as the American Electric Power System which has its plants primarily located in the Ohio River Valley. Already Carter has signed 30 year contracts calling for approximately 10 million tons of coal per year. Atlantic Richfield which has leased approximately 7 thousand acres of federal coal lands south of Gillette has signed contracts with utilities companies in Muskogee, Oklahoma and Sutherland, Nebraska. The

company is planning a 10 million ton per year mine which will be able to ship its coal to markets via a planned railroad line between Gillette and Douglas. Kerr-McGee's holdings on Federal coal lease lands are in the developmental stage with plans for a 7 million ton per year surface mine to be shipping coal by 1978. Contracts have been signed with power companies in Louisiana, Arkansas and Texas. A newly formed corporation, Medicine Bow Coal Co., established in 1972 as a joint venture of Rocky Mountain Energy Co. (a subsidiary of Union Pacific Railroad) and Arch Mineral Corporation (Ashland Oil and Hunt Enterprises) has signed a 10 year contract with Northern Indiana Public Service Company. Under terms of the contract Medicine Bow is to supply the utility with 15 million tons of coal per year. Much of the reserves are held by Rocky Mountain Energy in southern Wyoming on Union Pacific lands and are estimated to be in excess of 10 billion tons.<sup>11</sup>

#### The Estimated Role of Coal as a Future Fuel Source

A recent article noted that even at the current rates of consumption the proven coal reserves in the United States could last for over 600 years. "Even if coal were the sole source of energy and the total demand for energy rose at the rate of 3.5 percent per year, the proved reserves would last for 47 years and total coal reserves for nearly 75 years."<sup>12</sup>

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<sup>11</sup>Gary B. Glass, "Wyoming: production seen doubling by 1976", Coal Age, May 1974, pp. 102-106.

<sup>12</sup>Harry Perry, "The Gasification of Coal", Scientific American, March 1974, pp. 19-25.

On a national scale coal supplied slightly more than 18 percent of the nation's fuel requirements in 1971. The Department of the Interior expects that even by the year 2000 coal burned for the production of power will still contribute only about 16 percent of the energy consumed in the United States (see Figure 14).

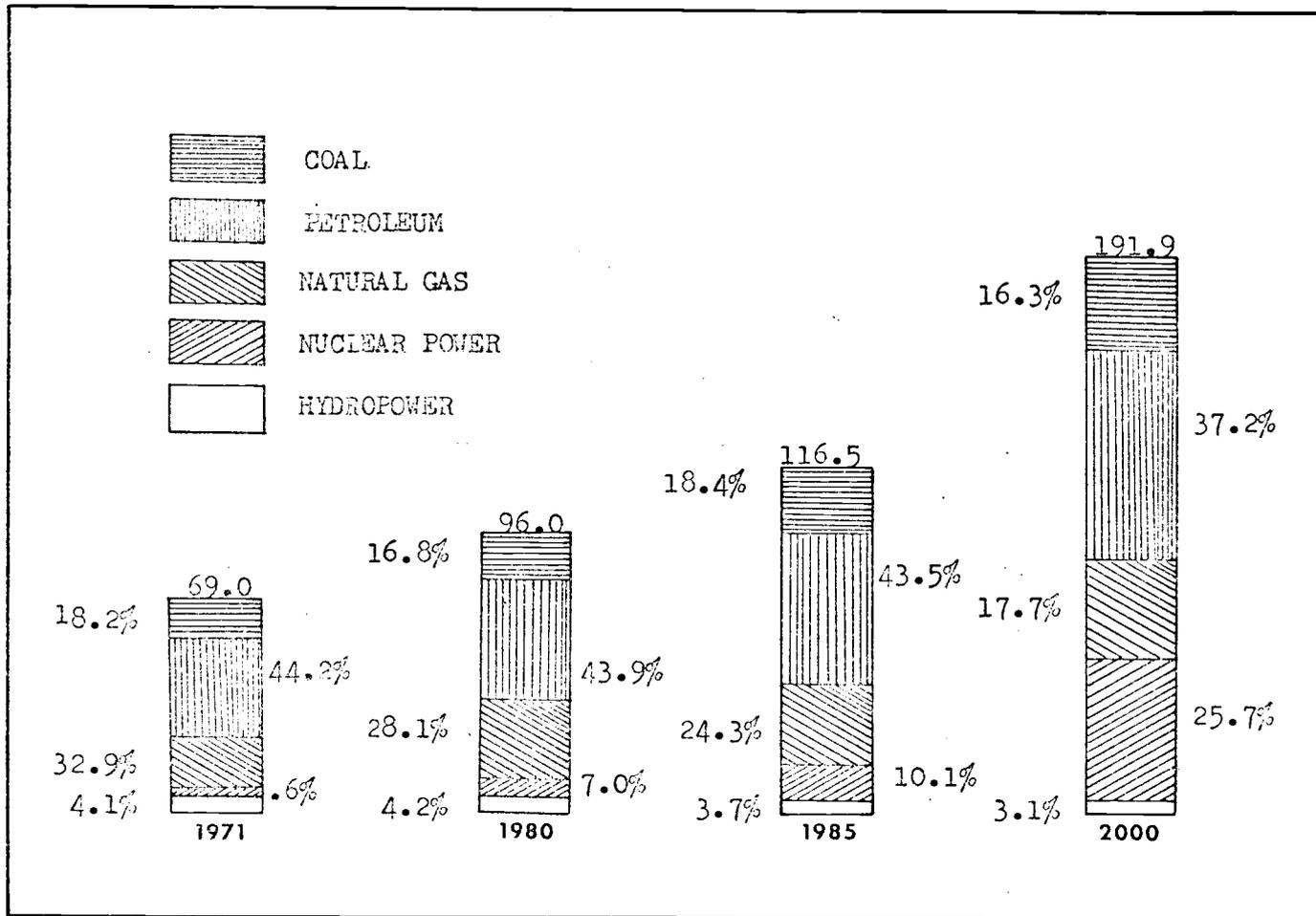
Even on a regional level the North Central Power Study, sponsored by the Bureau of Reclamation, estimated that in the ten state Northern Plains Rocky Mountain area there are "...proven reserves of coal adequate to supply well over 200,000 MW of thermal generation which is only a small part of the total resource potential."<sup>13</sup> In all, the preliminary NCPS study proposed to use 17 percent or 8 billion tons of an estimated resource of 46 billion tons of generally low sulfur coal deposits. It was also pointed out in this controversial preliminary study, that other coal conversion processes such as coal gasification are equally important in the long run development of coal resources. Although Figure 15 indicates only about 16 percent of the national power consumption in the year 2000 being coal, the approximately 55 percent listed as petroleum and natural gas, may in the future be derived from coal. Current technological capabilities regarding the gasification and liquification of coal may well make coal more of a "swing fuel"<sup>14</sup> than petroleum is believed to be.

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<sup>13</sup>North Central Power Study Coordinating Committee, North Central Power Study, Report of Phase I Volume 1, (Washington, D.C.: Bureau of Reclamation, [1971] ), p. 10.

<sup>14</sup>A fuel source available in sufficient quantities to fill the gaps between supply and demand for other fuels. (Source: Energy Crisis In America, p. 4).

Fig. 14 Estimated U.S. Power Consumption by Source  
(Quadrillion BTU's)



BTU: Quantity of heat required to raise temperature of one pound of water one degree Fahrenheit.

Source: U.S. Department of Interior "United States Energy Through The Year 2000" Energy Crisis In America, p. 5.

### Coal Conversion Technology

At the present time approximately five major coal conversion processes are being developed which range from an in situ type combustion of coal to produce coal gas to a process which is designed to produce both synthetic gas and liquid from solid coal. For example at Hanna, Wyoming, the U.S. Bureau of Mines has maintained combustion in a coal seam approximately 400 feet below the surface and collected a low BTU gas from an exhaust hole. Research is centered on making a cheap synthetic gas from which an eventual substitute for natural gas can be produced. Additionally, it is hoped that the synthetic gas derived from coal can also be utilized as a raw material for the manufacture of a variety of petroleum-associated products such as waxes and alcohols.

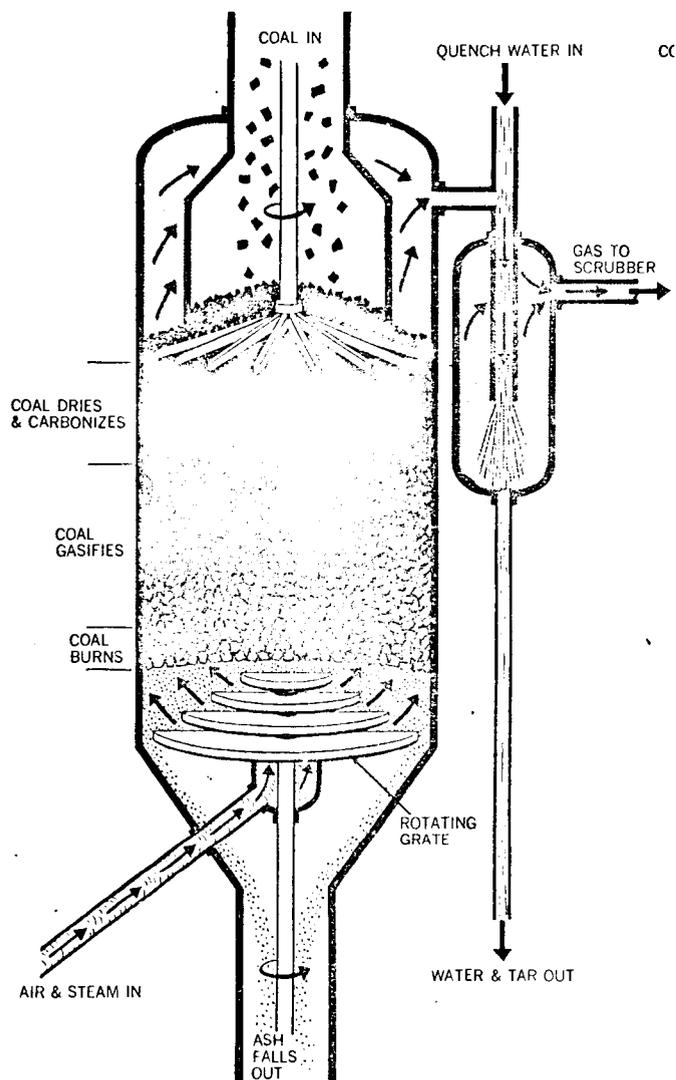
### Coal Gasification

Unfortunately, most of the processes produce a low BTU "power gas" which, when looked at in light of the high capital costs for plant and material requirements, is almost prohibitively expensive. Therefore, in order to produce higher quality lower cost gas a vital step, methanation, is utilized. In methanation the raw or power gas, composed of carbon dioxide, hydrogen, carbon monoxide and steam, is purified to remove any sulfur residue. Then the resulting gas is passed over a nickel catalyst which changes the ratio of hydrogen carbon monoxide and thus produces a methane gas. Although there is no full scale methanation plant in operation yet, four firms<sup>15</sup> are testing methanation from a Lurgi (see Figure 15) gas processing

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<sup>15</sup>Continental Oil; Lurgi; the British Gas Corporation; The American Gas Association.

Fig. 15 Lurgi Coal Gasifier



**LURGI** gasifiers, long used commercially in Europe, make low-Btu "power gas" suitable for electric-generator turbines. Coal dropped in the top gradually works its way down by gravity as it undergoes changes. Air and steam injected at bottom keep combustion going; gas leaves at top and is cleaned; unconsumed ash is shaken out by the grate.

plant operated by the Scottish Gas Board in Westfield, Scotland. In order to test the feasibility of using a commercial Lurgi gasifier and methanation on American coals, coal from Colstrip, Montana, has been shipped to the Scottish gasification plant. Early indicators are favorable in that synthetic natural gas has been produced and several U.S. companies subsequently announced plans to construct Lurgi-based coal gasification plants.<sup>16</sup> For example, Texaco Inc. which acquired 37,000 acres of coal with an estimated two billion tons of coal in the Lake DeSmet area of northeastern Wyoming, is planning a coal gasification/liquefaction plant on the shores of the lake.<sup>17</sup> It should be noted that low-BTU power gas can be utilized to produce electricity without any further processing. When burned and kept under high pressure the Lurgi-produced gas can spin gas turbines and still be hot enough to raise steam for conventional steam turbines.<sup>18</sup>

The Technological Expectations of Coal-fired  
Thermal-Electric Plants

MHD

Magneto hydrodynamics or MHD is an energy conversion system which turns heat into electricity by using a hot conducting gas.

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<sup>16</sup> Norman Metzger, "New Coal Technology - the Cinderella fuel comes out of the cellar," Popular Science Monthly, March 1974, pp. 83-85.

<sup>17</sup> "Texaco Will Build Wyoming Water Systems," The Denver Post, 30 May 1974, sec. E, p. E 75.

<sup>18</sup> Metzger, op. cit., p. 85.

Unlike other conventional generators which utilize an armature turned by steam or gas, an MHD generator uses a stream of very hot ionized gas "seeded" with metal particles to improve electrical conductivity (Figure 16). The advantages of MHD generators are that there are no moving parts, pollution rates are lower than conventional generators, and up to fifty percent more power can be produced from the same amount of fuel used by a conventional generator. The most efficient coal or oil burning electric plants operating at about 1000°F are only rated at about 40 percent efficient (60 percent is lost as waste heat). Nuclear power plants operating at even lower temperatures, are rated at only about 33 percent efficiency, while it is generally expected that MHD power plants will operate at around 60 percent efficiency. The extra efficiency of the MHD plant is due to its utilization of combustion gases directly which eliminates the wasted energy of making steam to turn a generator, and also by using hotter gases (about 5000°F).<sup>19</sup>

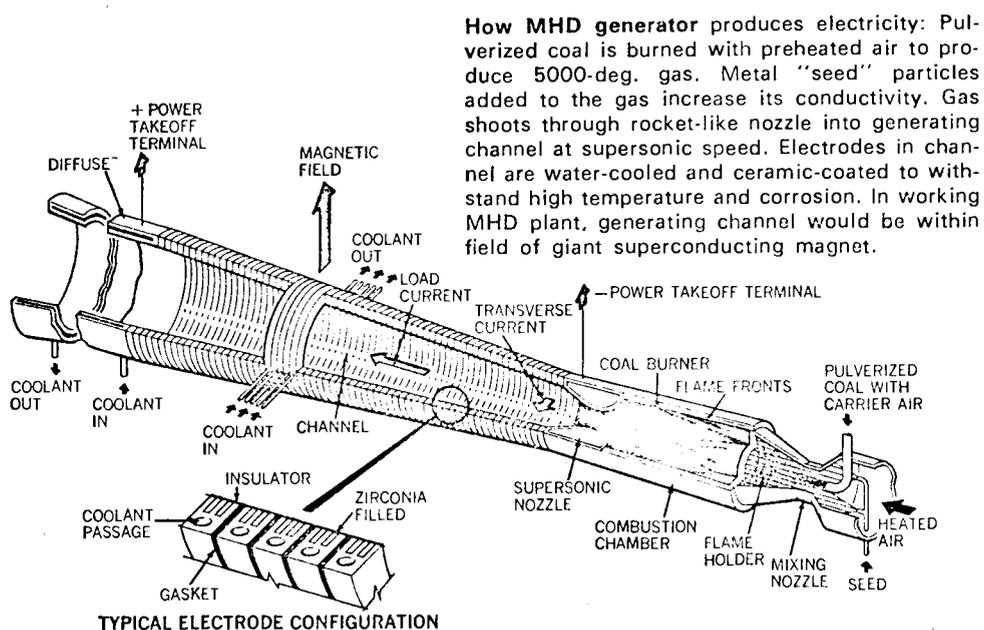
Although the MHD concept has been known since the early 19th century when Michael Faraday discovered the principle of the generator, very little work was done on its practical application until after World War II. Problems associated with the high operating temperatures had prevented its application to combustion gas plasma.<sup>20</sup>

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<sup>19</sup>Ibid., pp. 86-88.

<sup>20</sup>A gas in which the electrons have been stripped away from a large number of atoms which allows the gas to become a good conductor of electricity.

Fig. 16 MHD Generator



Source: Popular Science Monthly, March 1974, p. 86.

Currently there has not been much experience with MHD generators although 10 kilowatt generators have been run for a few hundred hours at a time, and MHD generators rated at the megawatt level have operated only a total of a few minutes. The world's largest operating MHD generator is in the Soviet Union where it is tied into a working power grid. The Soviet U-25 generator, located in a northern suburb of Moscow is designed to produce 25 megawatts but currently has been operated at a level of only four megawatts. With adequate funding for research on MHD (about \$8 million per year) it is projected that a 50 megawatt pilot plant could be in operation by 1976 and using the data and experience gained from such a pilot project a 1000 megawatt MHD plant could be operational by 1982.<sup>21</sup>

In a statement before the House Committee on Science And Astronautics, Dr. Arthur Kantrowitz, a pioneer in MHD research, noted that the implementation of MHD power plants can help supply great amounts of electric power as well as protecting the environment. In his plea for federal funding of MHD pilot plants Kantrowitz pointed out that the basic problems of physics have been solved and all that remains are relatively minor engineering problems. In his testimony Kantrowitz listed the advantages of MHD power generation:

1. An increase of approximately 50% in thermal efficiency and substantial reduction in generating costs over present methods of generating electricity.
2. Better utilization of our coal reserves, including those in water-scarce areas.

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<sup>21</sup>Ibid., pp. 88-148.

3. Optimum use of coal conversion technology also presently under development.

4. A technologically feasible and economically attractive method of removing almost all of the particulate matter and the nitrogen and sulphur pollutants before emission to the air, thus drastically reducing air pollution.

5. Elimination of the need for cooling water, thus resulting in no thermal pollution.<sup>22</sup>

The advantages of no thermal pollution in fuel-rich but relatively water-poor areas like Wyoming cannot be overemphasized. Because of the basic design of an MHD generator the need for cooling water as compared to a nuclear power plant can be reduced by about one fourth if used in conjunction with a supplemental steam turbine and totally eliminated if used with a supplemental gas turbine.

Already MHD power production costs compare favorably with conventional power production systems. In presenting the following comparative cost data Dr. Kantrowitz stated that:

...MHD offers unique opportunities for advancement and improvement in the very important area of energy conversion and power production without damage to the environment. It promises a much more effective utilization of our fuel and capital resources by the production of power at very low cost and with dramatic reduction in air and thermal pollution. Also, this new technology will be enhanced by utilization of developments in coal gasification and other coal conversion processes.<sup>23</sup>

That MHD already can compete with more conventional electric generation methods is amply illustrated by Table 14 which was presented to the House Committee.

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<sup>22</sup>U.S., Congress, House, Hearings Before The House Committee on Science And Astronautics, Energy Research And Development Hearings Before The Subcommittee On Science. (Testimony of Dr. Arthur Kantrowitz), 92nd Cong., 2nd sess. May 9,10,11,23,24,25 and 30, 1972, pp. 560-1.

<sup>23</sup>Ibid., p. 563.

TABLE 14 COMPARATIVE GENERATING COSTS  
OF THOUSAND MW NOMINAL POWER PLANTS

	Coal-Fired MHD		Conven- tional Steam	Nuclear (Present Technology)
	Early	Developed		
Efficiency (percent)	50	60	40	.33
Capital Cost (kilowatts)	\$165	\$125	\$175	\$230
Cost per Kilowatt-hours (mills)*	6.17	4.92	6.86	7.30
*Breakdown of Production Costs (Mills Per KW - HR)				
Capital Charges <sup>1</sup>	3.77	2.86	4.00	5.25
Fuel <sup>2</sup>	2.05	1.71	2.56	1.70
Operation & Maintenance	.30	.30	.30	.35 <sup>3</sup>
Seed	.05	.05	----	----
TOTAL COST	6.17	4.92	6.86	7.30

<sup>1</sup>Estimates based on 1971 U.S. dollars capitalized at 16percent and 80 percent plant capacity factor

<sup>2</sup>Fuel costs with coal at 7 dollars per ton

<sup>3</sup>Includes nuclear insurance

Source: Dr. Arthur Krantowitz, Director of AVCO Everett Research Laboratory, Everett, Mass. From a statement given to the Committee On Science And Astronautics, U.S. House of Representatives May 9-30, 1972. p. 563.

Political and Environmental Impacts  
On the Coal Industry

Coal and Taxes - Wyoming

In addition to a state excise tax of 3 percent, a gross production tax, also based upon the assessed valuation of the previous year's production is levied by the state of Wyoming. The tax is computed by the Wyoming Department of Revenue which fixes a cash market value at the mine on the coal (the assessed evaluation) and a levy is applied against that assessment. Although the levy varies between counties, the overall rate of revenue to the state from this tax will be increasingly greater as the market value, and thus the assessed value of Wyoming coal rises. Glass estimated that 1974 assessments for coal ran between two and five dollars per ton which is about double the assessed value of 1973. In terms of revenue the state of Wyoming might realize between 18 and 22 cents per ton from this production tax alone and when combined with the excise tax the state's revenue may well attain between 30 and 38 cents per ton. In 1972 those combined revenues were under 14 cents.<sup>24</sup>

Environmental Impacts

Although more than half of all coal mined in the United States today is strip-mined, almost 90 percent of the nation's coal reserves are too deep to be strip-mined. Of the estimated 118 billion tons of bituminous and subbituminous coal reserves only

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<sup>24</sup>Glass, 1974, op. cit., pp. 98-99.

about 38 percent or "...45 billion tons.. is appropriately termed a strippable reserve, available with existing technology."<sup>25</sup> In effect, as some individuals in the coal industry have indicated, "Mining technology is obsolete - all we've done is mechanize the pick and shovel."<sup>26</sup>

In addition to technological constraints on coal production, political and environmental influences have played a very significant role in the development of the coal industry on both a national and regional level. Table 15 is a duplication of Appendix B found in the U.S. Bureau of Mines Information Circular 8531 which summarizes the current laws and regulations concerning strip-mining on Federal lands.

In general, monetary penalties are more severe at the state level and the terms of enforcement are also more flexible at the state level. For example, the Soil Conservation Service, a federal agency, is tasked with developing replanting criteria in Wyoming. However, the Commissioner of Public Lands in Wyoming can determine the amount of land involved in strip mining operations.

#### Legislative Environmental Impacts - State Level

During a recent legislative session (1974) the Wyoming legislature passed an Environmental Quality Act which rescinded the 1969 Open Cut

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<sup>25</sup>U.S. Department of the Interior, Bureau of Mines, Strippable Reserves of Bituminous Coal and Lignite in the United States, (Washington, D.C.: Government Printing Office, 1971), p. 14.

<sup>26</sup>Metzger, op. cit., p. 83.

TABLE 15 SUMMARY OF STRIP-MINING LAWS IN THE UNITED STATES, BY STATES

A summary of the regulations governing surface mining  
on lands under the jurisdiction of the  
U.S. Government<sup>1</sup>

Law and date	Code of Federal Regulations. Title 43, Part 23, January 18, 1969, and Title 43, Part 3501. 1-4(b) (1), June 13, 1970. The Mineral Leasing Act of February 25, 1920 as amended and supplemented (30 U.S.C. 181-287), the Mineral Leasing Act for Acquired Lands (30 U.S.C. 351-359), and the Materials Act of July 31, 1947, as amended (30 U.S.C. 601-604).
Minerals subject to	All leasable or salable minerals owned by the U.S. Government
Regulating agency	The District Manager, Bureau of Land Management, in cooperation with the Federal agency having jurisdiction over the land, if appropriate, and in consultation with the Regional Mining Supervisor, U.S. Geological Survey, and, if necessary, in consultation with the Federal Water Quality Administration, and in consultation with the private owners of the surface rights, if appropriate.
Permit requirements:	
Basic Fee	Each application for permit, lease, or license must be accompanied by a service charge of \$10.
Additional	A minimum annual rental of 25 cents per acre for the first year, 50 cents per acre for the second through the fifth years, and \$1 per acre thereafter. Each permit may include up to 5,120 acres. An individual or corporation may hold up to 46,080 acres in permits or leases.

<sup>1</sup>Applies principally to Alaska, Arizona, California, Idaho, Montana, Nevada, New Mexico, North Dakota, Utah, Washington, and Wyoming.

Penalty for failure to comply	Failure of an operator to comply with the terms of a permit or lease shall be cause for the Mining Supervisor or District Manager to take action to cancel the permit or lease and forfeiture of bond.
Bond requirements: Minimum	\$2,000. In lieu of a performance bond, the operator may deposit cash or negotiable bonds of the U.S. Government.
Additional	The amount of the bond shall be sufficient to satisfy the reclamation requirements of an approved mining plan.
Reclamation requirements: Plan required	Yes, to be filed with the Mining Supervisor and outlining the mining operation and the measures to be taken to protect the environment and eliminate any hazards to health and safety.
Backfilling and grading	The mining plan shall show the proposed methods and timing of grading and backfilling of the areas affected by the mining operation. The mining plan is subject to review and approval by the Mining Supervisor or the District Manager. Mutual acceptance of a mining plan is binding on the part of the operator. The mining plan may be amended if warranted by unforeseen circumstances.
Replanting	If stipulated in the permit, lease, or contract, the mining plan shall show the method of preparing and fertilizing the soil, and the types and mixtures of grasses, shrubs or trees, and the amount per acre.
Substitution of lands permitted	No.

Mining and reclamation reports	Within 30 days of the end of each calendar year, or within 30 days of the cessation of operations, the operator shall file with the Mining Supervisor a description of the operation, including the area affected and the area reclaimed, the methods of reclamation and results, and the reclamation yet to be done.
Penalty for failure to reclaim Bond forfeiture	Yes, for failure to comply with the surface protection and reclamation aspects of an approved mining plan.
Denial of new permit	Yes, for forfeiture of bond unless the disturbed land has been subsequently reclaimed without cost to the Federal Government.

Source: U.S. Department of the Interior, Bureau of Mines, Strippable Reserves of Bituminous Coal and Lignite in the United States, (Washington, D.C.: Government Printing Office, 1971), pp. 122-3.

Reclamation Act and created a Department of Environmental Quality. Open pit mining operations are now controlled by the Division of Land Quality which is a branch of the Department of Environmental Quality. The Administrator, like his federal counterpart in the Environmental Protection Agency has been given a great deal of enforcement power. For example, the Land Quality Administrator can "...grant, deny or revoke mining permits and licenses..."<sup>27</sup> He is an enforcer of the state's mining laws and regulations as well as a collector of performance bonds by those who apply for mining permits. Currently the minimum application fee for any surface or underground mining activity is \$100 plus \$10 per acre up to a maximum of \$2,000. New state laws also require any applicant to provide legal and technical data concerning the proposed operations as well as the submission of a reclamation plan. Additionally, all applicants are required to advertise their permit intentions in public newspapers and to hold public hearings if any objections are aired.

New reclamation standards in Wyoming are much more rigorous than the old 1969 law. Much more emphasis is currently placed upon restoration of mined lands to include revegetation, reuse of topsoil, prevention of erosion, water pollution and landslides. Non-compliance with Wyoming's new reclamation rules can be very expensive. For example, penalties for non-willful violators can reach a maximum of \$10,000 per day while willful violators may be fined \$25,000 per day or one year's imprisonment, or both. Continued

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<sup>27</sup>Glass, 1974, op. cit., p. 97.

violation can lead to fines of \$50,000 per day and two years of imprisonment.<sup>28</sup>

In order to insure adherence to the new rules, the administrator's performance bonds are generally set at \$10,000 or \$200 per acre, whichever is greater. Since the mining operator has to file an estimate of their reclamation costs in advance, the administrator generally has enough prior knowledge to set the performance bonds high enough so that the state can reclaim the land itself if the bonds are forfeited.

At the conclusion of mining the administrator can recommend that the director [of Environmental Quality] return up to 75% of the bond. The remaining 25% or not less than \$10,000 is held for a minimum of five years to assure proper revegetation. As an additional precaution, the new act prohibits a company from mining in Wyoming if it ever forfeits a surety bond.<sup>29</sup>

#### Environmental Controversy - Federal Level

Although the state of Wyoming has outlined specific requirements for the backfilling and grading carried out on strip-mine lease lands the federal government is vague on this issue which has become the tip of the strip-mining iceberg at the federal level. Like an iceberg, the controversy and confusion as well as the great political and economic consequences of developing a comprehensive federal surface mine law are only partially perceived at the surface. Currently the focus of the struggle seems to be on two aspects involved with

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<sup>28</sup> Ibid., p. 98.

<sup>29</sup> Ibid.

strip mining coal; 1. the determination of which federal lands can be leased for the exploitation of their mineral deposits; 2. the type and degree of reclamation which shall be carried out on leased federal lands.

#### The EMARS Plan

Some of the broader aspects of the environmental issue and their specific interface with Wyoming's fuel base have previously been discussed. However, a relatively new and controversial environmental conflict specific to coal at a national scale should also be examined.

The U.S. Department of the Interior through the Bureau of Land Management plans to allow the issuance of new federal coal leases which have not been granted since 1971. The new coal leases would be implemented under a program known as the Energy Minerals Allocation Recommendation System (EMARS) which would offer publicly owned coal lands for lease. In the past private companies approached the federal government for permission to lease certain tracts of public land. Currently, since very little is known about the location and extent of federally owned mineral rights, the BLM is undertaking a mapping project which, it hopes, will more completely delineate the extent of coal resources found on federal lands. Proponents of the EMARS plan maintain that it will provide incentives for coal operators to move into a lease area quickly because one of the tentative provisions of the plan is to delay bonus bids for five years while allowing the coal operators credit against the unpaid portion with payment of the full royalty to the government in the

sixth year. Another planned incentive is the much discussed option of combining a coal lease on federal land to a ten year water rights purchase plan in cooperation with the Bureau of Reclamation. It is believed that water availability will encourage large companies to build coal gasification plants in areas where there are large coal deposits and adequate supplies of water.<sup>30</sup>

#### The Impacts of Environmental Factors

The environmentally oriented problems concerning the development of coal (and other mineral) resources on federal lands is a complex and unresolved conflict which the author has chosen to classify as an externality. Obviously the interface between the extraction of coal deposits and the environmental issues is great and as yet not thoroughly charted. The political and economic impacts resulting from the utilization of coal from federal lands are more clearly seen than some intangible factors which are still largely unmeasured. The irreversibility of certain decisions such as water use in relation to coal development are widely discussed but are not yet fully comprehended. The alterations of wildlife, soil, geologic and topographic characteristics are assumed but still largely unknown. The traumas associated with the human impact upon existant and developing communities in the coal rich areas have only recently begun to emerge as significant factors of a coal development plan for the western United States.

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<sup>30</sup>"Interior Department Reverses Policy, to Lease Coal Lands," The Denver Post, 1 January 1974, p. 22; and "Federal Coal Leasing Could Cause Traumas," The Denver Post, 29 May 1974, p. 28.

Air Quality Standards

In recognition of the conflict between increased demands for energy and clean air the Environmental Protection Agency has opted to modify existing federal air quality regulations. According to the EPA Current Laws for air,

The Administrator...shall publish proposed regulations prescribing a national primary ambient air quality standard and a national secondary ambient air quality for each air pollutant for which air quality criteria have been issued...Each State shall, after reasonable notice and public hearings, adopt and submit to the Administrator, within nine months after the promulgation of a national primary ambient air quality standard (or any revision thereof) under section 1857c-4 of this title for any air pollutant, a plan which provides for implementation, maintenance, and enforcement of such primary standard in each air quality control region (or portion thereof) within each State.<sup>31</sup>

Additionally, the current law requires that state air pollution control plans attain and implement primary national ambient standards within three years after the state plan has been approved by EPA. Though no specific time limit is set upon a state wishing to implement a national secondary ambient air quality standard the current laws specify "...a reasonable time at which such secondary standard will be attained."<sup>32</sup>

In an attempt to comply with national air pollution standards the Wyoming Public Service Commission promulgated rules which went into effect late in 1971. The rules state that powerplants larger than 10 megawatts must file an application a minimum of two years

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<sup>31</sup>United States Environmental Protection Agency, Current Laws Statutes and Executive Orders 1972, 1973, vol. 1 - Air p. 20, sec. 1857c-4 and 1857c-5.

<sup>32</sup>Ibid., sec. 1857c-5.

before construction begins. Smaller plants are constrained by a one year filing time and must present an acceptable plan for meeting Wyoming's air and water standards. Acting in conjunction with the Public Service Commission, the Wyoming Division of Health and Medical Services announced in December 1971 that it intended to reduce particulate emissions over 75 percent in order to comply with EPA primary air quality standards.<sup>33</sup> It may be added that an emission survey of Wyoming carried out in 1971 pinpointed coal combustion as a "...major source of NO<sub>x</sub> emissions..." in southwestern Wyoming and Fremont, Natrona and Converse counties. Significantly these areas are where coal is not only mined but burned in power plants such as the Naughton (710 MW) and Dave Johnston (750MW) power stations. The new 1500MW Jim Bridger plant is also being constructed in the affected region (Wyoming Intrastate Air Quality Control Region 243).<sup>34</sup>

#### Possible Modification of Standards

A problem also exists at the federal level (EPA) which has serious ramifications at the regional and state levels. The EPA has recently proposed that each state should select the level of air quality they are willing to tolerate. The problem is focused upon the national secondary air quality standards which already are

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<sup>33</sup>U.S. Department of the Interior, U.S. Bureau of Mines, Minerals Yearbook, 1971, 3 vols. (Washington, D.C.: U.S. Government Printing Office, 1973), vol. 1: Metals, Minerals, and Fuels, pp. 796-7.

<sup>34</sup>Raymond D. Fox, Harry V. Geary and Robert N. Swanson, Statewide Emission Inventory of Wyoming (Bedford, Massachusetts: GCA Corporation, [1971]), pp. 10-11.

far below the quality of air found in many areas of the western United States. Should EPA standards become more flexible, then stationary sources of pollution, such as power plants might be found to be more advantageously located at mine-mouth locations rather than shipping coal to market areas. Smith, for example, suggests that the most important factor determining where electric utilities will be located is total transport costs.<sup>35</sup>

Almost half of all the coal produced in Wyoming in 1971 (8 million tons) was used for electric power production within Wyoming. The other half was exported for electric power production in other states.<sup>36</sup> Modification of EPA rules may cause a shift in those statistics. Indeed, Smith has noted that water availability may decrease in importance as a locational factor relative to air and water pollution considerations.<sup>37</sup>

#### Summary

The degree of governmental impact upon the developmental patterns of Wyoming's coal resources has not been as great as that of petroleum. However, the situation is changing in response to the environmental disruption created by extensive surface coal mining. Chapter six was designed to illustrate that although Wyoming's

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<sup>35</sup>Bruce W. Smith, "Analysis Of The Location Of Coal-Fired Power Plants In The Eastern United States," Economic Geography 49 (July 1973): 249.

<sup>36</sup>Mining Informational Services, 1973 Keystone Coal Industry Manual (New York: McGraw-Hill, 1973), p. 568.

<sup>37</sup>Smith, op. cit., p. 249.

role as a supplier of coal is an old one, external factors such as technological capabilities and political-environmental considerations are rapidly changing the old patterns of coal development.

More emphasis has been placed upon current and future development problems associated with environmental and technological factors than an historical treatment of what has gone before. The town of Gillette for example, was singled out as a representative modern boom town in Wyoming which is expected to experience extensive coal development activity. The types of companies entering into coal development work in Wyoming are mostly national corporations with extensive experience in the petroleum industry.

One reason so much detail concerning the technology of coal combustion was included in this discussion was to illustrate that coal's future as a power source is still virtually unlimited. Already coal gasification processes can augment scarce natural gas supplies and magnetohydrodynamics can produce electricity from coal more efficiently than any other method presently available and at a competitive cost.

The environmental impacts of legislation at both federal and state levels of government is beginning to have a very important role in relation to further coal developmental plans in Wyoming. Although initially designed to provide social benefits they have also encouraged development of Wyoming coal fields. Restrictions such as those found in the Coal Mine Health and Safety Act were viewed as being much less significant by the coal companies strip mining coal in Wyoming. On the state level however, new and more stringent

laws regarding strip mining, reclamation, and tax payments have been implemented. Consequently future development plans of many coal companies interested in mining Wyoming coal will be dependent upon the settlement of controversies concerning energy development and environmental protection at the federal level of government.

As pointed out in the chapter, the ramifications of the interrelationships between technological capabilities, economic desirabilities and environmental preservation are not yet fully understood. Modification of environmental standards at the federal level will most certainly have an effect at the state level but to what degree or what the response of the local coal producers to such modifications would be cannot be clearly discerned.

## VII THE FEDERAL GOVERNMENT'S DEVELOPMENT AND PARTICIPATION

### ROLES IN THE URANIUM INDUSTRY

Under the Atomic Energy Act of 1946 a civilian run Atomic Energy Commission was created whose national policy was to be

...subject at all times to the paramount objective of assuring the common defense and security, the development and utilization of atomic energy shall, so far as practicable, be directed toward improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise, and promoting world peace.<sup>1</sup>

Eight years later another Atomic Energy Act was passed by Congress. The 1954 Act substantially amended the 1946 Act so that the federal government's monopolistic position in regard to civilian applications of atomic energy to electric power production was altered. In essence the Atomic Energy Act of 1954 recognized that conditions had changed so that it was obvious that greater private participation in power development was not necessarily a dangerous activity for the safety and health of society.<sup>2</sup>

Although the federal government's role in the domestic uranium industry as carried out under the aegis of the AEC has been reduced in some sectors it has certainly not been totally abandoned. With increasing interest on the part of government in the development of

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<sup>1</sup>U.S. Code Congressional And Administrative News, 93rd Cong., 1st sess., vol. 3 p. 4986.

<sup>2</sup>Ibid., pp. 4987-88.

fuel substitutions and energy conservation, the developmental role of the federal government has re-emerged at the forefront of atomic energy policy. Recently, Dr. Dixy Lee Ray, then chairman of the United States Atomic Energy Commission, urged President Nixon to "Expand the production of nuclear energy as rapidly as possible, first to supplement and later to replace fossil energy."<sup>3</sup> Almost one quarter of the AEC's 1973 Energy Research and Development Program recommended budget was for nuclear energy production. In all, the AEC recommended that the fiscal 1973 budget for nuclear research and development of power production (395.8 million) be increased over ten times for 1975-79 fiscal years.<sup>4</sup> Under the proposal submitted by the AEC, many facets of the peaceful use of atomic energy in the production of electric power would be investigated. Dry cooling towers (the Wyodak powerplant in Wyoming is a joint government-industry venture), fast breeder reactors and uranium enrichment processes were expected to provide the supply equivalent of 3.6 million barrels/day of oil.<sup>5</sup>

#### Nuclear Power Plant Development

By 1972 civilian U.S. electric companies were operating 24 nuclear power plants and had contracted for 110 additional plants to be built. In capital costs alone U.S. companies had almost

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<sup>3</sup>The Nation's Energy Future A Report To Richard M. Nixon President Of The United States, by Dr. Dixy Lee Ray, Chairman, United States Atomic Energy Commission (Washington, D.C.: Government Printing Office, 1973), p. vii.

<sup>4</sup>Ibid., p. 15.

<sup>5</sup>Ibid., p. 22.

\$31 billion invested which could easily be expanded to about \$158 billion if operating and fuel costs are projected for the expected 30 year life of an average nuclear power plant.<sup>6</sup> Clearly a substantial committment has already been made by non-federal electric power producers. In a cooperative effort with private industry the AEC has focused its efforts upon the development of a Liquid Metal Fast Breeder Reactor (LMFBR) which is scheduled to be in operation by 1980 and operated by the Tennessee Valley Authority. Combined federal/private finances of the proposed 300 to 500 MW reactor are expected to be in the area of about one half billion dollars.<sup>7</sup> Though top priority has been given to the LMFBR, the federal government, through auspices of the AEC, has long been involved with both the uranium and nuclear-based electric industry.

In further recognition of the changing economic environment regarding nuclear power production, Public Law 88-489 was passed in 1964 which allowed civilians to own special nuclear materials. However, the finishing phase of transforming raw material ( $U_3O_8$ ) into enriched uranium was still controlled by the AEC. Approximately five years later, in late 1969, President Nixon stated that the enrichment process of uranium carried out exclusively in the AEC's enrichment plants should also be handed over to the private power producers. Nixon was quoted as believing "...that the Federal

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<sup>6</sup>U.S., Congress, House, Hearings Before The Committee On Interior And Insular Affairs, Fuel And Energy Resources. 92nd Cong., 2nd sess., 1972, pp. 706-7.

<sup>7</sup>Ibid., pp. 710-12.

Government's responsibility for uranium enrichment as the owner-operator of the nation's only enrichment facilities eventually should be ended."<sup>8</sup> Currently the federal government still controls the enrichment processes although at least two private companies have entered into one stage of the uranium enrichment market.

### Governmental Control - Problems and Conflicts

#### Control of Source Material for Nuclear Energy

Traditionally the AEC has converted  $U_3O_8$  into uranium hexafluoride, ( $UF_6$ ) which is then sent to a gaseous diffusion plant where the U-235 isotope content is increased. Recently Kerr-McGee Corporation has built a plant in Oklahoma which can convert 5,000 tons of  $U_3O_8$  per year into  $UF_6$ . Allied Chemical Corporation also operates a  $UF_6$  plant outside Chicago which has a capacity of 10,000 tons per year. However, the gaseous enrichment process still remains under the control and operation of the AEC and herein lies a major problem as far as private industry is concerned, especially western uranium mining companies.

Although over 90 percent of the uranium reserves and production in the United States are located in the West, all the federal gaseous diffusion plants are located in the East. Unfortunately, the plants are located where power production costs are rising and demand for electric power in the consumer sector conflicts directly with the power requirements of the gaseous diffusion plants.

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<sup>8</sup>U.S. Code Congressional And Administrative News, op. cit., p. 5000.

The 2,000MW destined for the separation plants in 1970 needed to be reduced one third to permit New York and other eastern and midwestern areas to retain their grid voltages. By 1978, these three...separation plants<sup>9</sup> will be seeking 6,000MW.<sup>10</sup>

The paradoxical character of the situation is evident. On the one hand, nuclear power development is being encouraged, developed and funded by both government and industry in order to decrease the nation's reliance upon fossil-fueled power plants. On the other, the tremendous electrical energy requirements required to enrich  $UF_6$  into a useful atomic fuel currently must come from fossil-burning plants in the East. Additionally, up to one third of the total fuel costs for a nuclear power plant comes from the costs of enrichment. In 1970, for example, the average cost of power for the diffusion plants ran about 4 mills per kilowatt hour and was expected to rise yearly. In its 1973 Annual Report to Congress the AEC announced that it would automatically increase the enriching charges for its customers 1 percent every six months beginning 1 January 1974. The reason for the increase was to at least partially offset the cost increases foreseen for the future.<sup>11</sup>

#### Wyoming's Locational Advantage

It would seem reasonable, given the projected increases in nuclear power production, and the competing demands for electricity

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<sup>9</sup> Located at Oak Ridge, Tennessee; Paducah, K.Y.; Portsmouth, Ohio.

<sup>10</sup> Western Interstate Nuclear Board, Nuclear Energy In The West, (Lakewood, Colo.: Western Interstate Nuclear Board, 1971), pp. 8-9.

<sup>11</sup> U.S., Atomic Energy Commission, 1973 Annual Report to Congress, p. 97.

by the consumer market, that an ideal locational choice for an enrichment plant would be in an area of the country with reliable and low cost supplies of electric power. Wyoming is such an area. Already almost one third of all  $U_3O_8$  produced in the United States is accomplished in Wyoming where large deposits of low sulfur subbituminous coal are readily available for electric power production. Obviously factors which will determine whether or not new gas diffusion plants will be built will depend upon the development of breeder reactors (technology) and even the long-term growth of the electric energy market (economic factors). Like parquetry, each fuel source when seen in relation to the others, takes on a collective pattern which emerges as the overall consumption pattern of electric power. Even after twenty-five years of research and development nuclear energy provides only about one percent of the nation's total electric energy requirements. The input by nuclear fueled plants will be determined by two basic variables: 1. the rapid development of breeder reactors and 2. the amount of uranium reserves available.

#### Technical Capabilities of the Industry

When asked about the technical level of nuclear reactors, former AEC chairman Schlesinger admitted that only about 1 percent of the total energy contained in uranium was actually used by current light water atomic reactors. However, he quickly pointed out that the breeder reactors are expected to utilize 60 or 70 percent of the potential energy in a pound of uranium. The consequence of that statement was to figuratively expand the nation's uranium

resources 60 or 70 fold. Though Schlesinger freely admitted that the question of a long-run (beyond 20 years) supply of relatively low-cost uranium is "elusive" it is hoped that breeder reactors will be on line by 1980 and their characteristic of producing more fuel (plutonium) than they consume will answer the obvious question concerning the availability of uranium. Again the interdependence of elements which together determine the potential of nuclear energy programs becomes evident. Current reactors are generally inefficient converters of uranium fuel which, in turn, must be enriched through the use of large amounts of electric power. The status of fast breeder reactors is itself influenced by the rising cost of uranium which becomes more expensive as it becomes more scarce. The AEC is hoping that higher priced uranium will provide private companies the incentive they need to increase their efforts (in cooperation with the AEC) to develop fast breeder reactors before uranium supplies run out.

#### Uranium Ore Supplies

The problem of timing is very critical when the questions of uranium reserves are brought up. If fast breeder reactors are not on line by about 1980 there is a distinct possibility that the Atomic Energy Commission may have to import foreign uranium ores.

The AEC estimates that the 212 reactors operating in 1973 will require approximately 900,000 tons of  $U_3O_8$  during the course of their operational lifetime. According to the AEC's most recent report to Congress only 110,000 tons of uranium has been purchased by the electric utilities industry which indicates the likely

situation of a serious shortfall of uranium supplies. Current domestic uranium reserves at a recovery cost of 8 dollars per pound of  $U_3O_8$  are estimated to be only about 275,000 tons of  $U_3O_8$  even if the recovery cost rate were raised to 525,000 tons.<sup>12</sup>

Such estimates tend to give a certain amount of legitimacy to concern about the adequacy of uranium supplies. Again, the intricate linkage between diverse fuels and their impact upon electric power production begins to emerge. As uranium supplies become more scarce the price is likely to rise and might possibly aid in the development of fast breeder reactors. During testimony before the U.S. House Committee on Interior and Insular Affairs a member of Dr. Schlesinger's staff testified on the fast breeder program:

...the pressures from not only the plutonium production but from the rising cost of uranium will provide an incentive for the utilities to procure the liquid metal fast breeder. Therefore this incentive will be available in terms of use of recycle of plutonium in existing plants, and if we are indeed successful, the use of plutonium in the breeder. It is for this reason we are emphasizing breeder research and development so much at this time, in order to provide this option to the utilities in the early 1980's.<sup>13</sup>

However, one must wonder if the AEC really believes that adequate domestic supplies will ever be equal to the demand for uranium which is expected in the future. This comment is made in the light of a notice placed in the Federal Register by the AEC which announced that the agency was going to change the Atomic Energy Act of 1954 so that restrictions upon the importation and use of foreign

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<sup>12</sup>Ibid., p. 90.

<sup>13</sup>U.S., Congress, House, Hearings, op. cit., p. 718.

uranium ore would be dropped. Under the new plan 10 percent of the feedstock supplied to the AEC for enrichment could be of foreign origin by 1977. Each subsequent year would allow an increase in the percentage of foreign uranium to 15, 20, 30, 40, 60 and, by 1983, 80 percent would be allowed. After 1983 no restrictions of any kind would be placed on the amount of foreign uranium imported into the United States.<sup>14</sup> Until the AEC announcement was made, foreign uranium was not accepted by the AEC in their enrichment plants. The policy was instituted in order to protect the domestic industry but, as previously stated, the U.S. domestic uranium industry is no longer enjoying the protected market and guaranteed price supports once offered by the AEC. It is estimated that in 1974 uranium mining companies were planning to spend over 3.5 million dollars in foreign exploration projects with about 2/3 of the total expenditures located in Australia.<sup>15</sup> With foreign uranium entering the market place there may be at least an implied admission on the AEC's part that domestic suppliers of uranium will indeed be in a shortfall position long before the year 2000.

Regardless of the AEC's allowed importation of foreign uranium, approximately 87 percent of the nation's currently installed nuclear

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<sup>14</sup>U.S., Atomic Energy Commission, notice, "Restrictions On Enrichment Of Foreign Uranium For Domestic Use Notice of Proposed Modification," Federal Register 38, no. 227, 27 November 1973, 32595-6.

<sup>15</sup>U.S., Atomic Energy Commission, Grand Junction Office, Statistical Data Of The Uranium Industry (Grand Junction, Colo.: Lucius Pitkin Inc., 1974), p. 47.

capacity is still powered by uranium from the western states. Considering the likelihood that there will be a shortfall of uranium supplies (1972 and 1973 saw no significant net increases in national uranium reserves), the importation of foreign uranium may be one way to extend the uranium reserves of the western United States as well as encouragement for more exploratory drilling and mine development work. Although the rate of drilling has increased (16.4 million feet in 1973) the rate of discovery of 3.5 pounds of  $U_3O_8$  for every foot drilled is the same rate of discovery as 1968. If the discovery rate remains at the same level for an additional period of time the AEC estimates that over 60 million feet per year of exploratory drilling will have to take place as soon as 1980 to match supply with expected demand levels.<sup>16</sup>

#### Federal Regulatory Activities<sup>17</sup>

Concomitant with the federal government's activities which may or may not encourage the greater production levels of uranium

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<sup>16</sup>U.S. Atomic Energy 1973 Report to Congress, op. cit., pp. 90-91.

<sup>17</sup>The Energy Reorganization Act of 1974 was signed into law 11 September 1974 and with it came the abolishment of the present Atomic Energy Commission. In its place the Energy Research and Development Administration (ERDA) was created to take over the research and development activities of the AEC; the Office of Coal Research from the Department of the Interior; solar and geothermal research programs from the National Science Foundation; and alternative automotive power systems from EPA.

Another independent agency, the Nuclear Regulatory Commission (NRC) was also created which takes over all regulatory activities of the AEC. Included would be nuclear plant and material licensing and regulation and safety research programs relating to atomic energy. As stated in the Act the reorganization was completed by 8 February 1975.

required for future energy demands, is the broad spectrum of regulatory activities carried out by the AEC. Aside from the AEC's nuclear power licensing authority it also oversees all nuclear fuels and materials in categories such as radiopharmaceuticals and pacemakers for example, and the transportation of nuclear materials. As previously discussed, the AEC also regulates the processing of nuclear fuels which has a direct impact upon the nuclear power industry.

However, perhaps the most important and powerful influence upon the industry's development is found in the licensing process for nuclear power plants. It is the AEC's ability to bring nuclear plants into service which will have much to do with whether or not nuclear power plants will make a significant contribution to the nation's total electric energy production. In response to fossil fuel shortage problems and former President Nixon's urging, the AEC began a program to cut the leadtime required for nuclear plants to go on stream from 10 to about six years. Earlier selection of nuclear plant sites and standardization of plant design are expected to be the primary reasons for nuclear plant construction leadtime being shortened by four years. The licensing process itself is the best example of the overall control the AEC exercises in the power station site and its operation.<sup>18</sup>

Recently the federal presence in the nuclear materials program has been reduced through the formation of AEC Agreement States.

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<sup>18</sup>Ibid., pp. 1-10.

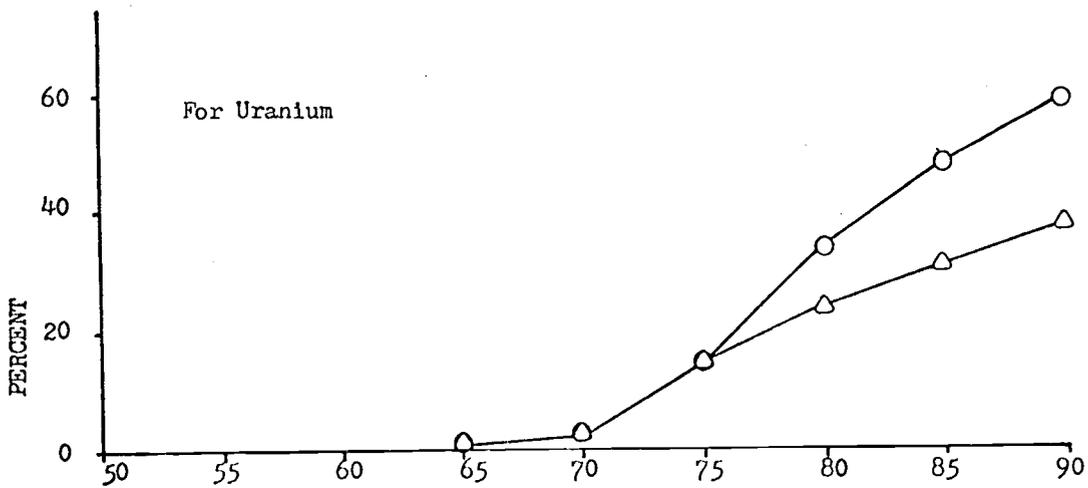
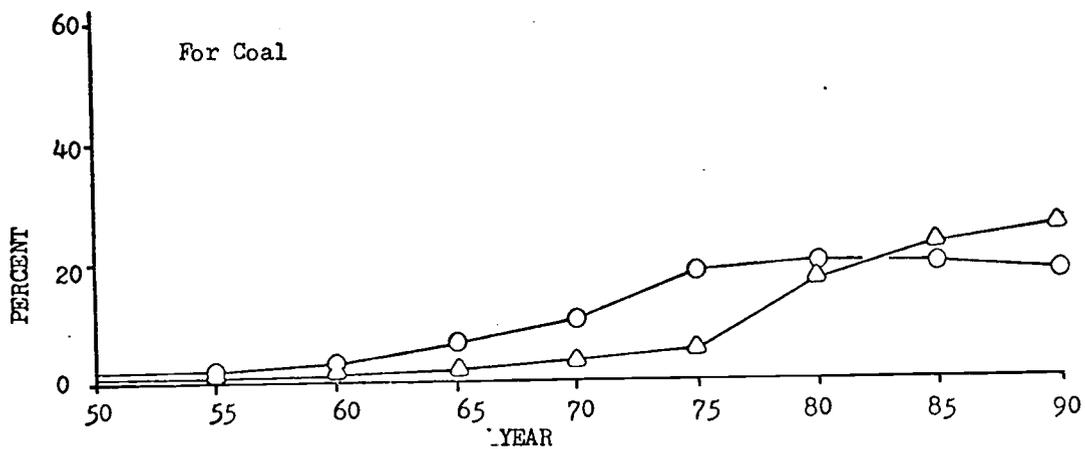
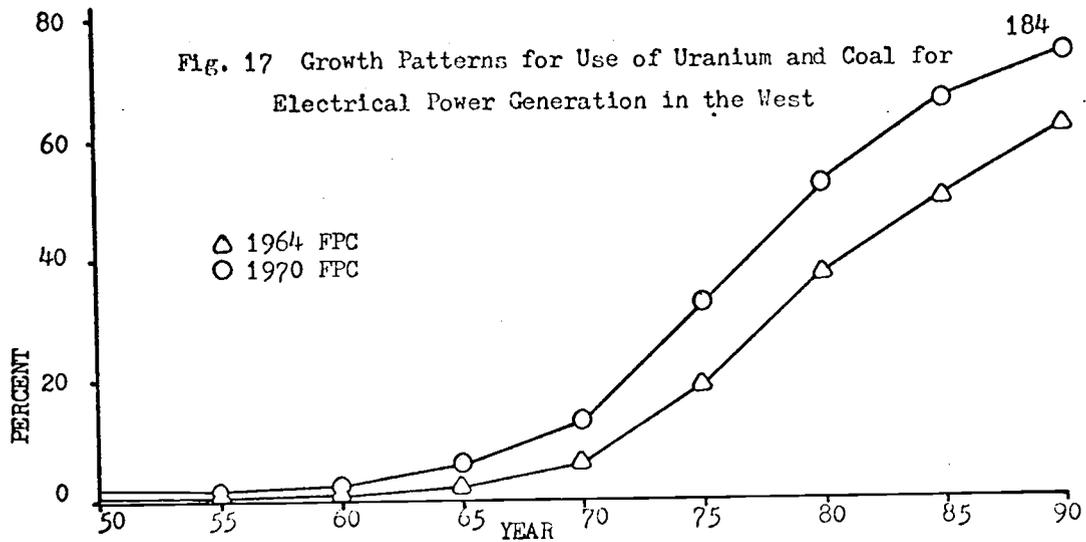
Under the provisions of Section 274 of the Atomic Energy Act, states may be granted regulatory authority over certain types of nuclear materials. As of 1973, 24 states had signed nuclear materials management agreements with the AEC and under AEC auspices actually granted more licenses than the AEC during 1973. Under the Agreement program the AEC provides technical assistance, and employee training both at an informal and formal level. Of the states in the Rocky Mountain region only Colorado and Idaho are Agreement members which means that in the non-agreement states the AEC must directly monitor and license all nuclear materials within the borders of those states.<sup>19</sup>

#### The Status of Western States in Nuclear Plant Development

As previously mentioned, the federal government has been the prime mover and responsible agent in the establishment of the domestic uranium industry in both its early protected market period and more recent independent market status. The short term future of the uranium industry appears to be contingent upon the development of the fast breeder reactors which should make nuclear-based electric power the important fuel source it has always been predicted to become. In the western states predicted growth patterns for uranium use in the production of electric power are at a critical point in that it is expected that the predicted 16 percent of power produced by nuclear energy in 1973 can increase to almost 60 percent by 1990 (see Figure 17). It should also be noted that only four states, Alaska, Montana, New Mexico and Wyoming produce more energy

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<sup>19</sup>Ibid., pp. 37-8.



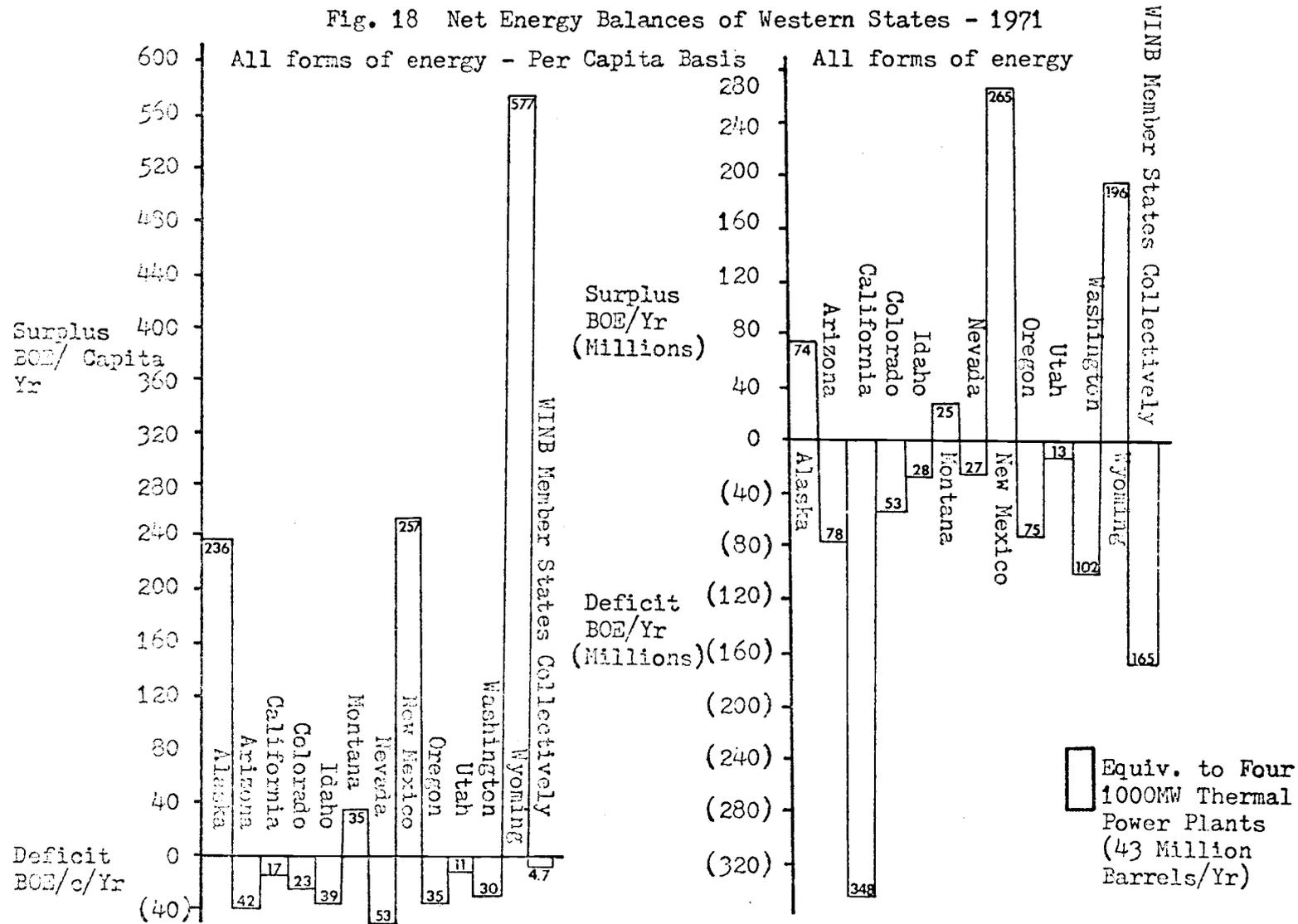
Source: Energy Resource Development for the West, p. 18.

every year than they consume (see Figure 18). In the case of Wyoming, considerable uranium reserves represent an important portion of the state's energy base.

However, as one can see from Table 16 there are only four operating nuclear power stations in all of the West and none are located in Wyoming. Traditionally one of the primary factors in explaining the total absence of nuclear power plants in a state such as Wyoming would be the availability of only limited amounts of coolant water. However, recent developments in dry cooling towers as exemplified by the Neil Simpson Plant (coal-fired) near Gillette have largely made the coolant water constraint an overstatement. Still there are no nuclear plants scheduled for construction in Wyoming for the foreseeable future. Instead the state remains a leading producer of uranium and  $U_3O_8$ .

Wyoming's role has traditionally been one of considerable importance and as Figure 19 indicates, Wyoming has ranked second only to New Mexico during a ten year period of production. Recently, however, the role of Wyoming's uranium resources seems to be taking on additional importance as evidenced by increased production levels (Table 17) and the very high level of uranium land holding relative to other states in the West (Table 18). As one can see from Table 17 heavy investment in terms of land acquisition has been carried out in the 1971-74 period. With approximately 32 percent of the nation's uranium ore processing capacity already located in Wyoming, one can better appreciate the great expansion in uranium land holdings.

Fig. 18 Net Energy Balances of Western States - 1971



Source: Energy Resource Development for the West, p. 19.

TABLE 16 EXISTING AND SCHEDULED NUCLEAR POWER PLANTS IN THE WINB  
MEMBER STATES

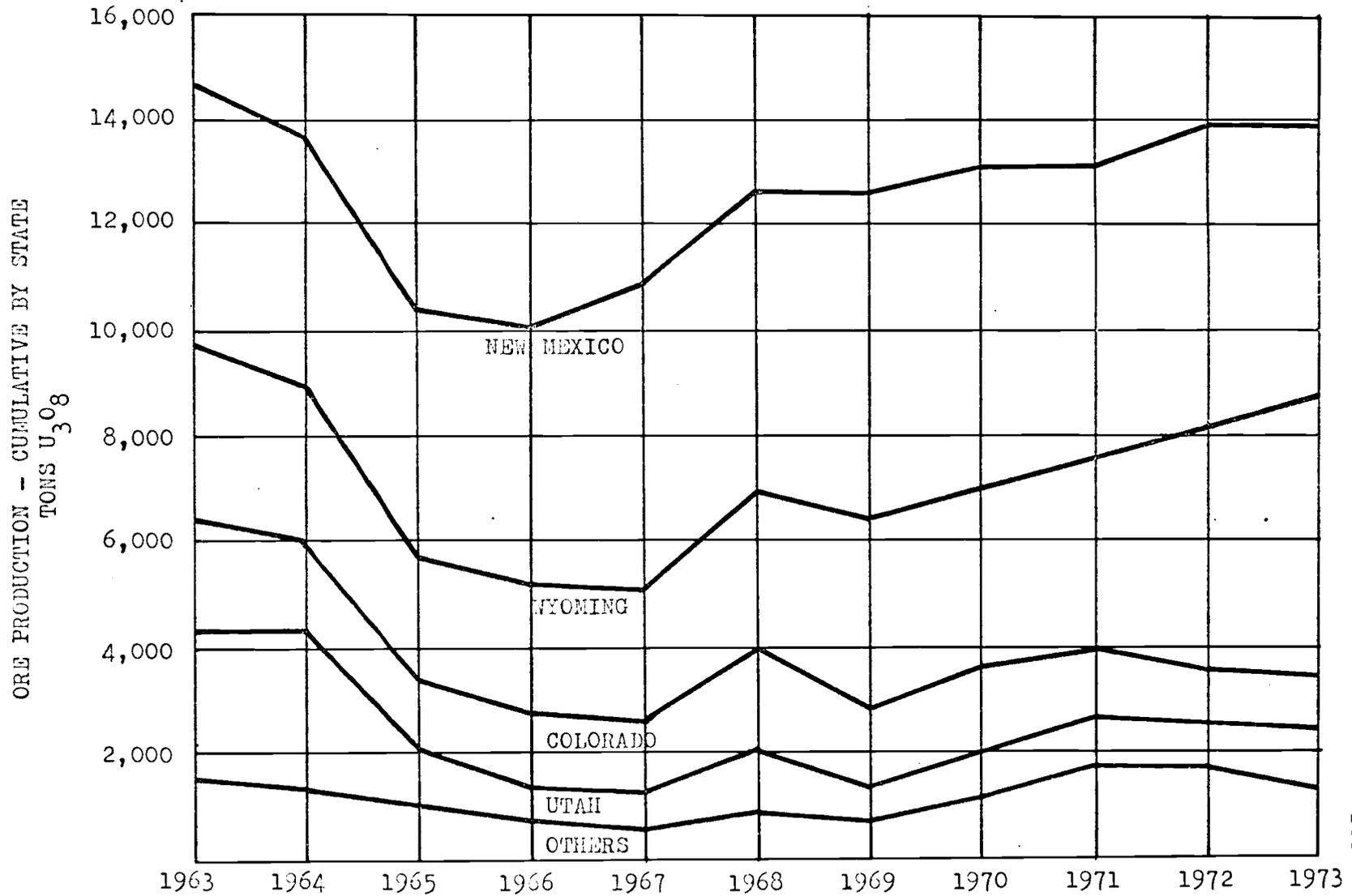
Existing

	<u>Name</u>	<u>Rating (Net. Electric)</u>	<u>State</u>
1963	Humboldt	68	California
1966	Hanford No. 1	800	Washington
1967	San Onofre No. 1	430	California
1973	Ft. St. Vrain	<u>330</u>	Colorado
	Sub-total	1298	

Planned

Jul. 1974	Rancho Seco No. 1	913	California
Sept. 1975	Diablo Canyon No. 1	1084	California
Jul. 1975	Trojan	1130	Oregon
June 1976	Diablo Canyon No. 2	1106	California
Sept. 1977	Hanford No. 2	1100	Washington
Sept. 1980	San Onofre No. 2	1140	California
Sept. 1980	Hanford No. 1	406(Rerate)	Washington
Sept. 1980	Boardman No. 1	1150	Oregon
June 1981	Arizona	1260	Arizona
Sept. 1981	WPPSS No. 3	1240	Washington
Dec. 1981	Wan Onofre No. 3	1140	California
June 1982	HTGR No. 1	770	California
July 1982	Skagit	<u>1200</u>	Washington
	Sub-total	13,969 MW	
	Total	15,265 MW	

Fig. 19 Uranium Ore Production By States  
1963 Through 1973



Source: Statistical Data of the Uranium Industry, p. 15.

TABLE 17 URANIUM CONCENTRATE PRODUCTION BY STATEIn Tons of  $U_3O_8$ 

Calendar Year	Colorado	New Mexico	Wyoming	Others <sup>1/</sup>	Total
1966	1,423	5,076	2,248	1,842	10,589
1967	1,340	5,933	2,667	1,313	11,253
1968	1,614	6,192	2,873	1,689	12,368
1969	1,678	5,943	3,063	925	11,609
1970	<u>1/</u>	5,771	3,654	3,480	12,905
1971	<u>1/</u>	5,305	3,487	3,481	12,273
1972	<u>1/</u>	5,464	4,216	3,220	12,900
1973	<u>1/</u>	4,634	5,159	3,442	13,235

<sup>1/</sup> Data included in "Others" category when state production is from less than three companies. States included in this category for one or more years are: Arizona, Colorado, South Dakota, Texas, Utah and Washington.

Source: Statistical Data of the Uranium Industry, p. 64.

TABLE 18. ACRES HELD FOR URANIUM MINING AND EXPLORATION  
(in thousands of acres)

State	<u>DISTRIBUTION BY STATES</u>					
	1/1/66	1/1/71	1/1/72	1/1/73	10/1/73	1/1/74
Arizona	2	221	231	486	486	754
California	6	436	450	491	528	587
Colorado	213	1,959	1,315	1,123	1,188	1,291
Idaho		21	24	34	34	34
Montana		386	349	324	319	380
Nevada		250	250	250	263	264
New Mexico	137	4,717	4,119	3,109	3,133	3,158
North Dakota						100
Oregon			5	30	31	31
South Dakota		276	237	224	224	81
Texas	34	1,079	899	641	630	641
Utah	113	3,640	2,420	2,602	2,787	2,783
Washington		398	113	88	72	72
Wyoming	226	11,023	8,575	8,275	8,557	8,598
Total	731	24,406	19,007	17,677	18,252	18,774

Source: Statistical Data of the Uranium Industry, p. 52

### The Interrelationship of Coal and Nuclear Power

Rather than nuclear plant construction, it seems likely that the abundant coal reserves found in Wyoming will make it more feasible to expect uranium fuel enrichment/diffusion plants to be built. Because of the heavy electric power demands of the diffusion plants, as previously discussed, and the certain growing need for more nuclear fuel, the symbiotic relationship between coal and uranium will probably increase in Wyoming. In short, the replacement of fossil fueled power plants by nuclear powered facilities is contingent upon power production from fossil fuels. The implications for both the coal and uranium industries in Wyoming are great because both fuel resources are so interdependent in Wyoming. A controversy already exists over whether or not Wyoming's coal resources should be burned within the state's boundaries to produce large amounts of electric power which can either be exported as coal by wire through the "Western Loop" power grid system, or utilized within Wyoming to supply power to uranium diffusion plants which could be located in Wyoming.

The current patterns of utilization of Wyoming coals reflect the movement of fuels to the market areas which traditionally lie outside the boundaries of Wyoming. Although mechanisms external to the site factors namely, the passage of the Clean Air Act and the Mine Safety Act, have proven to be profitable motivating forces which move Wyoming coal out of the state as coal, the characteristics of those externalities can change in a relatively short period of time. For example, the conquering of some engineering difficulties

may make coal with higher sulfur content closer to the consumption points much more competitive, as it traditionally has been, than low sulfur coal from Wyoming hauled to distant markets by unit trains. Coupled with this possibility is the likelihood that the Clean Air Act restrictions on sulfur emissions may be relaxed by the EPA. With considerable capital investments in coal-mining activities, coal might be burned within Wyoming to sell to customers as electric power rather than coal. If that contingency were to occur it would not make a significant difference if the customers were uranium diffusion plants in the Shirley Basin, or utilities companies lighting the streets of various urban areas.

Thus the implications of future development within Wyoming of both the coal and uranium industries are inexorably related to decisions made at the state and federal levels on factors external to the mere location of the fuel reserves. These decisions would be concerned with land ownership rights especially upon Homestead Act and Public Lands, upon the degree of air pollution to be deemed desirable in the light of economic needs and aesthetic desires. They would also display a greater or lesser impact upon the development of Wyoming's fuel resources as questions such as reclamation policies and additional safety regulations for strip miners are considered. Finally, basic philosophic questions such as the possibility of a no-growth policy of economic planning will have to be addressed at both the federal and state levels of government before even tentative decisions regarding Wyoming's role as a national "fuel pool" can be made.

### Summary

No fuel resource has been developed and utilized under more governmental control and scrutiny than uranium. As previously discussed, the uranium industry was largely conceived and supported by the federal government after World War II. However, since nuclear power derived from uranium fuels has been so highly publicized as the ultimate replacement power source for fossil fuels, a great deal of attention and controversy regarding its future development has occurred. Consequently the extent of federal governmental participation, especially in terms of regulatory controls ranging from the leasing of uranium lands to the licensing authority of nuclear power plants, deserved an inquiry.

Energy shortages on a national level are beginning to force changes in federal governmental activities concerned with the uranium and nuclear power industries. The federal government is actively attempting to speed the development of new breeder atomic reactors which can produce fuel as well as consume it. Control of the source materials of nuclear energy through the enrichment process is changing due, in part, to reassessments by the government and a shortage of electrical power for the uranium enrichment process. In response to a possible uranium shortage the federal government has also, in effect, abrogated its protective role in the domestic uranium industry by allowing increasing amounts of foreign ore to be imported into the United States.

The strong degree of interconnectivity between fossil fuel-fired electric plants and the development of their nuclear-fired

replacements was emphasized in this discussion to illustrate the particular locational advantage of Wyoming. With abundant coal resources, much of the nation's uranium ore supplies, and low consumer demands for electric power, Wyoming would seem to be one of the most logical choices for uranium enrichment plants. That this development has not occurred is due almost entirely to an external factor, governmental policy, rather than geographic or economic circumstances.

The impact of governmental factors has been particularly stressed in the preceding chapter because of their traditional overwhelming presence in the industry. Governmental decisions have alternately acted as a triggering device and a retardant to the developmental history of the uranium industry even at a state level. It is certain that the role of government is changing in relation to the degree and direction of guidance it has provided the industry. However, perhaps more than any other time the level of controversy and challenges regarding the overall development policies of nuclear energy have reached a critical point. Basic philosophic and economic questions have been raised which, at this point, have no easy or clear answers.

### VIII SPATIAL PATTERNS OF FUEL RESOURCE DEVELOPMENT

Up to this point much emphasis has been placed upon the external factors and their apparent impact upon the developmental patterns of the fuels selected for this study. The following section however, is oriented toward examining the historic and current spatial characteristics of production patterns. Coal, petroleum, and natural gas are chosen for analysis to illustrate the two selected characteristics. Coal's patterns of production and transportation are examined as is the distributive pipeline network of petroleum and natural gas. Additionally, methods of land acquisition and physical and non-physical restrictions placed upon the production of coal are introduced.

#### The Impact of Mineral Leases on Public Lands in Wyoming

Public land statistics reveal that over 48 percent of all the land acreage of Wyoming is owned outright by the federal government.<sup>1</sup> Historically, as Table 19 indicates, Wyoming's rank in terms of patents on public lands has been first in the nation. The fact that 41 percent of all federally owned land in the state and fully 20 percent of the state's entire acreage has been involved with mineral leasing lends credence to any statement pointing out the important role of minerals in Wyoming's development. Traditionally, coal

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<sup>1</sup>U.S., Department of the Interior, Bureau of Land Management, Public Land Statistics - 1972, p. 10.

TABLE 19 PATENTS ISSUED WITH MINERALS RESERVED TO THE UNITED STATES, THROUGH 1972

State	Type of mineral reservation						
	All minerals	Coal	Oil and Gas	Phosphosphate	Oil and Gas plus other minerals	Miscellaneous minerals and combinations	Total
Through 1948	acres	acres	acres	acres	acres	acres	acres
Alaska	6,501	10,823	1,095		773		19,192
Alabama	4,412	63,586	9,563		2,889		80,450
Arizona	2,547,517	4,403	27,497			101,880	2,681,297
Arkansas	1,107	1,520	15,043	85	40		17,795
California	2,352,070	3,005	156,783		23	1,864	2,513,745
Colorado	4,271,042	1,348,288	215,423		38,494		5,873,247
Florida	1,154		2,304	71,259	520		75,237
Idaho	1,291,163	11,749	4,940	270,036	216,060		1,793,948
Illinois	634	120					754
Iowa	359						359
Kansas	54,384		1,421				55,805
Louisiana	1,223		17,105		3,844		22,172
Michigan	1,935		3,261				5,196
Minnesota	235			8			243
Mississippi	974		10,231				11,205
Missouri	166						166
Montana	3,993,640	6,658,554	987,472	11,290	17,788	150	11,668,894
Nebraska	72,964		3,253				76,217
Nevada	242,717	960	1,119		80	40	244,916
New Mexico	6,378,118	614,779	112,995	680	70,673	2,092,091	9,269,336
North Dakota	134,578	4,636,851	11,915		1,164	40	4,784,548
Ohio	38					744	782
Oklahoma	48,781		10,917				59,698
Oregon	1,639,742	5,598	14,369		480		1,660,189
South Dakota	1,565,802	187,722	6,328				1,759,852
Utah	856,083	215,528	98,922	21,576	8,157	1,680	1,201,946
Washington	262,444	14,535	2,518		384	400	280,281
Wisconsin	1,546						1,546
Wyoming	9,541,179	2,297,363	376,906	32,037	17,341	257	12,265,083

Source: Public Land Statistics, Bureau of Land Management, 1972, Table VI p. 1.

leases have constituted the largest amount of public land, in terms of acreage, committed to specific mineral exploitation (19 percent through 1948). There is no reason to assume that the pattern has been altered greatly in the 1948-1972 period. However, mere acreage figures belie the value of the mineral produced. Thus, even in 1972 oil and gas leases produced more revenue for the state and federal governments than coal leases.

For example, during 1972 approximately 80.8 million barrels of petroleum were produced on public lands in Wyoming while slightly over 2.8 million tons of coal were produced during the same period. Assuming very conservative prices of \$5 per barrel and \$3 per ton of coal (F.O.B. mine) the respective market values are over \$400 million for petroleum and only \$8.4 million for coal.<sup>2</sup> If the more realistic 1973 prices of \$12 per barrel and \$7 per ton (F.O.B. mine) were considered the resulting figures would be enormous. During the year 1972 alone \$12.26 was received in bonuses<sup>3</sup> for each acre of public land leased for gas and oil on the 40 competitive mineral leases granted by the Bureau of Land Management.<sup>4</sup>

#### Coal Leasing on Public Lands

The acquisition of public lands for mineral fuel development through various leasing arrangements has been previously discussed (see Chapter IV) but the competitive bidding system will be re-

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<sup>2</sup>Actual Department of Interior figures show a value of \$10.5 million for 1972.

<sup>3</sup>The cash consideration paid to the United States by the successful bidder for a mineral lease such payment being made in addition to the rent and royalty obligations specified in the lease.

<sup>4</sup>Ibid., p. 113.

examined. Walter Mead's work with petroleum leasing in offshore tracts in the Gulf of Mexico indicated that the competitive bidding system was affected by several variables which influenced the outcome of the leasing permit. Among the variables examined by Mead were the size of the bidding companies (either one of the largest 8 oil producers or a smaller producer), the size of the potential lease tract, the value of oil production from the awarded lease through time, and the depth of the water. Several hypothesis were tested, among which included a high winning bid value when there were many joint bidders from large firms; the tract was in a highly productive area and the water was shallow. Mead's investigation showed that the most important variable which related to the winning bid was the number of bidders on the tract.

As a consequence of Mead's inquiry into competitive leasing in the petroleum industry the author hypothesized that the same types of factors may also be functionally important in the leasing of public coal lands in Wyoming which are subjected to competitive bidding. Accordingly, coal lease data were obtained from the Bureau of Land Management files in Cheyenne, Wyoming and an initial frequency distribution of the number of bidders per coal tract was constructed. The results showed that only 30 percent of the tracts leased through the competitive bidding process had three or more bidders. A comparable figure of 27 percent was obtained by Mead for oil leases in the Rocky Mountain area. In an attempt to determine which factors seemed to be most important in determining the high bid on public coal lands (which ranged from \$505 per acre to \$1.00 per acre) a step-wise regression procedure was chosen.

Coal Lease Analysis

Thirty leases in the BLM files were bid on since approximately 1954 which limited the value of the analysis somewhat but still proved to be a workable n size for the statistical procedure. The dependent variable (y) was the high bid on the tract while the following six independent (x) variables were considered: 1. the size of the bidder in which a value of 10 was given to any bidder who was one of the top twenty-five oil producers or top 10 coal producers; 2. a bidder who did not meet the above criteria was given a value of zero and thus was able to drop out of the equation; 3. the total production from the lease from the time the lease was granted (in tons); 4. the time (in months), that the lease was held; 5. the size of the lease tract in acres; 6. the number of bidders on the lease.

One of the advantages to the stepwise regression procedure is that any variable which does not make a significant contribution to the regression model is removed and the process is continued until no more variables are admitted or are rejected.<sup>5</sup> Thus the process provides a judgment of the contribution of each variable introduced into the model. The results show that the most important factor contributing to a high lease bid was the number of bidders, with the size of the large companies being the next most important factor.<sup>6</sup> The findings seem to be similar to Head's analysis of oil

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<sup>5</sup>N.R. Draper and H. Smith, Applied Regression Analysis, (New York: John Wiley & Sons, Inc., 1966), p. 171.

<sup>6</sup>The coefficients of determination ( $R^2$ ) were number of bidders, Var. 7, (.53658); top 25 producers, Var. 2, (.17254); acres in lease, Var. 6, (.03243); total production, Var. 4 (.02016); time held, Var. 5, (.00724); all other bidders smaller than top 25, Var. 3, (.00076). In all the model accounted for almost 77 percent of the total variability in the high bid.

lease bidding and certain interesting characteristics of both a spatial and economic nature emerge from such analyses.

Initially the wide range of bids for public coal lands indicates that the greater the number of bidders involved with the lease the more likely the price (or the perceived value) of the lease will increase. The present competitive bidding system is designed so that an increased number of bidders will raise the lease bid level and early production of coal will follow. Unfortunately, just the opposite has occurred. High bids of over \$500 and \$400 per acre by large petroleum companies such as Sun Oil and Mobil have resulted in absolutely no coal production to date. The two examples cited have been held for 5.6 and 5.7 years respectively<sup>7</sup> and there are no immediate plans to mine coal in the future. On the other hand, coal has been produced by smaller corporations on leases which have ranged from \$1.00 per acre to \$257 per acre. These data may indicate that the production incentives of the competitive lease bidding system may not be very effective (only 6 of 30 leases have been coal producers) and may in part explain the Department of Interior moratorium on coal leasing since late 1971. It is suggested that the lack of development of coal leases, perhaps for speculative reasons, is an important reciprocal consideration of the more prominent environmentally disruptive elements of exploited coal deposits.

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<sup>7</sup>Bureau of Land Management Coal Lease data; U.S.G.S. correspondence with regional offices.

A Consideration of Some Physical Constraints  
Upon Fuel Development

In terms of the disruptive aspects of mining a recent report from the Bureau of Mines indicates that only 3.6 million acres or 0.16 percent of the nation's total land area has been used for mining.<sup>8</sup> As a contrast the report also estimated that the land utilized for railroads and airports in 1971 roughly equaled the acreage used for mining activities in the 1930-71 period. In comparison the total acreage underlain by highways on a national level was almost 23 million acres.<sup>9</sup> Because most coal and uranium production in Wyoming is from surface mining operations and will probably be surface mined in the foreseeable future, a considerable amount of land is assumed to be affected by mining activities in the state. For example, even after more than a century of mining it is estimated that approximately 99.4 percent of Wyoming's coal reserves are still untouched.<sup>10</sup>

A recent environmental impact statement developed by the Bureau of Land Management, U.S. Forest Service, U.S. Geological Survey and the Interstate Commerce Commission<sup>11</sup> indicates that

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<sup>8</sup>James Paone, John L. Morning and Leo Giorgetti, Land Utilization and Reclamation in the Mining Industry, 1930-1971 (Washington, D.C.: U.S. Government Printing Office, 1974), p. 1.

<sup>9</sup>Mining Congress Journal, "Mining Newsmoth", August 1974, p. 5.

<sup>10</sup>Gary B. Glass, "Wyoming", Coal Age, Western Coal Edition, Mid-April 1973, p. 193.

<sup>11</sup>U.S., Department of the Interior, Bureau of Land Management, U.S. Geological Survey, Interstate Commerce Commission, Draft Environmental Impact Statement, Development of Coal Resources in the Eastern Powder River Coal Basin, Vol. 2, pt. 1, pp. 459-60.

great changes are forthcoming for the Powder River Basin of Wyoming. By 1990 an additional 150 miles of railroad, 225 miles of powerlines, 30 miles of coal slurry pipeline and at least 24 additional miles of roads are all expected to be constructed in the area. The impact statement which was done as a cooperative project by several federal agencies will be drawn upon to illustrate some of the constraints that many fuel rich areas of Wyoming might encounter. Although the Impact Statement is concerned only with coal development, the author believes that some of the same constraints, especially their spatial component, can also be applied to the other four fuels previously mentioned in this dissertation. The Impact Statement appears to be especially valuable in two aspects: 1. it was prepared by four different federal agencies which should present a more diversified point of view and hopefully a less biased product; 2. the statement is up to date and has only recently been released to the public.

#### Theoretical Impacts of Coal Mining on a Representative Area

It is acknowledged that an impact statement written for one portion of one coal basin does not necessarily apply to all coal basins in the state, but it is typical of the types of constraints that would be encountered in other areas as well. More importantly is the fact that the Powder River Coal Basin with its tremendous coal reserves and generally good accessibility will probably be the first large scale fuel resource development area in the state.

It is expected that over 29,000 acres of land will be disturbed by mining during the 1974-1990 time period. When production hits

the 118 million tons/yr rate between 1974 and 1980, the operation of seven strip mines is estimated to disturb approximately 35,000 acres per year. Additionally, the construction of roads and railroads will almost match the amount of land disturbed in the 1974-1980 period. Mining activity alone is expected to reduce the local relief patterns in the vicinity of the coal seams from about 28 to 68 feet depending on the amount of overburden removed and the thickness of the coal seam being mined. In sum, the impact statement estimated that by 1990 rights of way for roads, pipelines, transmission lines etc., will account for an additional 7500 acres of land being disturbed annually. Mining facilities and housing construction are expected to require another 7500 acres and of the 15,000 acres estimated to be disturbed, 9500 acres (63 percent) is expected to be permanently lost as productive soil surface.<sup>12</sup>

In order to facilitate the movement of coal out of the region by rail, a new rail line which would link the eastern Powder River Basin coalfields with the mainline of the Burlington Northern/Chicago and Northwestern is being considered (see Chapter VI).

The railroad as presently proposed will be located above coalbeds which are amenable to mining by surface or underground methods. The right-of-way crosses an estimated 161 million tons of presently economically strippable coal. Should it become economically feasible to strip overburden to depths of 400 feet, then the proposed right-of-way crosses an additional 195 million tons of coal. The spur lines to be built into the mines will cross additional large amounts of presently strippable coal (73 million tons to 400 feet of overburden).<sup>13</sup>

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<sup>12</sup>Ibid., pp. 470-77.

<sup>13</sup>Ibid., p. 479.

In effect the construction of just one form of transportation link to the mining operations will constitute a considerable non-productive factor. If one were to include highways, mine support facilities and especially housing requirements, the amount of non-productive coal land created by surface mining is truly impressive.

#### Non-physical Impacts

Other types of possible impacts include cultural amenities such as historical sites or recreational areas. Although the impact statement being used as an example notes that these types of limitations are not present, the possibility of mining impacts on such sites has caused some concern at the state level. The Bureau of Land Management's State Multiple Use Advisory Board recently passed a resolution that "...called for a public education program for preservation... [of sites] known to have historic value."<sup>14</sup> As a precaution against destruction, such sites were recommended to be identified, inventoried and photographed.

Often overlooked are other social and political constraints to fuel resource development. The tourist industry ranks third in the state's economy after minerals and agriculture partly because of the great abundance of public areas reserved for tourism. For example, national parks and monuments constitute 4 percent of the state's total land area and national forests also account for an additional 4 percent. Over 73,000 acres are devoted to four wildlife refuges. At the state

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<sup>14</sup>"BLM Asked to Protect Historic Sites in Wyoming," The Denver Post, 16 September 1974, sec. B, p. 21.

level, eight recreation areas of almost 152,000 acres plus 17 historic sites (158 acres) and markers are maintained. The Wyoming Game and Fish Department operates 11 fishing areas (3,000 acres) and 24 wildlife management areas of almost 34,000 acres. Local parks and monuments constitute an additional 1,024 acres. In all, over 23 percent of the total land area of the state of Wyoming is already devoted to public recreation use and is therefore placed in the non-productive category of fuel resource development.<sup>15</sup> Not all the reserve areas are assumed to contain fuel resources of significant size. However, areas such as the Jackson Hole Coal Field and the Wind River Coal Basin contain considerable amounts of coal, and in the case of the Wind River Indian Reservation, oil and gas as well. Thus, any inventory of fuel resources must also include the cultural and political spatial restrictions placed upon the resource in addition to their mere size and quality.

The History of Movement of Fuels Within and Outside  
of the Rocky Mountain Region

Petroleum

Another aspect of fuel inventory is the pattern of their transportation over time. General trends concerning fuels originating in Wyoming can be discerned from federal data. For example, roughly half of all the petroleum produced within Wyoming is still exported either as crude oil or refined products. The

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<sup>15</sup>U.S., Department of the Interior, National Park Service, Parks For America, A Survey of Park and Related Resources in the Fifty States, 1964, pp. 471-2.

pattern developed when pipelines were built to Denver in 1938 and across the Continental Divide to Salt Lake City by 1939. An additional pipeline to Billings, Montana was constructed during the same period which made it easier to market Wyoming petroleum outside the state. This does not imply that petroleum did not move out of Wyoming prior to 1939. Indeed, over 2½ million barrels per year were moving from the Casper area to the Midwest markets of the Standard Oil Company during the Great Depression.<sup>16</sup>

#### Pipelines to Markets

This latter pipeline was converted from a natural gas carrier back to crude oil in 1936 by Standard of Indiana largely because demand was still high due to relatively static oil production levels and the capability to move oil to large out-of-state markets. A combination of low crude oil prices, pro-rationing programs at state levels, and natural declines in oil field production all contributed to the construction of short trunk lines within several states, including Wyoming.<sup>17</sup> When the Lance Creek Oil Field in west central Niobrara County was developed, Continental Oil Company built a six inch line to its Denver refinery in order to compete with other independent oil producers who were selling

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<sup>16</sup> Harold F. Williamson et al; The American Petroleum Industry, (Evanston: Northwestern University Press, 1963), pp. 571-2.

<sup>17</sup> Ibid.; U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1946 (Washington, D.C.: Government Printing Office, 1948), p. 903.

to the Bay Petroleum Company Refinery which was also located in the Denver area.<sup>18</sup>

Movement of petroleum from Wyoming to regional markets rather than extra regional ones began to take on importance during the late 1930's. It was during this period that oil production "booms" in Kansas and Illinois especially, negated an increase in Wyoming's petroleum production and made regional market opportunities more attractive. As population growth continued within the Rocky Mountain region a greater portion of Wyoming petroleum was consumed within the region. This trend is especially evident after World War II when the population of the region increased 31.5 percent, 44 percent and 24 percent during the 1950, 1960, and 1970 censuses. During the 1960-70 period the Colorado population increase (26 percent) created an important regional market area for Wyoming petroleum. Not surprisingly, the amount of Wyoming produced petroleum which is consumed within the Rocky Mountain Region (Montana, Wyoming, Colorado, Utah) has increased from 22 percent of Wyoming's total production in 1960 to 38 percent in 1972.<sup>19</sup>

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<sup>18</sup>T.R. Ingram, "To Lay 230-Mile 6-Inch Line From Lance Creek to Denver," Oil and Gas Journal, June 1938, p. 24.

<sup>19</sup>U.S., Department of Commerce, Bureau of the Census, 1970 General Population Characteristics: Wyoming, (Washington, D.C.: Government Printing Office, 1971), pp. 1-23; and U.S., Department of the Interior, U.S. Bureau of Mines, Minerals Yearbook, 1972 3 vols. (Washington, D.C.: U.S. Government Printing Office, 1974), vol. 1: Metals, Minerals and Fuels, pp. 952-3.

Governmental Impacts on Pipeline  
Movements of Petroleum and Natural Gas

That the movement of both petroleum and natural gas on an interstate basis has been powerfully influenced by federal regulations need not be expounded upon at this point. However, federal control of pipelines can clearly be traced back to 1906 with the passage of the Hepburn Act. It was this legislative act which for the first time placed oil pipelines under the control of the Interstate Commerce Commission which regarded interstate pipelines as common carriers and therefore subject to the same regulations as railroads. One of the thrusts of the Act was toward the Standard Oil Company which was singled out by the ICC as a company which had used pipelines to its advantage. In the ICC report to Congress in 1907 it was said that:

More than anything else the pipeline has contributed to the monopoly of the Standard Oil Company, and the supremacy of that company must continue until its rivals enjoy the same facilities of transportation by this means.<sup>20</sup>

It was the Hepburn Act of 1906, or more specifically, the pipeline amendment to the Act which placed the federal government in a position to regulate the operation of the pipelines directly, and indirectly to influence the pattern of pipeline development.

The precedent established by a small oil marketing firm in 1922 illustrates the point. The Brundred Brothers company which sold oil products to small refiners in western Pennsylvania sued

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<sup>20</sup> Arthur M. Johnson, Petroleum Pipelines and Public Policy, 1906-1959, (Cambridge: Harvard University Press, 1967), p. 235.

a pipeline owned by the Prairie Pipeline company to reduce the minimum tender<sup>21</sup> required to transport oil. The ICC found for the Brundred Brothers and cut the tender requirement to a fraction (10,000 barrels Vs 100,000) of its former amount. Since the Prairie Pipeline Company was engaged in the construction of a six inch pipeline from Casper to Missouri (see Figure 20) at the time the ICC decision had some influence upon petroleum developmental patterns in Wyoming as well. Because the extremely high and expensive tender requirements (in 1920 a conservative estimate of \$350,000 in inventories was placed on a 100,000 barrel tender) were cut by the ICC, small producers in Wyoming and other states were not discouraged in their production and marketing activities.<sup>22</sup> Today the benefits of a federal intervention into the distributive aspect of the petroleum industry have helped create a situation in Wyoming where the small independent producers and refiners play a viable and increasingly important role in the state's petroleum industry.

#### Natural Gas

As of 1972 there were seven interstate natural gas pipeline companies operating in Wyoming who collectively delivered over 3.4 trillion cubic feet of natural gas to 16 states including Wyoming.<sup>23</sup>

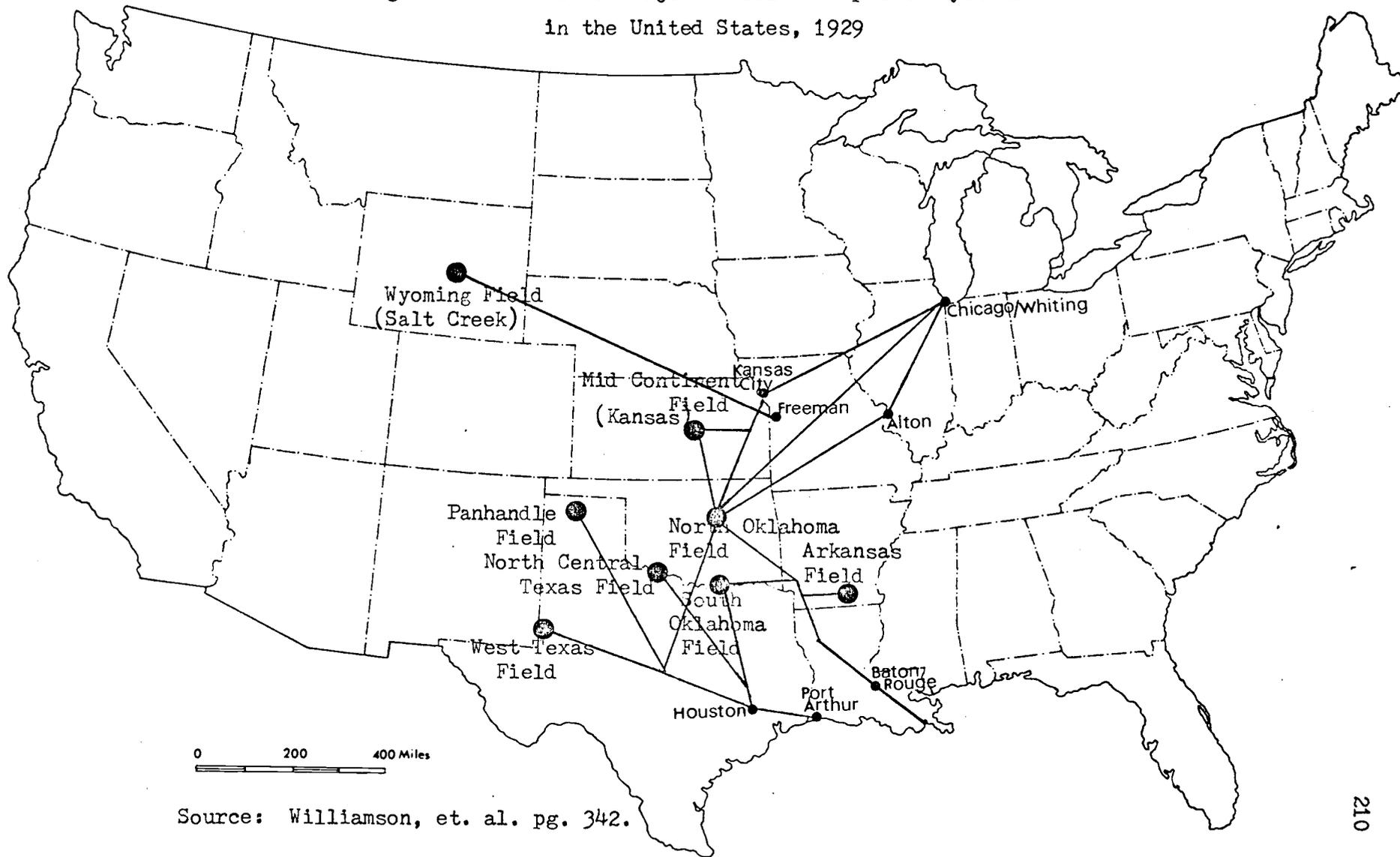
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<sup>21</sup>A rate schedule agreement whereby each shipper agreed to ship a certain amount of oil which he had in storage above ground and ready to be shipped to a single point before the pipeline company would move the oil.

<sup>22</sup>Williamson, et. al., op. cit., p. 342.

<sup>23</sup>Federal Power Commission, Statistics Of Interstate Natural Gas Pipeline Companies 1971 (Washington, D.C.: Government Printing Office, 1972), pp. 602-708.

Fig. 20 Structure of Major Petroleum Pipeline Systems  
in the United States, 1929

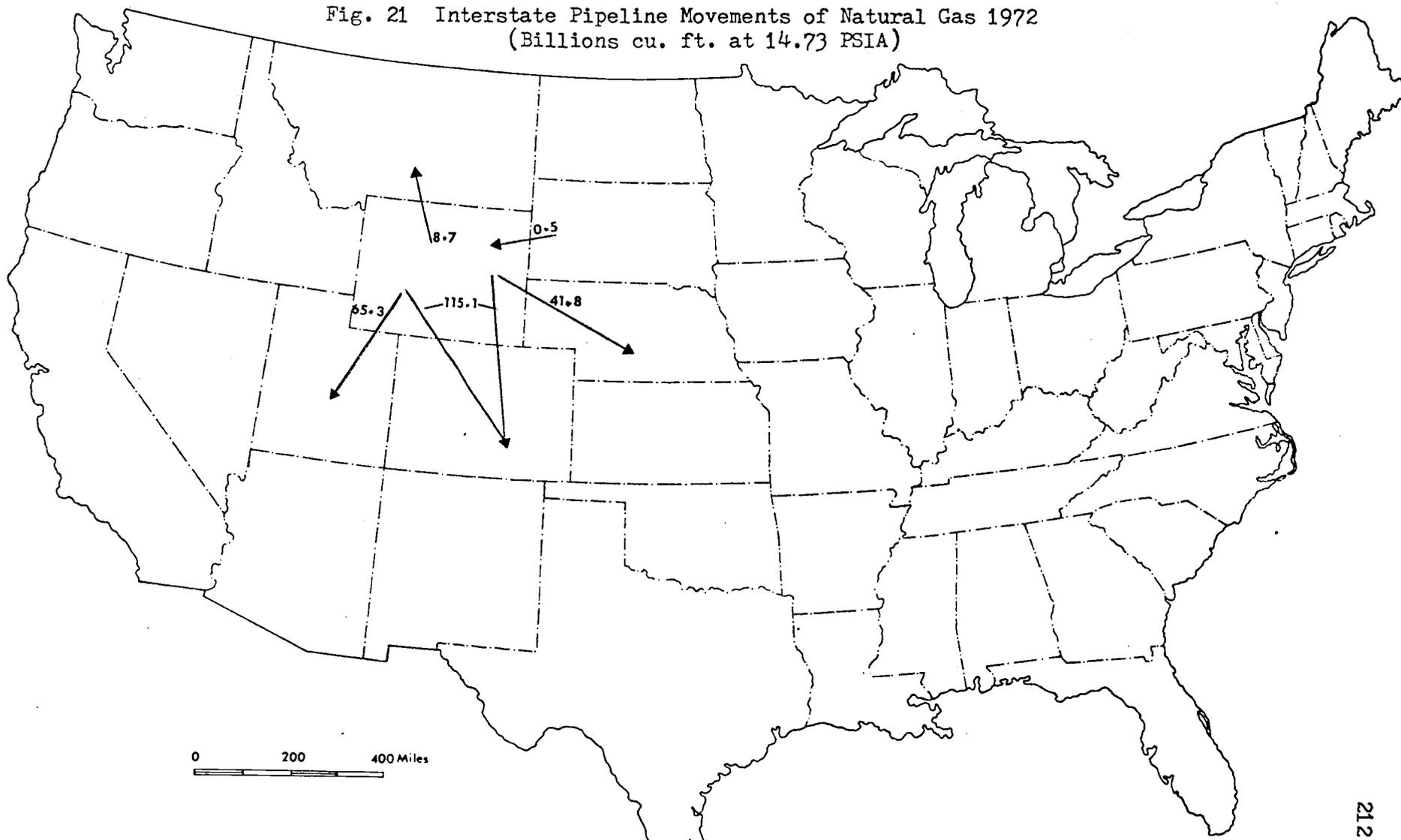


Source: Williamson, et. al. pg. 342.

Approximately 96 percent of all the natural gas produced in Wyoming was marketed which reflected a trend since World War II when natural gas demand both at a national and regional scale was great enough to eliminate the wasteful gas flaring activities of the 1920's and 30's. At the present time Wyoming is playing an increasingly important role as a regional natural gas supplier. As Figure 21 illustrates, the largest consumer of natural gas from Wyoming is Colorado which has also experienced the greatest overall population increase in the region during the last twenty years.

Unlike petroleum interstate pipelines, which are under the control of the Interstate Commerce Commission, natural gas pipelines as discussed in Chapter III are regulated by the Federal Power Commission. In its regulatory capacity the FPC not only has the power to control or decontrol natural gas prices but can approve or disapprove pipeline construction. In addition the FPC may approve or disapprove gas exploration plans presented by individual companies who most often generate the funds for such programs through increased well-head production rates. The federal government's activities in the natural gas industry therefore exert an influence on not only the price structure of natural gas but on such locative factors as where new pipelines will be constructed or which new gas supply areas may be tapped. Even with the current FPC plan to deregulate natural gas well head rates, demand levels have increased greatly in the consumer sector of the regional natural gas market.

Fig. 21 Interstate Pipeline Movements of Natural Gas 1972  
(Billions cu. ft. at 14.73 PSIA)



Source: Minerals Yearbook 1972, Vol. I, Metals, Minerals And Fuels, p. 834.

### Increased Regional Demand for Natural Gas

The Public Service Company of Colorado which also operates subsidiaries in the Cheyenne area supplies both electric power and natural gas to its customers. The company purchases over 90 percent of its natural gas supply from Colorado Interstate Corporation which has major holdings of natural gas producing areas in Wyoming. During the 1973-74 heating season the utilities company was advised that Interstate could not meet the 1974-75 requirements requested by Public Service Co. of Colorado. Because of the supply shortages the FPC was called in to establish the maximum daily demand obligations of Interstate to the utilities company.

The FPC, in certain circumstances, has the authority to allocate the natural gas transported and sold in interstate commerce by natural gas companies regardless of existing contractual obligations.<sup>24</sup>

The point illustrated by this example is that even in a relatively localized situation involving the movement of natural gas across a state boundary, the political externality embodied in the FPC plays a powerful role in determining movement patterns.

### The Location Patterns of Wyoming Coal Producers

#### Production Characteristics

When surface mining of coal became more widespread after the second world war Wyoming's productivity in coal production also began to increase rapidly. On the basis of coal produced per man

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<sup>24</sup> Merrill, Lynch, Pierce, Fenner & Smith Inc., Prospectus Public Service Company of Colorado (Denver: Merrill, Lynch, Pierce, Fenner & Smith, Inc., September, 1974), p. 15.

hour worked, a twenty-five year period from 1947 to 1972 (see Figure 22) shows that productivity in the state has been far above the national average. A particularly sharp increase can be discerned during the 1960's when strip-mining became very prominent on both a national and state level. The peak production point on a national basis was reached in 1969. Later that year the Federal Coal Mine Health and Safety Act was passed. As production levels began to drop (possibly due in part to the passage of the federal law) after 1969, Wyoming productivity increased rapidly possibly because restrictions on surface mining operations were not as stringent as those for underground mines. The author believes that the pronounced decline in productivity in the 1970-71 period coincided with the rapid development of the state's coal industry and a corresponding rapid increase in both the total number of employees and the percentage of relatively unskilled miners.

#### Coal Producing Counties

Production data on a county basis were plotted on a state map to determine county production levels (in percentages) over time. Figure 23 illustrates the two peak years of coal production on record, 1945 (9,836,798 tons) and 1973 (14,800,000 tons). The rather wide variation in production percentages over the twenty-eight year period generally reflects the shift away from underground to surface mining. As previously mentioned, by 1973 over 97 percent of all the coal mined in the state of Wyoming was surface mined while in 1945 six strip mines produced only 9 percent of that record year's coal production. As might be expected, each

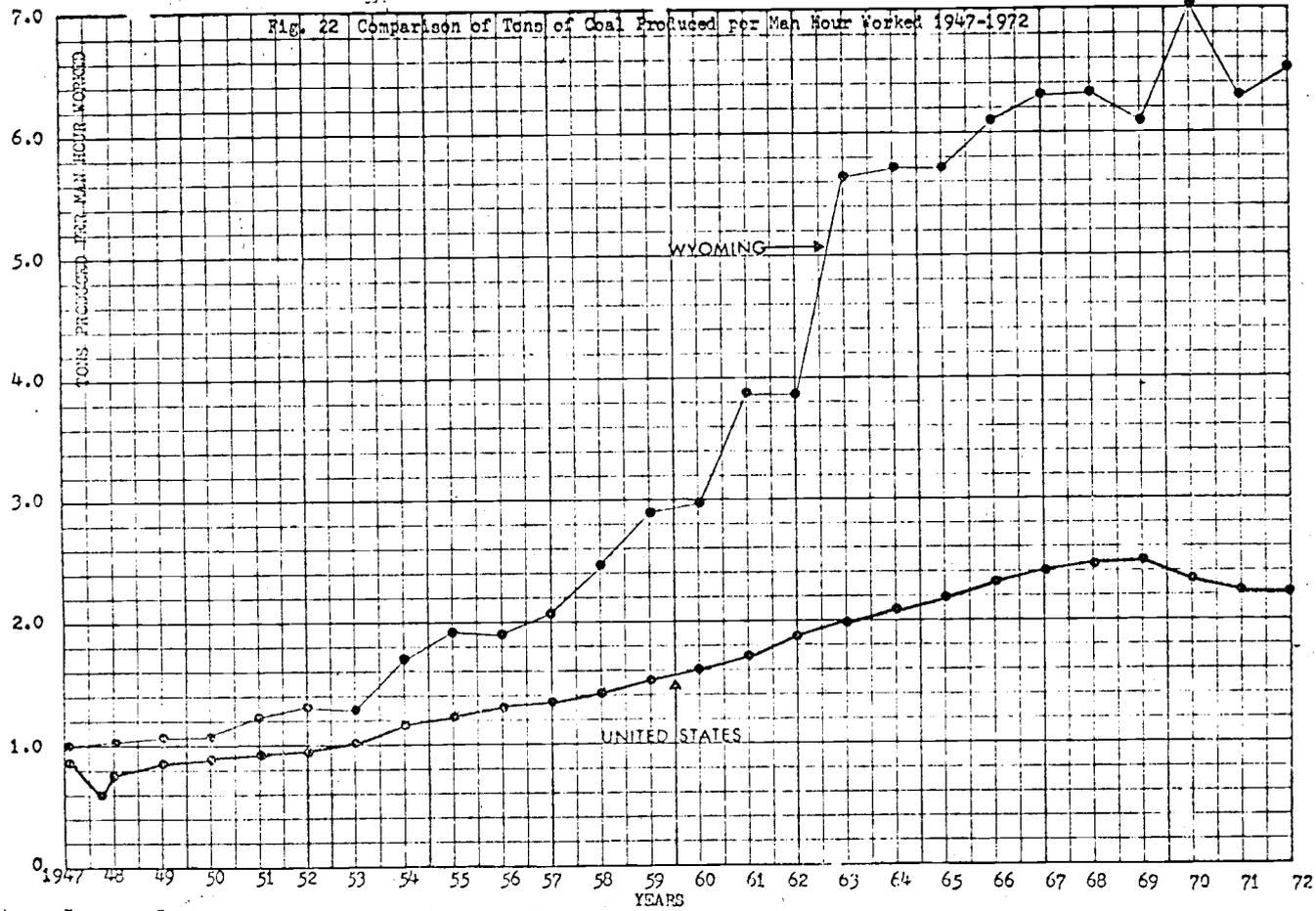
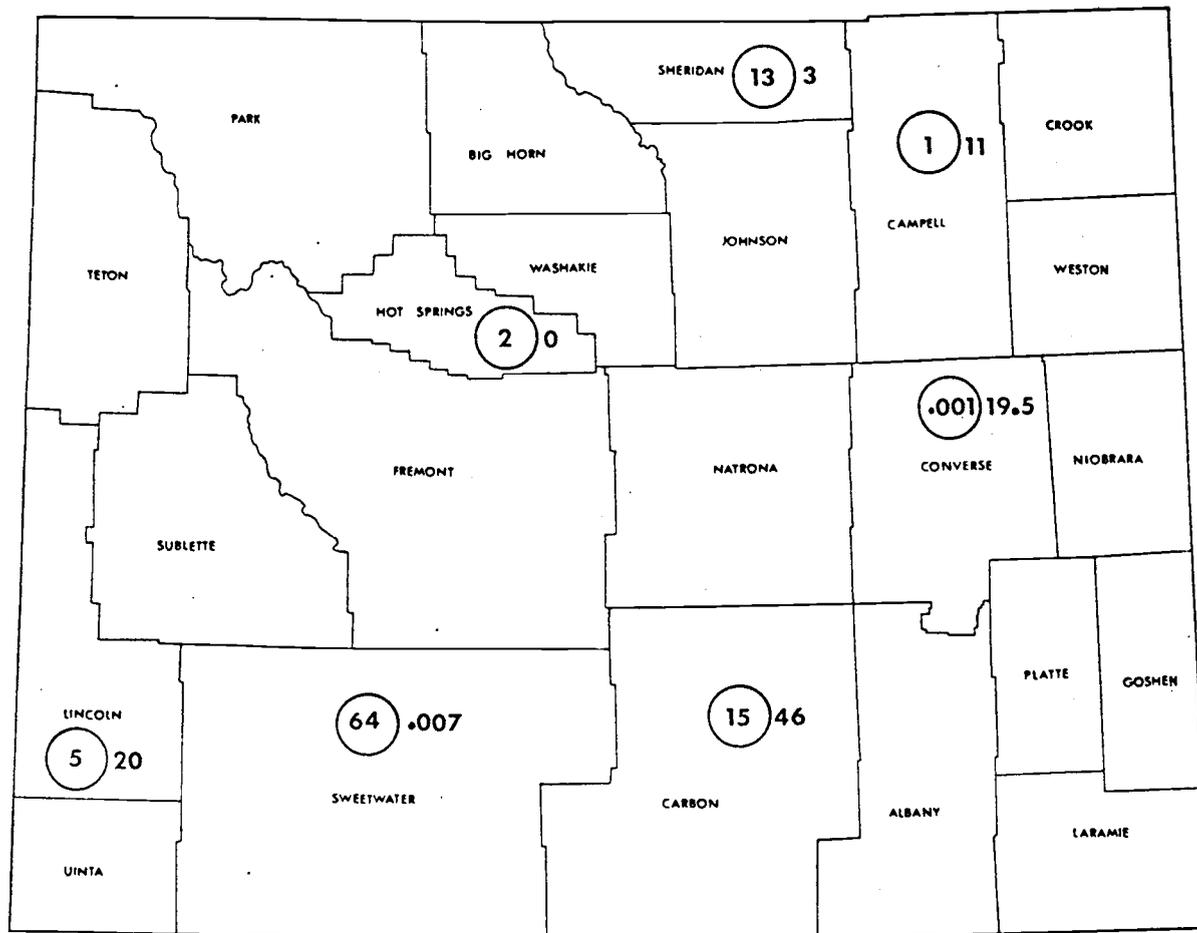


Fig. 23 Percentage of Wyoming Coal Production 1973 V. 1945



1945 Percentage share of total coal produced

1973 Percentage share of total coal produced

county has a dominant producer but the disparity between the largest producer and the next largest is surprisingly great as Table 20 illustrates.

When an additional step of plotting the rank and type of mine on a map is taken, some interesting patterns emerge (see Figure 24). With the exception of the largest producing county (Carbon) and the smallest (Fremont), there are no more than two coal mines per county. This raises the question of whether an optimal threshold of mining operations per county may exist. The term threshold is generally applied to firms selling goods or services. However, in spatial terms concerned with coal mining, it is intriguing to consider that the same factor may play a role at the county level in determining the minimal number of mines required to exploit the resource.

#### One Method of Measuring Production Change

The question of change or lack of change concerning the production of coal on a county basis nationwide was approached by Maresh who used a non-parametric statistical technique as a surrogate measure of change or constancy.<sup>25</sup> In the case of Wyoming alone, the  $r_s$  value with an  $n$  size of only 11 was .93 (see Figure 25), but when combined with Utah counties raising the  $n$  size to 20 the  $r_s$  value declined to .81 (Figure 26). These coefficients of correlation would indicate that both on a regional and state scale the constancy of coal production by county appears to be fairly great (Maresh

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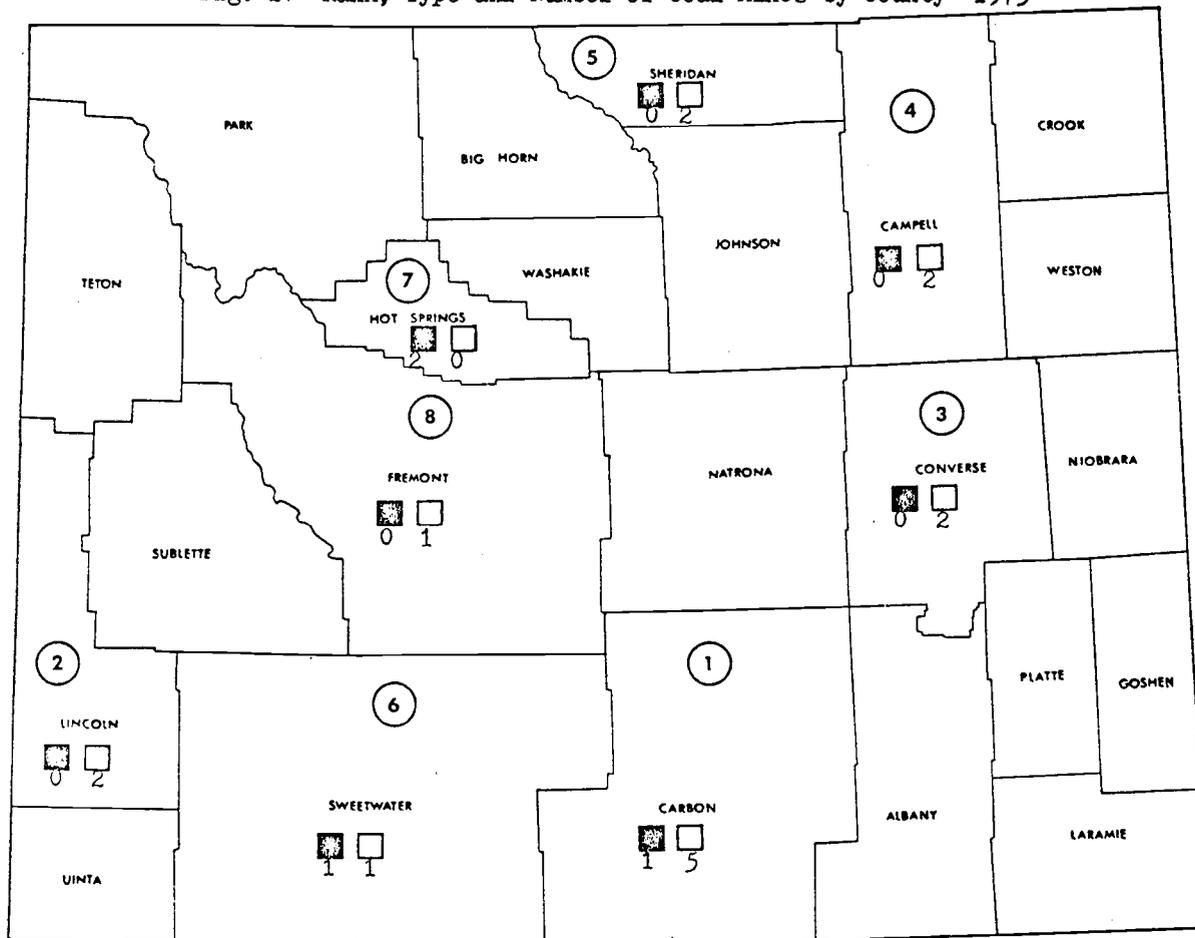
<sup>25</sup>Thomas J. Maresh, "On Constancy and Change in the Distribution of Mineral Production," Land Economics, May 1972, pp. 179-83.

TABLE 20 PRODUCER'S PERCENTAGE OF COAL PRODUCTION BY COUNTY (1973)RANK

1	<u>Carbon County - Hanna Basin</u> Arch Minerals - 64% Rosebud Coal Sales - 22% Resource Exploration & Mining - 09% Energy Development Corp. - 05%
2	<u>Lincoln County - Hams Fork Basin</u> Kemmerer Coal Co. - 100%
3	<u>Converse County - Powder River Basin</u> Pacific Power & Light - 100%
4	<u>Campbell County - Powder River Basin</u> Amax Coal Co. - 54% Wyodak Resources - 46%
5	<u>Sheridan County - Big Horn Basin</u> Big Horn Coal Co. - 96% Welch Coal Co. - 04%
6	<u>Sweetwater County - Green River Basin</u> Gunn-Quealy Coal Co. - 100%
7	<u>Hot Springs County - Bighorn Basin</u> Roncco Coal Co. - 59% Dusky Diamond Coal Co. - 41%
8	<u>Fremont County</u> John Gianunzio - 100%

Compiled from Wyoming State Inspector of Mines production data: 1973

Fig. 24 Rank, Type and Number of Coal Mines by County 1973



- County rank 1973
- Number of underground mines
- Number of surface mines

SCALE  
0 10 20 30 40 50 Miles

Fig. 25 Wyoming Coal Production by Counties

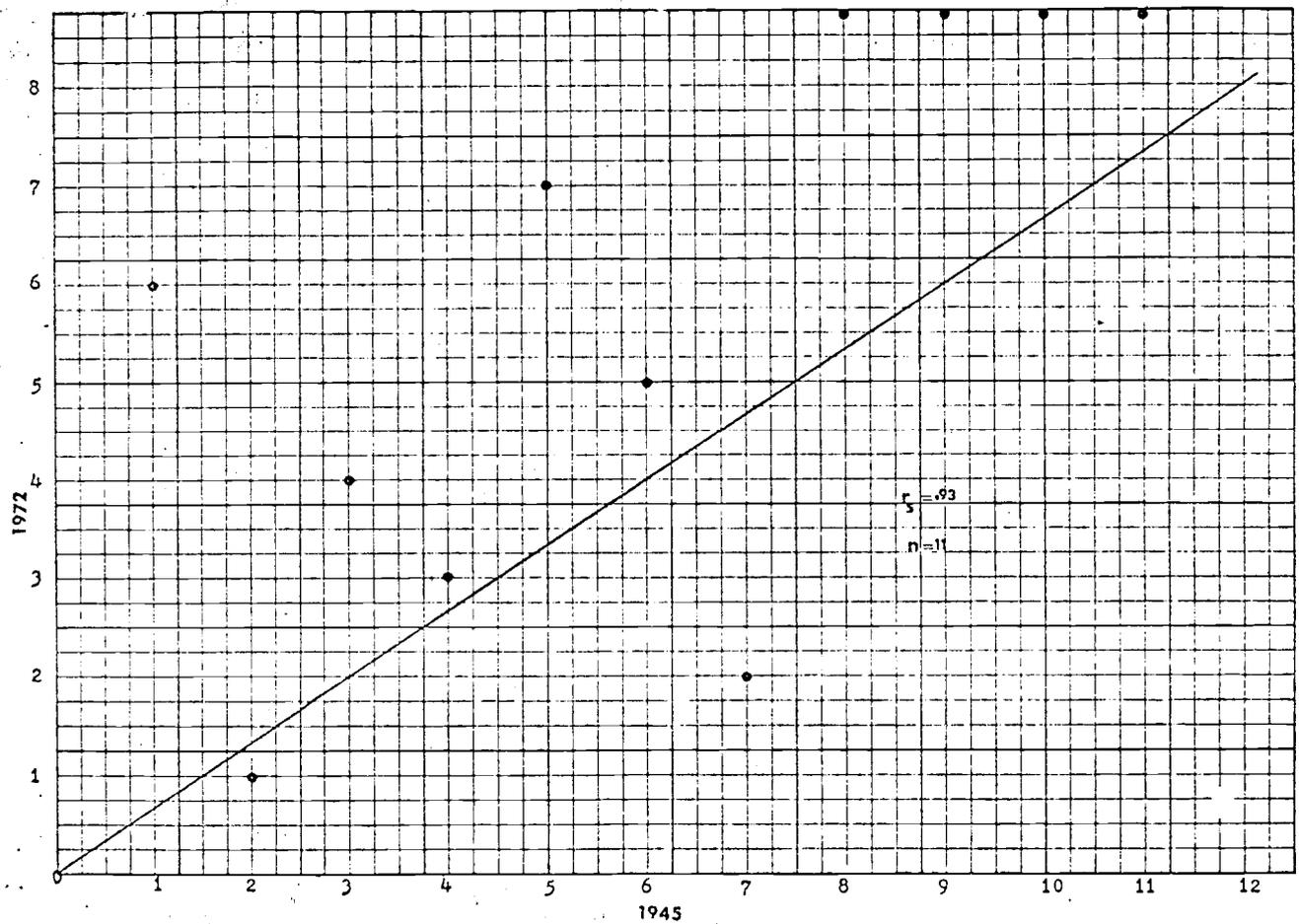
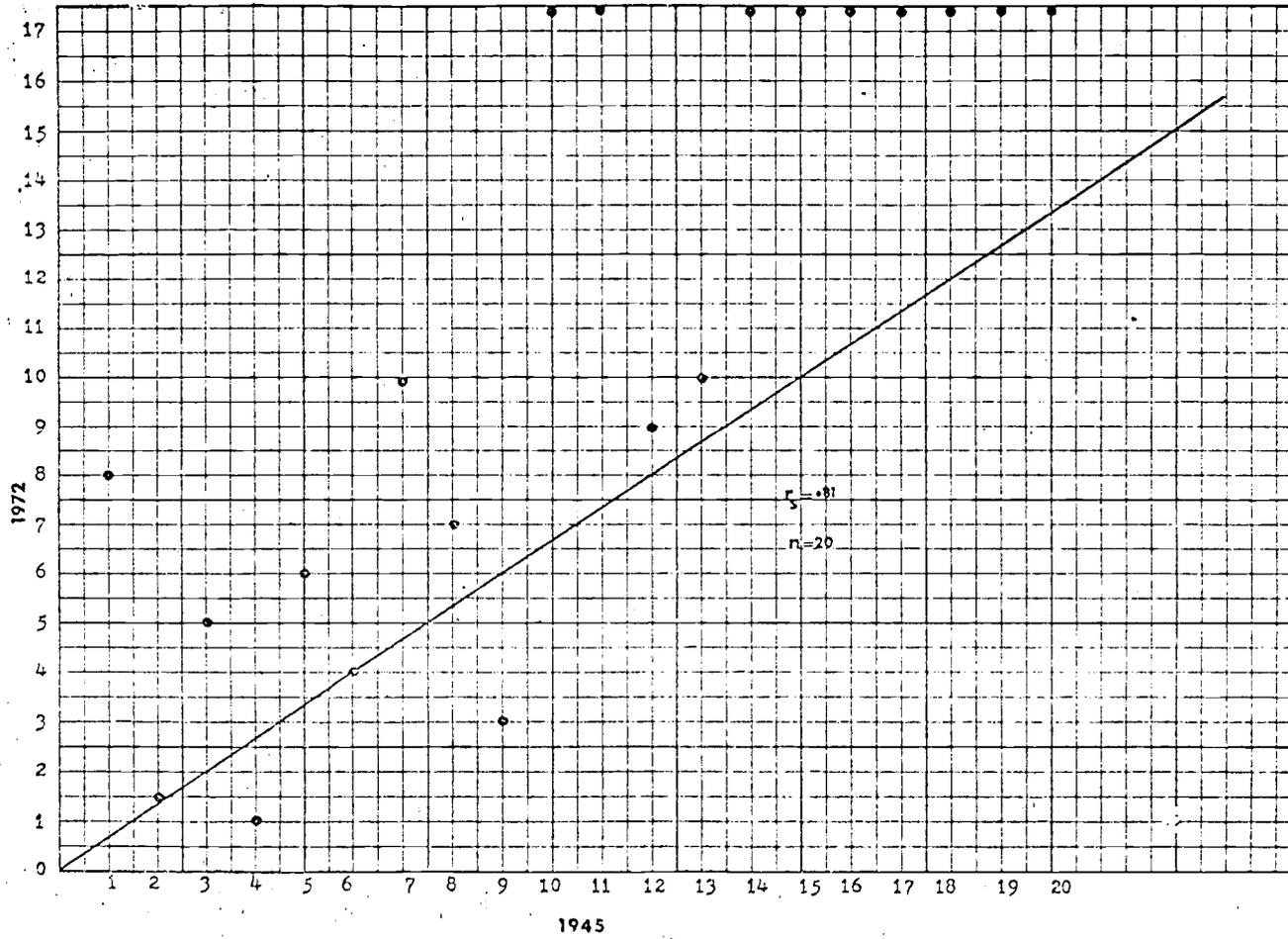


Fig. 26 Wyoming and Utah Coal Production by Counties



found an  $r_s$  value of .61 for an n size of 121). Thus, in general, between eight and eleven counties in Wyoming and 10 and 18 counties in Wyoming and Utah combined have been producing coal since 1945 and continued to do so in 1973. Maresh mentioned that he believes production is "...dominated by a small number of the producing counties...",<sup>26</sup> and this appears to be the historic case in Wyoming. In 1945 for example, just three counties (Sweetwater, Carbon and Sheridan) accounted for 92 percent of the state's coal production while in 1973 over 85 percent of the state's coal production is accounted for by the top three counties. However, two of the three top producing counties in 1973 were ranked fourth and seventh in 1945. Since the advent of strip mining those two counties (Lincoln and Converse) rank number 2 and number 3 respectively.

#### The Transportation of Coal

As might be expected, most of the coal produced in Wyoming during the 1920's was consumed by the railroads for fuel. In the 1918-1919 period over half of the coal produced in northern Wyoming and almost half of the coal produced in southern Wyoming were used solely by railroads. During that same time only  $3\frac{1}{2}$  percent was shipped to public utilities consumers.<sup>27</sup> This consumption pattern had changed greatly when re-examined fifty-six years

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<sup>26</sup>ibid.

<sup>27</sup>U.S., Department of the Interior, U.S. Geological Survey, Mineral Resources Of The United States, 1918 (Washington, D.C.: Government Printing Office, 1919), pt. 2, p. 1373.

later. In 1973 approximately 92 percent of the coal mined in Wyoming was consumed by electric power producers and none recorded for the transportation sector.<sup>28</sup>

Wyoming coal mines have long produced coal for export to markets quite distant from the Rocky Mountain region. For example, in 1910 roughly 15,000 tons of Wyoming coal were consumed annually by the city of Portland while 200,000 tons of Rocky Mountain coal (some of it from Wyoming) were shipped to California.<sup>29</sup> Indeed, by 1918 almost 52,000 tons of coal from southern Wyoming and Utah were shipped to overseas users. Most of the coal was bunker coal for foreign ships taking on fuel at San Francisco. Domestic markets external to the Rocky Mountain Region also consumed roughly one quarter of all Wyoming coal produced in the 1917/1918 period. In an itemized report on coal consumption and distribution appearing in Mineral Resources of 1918, no fewer than 14 states received coal shipments from Wyoming. The fact that overall percentages of coal shipped to other states declined from almost 24 percent in 1917 to barely 21 percent in 1918 probably reflects the readjustment to normal peacetime demands for coal. As in the data for foreign exports, almost all Wyoming coal shipped to other states was for

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<sup>28</sup>Gary B. Glass, "Wyoming: production seen doubling by 1976", Coal Age, May 1974, p. 107.

<sup>29</sup>U.S., Department of the Interior, U.S. Geological Survey, Mineral Resources Of The United States, 1910 (Washington, D.C.: Government Printing Office, 1910), pt. 2, p. 89.

railroad fuel.<sup>30</sup> Thus the pattern of coal export to non-regional markets was set early in this century.

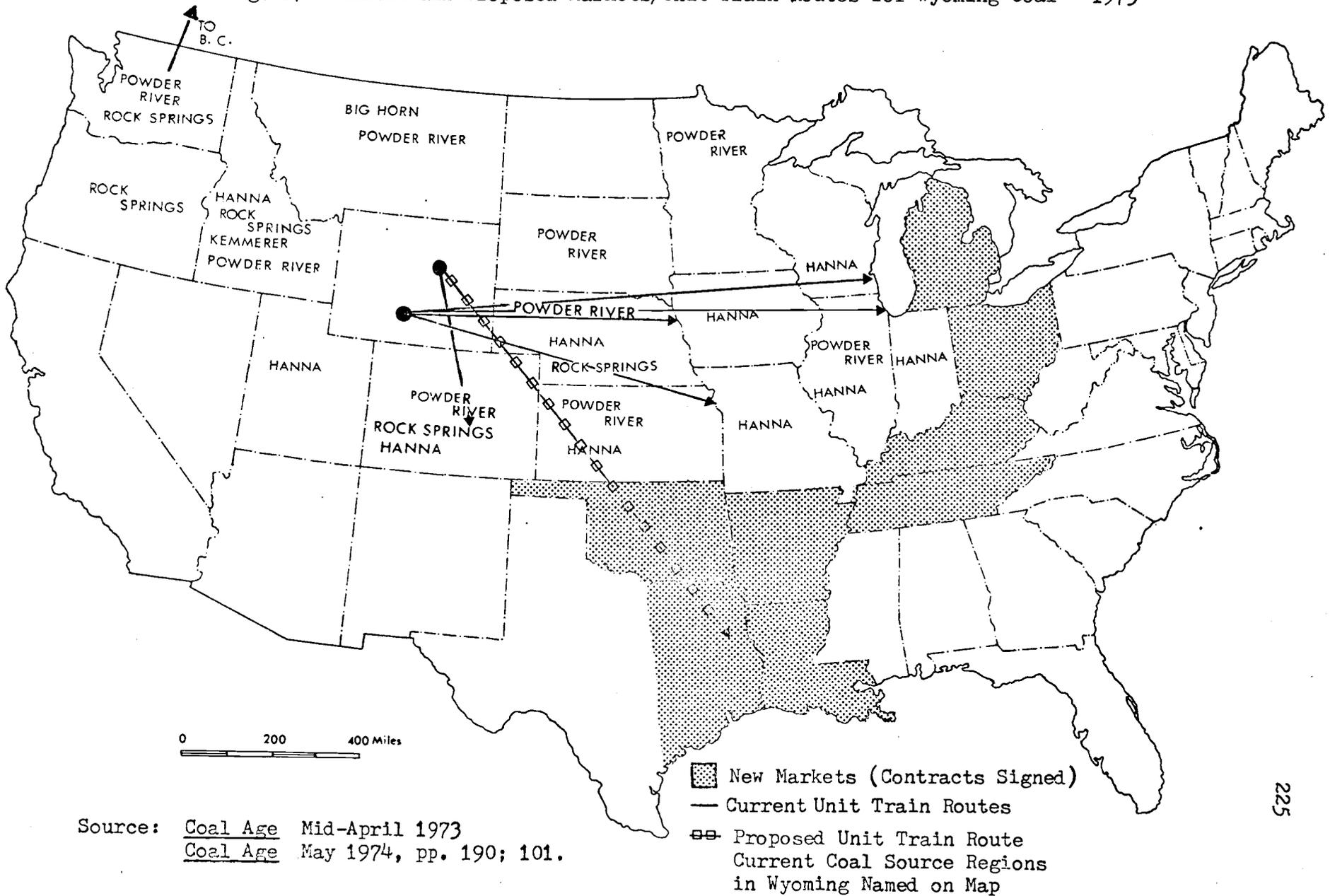
One surrogate measure of the consumption patterns of Wyoming coal are current market areas, by state, and the destination of coal unit trains from Wyoming. Figure 27 illustrates the market and the source areas in Wyoming for those particular state markets and coal unit train routes. In all, almost  $63\frac{1}{2}$  percent of the coal mined in Wyoming during 1973 was shipped out of state while in-state uses only comprised 36.6 percent. If one were to look at comparable statistics for 1915 (Figure 28) the percentage of coal shipped out of Wyoming (excluding railroad fuel) was 26 percent, in state use was only 9 percent and a very high 65 percent was used by railroads (almost 60 percent of out-of-state use in 1973 was for power plants).

As one can clearly see from the preceding maps coal from Wyoming has historically moved over a surprisingly extensive area of the United States. Most current market areas still roughly correspond to the markets of 1915 except for the more easterly extent of the markets. Unlike 1915, however, is the nature of the coal consumers, which has changed from being almost entirely railroad companies to electric power utilities. One of the historic characteristics and problem areas of Wyoming coal production has been the orientation toward a single use market. In 1915 through the 1940's the market was for steam locomotive fuel and in the 1970's

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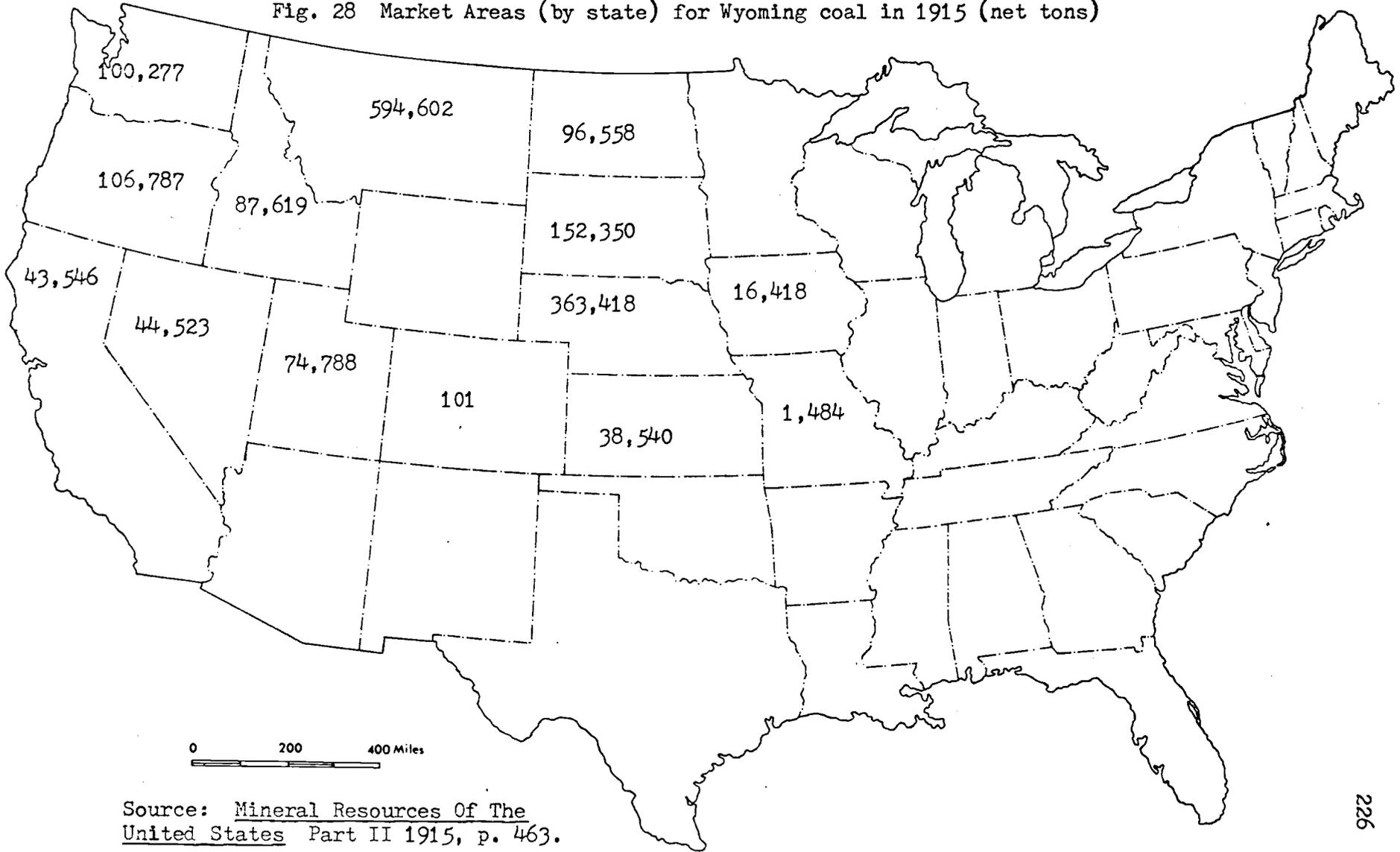
<sup>30</sup> Mineral Resources Of The United States, 1918, op. cit.,  
pp. 1324-57.

Fig. 27 Current and Proposed Markets/Unit Train Routes for Wyoming Coal - 1973



Source: Coal Age Mid-April 1973  
Coal Age May 1974, pp. 190; 101.

Fig. 28 Market Areas (by state) for Wyoming coal in 1915 (net tons)



Source: Mineral Resources Of The United States Part II 1915, p. 463.

over 90 percent of both in-state and out-of-state markets for coal are using fuel in power plants. Interestingly, it was the development of a transportation network, especially railroads which gave birth to the coal industry in the state, almost killed it, and most recently has helped resurrect the importance of the coal industry in Wyoming.

#### Transportation Network Development

The multiplier effects of transportation development especially in a traditionally underpopulated area like the state of Wyoming were especially significant in the 1890's. As part of a grand strategy of the Chicago Burlington and Quincy Railroad to tap the mineral resources of the Black Hills area, new rail lines were built into the Black Hills and beyond. During 1890 tracks were laid from Newcastle, Wyoming, and extended the railhead to what became the town of Gillette in 1891. The next year, 1892, CB&Q tracks were extended to Sheridan. The following excerpt from a history of the Burlington Route gives a vivid account of the immediate effects of the railroad's arrival:

For Sheridan this was like a shot in the arm. Within a month, farmers of the region had paid off loans on which they had been paying interest at the rate of two percent a month. Ranches turned into farms, coal mines were opened, more people went into stock-raising, and the economy in general reached a new and higher level. As Gillette, in charge of the railroad's construction, put it: "Rich soil, the finest supply of good water for domestic and irrigation purposes, the magnificent Big Horn Mountain full of elk and deer, numerous lakes, trout in all the streams, grouse in the valleys, and the whole country underlaid with coal convinced

many in the party that this at last was what they had been looking forward to in making their permanent homes..."<sup>31</sup>

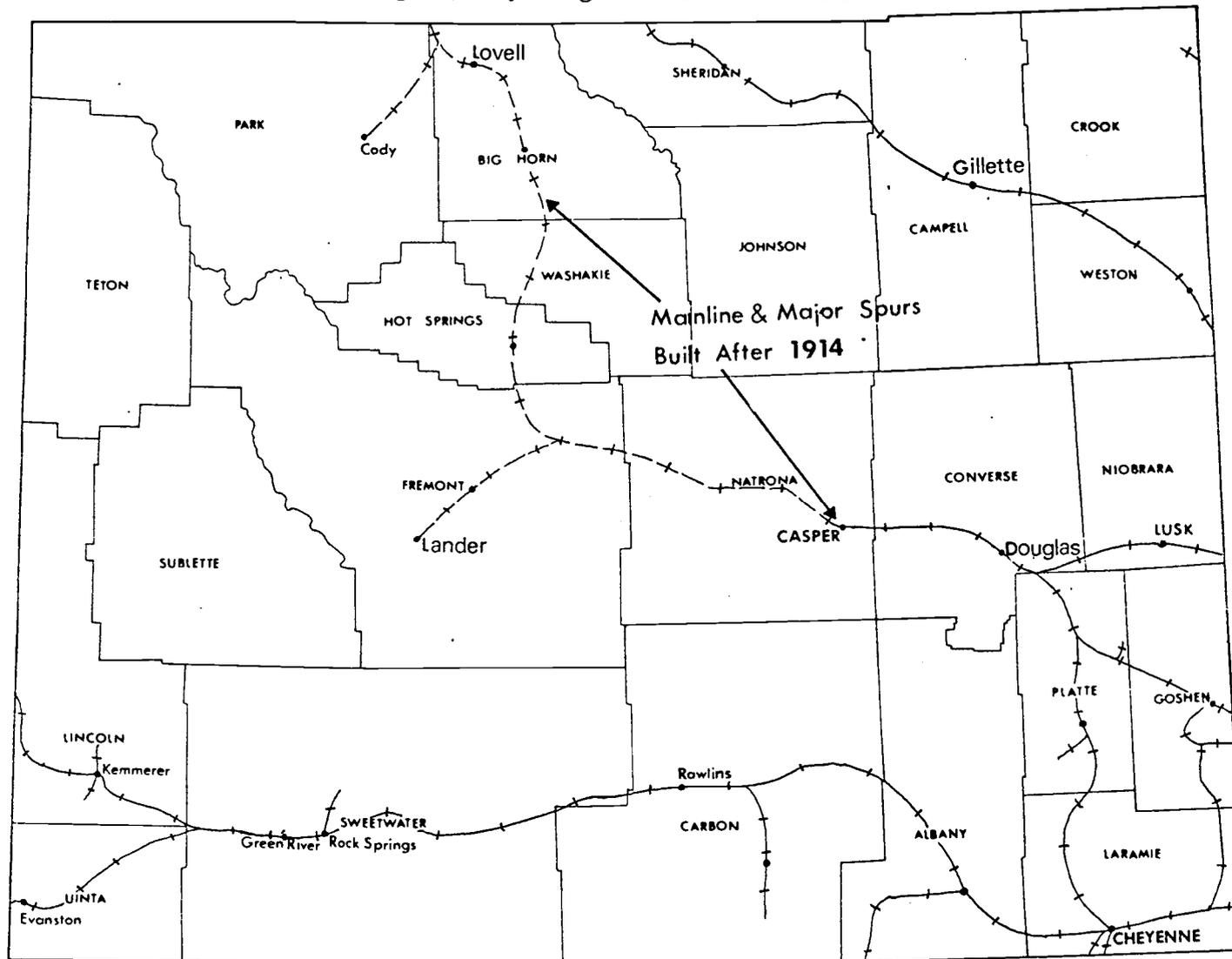
The present day railroad network was essentially established and functioning in Wyoming by 1914. As Figure 29 indicates the only significant mainline trackage which was built between 1900 and 1914 was the stretch between Casper and the Montana border. When the railroad network of Wyoming is examined using graph theory to determine the relative accessibility of town (nodes) in the network, the post 1914 system displays a higher degree of connectivity. Using Kansky's<sup>32</sup> beta index ( $B = \frac{e}{v}$ ) where e is the number of edges or routes and v is the number of nodes or towns, the calculated value for the pre-1914 rail network is .71 compared to 1.00 for the post-1914 network. In terms of accessibility, prior to 1914 Cheyenne and Wheatland were equally central to all other places connected by railroads. After the new route from Casper to the Montana border was completed in 1914 the most accessible place shifted to Douglas. Table 21 illustrates the ranking of ten places in terms of their degree of connectivity with all other places (nodes) in the rail network. The fact that southern Wyoming towns are found in the pre-1914 rankings indicates the historical development of the Union Pacific Railroad's mainline location and, not coincidentally, the location of coal deposits.

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<sup>31</sup>Richard C. Overton, Burlington Route: A History of the Burlington Lines (New York: Alfred A. Knopf, 1965), p. 228.

<sup>32</sup>K.J. Kansky, Structure Of Transportation Networks (Chicago: University of Chicago Press, 1963), p. 17.

Fig. 29 Wyoming's Railroad Network



SCALE  
0 10 20 30 40 50 Miles

Source: Rand McNally Handy Railroad Map, Wyoming, p. 52.

TABLE 21 CONNECTIVITY RANKING OF NODES IN RAIL NETWORK

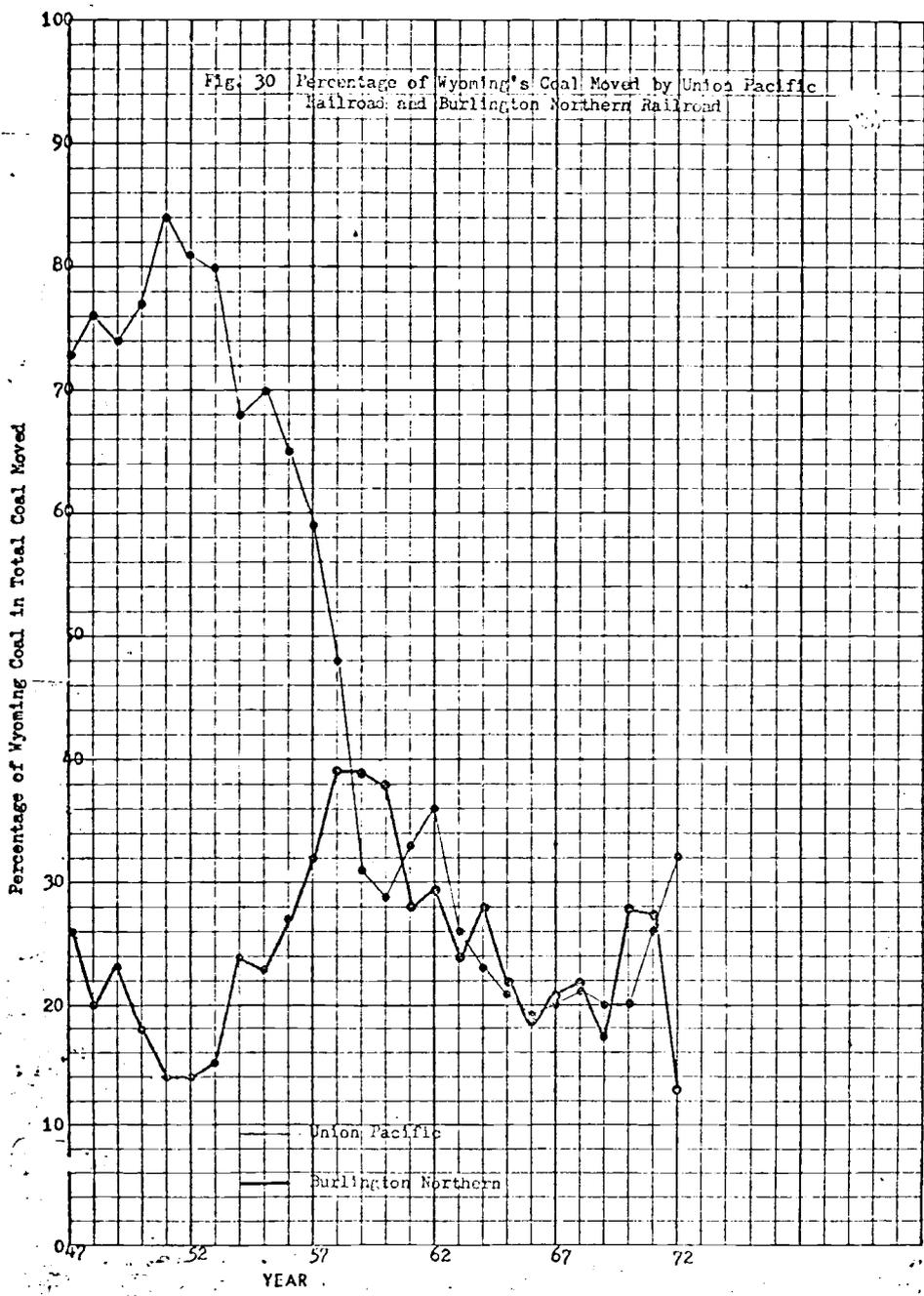
<u>Place</u>	<u>Pre 1914 Rank</u>	<u>Place</u>	<u>Post 1914 Rank</u>
Wheatland	1	Douglas	1
Cheyenne	1	Wheatland	2
Laramie	2	Lusk	2
Lusk	3	Casper	3
Douglas	4	Cheyenne	4
Rawlins	5	Laramie	5
Saratoga	6	Thermopolis	6
Torrington	7	Torrington	8
Rock Springs	8	Newcastle	9
Green River	9	Riverton	10
Casper	10		

In his dissertation concerning the selection of a route for the Union Pacific Railroad, Grey stated that the presence of known coal deposits along the proposed southern Wyoming route "...seems to have been a rationalization rather than a reason in the choice of a route."<sup>33</sup> Nevertheless, Wyoming coal has been a particularly important freight item for the Union Pacific.

By far the most important carrier of Wyoming coal has been the Union Pacific Railroad, which during the period 1917-1945 was also the largest producer of coal in the state. An examination of Figure 30 indicates several features of the two major transporters of Wyoming coal. Aside from the obvious differences in the percentages of coal moved, the switch to diesel-electric motive power is indicated by the decline in coal carried during the middle 1950's. The Union Pacific in particular shows a sharp decline in that several of the company's own coal mines, which provided much coal traffic, were closed down. The general trends during the 1970-72 period probably reflect several changing factors. First, other railroads are beginning to carry Wyoming coal to markets. Second, more coal is being burned by power plants located within the state. Third, unit trains, which are sometimes owned by the consumer (such as Commonwealth Edison of Chicago) and only operated by the railroad are recent innovations which reduce the share of Wyoming coal carried solely by the two aforementioned railroads.

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<sup>33</sup>Alan Hopwood Grey, "A Railroad Across The Mountains: Choosing The Route Of the Union Pacific Over The Eastern Rockies" (Ph.D. dissertation, University of Wisconsin, 1963), p. 147.



### Unit Trains' Impact on Moving Wyoming Coal

The unit train concept began in 1959 as a management technique to reduce the transportation cost of moving a bulk commodity like coal from the mine to market. A variety of new types of equipment and technological innovations such as flood-loading of coal cars have all aided in increasing the efficiency and lowering the costs of operating unit trains. However, it is estimated that one of the best cost reducing innovations which is currently practiced is the consumer purchase of the coal cars. The savings of consumer ownership of coal cars is often placed at about \$1.00 per ton when all factors are taken into consideration.<sup>34</sup> In general the weight of unit trains is greater and the train is in continuous motion, not even stopping for loading. The resulting shipping costs are often 50 percent lower than conventional railroad owned coal trains. It has been the unit train concept which has held down the costs of transporting coal from Wyoming to distant market centers. Almost all the consumers of Wyoming coal are electric power utilities which have usually signed long term contracts for coal. As one might expect, the fuel costs vary between supplier and consumer but some representative costs for coal being supplied from Wyoming may be illustrative of the range of coal costs.

Wyoming coal burned by an electric utility in Omaha in 1972 for example cost 42.3¢ (per million B.t.u.); in Sioux City, Iowa,

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<sup>34</sup> Mining Informational Services, 1971 Keystone Coal Industry Manual (New York: McGraw-Hill, 1971), p. 142.

39¢; 35.8¢ in Des Moines; 42¢ in Genoa, Wisconsin (south central Wisconsin); and 32¢ in Rapid City, South Dakota.<sup>35</sup> Figure 31

locates the major power plants which have contracted to use coal from Wyoming. Recently, a unit train-to-barge combination transportation system was tested by the Burlington Northern Railroad.

We made some test rail-to-barge runs early in 1973, hauling coal in unit train quantities to East St. Louis for trial burning in power plants owned by American Electric Power on the Ohio river [sic]. This coal came from the Belle Ayre mine in Wyoming and from the Decker mine in Montana, and it was transloaded to barges through the dock at East St. Louis, owned jointly by the Illinois Central Gulf and Burlington Northern and operated by Peabody Coal. Barges then took the coal down the Mississippi and up the Ohio as far as Wheeling, W.V. Burning tests were satisfactory and planning is now under way for a new coal dock in the St. Louis area served by Burlington Northern.<sup>36</sup>

The spokesman for Burlington Northern later states that the company believed it could deliver western coal to Appalachia for costs approximating 70¢ per million BTU "...a figure that soon may be competitive with low-sulfur eastern coal."<sup>37</sup>

On a regional scale, the Public Service Company of Colorado again provides an example of how fuels from Wyoming are currently used. Approximately 64 percent of all the fuel Public Service Company uses is low sulphur western coal with most of it originating in Wyoming. The company is supplied through seven contracts with mining firms in Colorado and Wyoming.

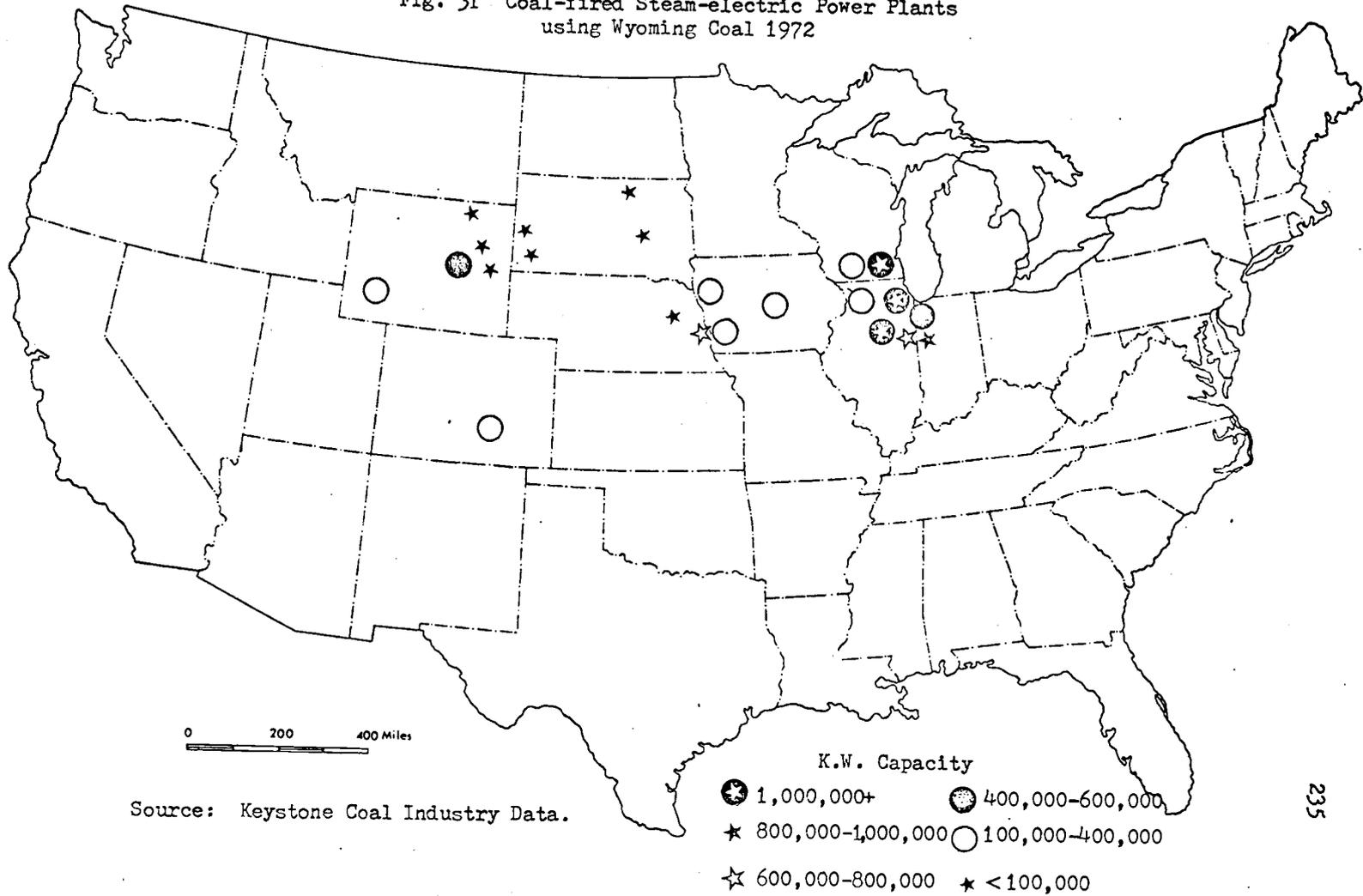
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<sup>35</sup>Mining Informational Services, 1973 Keystone Coal Industry Manual (New York: McGraw-Hill, 1973), pp. 158-162.

<sup>36</sup>George R. Powe, "Economics of Using Western Coal In Appalachian Markets", Mining Congress Journal, June 1974, p. 20.

<sup>37</sup>ibid., p. 23.

Fig. 31 Coal-fired Steam-electric Power Plants  
using Wyoming Coal 1972



The impact of inflation, higher labor costs and taxes and royalties plus governmental programs (such as the easing of price controls on natural gas) have all been reflected in the increased cost of fuels purchased by the Public Service Company of Colorado (Table 22).

TABLE 22 DELIVERED COSTS OF FUELS TO PUBLIC SERVICE COMPANY  
OF COLORADO

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(Cost Per Million B.t.u.)

Twelve months ending  
31 December

	<u>Coal*</u>	<u>Gas</u>	<u>Oil</u>	<u>Average of all fuels</u>
1969	24.9¢	22.9¢	25.4¢	24.6¢
1970	25.3¢	24.1¢	38.8¢	25.6¢
1971	27.4¢	26.5¢	60.7¢	28.2¢
1972	29.1¢	28.2¢	59.7¢	29.6¢
1973	31.0¢	35.8¢	103.7¢	34.4¢
June 30, 1974	33.5¢	38.3¢	140.0¢	39.4¢

\*The average cost per ton of coal of the periods shown was \$5.56, \$5.56, \$6.15, \$6.44, \$6.72, and \$6.74 respectively.

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Source: Public Service Company of Colorado Prospectus, p. 13.

Since the cost of coal has increased at a less rapid rate than other fuels it seems reasonable to assume that at least the largest utility company in the region will increase its use of coal in the future. The implementation of unit trains especially to large electric generating like the 350,000KW Comanche Plant near Pueblo have helped keep the net cost increase in coal purchases to levels below 10%.

### Slurry Pipelines

Yet another innovation in transportation technology which may have a significant impact on the development of fuels in Wyoming are pipelines. New pipelines which would transport coal as a slurry or gas derived from the combustion of coal or water to support the coal slurry or gasification plants have already been proposed. The high volume low-operating costs of pipelines appear to be an attractive alternative to railroads at the present time. The State Engineer of Wyoming has recently approved a plan by Energy Transportation Systems Inc. to construct a 1040 mile, 38 inch coal slurry pipeline from the Powder River Coal Basin to Arkansas. When completed the pipeline would have a capacity of 25 million tons per year which would require an estimated 15,000 acre feet of water per year to operate.<sup>38</sup> The plan is to utilize subterranean water sources which are believed to be too saline for either human or agricultural use, but recent drilling indicates that the salinity levels of water taken from test wells is much lower than estimated. Amid great controversy and opposition from both environmental groups and the state of South Dakota, which feels that interstate aquifers in the vicinity of the supply wells are threatened, the State Engineer of Wyoming approved a permit for water well drilling to proceed. The result has been that the state of South Dakota

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<sup>38</sup>Draft Environmental Impact Statement, Development of Coal Resources in the Eastern Powder River Coal Basin, op. cit., vol. 1, pp. 49-50.

has brought suit against the state of Wyoming in the federal courts and at this writing the case is still pending.

#### Summary

This chapter has attempted to examine some of the development patterns concerned with Wyoming's petroleum, natural gas and coal resources. The emphasis has been on location of the resources and how they move. The author has attempted to indicate through a limited number of measurements that the spatial characteristics of Wyoming fuels has displayed a mutable nature.

For example, because of the high percentage of federally owned land in Wyoming, many acres of mineral lands have been leased via the competitive leasing system. When a leasing program for coal was examined the author found coal bids were really not competitive and that the leasing system encouraged speculation rather than production. It is suggested that the competitive bidding system of leasing coal on public lands in Wyoming should be re-evaluated. The current four year moratorium of coal leases on public land indicates that the Department of the Interior may be aware of the inequities involved in bidding between multi-national corporations and individuals with limited financial backing.

Because federal statutes require the submission of environmental impacts before development of fuels, recent studies have found that a considerable amount of well-endowed coal lands will never be productive units for a variety of physical and cultural reasons. Such physical constraints to coal development as highway and railway rights-of-way, supportive structures for mines, and

housing areas are just now becoming recognized as significant constraints upon surface mining activities within the state. How these problems will be dealt with is still a matter of conjecture but the euphoria connected with strip mining vast tracts of thick-seamed low sulfur Wyoming coal has become tempered through the utilization of impact studies required by both federal and state governments.

Historically the development of petroleum and natural gas pipeline systems in Wyoming have been influenced greatly by the federal government. Largely because Wyoming's petroleum and natural gas moves to out-of-state markets their prices, and as a consequence their development patterns, have been dictated by the Federal Power Commission and the Interstate Commerce Commission. Increasingly, even on a regional level, the federal presence has grown so that in at least one case the FPC was used as the final arbiter between a natural gas supplier in Wyoming and its customer in Colorado.

In the development of coal production patterns technological impacts rather than governmental intervention have seemed to be the prime force of change in Wyoming. The sharp increase in surface mining of coal in the 1960's changed the traditional county ranking in terms of coal production. Counties which had been traditional production leaders using underground mining techniques have been supplanted by counties in which surface mining is dominant. The author found that the changes were generally in rank structure only not in geographic distribution. Most counties which have always produced coal are still producing it. The number of mines however

has declined and the disparity between the largest producers and the next rank has increased. With the exception of the most productive and least productive counties there were no more than two coal mines per county. This suggests that a type of optimal threshold for coal mining counties may exist.

An analysis of the transportation network used to move Wyoming coal to markets showed that the state's coal has always moved great distances to market. The pattern has only recently changed in that the distances coal moves today is even greater than when compared to patterns at the turn of the century. The application of graph theory to Wyoming's railroad network during two different stages of its development showed that the overall efficiency (connectivity) of the system was increased after 1914. With the addition of the unit train concept and the eventual utilization of coal slurry pipelines the level of transportation efficiency as it relates to coal movement is also likely to increase.

No particular external factor was emphasized in the preceding chapter because it was planned to examine the patterns of development as they once existed and how they exist today. Obviously previously discussed external factors, acting in concert, have affected the patterns of development in at least the three fuels selected for this discussion. Governmental activities, economic conditions, technological capabilities and social-environmental factors all play a part in shaping the patterns of fuel resource development on Wyoming's landscape.

## IX SUMMARY AND CONCLUSIONS

One of the propositions stated in this dissertation is that factors external to the site or situation characteristics of Wyoming fuels have, through time, been responsible for the developmental patterns of those fuels. External factors such as the economic or social environment and technological developments were examined across a time spectrum with particular attention given to the resultant governmental policies toward fuel development. An additional implicit assumption was that such governmental policies were responsive to economic societal and technological inputs. As such inputs changed in either intensity or character through time one would expect to observe a cyclic nature in the types of government policies on both a federal and state level. Though the other factors which the author has chosen to call externalities have changed through time, the same cannot be said for governmental activities and policy decisions until recently.

Governmental impacts on the developmental patterns of Wyoming fuels were particularly important because increasingly more development is taking place on public lands than private holdings. Yet leasing policies for mineral and fuel resource development are essentially the same today as they were in the 19th century. The most current leasing guidance being used on federal lands is based on a 1920 law and its amendments. Clearly the economic social and technological environments have experienced drastic

changes in the last fifty-five years but basic federal policy concerned with mineral resources has been unresponsive to the changes in those other factors. Competitive leasing systems based on the 1920 law do function very efficiently in their ability to determine an economic value for a particular mineral resource. More strip mining of coal is being carried out nation-wide than ever before, yet no nationally established workable plans at the federal level have been yet developed for the reclamation of those areas. Though encouraged to develop peaceful uses for uranium-derived nuclear energy, private utility companies have been denied the right to produce their own nuclear fuel sources because the federal government has decided to retain control over the enrichment process.

In a commendable response to societal demands for cleaner air and safer mining conditions, the federal government passed the Clean Air Act and the Mine Safety Act but until recently has not been aware of the economic as well as social implications on these belated governmental responses to changed external factors. The development of Wyoming's low sulfur coal deposits has probably been enhanced because of these two socially and environmentally oriented statutes. However, the scope of the ramifications resulting from such legislation is only beginning to be perceived.

For example, the environmental impacts of such a primary economic activity as mining are new items which must be recognized and evaluated in any energy or fuel development plan. It may well be that in the future the environmental impacts of the mineral industry in general will become the major factor of industry operations. One need only examine the lack of development of coal

resources in Wyoming to gain a feeling of how important environmental factors are perceived to be by coal operators. This statement is made even in light of the fact that government on the federal level has deemed development of domestic fuel resources as one of the highest national priorities.

In conjunction with environmental constraints and concerns are the social implications and consequences of fuel development which heretofore had not been considered vital factors in decisions relating to the development of fuel resources. For example, in the state of Wyoming much more public concern is expressed over the influx of new people into the state as the result of increased fuel development than the physical removal of the state's fuel deposits. Indeed, a growing feeling of social responsibility on the part of both federal and state levels of government has emphasized the desirability of utilizing western fossil fuels in an attempt to mitigate the adverse environmental and social consequences of growing demands for fuel in other more populous areas of the nation.

A major problem which must be faced by both federal and state levels of government is not if but how the fuel resources of Wyoming will be developed. It is the author's belief that given the mining and transportation technology available and the economic incentives to do so, Wyoming's fuel resources will continue to be developed until the state reaches a position of being a national fuel pool. This statement is made in light of the fact that even if all 300,000 citizens of Wyoming opposed the development of the state's fuels (which is not true), development would be almost inevitable in

response to national demands for those fuels. Historical analysis shows that the state has traditionally acted in the role of at least a regional supplier of fuels. The historic constraints upon the greater national role of a fuel supplier have generally been because of technological limitations and economic disincentives such as the distance to markets.

An investigation of the geographic circumstances related to the state's fuel deposits shows that the transportation and general development pattern, in terms of their location, have been established for a considerable length of time. Generally counties which have produced coal in the past will be those whose coal deposits will continue to be developed. With minor modifications the same condition applies to those areas with uranium and petroleum as well as oil shale deposits. The greatest variation in terms of the spatial aspect will be in the development of coal deposits because of the extensive nature of those deposits.

The exploitation of Wyoming's coal resources will be the focal point for the combined impacts of technologic, economic, social and governmental factors. It is the already great capital investment in coal production facilities which will lead to a confrontation between proponents of burning the coal in Wyoming-based electric power plants, and those supporting the continuance of coal shipments out of Wyoming. It is the strip-mining of coal which has led to a controversy over how much scarce water should be allocated to the irrigation of surface-mined land which must be reclaimed. It is because of the use of ground water in proposed coal slurry pipelines

that the states of Wyoming and South Dakota are now confronting each other in the courts. In short it is because of coal development that heretofore unrelated issues of social, environmental, economic and technologic factors are being focused at the state level of decision-making.

#### Scale of the Study

It is at the state level where national policies concerning the development or lack of development of fuel sources are implemented. National priorities with regard to new fuel sources or the development of alternative sources by necessity must pass through the filter of state governmental interpretation before action is begun. Constraints and support for fuel development through leasing regulations, tax policies and the perception of the state's resources find their nexus at the state level. Wyoming's government views its fuel resources as a national, not a local treasure in contrast to the neighboring state of Montana which has been a leader in opposing large-scale strip mining operations. Nonetheless as political regimes change, so do their perceptions concerning the state's resources. As a consequence of the Fall 1974 elections, Wyoming's governor elect has gone on record in opposition to the development of additional coal slurry pipelines which move Wyoming's coal to extra regional markets. In short the spatial patterns of energy development change on a state as well as national scale and it is suggested that adequate state level investigations would provide a most fruitful input to national energy programs.

The author believes that the implications for policy decisions concerning energy on a national level are magnified at either a regional or state level. The solutions to environmental, economic and social problems as well as the traditional technological difficulties of mining which are found in Wyoming may be a microcosm of solutions which could be implemented on a national scale. Wyoming has traditionally been an exporter of its fuel resources, and the state's economy has generally been reactive to the national economic and political environment. The state has now begun to assume a role of leadership in energy resource development. Assuming an ever greater role as a regional and national supplier of fuels, Wyoming's future role may become more prominent in national affairs. An examination of its past experiences might provide a better understanding of the state's current position as a major fuel supplier.

Much work, especially dealing with the dynamics of fuel movements, needs to be done at the state level. The geographies of energy at such a level are not merely idiographic exercises with no applicative value, but are the incremental pieces required for the formulation of a rational, workable national energy policy. This study has been oriented ultimately, at filling a void in that geographic level of analysis of energy.

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