Powder River Basin Coal: Powering America

Final Report to
The Wyoming Mining Association

By

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Executive Summary

The Powder River Basin (PRB) contains the largest reserve of low cost hydrocarbons on the planet. This report finds that PRB coal should be considered a strategic asset for the U.S. economy that

- Helps keep electricity rates low in the Midwest & South,
- Ensures low cost, reliable electricity,
- Maintains a competitive restraint on natural gas prices,
- Acts as a low-cost cushion to absorb high cost sources for electric power, and
- Serves as a critical backstop for future production of electricity and liquid fuels.

PRB coal is essential in providing reliable electricity at affordable rates while improving environmental quality. Cost effective electricity is a key element in driving multi-factor productivity growth and enhancing U.S. industrial competitiveness. Electricity helps drive technological innovation, which is an essential factor in propelling the economy forward with lower carbon intensity.

Coal production from the PRB has more than doubled in the 15 years since 1994. PRB coal companies produced greater amounts of coal at declining real prices over much of this period through investment in equipment and production systems that achieve massive economies of scale, unrivaled in the world energy complex. To accomplish these impressive results, Wyoming PRB coal producers acquired almost $2.3 billion of supplies from 47 states during 2008.

The bulk of PRB coal is shipped to the middle part of America from Texas in the south to Michigan in north and New York in the east. States that consume significant amounts of PRB coal have electricity rates well below the national average. The largest industrial users of electricity are in these regions. Americans need look no farther than our own borders to witness the location of industry near low cost electricity. Since the year 2000, however, real electricity prices have increased because nearly all-new electricity generating capacity is powered by either natural gas or wind energy. Were it not for the cost dampening effect that PRB coal exerts on electricity rate bases that employ average cost pricing, these real rate increases would have been far higher.

Given difficulties of choosing sites for nuclear power plants and the limitations of renewable energy to supply base load electric power, the next best alternative to PRB coal is natural gas. Replacing PRB coal would require almost 6 trillion cubic feet of natural gas per year, representing a 30 percent increase in demand. Such an increase in gas consumption would more than double prices for natural gas. In such a world, U.S. energy users would pay $162 billion more each year for electricity and $118 billion more per year for natural gas. Hence, by using PRB coal, the U.S. economy avoids $280 billion per year in higher energy costs. Given the challenges facing our nation to pay for national security, health care, and social security, PRB coal is an asset America cannot afford to lose.

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I. Introduction

Energy is a key factor in economic development, transforming agrarian societies to modern industrial ones. This societal transformation driven by the accumulation of income and wealth eliminates many contagious diseases, reduces child mortality, and lengthens adult life expectancy. This virtuous cycle has been demonstrated over the past two centuries in dozens of countries around the world. The emergence from poverty begins as countries develop transportation systems using petroleum and electricity networks, often based upon coal. These technologies are capable of achieving massive economies of scale that provide large amounts of energy at low cost. These abundant and reliable supplies of energy spur technological change, and productivity growth, improving the living standards of millions of people.

It is no coincidence that the world energy complex is built upon fossil fuels. Consumers prefer low cost, reliable energy and producers who provide these services prosper. The fact that the U.S. economy currently derives 85% of its total energy from coal, oil, and natural gas is a testament to the competitive advantage of fossil fuels. These fuels have empowered modern industrial societies to raise living standards for billions of people. Of the15% of carbon-free energy we use today 8.3% is nuclear, 2.4% is hydroelectric power, 3.6% is biomass, and the remaining 0.7% is wind and solar energy.

Proponents of carbon-free energy argue that these low shares are the result of market distortions, such as the absence of pricing for environmental externalities. Even as these external costs eventually appear in market prices, the fundamental competitive advantage of fossil fuels likely will persist well into the foreseeable future because carbon-free energy is considerably more expensive than fossil fuels and renewable energy is intermittent and does not yet enjoy the scale economies of conventional energy.

To promote these inherently uncompetitive technologies, governments have resorted to subsidies and production mandates, or so-called renewable portfolio standards. These policies not only increase government spending but also impose hidden efficiency costs on our economy that silently erode our standard of living. Spending that once went for education and housing is diverted to energy expenditures. Companies, if they continue production here, also pay more for energy and pass these higher costs onto consumers who pay more for all goods and services. Consumers in turn are forced to cut back again. The result is cascading efficiency losses through the entire economy.

These economic impacts are real and even advocates of carbon free energy often implicitly acknowledge their existence by arguing for gradual implementation. As these policies take hold in the electricity sector, their true costs to society are hidden by average cost pricing. Consumers end-up paying more for energy and get less, but could pay much more were it not for the cushioning effect of low-cost sources of energy.

The largest low-cost source of energy on the planet is Powder River Basin (PRB) coal. Under the open rolling range of the American high plains where Sitting Bull once eluded the American Calvary, lies the PRB coal reserve. Unlike Eastern coal deposits that average a few feet in thickness, PRB coal seams are as large as eight-story office buildings. Indeed, the only building in Washington, DC taller than the average PRB coal seam would be the U.S. Capitol

Building. Coupled with advanced mining technology and efficient transportations systems, these enormous coal seams enable incredible economies of scale and low production costs. In addition, PRB coal has very low sulfur content, allowing electricity producers to use it directly without installing and operating expensive pollution control equipment. These cost and environmental advantages have contributed to a doubling of PRB coal production over the past two decades.

The expanded use of PRB coal has generated important economic and environmental benefits for the United States. The rising market share of PRB coal was one of the key factors contributing to falling real electricity prices during much of the 1980s and 1990s. Lower electricity costs encourage the adoption of advanced electricity-using technologies that reduce the direct use of fossil fuels and increase end-use energy efficiency in a wide range of applications. These technologies augment productivity growth, which is the key driver for higher per capita income and wealth. Like the giant oil fields of the past, the development of PRB coal has contributed to stable economic growth with low inflation.

A world without PRB coal would look much like our recent experience with supply constraints in the oil and gas complex. In this case, electricity prices would be significantly higher and more volatile, stifling economic growth and raising unemployment. Moreover, not utilizing PRB coal would limit our economic growth potential in the long run, robbing future generations of wealth and prosperity.

Expanding the use of PRB coal would lay an important pillar for future economic growth. The size of PRB coal reserves would allow a significant expansion of coal production for electricity and for a wide range of coal derived energy products, such as methane, chemicals, and liquid transportation fuels. With advanced technologies for carbon capture and sequestration, this expansion would improve environmental quality by expanding the use of electricity in end-use applications, such as transportation, and reducing life-cycle carbon emissions. A key consideration in the adoption of these technologies is the management of market risk arising from the price volatility of petroleum and natural gas prices.

The remaining sections of this report provide an examination of these issues. To attain a deeper understanding of the importance of PRB coal, section two provides an overview of energy and economic development. Along this continuum is another important linkage between energy and productivity growth, which is the focus of section three. The fourth section provides an overview of the rise of PRB coal. The supply chain linkages of PRB coal production with the rest of our economy are discussed in section five. The driving forces encouraging its use are identified and discussed in the sixth major section. The role of PRB coal in providing low-cost and clean electricity to nearly 40 states is then examined in section seven. To appreciate how important a cog PRB coal is to our electricity sector, the impacts on electricity rates of replacing Wyoming PRB coal with natural gas are estimated in section eight. The results reveal that electricity rates would increase substantially. While such a switch is unlikely for a variety of economic and political reasons, this exercise illustrates the opportunity cost of not using PRB coal. The challenges that lie ahead are then described in section nine. The report concludes with a discussion of the implications for policy and strategic decision-making.

II. Energy and Economic Development

Energy plays an important role in economic development. The discovery of large fossil fuel reserves and the development of technology to deliver energy from these resources literally provides the fuel for an economic growth engine in which declining costs for energy contributes to lower prices for goods and services and increasing demand for these lower priced outputs, which then drives costs down further due to economies of scale and learning effects. The United States during the late 19th and early 20th century provides a classic example of this growth engine. Indeed, China is providing a template of how coal can be used to pull people out of poverty and lift an entire society to higher living standards. India and many other countries around the world are learning from China's example.

Energy provides basic services for human existence, such as light for reading and fuel for cooking. Barnes and Floor (1996) describe a continuum of different fuels used through various stages of economic development, known as the "energy ladder." For subsistence cultures, energy tends to come from harvested or scavenged biological resources, such a wood and dung. During the intermediate stage, processed biofuels, such as charcoal, animal power and some commercial fossil fuels are consumed. Liquid fuels, natural gas, and electricity delivered via expansive distribution networks are widely used during the last stage of industrialization.

These stages entail different resource requirements with labor intensity falling and capital intensity rising as the economy advances. For example, households relying upon wood for cooking devote considerable amounts of labor to collect firewood. During the intermediate stages, some capital outlays are required for kerosene lamps or coal-fired cook stoves. Much more capital is required during the final stage of development to build electricity and natural gas supply networks.

Expanded energy availability leads to a disproportionate increase in productivity and economic growth. The first source of these gains arises from the expanded use of commercial energy by households. Consider the shift from kerosene to electric lighting. As the price of light declines, more illumination services are consumed, which leads to a direct increase in economic welfare. For example, households can read and learn during the evening hours. There is a second round effect stemming from the productivity enhancements that light provides. Households can divert hours once spent gathering firewood to working in the market economy, which generates income for the household and labor services for the economy. In addition, with inexpensive illumination household members can devote time at night to improving literacy and education capacity. These productivity enhancements lead to an additional increase in the demand for lighting that contributes even more economic welfare for society.

Besides raising households from the depths of poverty, increased energy availability contributes to the construction of infrastructure and buildings and the fabrication of durable producer equipment. These durable assets are made from materials, such as steel, aluminum, copper, concrete, and glass. Producing these materials requires significant amounts of energy. Utilizing abundant energy supplies helps lower the cost of materials, structures and equipment, which facilitate the accumulation of capital assets.

All economies advancing into the industrialization stage go through this phase of infrastructure development. For example, during the period from 1880 to 1920 the United States experienced material intensive economic development so that energy intensity, or the ratio of energy consumption to gross domestic product, was rising. China is at a similar stage in recent years.

Greater energy availability also may enhance the productivity of energy infrastructure investments, leading to lower transportation costs and expanding the geographic size, scale and efficiency of markets. Efficient electricity networks also generate powerful economic externalities by lowering the costs of telecommunications and information, which in turn generate additional productivity enhancements.

Many case studies done by the Office of Technology Assessment (OTA) and others provide definitive evidence of how energy service availability spurs economic growth. For example, the 1994 *World Development Report* (World Bank, 1996) discusses the importance of infrastructure provision to economic development. The OTA studies (OTA, 1991; 1992) identify how much labor time is invested in subsistence energy provision and how much inefficient manual labor is used for activities that could be accomplished with simple machines powered by external energy sources.

On the business side of the economy, greater supplies of energy and lower costs for energy services foster:

- Economies of scale from larger scale energy provision, such as petroleum refineries and electric power generation,
- Lower transportation costs and more competitive manufacturing, and
- The development of communication networks that generate powerful productivity enhancements across broad swaths of the economy

Therefore, household and business sector impacts contribute to an overall increase in the quality of life, including better health, less drudgery, more leisure, greater communication, and increased social status.

All of these factors contribute to a strong positive correlation between economic output and energy use, which also generates greenhouse gas emissions as Figure 1 illustrates. The growth in greenhouse gas emissions, however, has been less than the rate of growth in gross domestic product (GDP). For example, during the 1950s real GDP grew at a 4% annual rate while CO_2 emissions from energy rose 2.4%. From 1960 to 1973, the growth rates were 4.1 and 3.7% respectively. CO_2 emissions increased only 0.7% from 1974 to 1986 while GDP growth also slowed to 2.8%. During the next two decades from 1988 to 2008, GDP rose nearly 3% per annum while CO_2 emissions grew 1.2 % per year. In 1950, the carbon intensity of GDP was 1.34 million metric tons of carbon dioxide per billion dollars of GDP. In 2008, the carbon intensity of GDP was 0.51 million metric tons per billion dollars of GDP. So as the economy grows, carbon intensity, defined as CO_2 per dollar of GDP, falls.

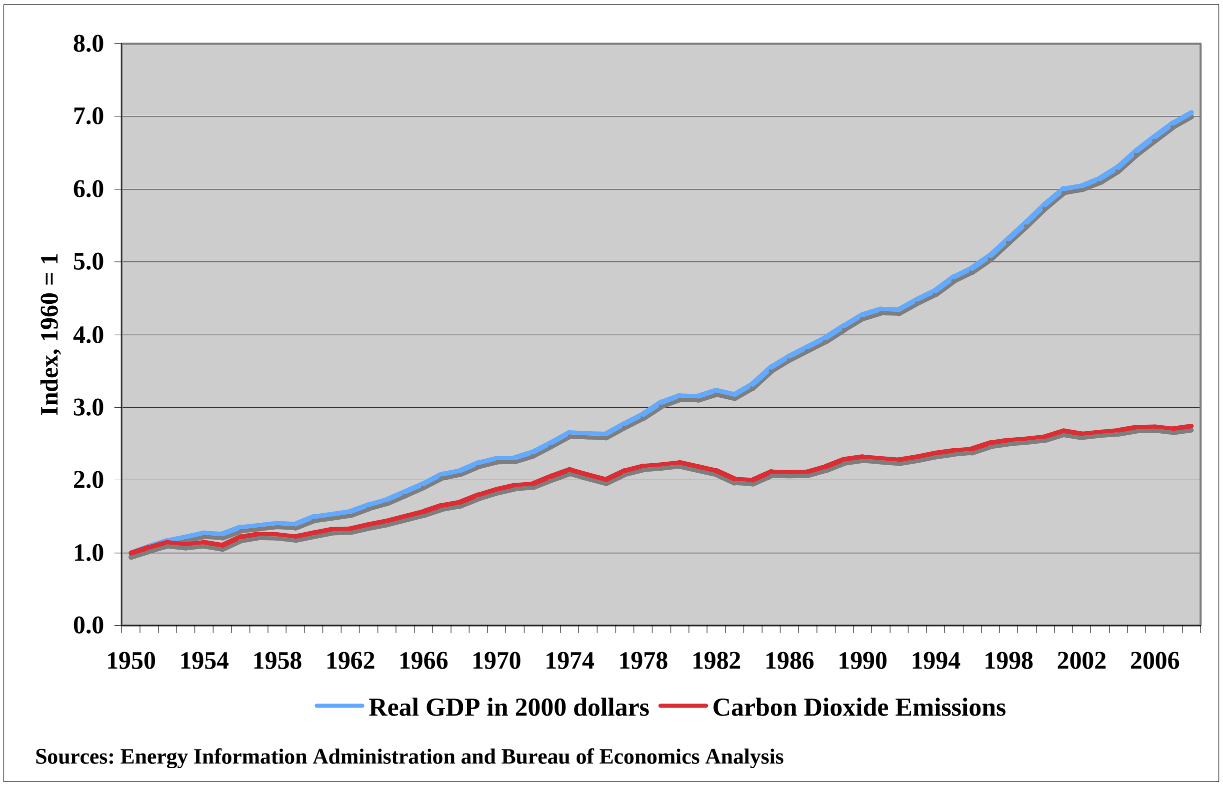

Figure 1: Real Gross Domestic Product and Carbon Dioxide Emissions, 1950-2008

These improvements in carbon intensity arise largely from productivity growth that ultimately comes from higher levels of investment, spurred by expectations of higher sales from greater economic growth. There are many sources of productivity growth - education, training, technological innovations, and notably – reliable and low cost supplies of energy. A closer look at the energy connection now follows.

III. Energy and Productivity Growth

Schurr (1984) maintains that the increased use of more flexible energy forms, liquid fuels and especially electricity enhanced "the discovery, development, and use of new processes, new equipment, new systems of production, and new industrial locations." The effect was powerful enough in terms of raising labor and capital productivity that the energy intensity of output fell. In other words, changes in the quality of energy services drive broader economic productivity, apart from the physical availability of energy.

Economists have long sought to accurately measure and identify the key drivers for productivity growth. Multifactor productivity is defined as total output divided by all factor inputs. Output growth in excess of the growth of inputs is known as the rate of technical progress. Economists have used a variety of advanced econometric methods to identify the separate contributions of input growth and technical change in multifactor productivity growth. Jorgenson (1981; 1984) disaggregates technical change into several components, including that portion of productivity growth associated with the use of electricity. Jorgenson finds that for 23 of 35 sectors of the economy, technical progress tended to be electricity using, which emphasizes the connection between electrification and broader economic progress. In addition, 28 sectors had technical progress that were non-electric energy using. So the relationship between technical change and energy use is pervasive. Jorgenson's studies clearly demonstrate that technical progress is closely linked with energy use. Overall, Jorgenson finds that for 32 of the 35 sectors of the economy, energy-using technical change occurred. By symmetry, this finding suggests that higher energy prices act as a drag on productivity growth.

Another important dimension is energy reliability, especially for electricity. The costs of electricity supply interruptions per lost megawatt hour are several orders of magnitude larger than the cost of base load or peak electricity supply costs (OTA, 1990). These costs arise from the need to maintain backup generators that could be more productively employed under greater system reliability.

While the growing use of microcomputers and the Internet get a good share of the credit for the impressive productivity growth in the U.S. economy since the late 1980s, based upon the findings of Schurr (1984) and Jorgenson (1991, 1994), falling real electricity prices at least should be considered as a contributing factor. Indeed, the deceleration in productivity growth since 2000 could be associated with rising real electricity prices (see Figure 2) and rising real oil and natural gas prices.

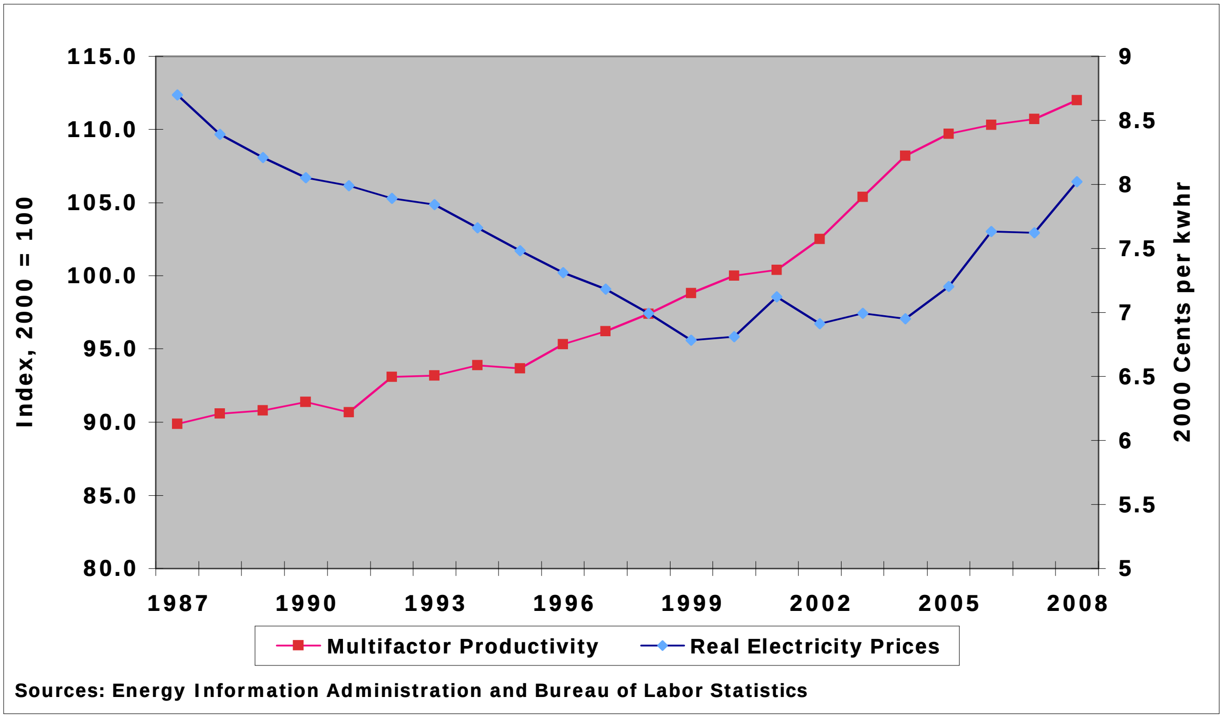

Figure 2: Real Electricity Prices and Multifactor Productivity, 1987-2008

One of the key factors contributing to the fall in the real price of electricity during the 1980s and 1990s was the development of Powder River Basin coal. This is an important lesson of how advances in a basic industry can have broad ramifications for our entire economy. A closer look at the Powder River Basin now follows.

IV. The Emergence of Powder River Basin Coal

Great energy reserves have played an important role in economic development and national strategy. The giant oil field in East Texas that went into production during the Great Depression allowed America to power the Allied war effort during World War II. The super-giant oil fields of the Middle East developed during the 1950s fueled the Marshall Plan for rebuilding Western Europe and Japan after the war. Together these fields contributed to strong, non-inflationary economic growth from 1948 to 1972 by supplying large amounts of energy at low and stable prices.

Similar to the aftermath of the oil price shocks during the 1970s and 1980s, the world is emerging from a deep recession after record high oil and natural gas prices during 2008. Unlike the cartel actions that contributed to earlier price shocks, energy supply constraints were the principal culprit for the recent surge in prices. Once the economy recovers, oil demand growth may once again outpace the expansion of supply. As the world renews its search to replace the aging oil giants, there is an enormous energy reserve right here in America poised to fill the void: Powder River Basin coal.

The Powder River Basin (PRB) in eastern Wyoming and Montana contains the largest source of low-cost, concentrated energy on the planet. According to a recent assessment by the U.S. Energy Information Administration (EIA), the PRB has over 200 *billion* short tons of coal, which is equivalent to over 3,616 quadrillion British Thermal Units (quads) (see Table 1). The next largest energy reserve, the North Dome – South Pars natural gas field in the Middle East, is a distant second at 1,228 quads. Ghawar, the world's largest oil field in Saudi Arabia has 418 quads in reserve.

Table 1: Comparative Size of Powder River Basin Coal Reserves

Field	Resource	Quadrillion BTU
Powder River Basin (Wyoming & Montana)	Coal	3,616
North Dome - South Pars, Qatar-Iran	Natural Gas	1,228
Ghawar, Saudi Arabia	Oil	418
Burgan, Kuwait • in decline	Oil	365
Urengoy, West Siberia, Russia	Natural Gas	275
Next 22 Largest Oil Fields	Oil	1,934
Next 20 largest Natural Gas fields	Natural Gas	1,997

At current production rates of roughly 450 million tons per year, Powder River Basin reserves would support over 400 years of continuous coal production. Even if production doubled, there would be enough reserves to last over 200 years. As mining technology and extraction strategies continue to advance, another 300 billion tons of PRB reserves could be produced that would extend the production horizon to the distant future.

The Powder River Basin is in northeast Wyoming and southeast Montana, measuring approximately 120 miles from east to west and about 200 miles from north to south. Most of the coal being mined there now comes from a relatively narrow string of mines located in the green shaded area in the map below, which is from the U.S. Geological survey.

The coal deposits formed about 60 million years ago when the land began uplifting from a shallow sea. During that time, the local climate was subtropical with about 120 inches of annual rainfall. Organic material collected into peat bogs on the basin floor for over 25 million years. Sediments from mountain runoff buried the peat, compressed it, and converted it into coal. Over the last several million years, the overlying sediment eroded, leaving the coal seams relatively near the surface.

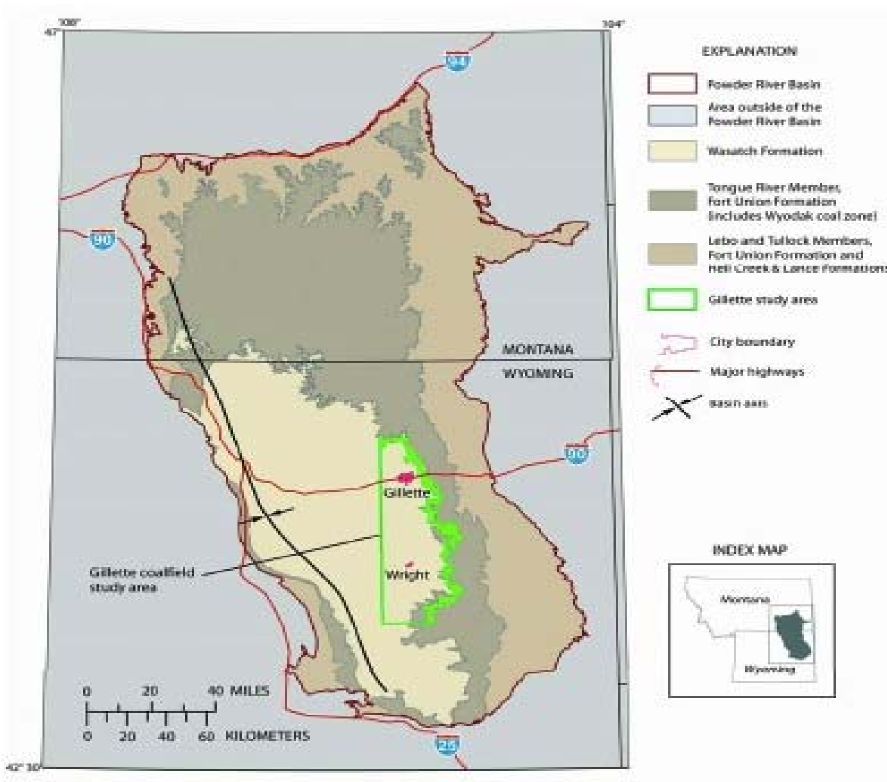

Figure 3: Map of the Powder River Basin Coal Field

The Powder River Basin coal producing area includes two counties in Wyoming, Campbell and Converse, and two in Montana, Big Horn and Rosebud. Campbell County with Gillette as the center is by far the largest producing area within the PRB.

The first coal mine in the Powder River Basin dates back to the 1920s, but large-scale open cut mining did not begin until the 1970s. By 1994, the PRB was producing more than 250 million tons, which was 25% of total U.S. coal production (see Figure 4). After growing at a 4.8% annual rate from 1994 to 2008, total PRB coal production reached almost 496 million tons in 2008, constituting 42.3% of U.S. coal production. Non-PRB coal production increased only 0.8% per annum over the same period.

As Figure 4 below indicates, most PRB coal comes from Wyoming, where PRB coal production went from 216 million tons in 1994 to 452 million tons in 2008. In contrast, PRB coal production from Montana increased from 41 to 44 million tons between 1994 and 2008.

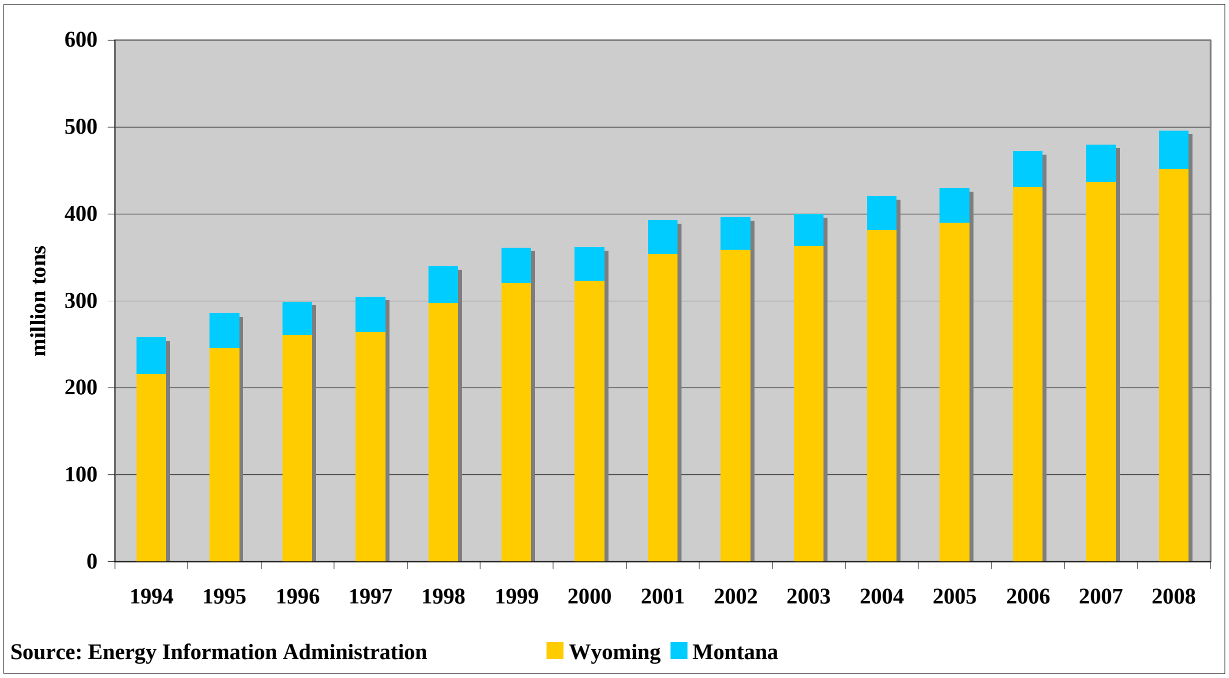

Figure 4: Coal Production from the Powder River Basin, 1994-2008

V. The Powder River Basin Supply Chain

This dramatic increase in Wyoming PRB coal production was achieved by using equipment and supplies from other sectors of the economy. In general coal mining creates significant economic stimulus for industries supplying the goods and services required to extract, process, and deliver coal to customers. To quantify this spending and its geographical distribution, this study conducted a confidential survey of PRB coal producers, asking them to report their spending on supplies purchased from other businesses to conduct current operations. The companies that submitted information represent 91 percent of total output from the Wyoming PRB. As a result, the estimates of total spending by Wyoming PRB producers reported below are equal to the sample estimates multiplied by the ratio of total Wyoming PRB production to production from the reporting companies.

The analysis also identifies the location of each supplier using the Manta industrial database. Many suppliers have regional offices in Wyoming. Accordingly, this study identifies the regional headquarters of these companies and designates that location as the supplier source. This eliminates the over-estimation of spending in Wyoming for supplies. A complete tabulation by state and category appears in Appendix A.

This study estimates that PRB coal producers spent more than $2.27 billion on supplies purchased from other businesses during 2008. To place this amount in perspective, Wyoming coal producers spent about $601.7 million on payroll including benefits for their 5,905 employees, which implies average total compensation of $101,896 per year. During 2008, Wyoming PRB coal producers spent $1.7 billion on taxes and royalties (see Table 2). Given reported Wyoming PRB coal production during 2008 of 452 million tons and assuming an average mine mouth price of $12 per ton, this level of taxation is 32% of gross revenues, which is a surprisingly high rate, especially since it does not include federal corporate income taxes. Operating under such a tax burden while maintaining the lowest cost energy in the United States illustrates the competitiveness of PRB coal producers.

Table 2: Taxes and Royalties paid by PRB Coal Producers during 2008 in Millions

Tax Category	Amount
Severance Tax	238.31
Ad Valorem Tax on Production	204.98
Ad Valorem Tax on Real and Personal Property	12.79
Federal Mineral Royalty (total paid)	568.65
Abandoned Mine Reclamation Fee (total fee)	137.81
Bonus Bids (total paid)	310.78
State Royalties	32.43
Sales Tax	63.78
Black Lung Tax	186.80
Total	$1,756.34

An overview of spending on supplies purchased from other businesses by Wyoming PRB coal producers is presented in Table 3 below. The largest category is fuel supplies and services at $538.5 million followed by industrial supplies and equipment at $454.1 million, and operating repair and rentals at $449.1 million.

Table 3: Estimated Wyoming PRB Coal Spending by Category during 2008 in Millions

Category	Amount
Fuel supplies and services	538.5
Industrial supplies & equipment	454.1
Operating, repair and rentals	449.1
Freight expenses	208.8
Consulting & contractors	173.4
Support services & equipment	89.7
Explosives	82.4
Tires	67.2
Electrical supplies and services	58.9
Other Categories	
Lubricants	38.2
Non-classified	30.8
Drill parts and service	17.3
Wire rope	15.9
Safety & health	14.1
Administration	13.6
Chemicals	8.7
Communication products & services	6.7
Welding	5.2
Total	$2,272.5

As Figure 5 illustrates, these three categories constitute more than 63.5% of total expenditures on supplies acquired from other businesses. Expenditures on freight were $208.8 million during 2008. Consulting and contractor service expenditures were $173.4 million. These last two categories comprise 16.8% of total spending. Expenditures on support services and equipment totaled $89.7 million, or 3.9% of total spending. These top six categories constitute 84.2% of total spending. Electrical supplies, tires, and electrical supplies and services comprise 3.6%, 3.0%, and 2.6% respectively of supply-chain spending. A breakdown of the remaining 6.6% of spending is illustrated in Figure 6. For example, 1.38% of total spending is lubricants, 1.36% is non-classified, and the remaining categories are each less than 1% of total supply chain spending, including spending for drill parts and services, wire rope, safety and health, administration, chemicals, communication products and services, and welding (see Figure 6).

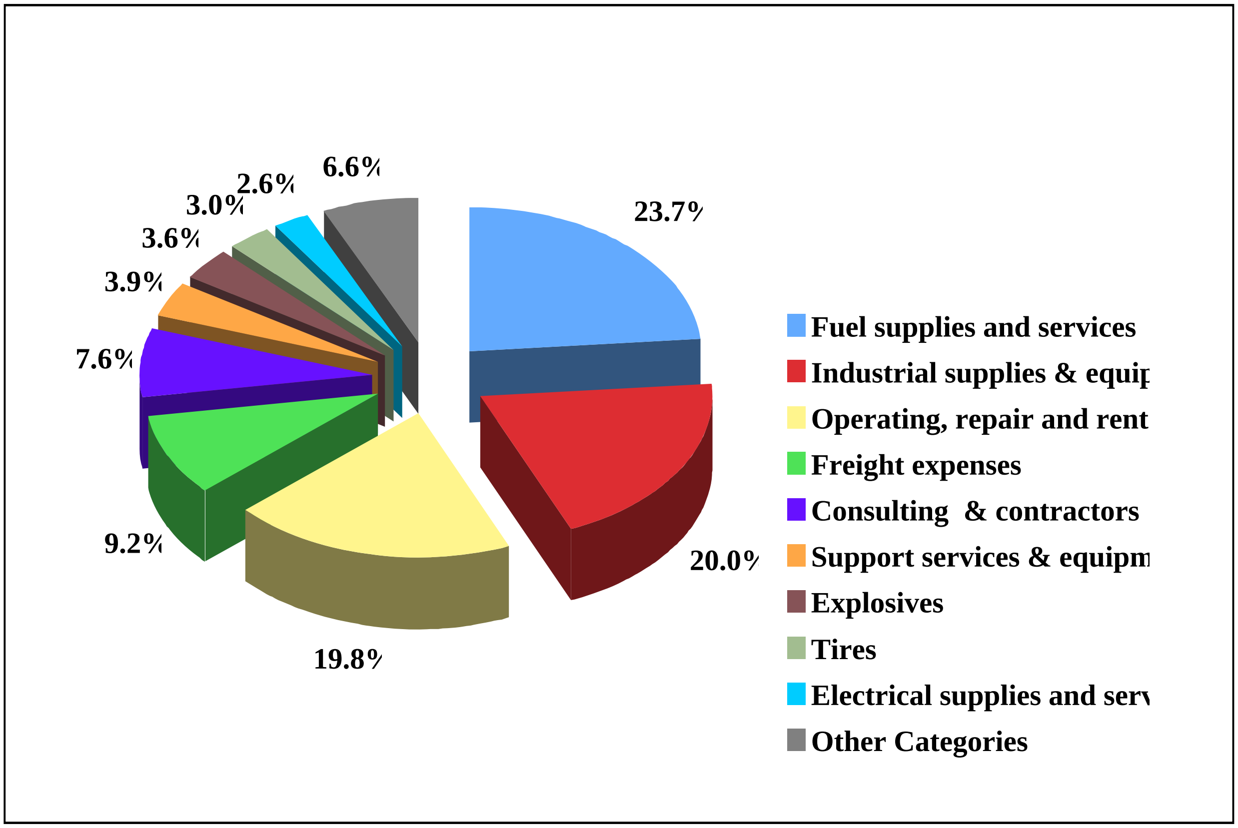

Figure 5: Cost Shares of Major Categories of Total Supply Expenditures in Percent

Unlike the concentration of spending by category, the geographical distribution of spending by PRB coal producers is quite widespread. Based upon the survey conducted by this study, PRB coal producers have suppliers in 47 states (see Table 4). Of the $2.27 billion in spending on supplies during 2008, more than $701 million occurs within Wyoming, constituting more than 31% of total spending across all states (see Figure 7). The next largest source of supplies is Utah at $229.6 million, Texas at $231.6 million, and Illinois at $178.7 million, collectively comprising 28% of total spending. Alabama and Pennsylvania each provide 7% of total spending and Colorado provides 5%. The remaining 40 states supply 22% of total spending.

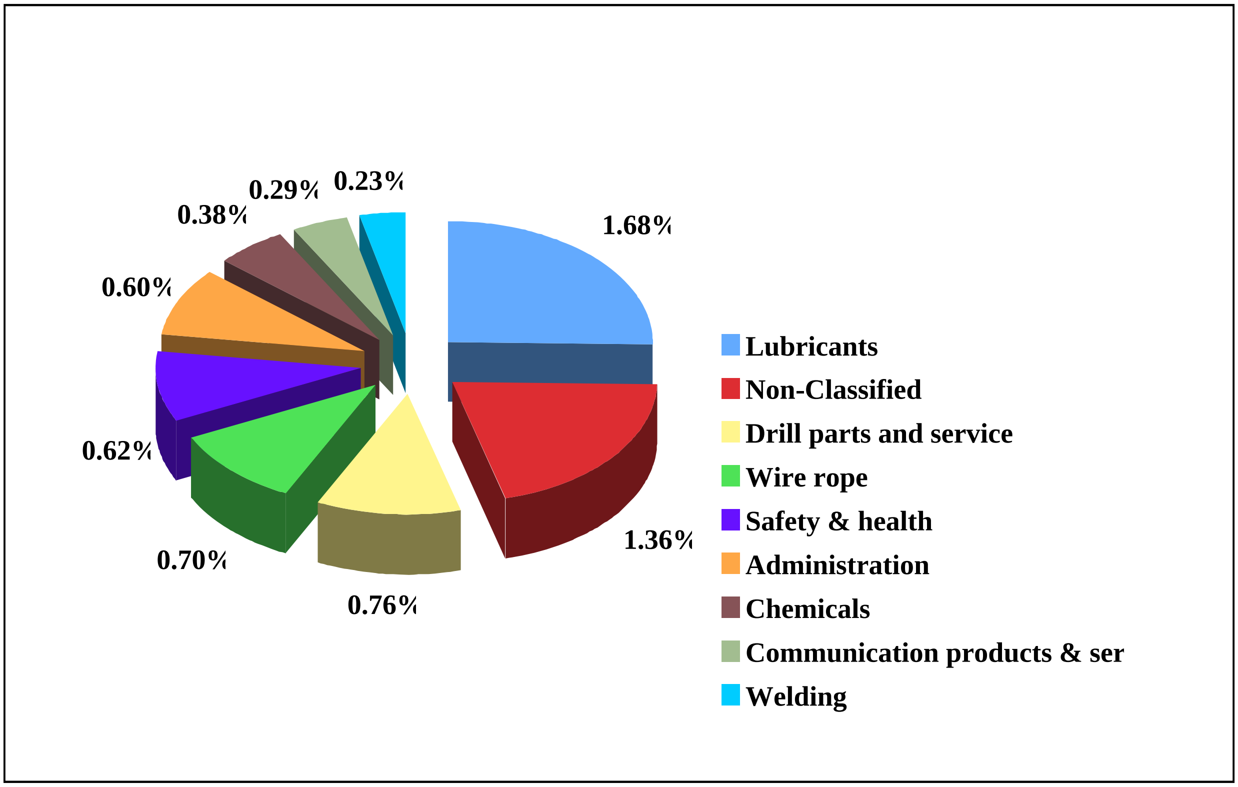

Figure 6: Cost Shares of Other Categories of Total Supply Expenditures in Percent

These expenditures on supplies generate indirect economic impacts as the initial stimulus from expenditures on coal production is spent and re-spent in other business sectors of the economy. For example, in developing coal seams companies employ the services of drilling and explosives contractors that in turn purchase goods and services from other businesses. These impacts are known as *indirect economic impacts*. The wages earned by these employees increase household incomes, which then stimulates spending on local goods and services. These impacts associated with household spending are called *induced impacts*. The total economic impacts are the sum of the direct, indirect, and induced spending, set off from the expenditures by PRB producers. These economic impacts are estimated by comparing gross output, value added, tax revenues, and employment in the local economy with and without PRB development.

Regional economic impact analysis using input-output (IO) tables and related IO models provide a convenient framework for measuring these economic impacts. Input-output analysis provides a quantitative model of the inter-industry transactions between various sectors of the economy and, in so doing, provides a means for estimating how spending in one sector affects other sectors of the economy and household disposable income. By identifying the regions and sectors affected by the stimulus generated from coal resource development this study lays the groundwork for such future analysis. Nevertheless, the downstream benefits of PRB coal in enabling the production of reliable and inexpensive electricity are likely several orders of magnitude larger than the economic stimulus generated by supply chain spending.

Table 4: Spending on Supplies by State during 2008 in Millions

State	Amount	State	Amount
Alaska	1.02	North Carolina	1.31
Alabama	151.18	North Dakota	4.33
Arkansas	7.29	Nebraska	2.69
Arizona	17.41	New Hampshire	0.14
California	21.69	New jersey	4.70
Colorado	121.04	New Mexico	2.47
Connecticut	0.33	Nevada	1.52
District of Columbia	0.17	New York	2.11
Florida	64.07	Ohio	9.67
Georgia	21.63	Oklahoma	2.44
Iowa	5.02	Oregon	7.21
Idaho	13.12	Pennsylvania	153.35
Illinois	178.73	Rhode Island	0.06
Indiana	23.66	South Carolina	22.35
Kansas	3.78	South Dakota	43.18
Kentucky	2.02	Tennessee	17.40
Louisiana	0.17	Texas	229.62
Massachusetts	1.37	Utah	231.63
Maryland	0.13	Virginia	2.89
Michigan	4.52	Washington	22.93
Minnesota	50.98	Wisconsin	54.25
Missouri	15.52	West Virginia	3.27
Mississippi	0.02	Wyoming	701.46
Montana	46.73	Total	$2,272.54

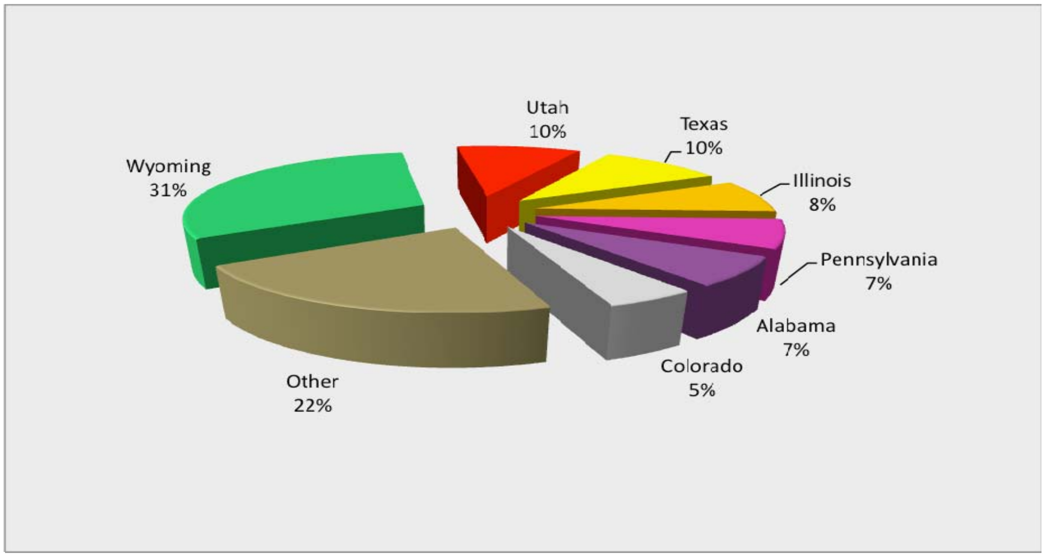

Figure 7: State Shares of Spending on Supplies

VI. Low Costs and High Quality of PRB Coal

The dramatic increase in PRB coal production is driven by the fundamental economics of coal production, transportation, and utilization. Most coal consumers in the U.S. are producers of electricity. These firms generally try to minimize their fuel costs. Most of these producers are regulated utilities. As a result, they must justify their fuel choices before Public Utility Commissions who are interested in keeping electricity rates at competitive levels. The unique geology of the PRB coalfields combined with the application of advanced mining technology enables PRB coal producers to satisfy their customer's needs to minimize fuel acquisition costs.

Other key players enhancing the competitiveness of PRB coal are the railroads. Roughly half of the delivered cost of coal to electricity producers is transportation. Deregulation and investments in rail improvement and access played a key role in reducing transportation costs for delivering PRB coal. Finally, another key factor involves environmental regulations. The Clean Air Act Amendments of 1990 mandated significant reductions in emissions of sulfur dioxide from energy consuming facilities, such as electric power plants. Electricity providers have a number of options to achieve emission control standards, including the substitution of low-sulfur PRB coal for higher sulfur fuels, such as Eastern coal and residual fuel oil.

A key source of PRB coal's competitiveness is the high productivity of the mining operations in the region. Figure 8 below plots labor productivity of coal producers in Wyoming, in the Powder River Basin, and outside the region. Labor productivity among PRB producers is on average nine times greater than other U.S. coal producers. PRB mines averaged 40 tons of coal mined per employee per hour while other producers averaged 4.4 tons per hour. To a certain extent, this huge difference in productivity reflects the relatively larger coal seams in the PRB. Other factors, however, are at work.

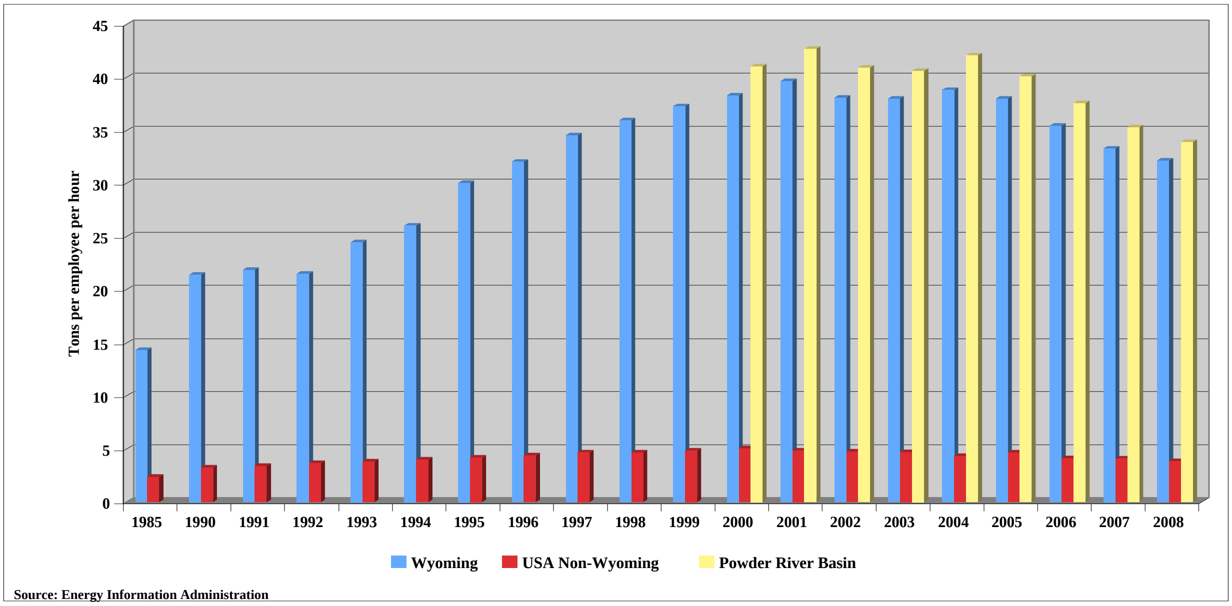

Figure 8: Labor Productivity of Various Coal Producers, 1985-2008

Rather than differences in absolute levels of productivity these factors are manifested in the trends in productivity over time. To measure these trends, a comparison between Wyoming and other U.S. producers is required because PRB productivity statistics are unavailable prior to 2000. The growth in labor productivity in Wyoming between 1985 and 2007 was 4.6% per annum, while the same measure in other regions was 3% per year. While both productivity growth rates are impressive, the higher growth rate in Wyoming may reflect differences in labor incentive structures, workplace rules, and technology adoption.

Another key factor contributing to PRB coal competitiveness has been lower transportation rates. In 1980, Congress passed the Staggers Rail Act that deregulated the U.S. railroad industry. Prior to passage, rail rates were linked to tariffs regulated by the Interstate Commerce Commission. After passage, railroads could charge their own tariffs and began to compete for business by setting competitive rates. After the early to mid-1980s average rates for coal transportation declined steadily. In Figure 8 below regional coal transportation rates are reported from 1979 to 2001 for coal shipped from Appalachia, the interior U.S. (Midwest), and the West to the Midwest and South regions of the U.S. On average, annual coal transportation rates across the U.S. declined 3.4% over this period. Coal transportation rates declined 72% from 1979 to 2001 with rates declining 78% and 90% respectively for coal shipped from the West to the Midwest and South (see Figure 9).

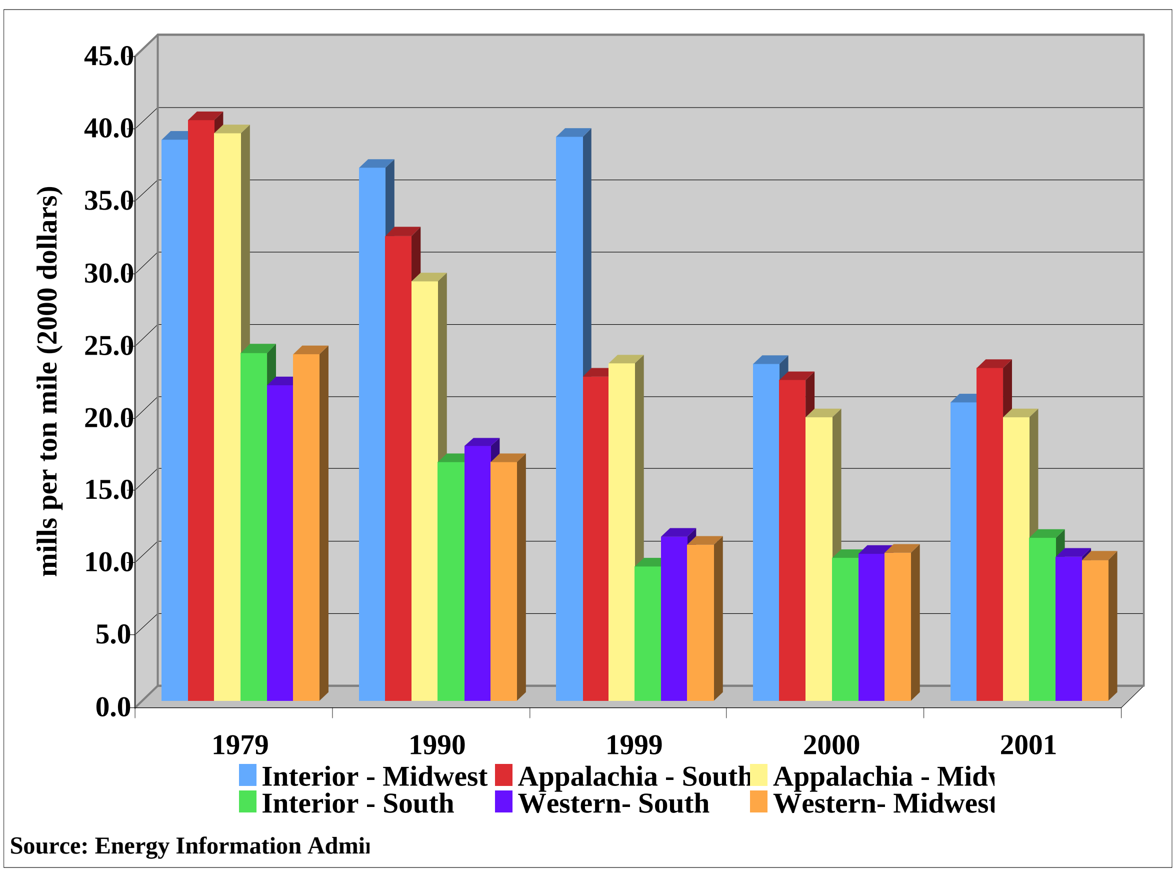

Figure 9: Coal Transportation Rates by Region, 1979-2001

Higher productivity and lower transportation costs contributed to a trend of declining real prices for coal in the U.S. from the late 1970s through the first few years of this century. Prices for bituminous and sub-bituminous coal are plotted in Figure 10 from 1979 to 2008. PRB coal is sub-bituminous so prices for this grade reflects trends in PRB coal prices. The first notable feature of this time series plot is the wide differential between prices for bituminous and sub-bituminous coal. These price differentials are consistent with a competitive market in which prices reflect productivity and cost differences between regions. Early in the sample, sub-bituminous coal prices were about 40% of prices for bituminous grades. Towards the end of the period, prices for sub-bituminous grades were only 25% of bituminous prices. These trends are also consistent with the productivity trends discussed above in which the PRB region is becoming relatively more productive over time.

These differences in prices between coal grades affected the relative composition of shipments over time. As Figure 11 illustrates bituminous coal shipments were substantially higher than sub-bituminous coal shipments until 2001. By 2006, sub-bituminous shipments were just 4 tons less than bituminous coal deliveries. These adjustments in part reflected fuel use decisions by electricity producers in response to delivered cost and environmental regulations.

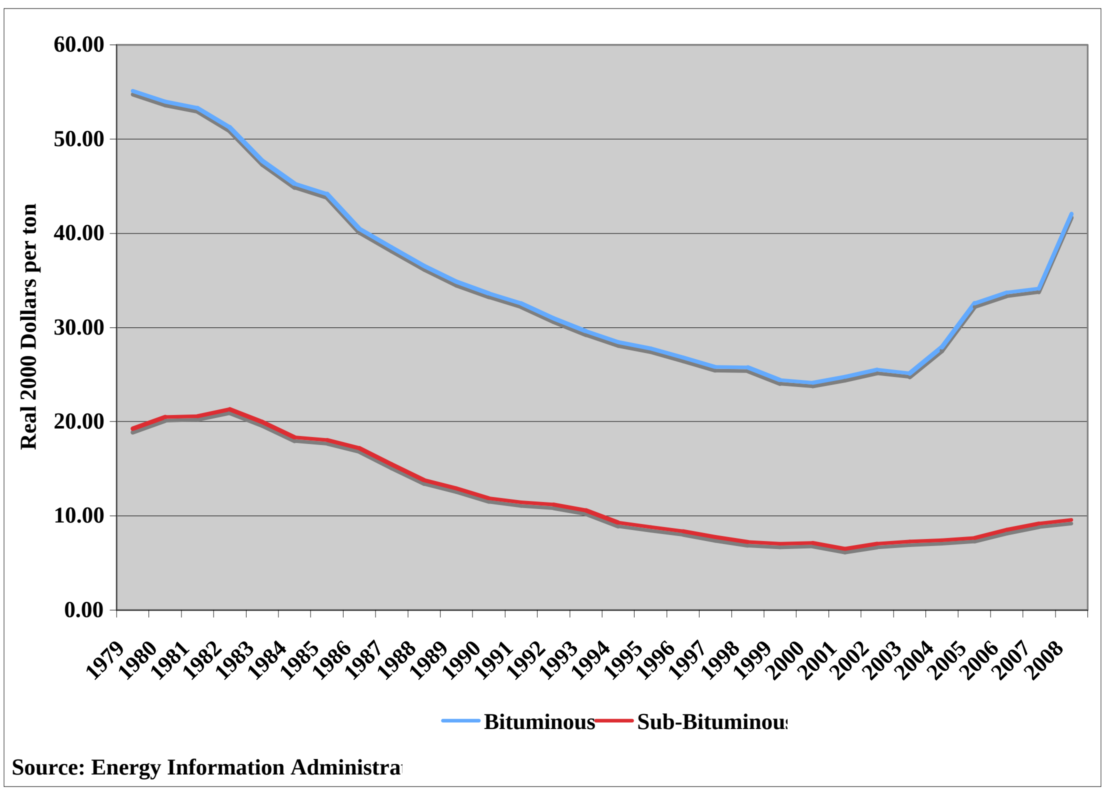

Figure 10: Real Prices for Coal by Grade, 1979-2008

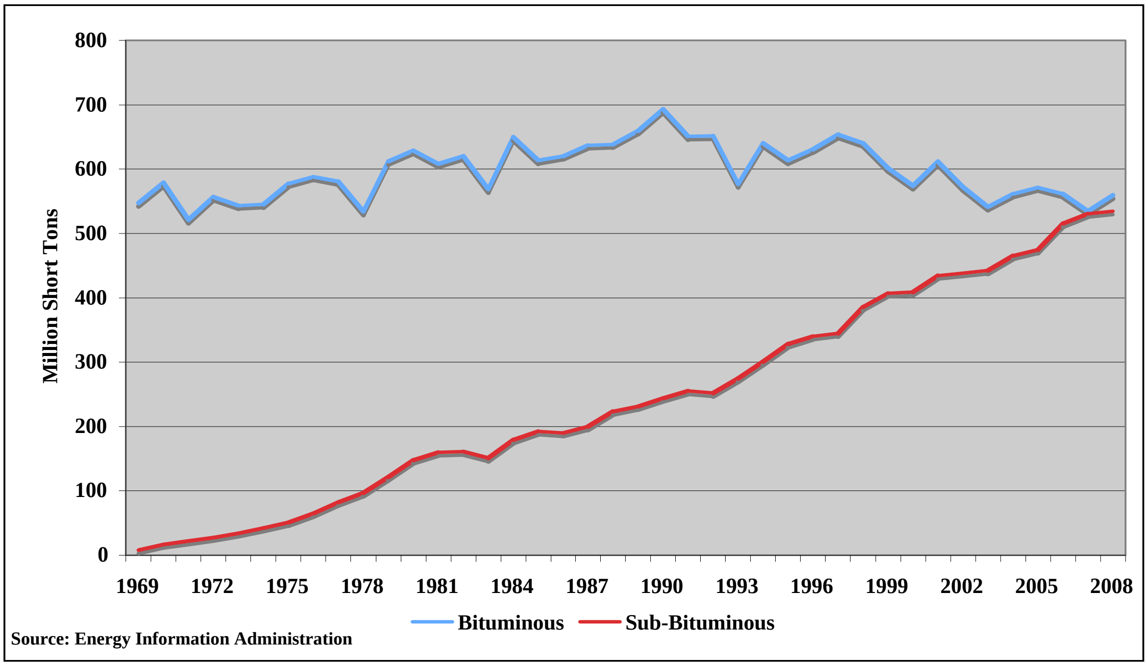

Figure 11: Coal Shipments by Grade, 1969-2008

Sub-bituminous coal has substantially lower sulfur content with about 0.4% sulfur by weight as opposed to 1.5% for bituminous coals. The rising share of PRB coal played an important role in reducing U.S. emissions of sulfur dioxide from 1995 to 2007. From their peak of 13.5 thousand tons in 1997, sulfur dioxide emissions dropped to 9 thousand tons in 2007 (see Figure 12). Emissions per unit of electricity generated from fossil fuels also declined (see Figure 13), which reflects switching to PRB coal and natural gas.

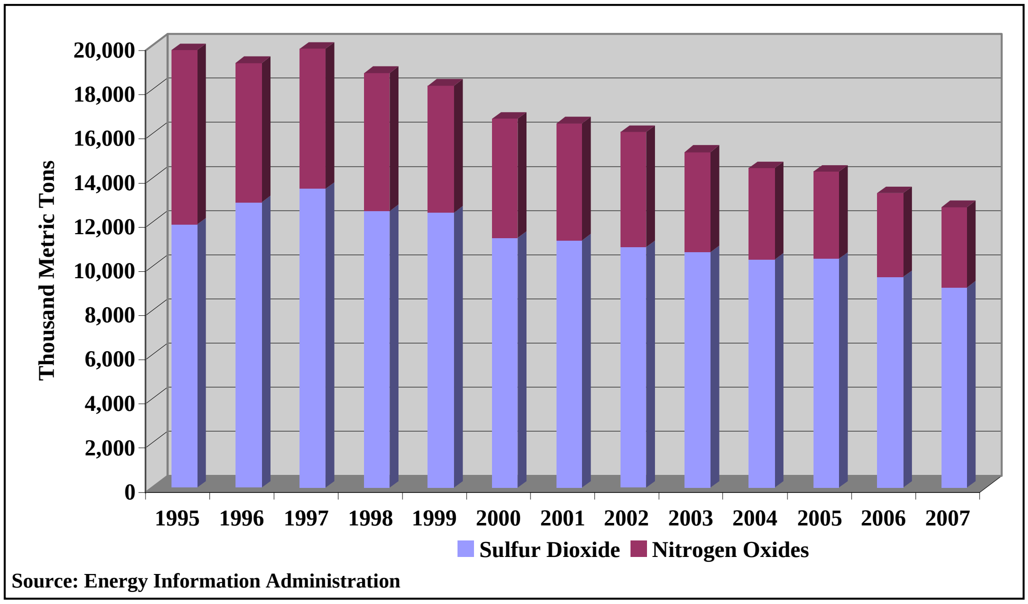

Figure 12: Sulfur Dioxide and Nitrogen Oxide Emissions from Power Plants, 1995-2007

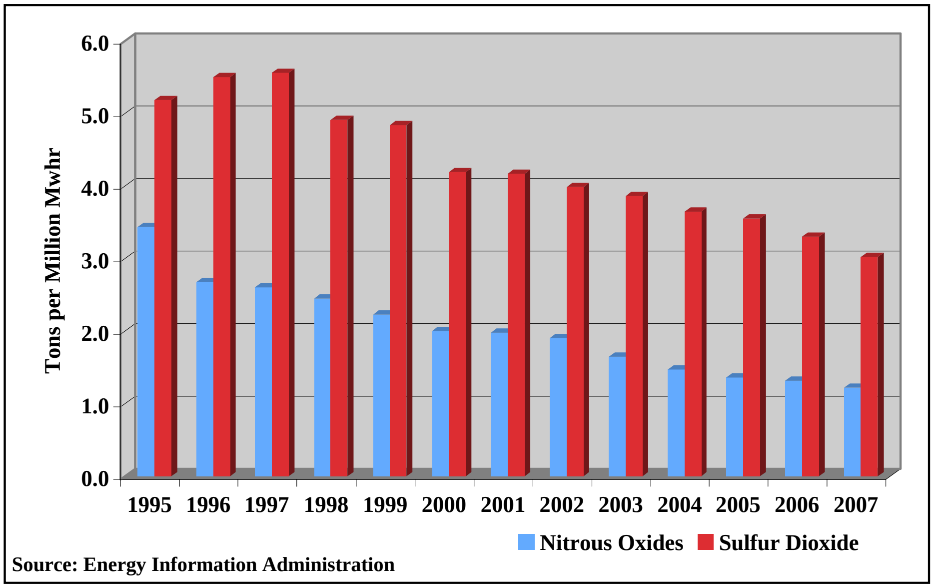

Figure 13: Emissions per Megawatt hour of Generation from Fossil Fuels, 1995-2007

VII. PRB Coal and Electricity Prices

The low cost and high quality of PRB coal have been the primary drivers for its expanding use and market share. This expanded consumption of PRB coal has broad geographical scope. Most of the growth in PRB coal consumption has been in the Midwest and Western United States. As Figure 14 below indicates, about 18% of coal consumed in the East, which includes New England, Mid-Atlantic, and North Central states, came from the PRB in 1992 but by 2008 that percentage increased to 52% of that market.

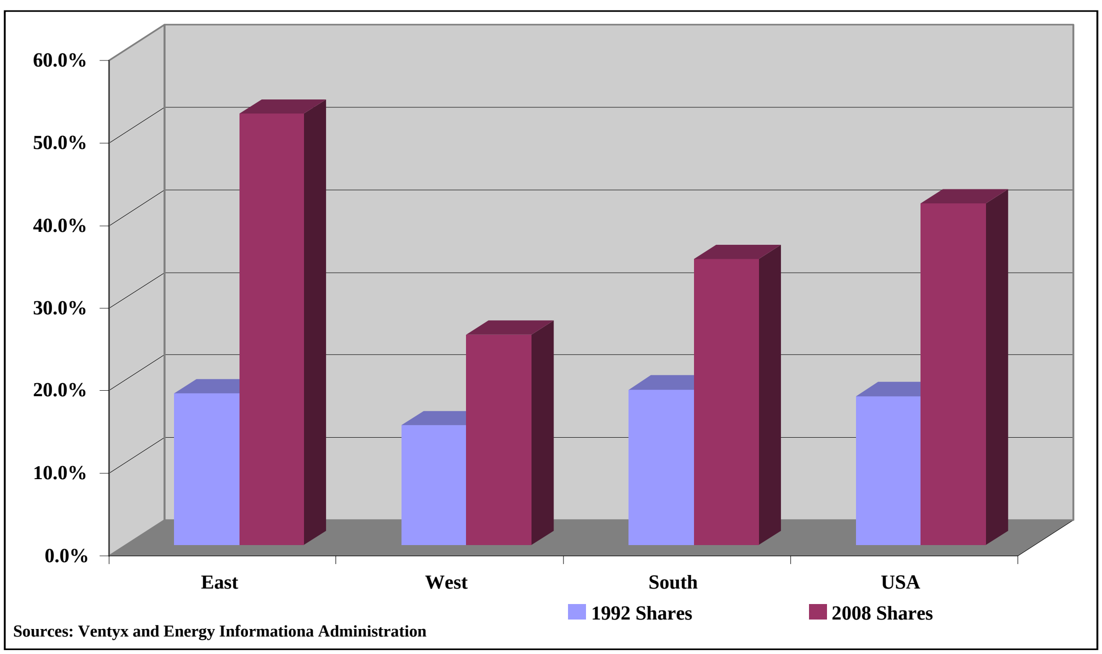

Figure 14: Growth in market share of PRB coal, 1992 and 2008

PRB coal is now used in 38 states. The largest market for PRB coal is Texas, which consumed over 64 million tons during 2008. The next largest market is Illinois at 54 million tons. Missouri is third at 42.6 million tons. Of the 20 states that consume more than 8 million tons of PRB coal, all but one has retail electricity prices below the national average of 9.8 cents per kilowatt-hour or $98 per megawatt hour. The only exception is Texas due to its high use of natural gas in power generation. These 20 states on average have retail electricity rates that are 17.8% below the national average (see Figure 15).

Of the 15 states that use very little or no PRB coal, 10 have retail electricity rates above the national average (see Figure 16). The three exceptions include Idaho, which uses large amounts of hydroelectric power, New Mexico, which uses local coal, South Carolina, which has significant nuclear energy assets, and Montana and Virginia that also use their own coal supplies. Average retail electricity rates are 21% above the national average for states that do not use PRB coal and 63% above the national average for this group without Idaho, New Mexico, South Carolina, Montana, and Virginia. These findings suggest that regions that do not use PRB coal are likely to have higher than average electricity rates.

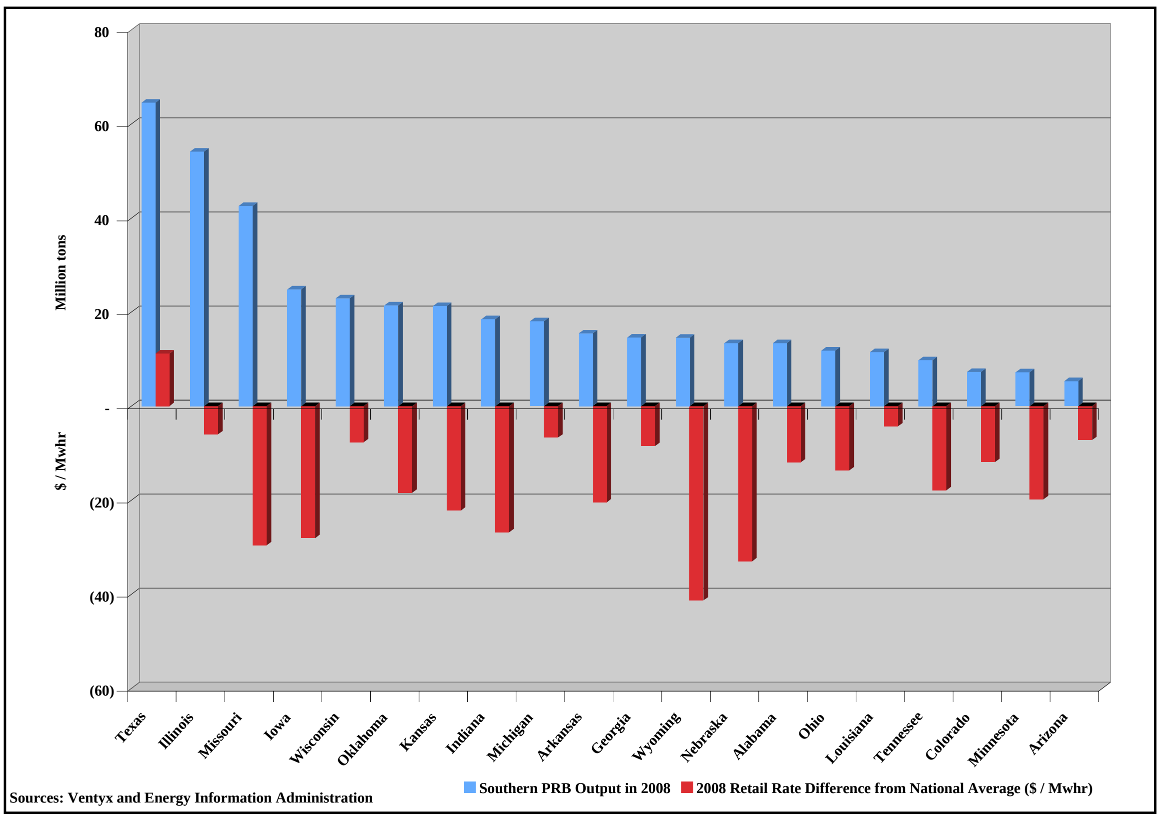

Figure 15: PRB Coal Users and Electricity Rate Differences in 2008

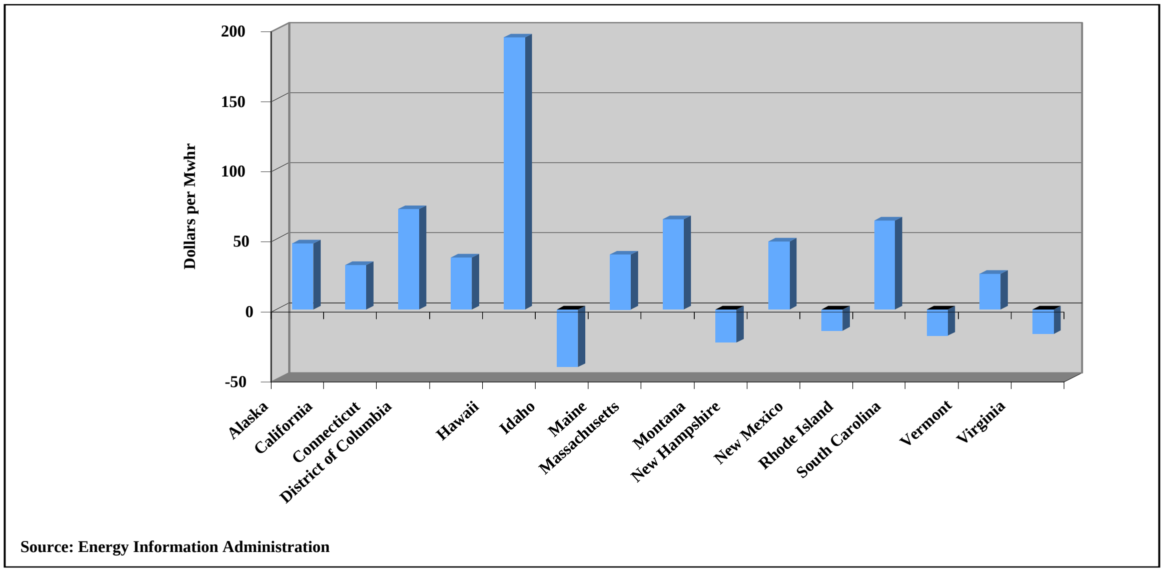

Figure 16: Retail Electricity Rate Differences for non-PRB Coal Users in 2008

The expanded use of PRB coal over time is also an important factor explaining electricity price trends. After reaching a peak of 9.7 cents per kilowatt-hour in 1982, real electricity prices declined steadily during the 1980s and 1990s, reaching a low of 6.8 cents per kilowatt-hour in 1999. During the same period, the share of all electricity generated from Wyoming coal, which is primarily from the PRB, rose from 8 to 15 percent. The increased market share of PRB coal directly contributed to lower real electricity prices during the 1980s and 1990s (see Figure 17). Hence, the PRB coal industry is a good example of how dramatic improvements in productivity of a basic industry like coal production translates into downstream benefits, such as reductions in the real electricity prices. Following the supply chain, these lower real electricity prices improve the competitiveness of electricity-using sectors.

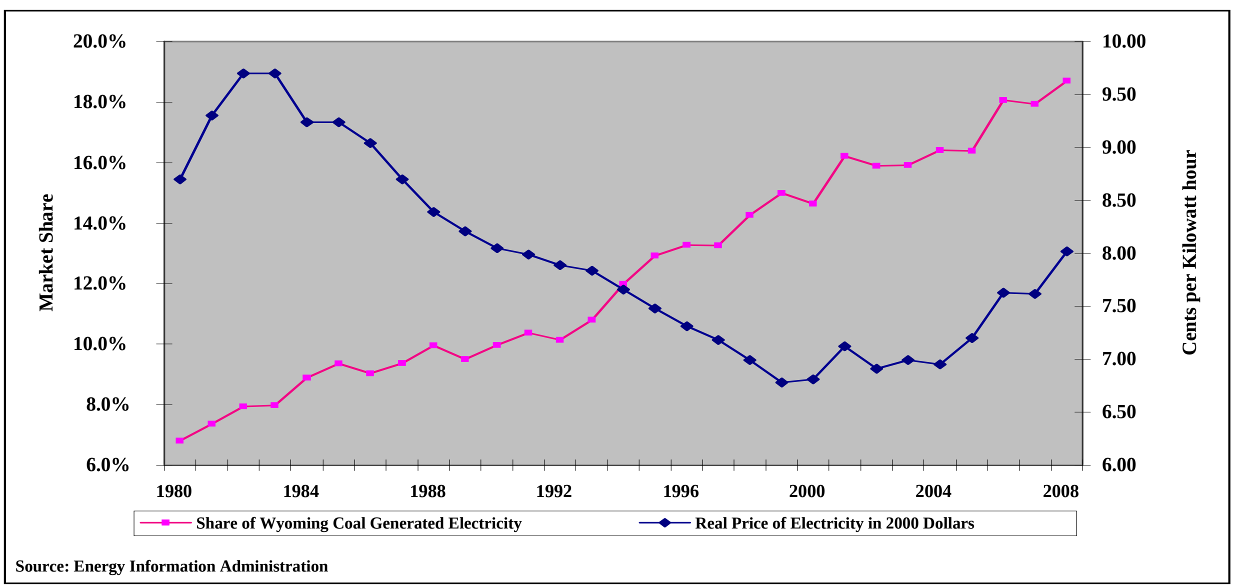

Figure 17: Share of Wyoming Coal Generated Electricity and Real Prices, 1980-2008

Once again PRB coal plays a pivotal role. As we have seen above, the consumption of high quality, low cost PRB coal contributes to lower prices of electricity observed in the industrial heartland of the United States. Figure 18 vividly illustrates that most industrial consumption of electricity occurs in the central and southern regions of the United States where industrial electricity rates are lowest. The West Coast and northeastern sections of the United States have the highest industrial electricity rates and substantially lower industrial electricity consumption. Historically, electricity intensive industries, such as metals and equipment manufacturers, gravitate to areas with relatively low electricity rates.

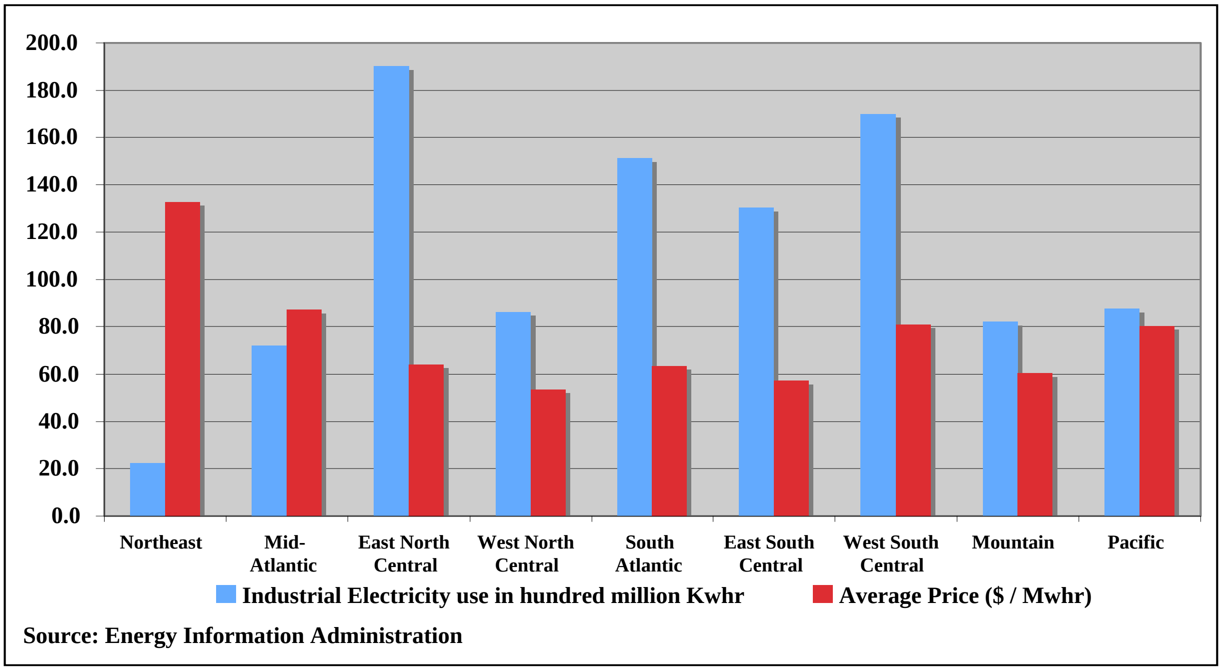

Figure 18: Industrial electricity consumption and rates by region in the U.S. in 2008

As the pace of PRB market penetration slowed and the use of natural gas in power generation increased, real electricity prices in the U.S. stopped falling and began rising significantly. Prices for natural gas paid by electricity producers increased from $3 per thousand cubic feet in the year 2000 to almost $8 per thousand cubic feet in 2008 (see Figure 19). The resulting increase in real electricity prices would have been larger without the cost cushioning impact of PRB coal.

Summing up, PRB coal has contributed to lower electricity prices nationwide and in particular in the Midwest, south, and western U.S. These lower electricity prices have spurred productivity growth by encouraging the continued electrification of our economy. These productivity enhancements have been important in maintaining U.S. industrial competitiveness and in retaining manufacturing in America. The energy and material efficiency of U.S. manufacturing is the highest in the world and is a key source of strength as U.S. companies compete in world markets. PRB coal plays an important role in maintaining this industrial leadership and the export capability of the U.S. economy.

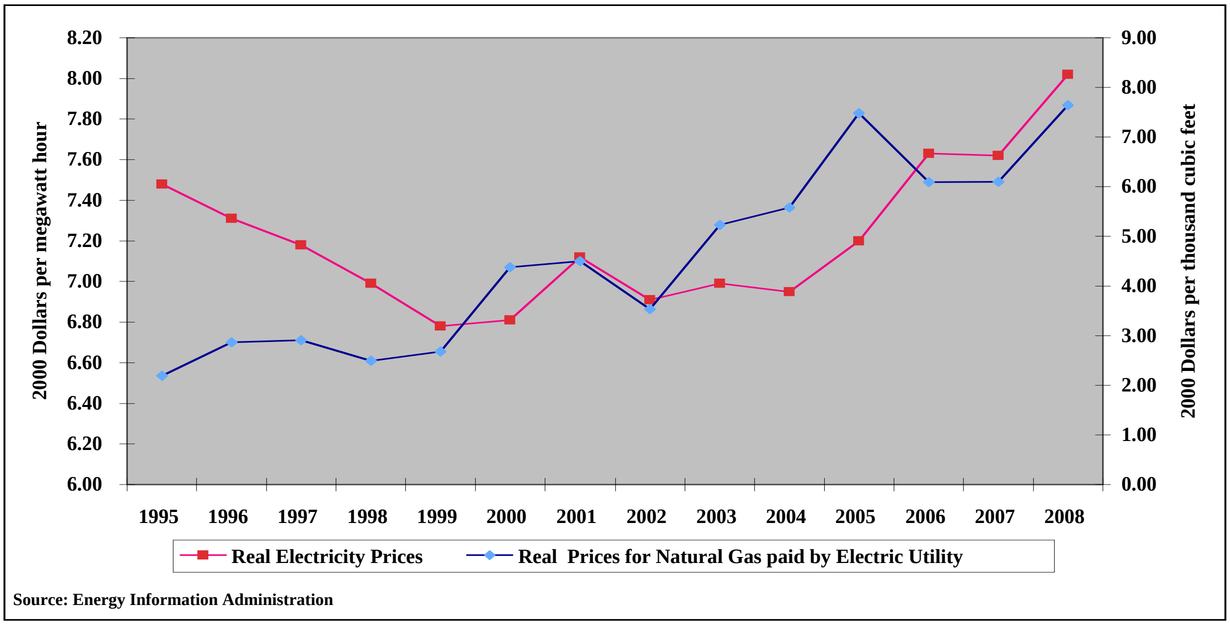

Figure 19: Real Prices for Electricity and Natural Gas, 1995-2008

VIII. The Value of PRB Coal to the U.S. Economy

Powder River Basin coal has become such a mainstay of the U.S. economy that it is difficult to imagine how our economy would function without it. Nevertheless, alternative electric power technologies are viewed as potential replacements for coal-fired power generation. Wind and solar energy are often touted as promising alternatives. Even though no nuclear power plants have been constructed since the 1980s, nuclear energy is yet another widely discussed possibility.

The key competitor with coal, however, is natural gas. Until the spike in wind power capacity additions during 2008, nearly all new-electric generating capacity since the mid 1990s has been fired with natural gas. Electric power generation is now the single largest end-use of natural gas in the United States. Continuing to turn to natural gas rather than PRB coal for new electricity generation may be subjecting our nation’s electricity grid and our industrial base to future price shocks down the road.

As Figure 20 illustrates, natural gas and residual fuel oil prices are far more volatile than coal prices. The chart below reports the mean and standard deviations (denotes as S.D. below in Figure 20) in prices paid by electricity producers for coal, petroleum, and natural gas. Based upon the standard deviation, natural gas prices are nearly seven-times more volatile than coal prices. As we increase our reliance on natural gas in power generation, the cushioning effect that low cost PRB coal has on average fuel costs diminishes and with this diminution average electricity rates become more sensitive to marginal natural gas prices. For regions like the Northeast and Pacific coast, this transition will further increase average electricity rates, which are already well above the national average. But for the industrial heartland, increasing the use of natural gas in electricity generation could dramatically increase electricity rates.

To understand the magnitude of this potential problem, this study estimates the impact on average retail electricity rates from phasing-out PRB coal in power generation and replacing it with natural gas. This exercise also provides a basis for estimating the opportunity cost to the U.S. economy of not using PRB coal. In this case, this opportunity cost is the cost of producing electricity from the next best available technology. There are several alternatives to evaluate. While there may be growing public support for nuclear power, long lead times for permitting and construction incur significant capital costs. Wind power is not a viable option because it is incapable of replacing base load capacity given its intermittent production profile. Thermal solar and photovoltaic power systems are even higher cost and have the same intermittency problems that wind power faces. Hence, the next best alternative to PRB coal is natural gas fired electricity generation.

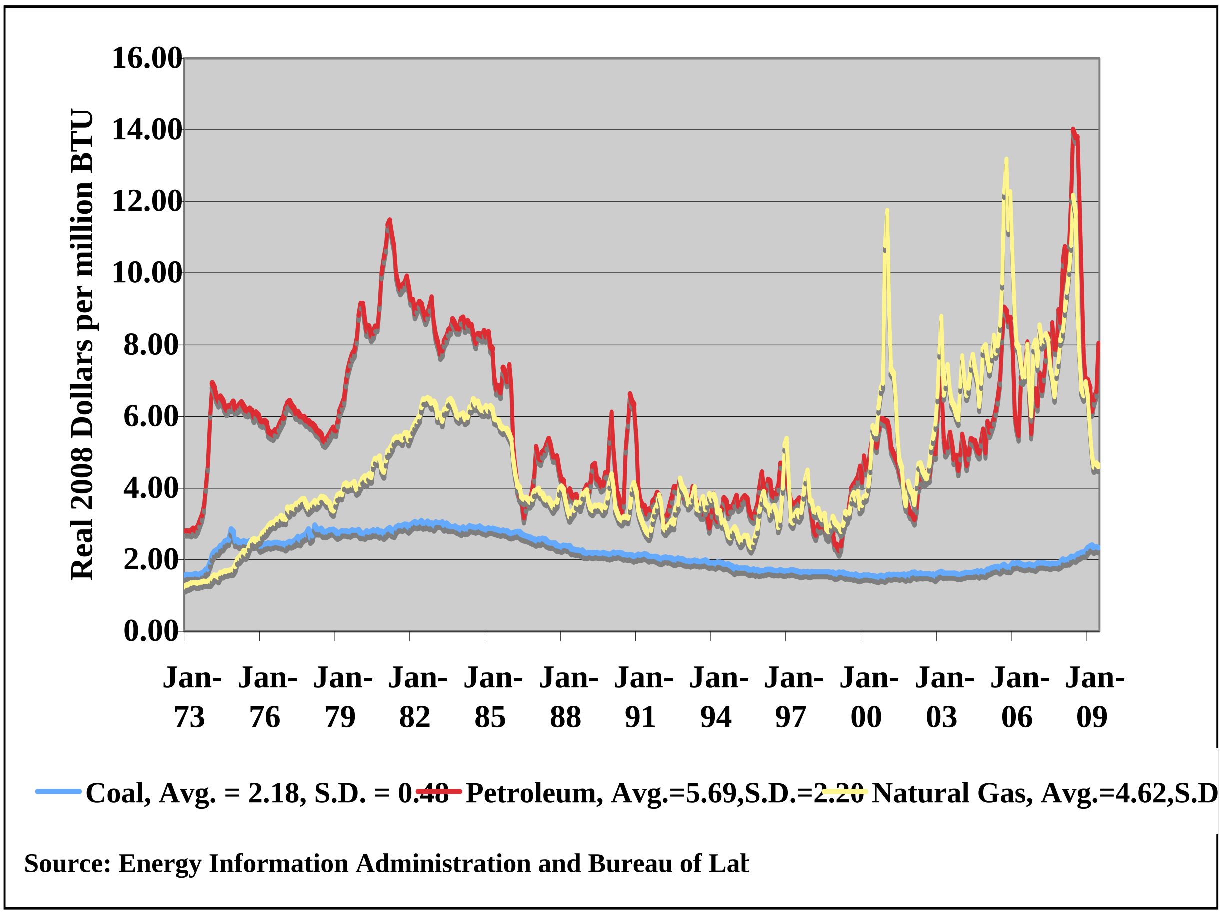

Figure 20: Real Fuel Prices in Electric Power Generation, 1973-2009

How much natural gas would be required to replace PRB coal? PRB coal is used to generate 707,535 million kilowatt hours of electricity, which is about 19% of total electricity consumption in the U.S. during 2008. Given the thermal efficiencies of natural gas capacity, replacing PRB coal-based generation would require slightly more than six trillion cubic feet of natural gas per year. This expansion of natural gas use would require a 29.3% increase in natural gas supplies to the U.S.

Even though natural gas markets are in surplus now, such a dramatic expansion of natural gas use would bid up prices. The natural gas market during 2008 provides an example of how high prices could increase. Natural gas prices increased 26.7% during 2008. During the same year, natural gas production increased 7.7%. Assuming that all other factors affecting gas supply are held constant these facts suggest a natural gas supply elasticity of 0.29. In other words, for every ten percent increase in gas prices, producers expand production almost three percent. To achieve a 29.3% increase in natural gas production to replace PRB coal, wellhead natural gas prices would have to increase over 101.3%, doubling wellhead natural gas prices from an average of $8 per thousand cubic feet (mcf) during 2008 to over $16 per mcf. This estimate may be conservative because natural gas prices peaked at over $12 per mcf several times over the past three years without a major expansion in demand. Assuming the costs of transporting and distributing natural gas are constant, this wellhead price increase would increase natural gas prices paid by residential, commercial, industrial, and electricity producers by 59%, 68%, 85%, and 87% respectively.

These higher natural gas prices would increase electricity rates. Electricity producers and consumers would have to pay for new capacity and for the higher costs of running new and existing capacity at higher natural gas prices. The central part of the United States with most of our nation’s manufacturing capacity would be most affected by replacing PRB coal with natural gas. Average retail electricity rates would increase more than 140% in the west north central states, 76% in the west south central states, 70% in the east north central states, and 41% in the east south central states. Even though other regions do not directly consume PRB coal, higher

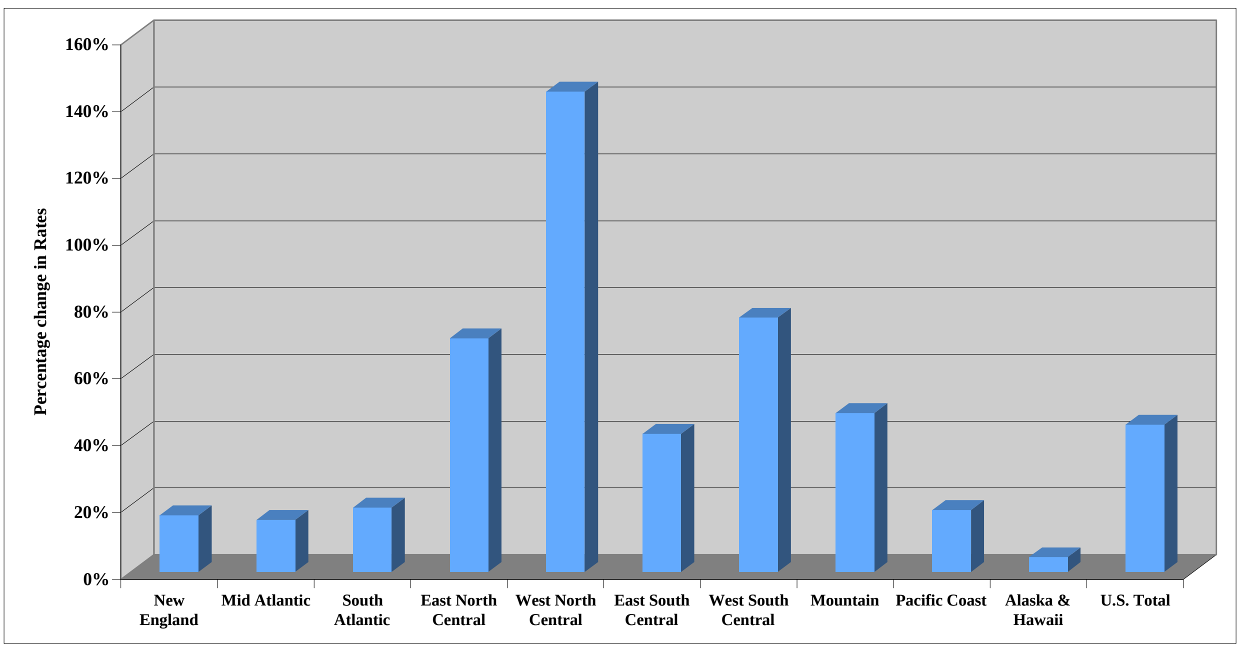

Figure 21: Changes in Electricity Rates from Replacing PRB Coal with Natural Gas

natural gas prices would force up electricity rates in these areas. For example, average retail electricity rates would increase on average 18% in New England, the Mid-Atlantic, South Atlantic, and Pacific regions. Nationwide, eliminating PRB coal use would drive up average retail electricity rates by more than 44%. Fortunately, this scenario is unlikely to transpire.

Nevertheless, this analysis reveals that PRB coal plays a very important role in keeping our nation's electricity costs under control, especially for the large industrial users in the central part of the United States. Without PRB coal, the very low and competitive electricity rates that keep large industrial users competitive in world export markets would be replaced by substantially higher rates (see Figure 22).

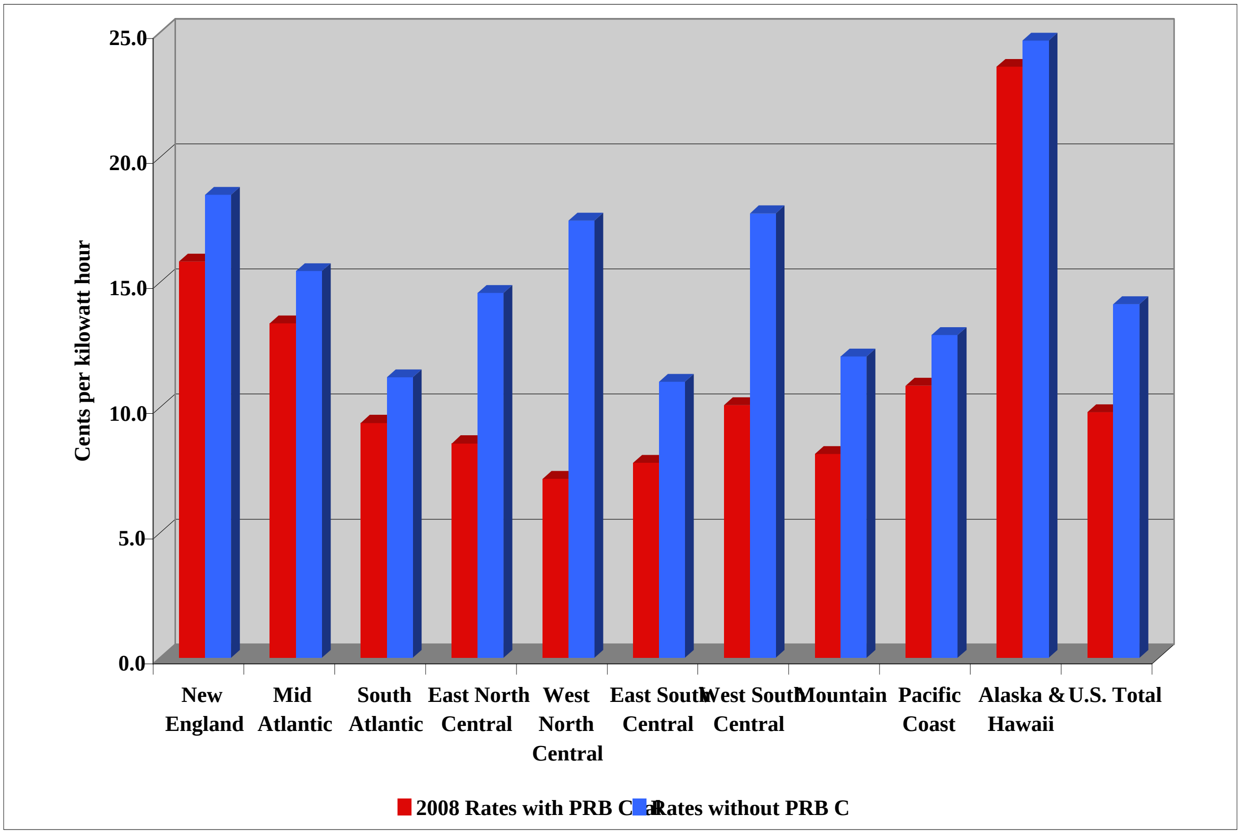

Figure 22: Electricity Rates by Regions with and without PRB Coal

Estimates of the increases in average retail electricity rates by state appear in Table 5. The second column of Table 5 reports the actual average retail electricity rate by state during 2008, which can be considered as the base case using PRB coal. The third column presents estimates of the rate increase due to replacing PRB coal with natural gas at these higher prices. The size of the increase reflects the relative importance of PRB coal in the electricity generation mix. For example, the rate increases for Iowa, Illinois, Kansas, Missouri, Nebraska, and Wyoming are all more than 10 cents per kilowatt-hour because PRB coal-based generation constitutes such a large share of their portfolio of electric power generation assets.

Given higher natural gas prices, the costs of operating existing gas-fired capacity across the nation also would increase. The incremental effect of these cost increases on electricity rates appear in the fourth column of Table 5. For example, rates increase 2.3 cents per kilowatt-hour in California even though that state does not consume PRB coal. The combined impact of these two components on average retail electricity rates and their percentage increases appear in the last two columns of Table 5. In a world without PRB coal, average retail electricity rates for many states would be more than double from what they are today (see Table 5).

These electricity rate increases imply that consumers in the U.S. would pay $162 billion more each year for electricity. In addition, consumers of natural gas would pay $118 billion more per year because natural gas prices would be higher without PRB coal. So in total, by using PRB coal, the U.S. economy avoids $280 billion per year in higher energy costs. In addition to these costs are the avoided macroeconomic impacts, such as reductions in industrial output and employment that would result from large industrial users relocating to other nations with relatively lower electricity rates.

Table 5: Average Retail Electricity Rates with and without PRB Coal

	cents per kilowatt hour				
		Rate Increases due to………			
State	Base Rates with PRB Coal	Direct Replacement of PRB Coal	Higher Costs for Existing NG Capacity	Rates without PRB Coal	Percentage Increase in Rates
Alaska	14.5	0.0	2.7	17.2	18.9
Alabama	8.6	3.7	1.7	14.0	62.7
Arkansas	7.8	7.0	1.0	15.8	103.2
Arizona	9.1	1.4	2.8	13.3	46.3
California	13.0	0.0	2.3	15.3	18.1
Colorado	8.6	2.6	1.3	12.6	45.9
Connecticut	16.9	0.0	1.6	18.5	9.3
D. of Columbia	13.5	0.0	0.0	13.5	0.0
Delaware	12.3	0.0	0.9	13.2	7.8
Florida	10.8	0.0	3.3	14.1	30.2
Georgia	9.0	2.6	0.7	12.3	37.0
Hawaii	29.2	0.0	0.0	29.2	0.0
Iowa	7.0	13.2	0.3	20.5	193.4
Idaho	5.7	0.0	0.3	6.0	5.5
Illinois	9.2	10.7	0.2	20.2	119.0
Indiana	7.1	4.9	0.2	12.2	71.6
Kansas	7.6	15.4	0.5	23.5	210.2
Kentucky	6.3	0.7	0.1	7.1	13.3
Louisiana	9.4	2.9	3.5	15.7	67.6
Massachusetts	16.2	0.0	2.6	18.8	15.9
Maryland	13.0	0.1	0.2	13.4	3.0
Maine	13.7	0.0	3.7	17.4	26.6
Michigan	9.1	3.9	0.6	13.6	49.1
Minnesota	7.8	2.7	0.2	10.8	37.4
Missouri	6.9	12.6	0.4	19.8	189.3
Mississippi	8.9	0.5	3.1	12.5	40.2

Table 5: Average Retail Electricity Rates with and without PRB Coal (continued)

	cents per kilowatt hour				
		Rate Increases due to………			
State	Base Rates with PRB Coal	Direct Replacement of PRB Coal	Higher Costs for Existing NG Capacity	Rates without PRB Coal	Percentage Increase in Rates
Montana	7.4	0.0	0.0	7.5	0.5
North Carolina	8.1	0.0	0.2	8.4	3.0
North Dakota	6.6	0.0	0.0	6.6	0.1
Nebraska	6.5	12.5	0.2	19.2	194.7
New Hampshire	14.6	0.0	4.0	18.6	27.1
New Jersey	14.9	0.0	1.9	16.9	13.1
New Mexico	8.3	0.0	2.1	10.4	24.9
Nevada	9.9	0.3	3.7	13.9	40.3
New York	16.7	0.7	2.5	19.9	19.1
Ohio	8.4	2.2	0.1	10.7	27.3
Oklahoma	8.0	8.3	3.6	19.9	149.3
Oregon	7.3	0.8	1.5	9.5	31.2
Pennsylvania	9.3	0.2	0.9	10.4	11.5
Rhode Island	16.1	0.0	6.7	22.8	41.2
South Carolina	7.9	0.0	0.5	8.5	6.8
South Dakota	7.1	7.9	0.2	15.1	113.8
Tennessee	8.0	3.3	0.0	11.4	41.7
Texas	10.9	4.0	3.4	18.3	67.2
Utah	6.5	0.3	1.4	8.2	25.0
Virginia	8.1	0.0	0.7	8.7	8.2
Vermont	12.3	0.0	0.0	12.3	0.0
Washington	6.7	0.3	0.6	7.6	13.6
Wisconsin	9.0	7.4	0.5	16.9	87.2
West Virginia	5.6	2.3	0.0	8.0	42.5
Wyoming	5.7	16.9	0.2	22.8	301.3
U.S. Total	9.8	2.8	1.5	14.1	44.1

Replacing PRB coal with nuclear power, solar thermal, or wind power would pose a daunting challenge and would raise electricity rates even more. The value of PRB to society includes the avoided costs from replacing this energy and the avoided adverse economic impacts from higher electricity rates and natural gas prices. As the natural gas example illustrates the additional costs from producing more than 6 TCF of natural gas and associated impacts on electricity rates are significant. Replacing PRB coal with other energy resources implies some rather implausible resource requirements such as:

- 95 one-thousand megawatt capacity nuclear power plants operating at 85% capacity, or
- 177 hydroelectric plants the size of Hoover dam producing 4 billion kwhr per year, or
- 500,260,417 cords of wood, or
- 201,922 wind turbines each at 2 MW operating with a 20% capacity factor.

The hydroelectric option is not feasible because capacity is already maximized. Harvesting over 500 million cords of wood per year is not sustainable because such a rate would deplete the entire stock of standing forests in the U.S. in slightly over three years. Wind generation faces daunting technical challenges because some form of backup generation would be required. This leaves nuclear power as the only technically feasible alternative to natural gas in replacing PRB coal. The cost of dramatically expanding nuclear electricity capacity, however, is likely to be quite significant due to insufficient engineering construction infrastructure and very long lead times for licensing and construction.

Quantifying the value of PRB coal in maintaining U.S. industrial competitiveness is a key question. The export capability of the U.S. economy and the ability to create, much less retain high paying manufacturing jobs may hinge on low cost and reliable electricity. In conclusion, the value of PRB coal to the U.S. economy is considerable, most likely well in excess of $280 billion per year. Given the challenges facing our nation to pay for national security, health care, and social security, PRB coal is an asset America cannot afford to lose.

IX. The Challenge Ahead

The key challenge for Wyoming and the nation is how to continue using PRB coal and achieve reductions in greenhouse gas emissions. Cutting GHG emissions can be achieved with a combination of mitigation efforts (e.g., planting trees that fix carbon dioxide), carbon-capture and storage (CCS), energy efficiency improvements, and replacement of fossil fuel based energy production with carbon-free energy.

While there is a divergence in various estimates of the economic impacts of GHG emission control policies, the general perception is that the macroeconomic costs while significant are manageable, especially if the transition is over a long period of time. The historical record, however, casts serious doubt on this conventional wisdom. An illustration of the challenge that lies ahead can be realized by examining the historical record for carbon emissions and the targeted level of emissions envisioned under the Lieberman-Warner Security and Climate Act. Under this bill, carbon emissions would be reduced to levels 72% below 2006 levels, which would bring greenhouse gas emissions in terms of their carbon dioxide equivalents to the levels of the 1920s (see Figure 23). Can this be accomplished?

As illustrated above in Figure 1, greenhouse gas emissions rise over time with economic growth but at a pace less than the rate of economic growth because the economy uses energy more efficiently over time. For example, carbon emissions per dollar of gross domestic product (GDP) declined at a 1.66% annual rate from 1966 to 2008. Assuming 2% annual growth in GDP from 2008 to 2050, the targeted level of emissions would require a 5% annual rate of improvement in carbon efficiency, more than three times the historical average rate of improvement in carbon efficiency.

How would this be achieved? There are a variety of options that involve some combination of carbon capture and sequestration, residential and commercial building energy efficiency improvements, continued advances in industrial energy efficiency, shifting our transportation sector from oil to carbon free energy, and extensive fuel switching in the electric utility sector. All of these options incur significant costs. Devising ways to continue using PRB coal will help cushion the effects of these higher costs on retail energy prices.

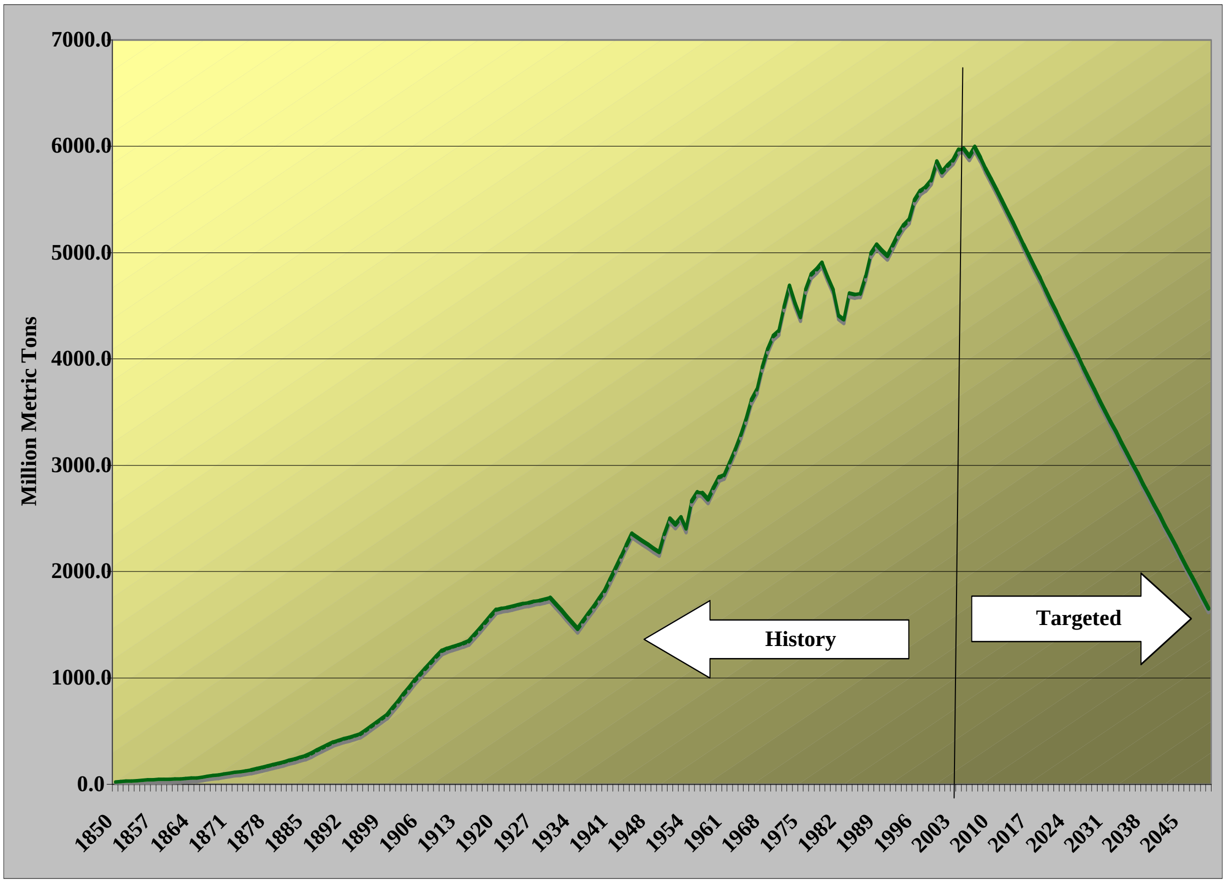

Figure 23: Historical and Projected Carbon Dioxide Emissions

X. The Way Forward

Powder River Basin coal plays a key role in providing affordable and reliable energy for the American economy. Given the sheer size of this energy reserve, the Powder River Basin likely will continue to provide energy for future generations. Significant challenges lie ahead. First and foremost are looming regulations on greenhouse gas emissions. For PRB coal to maintain and expand market share, the technology for converting coal with lower GHG emissions must be employed.

While technologies exist for capturing carbon dioxide (CO_2) from electric power plants, they are not yet deployed in the United States. In contrast, the technology for transporting and injecting CO_2 is commercialized in certain markets. Dedicated pipelines exist for transporting carbon dioxide and injecting carbon dioxide into oil reservoirs for enhanced oil recovery. So the technology exists for capturing, transporting, and storing CO_2 but large-scale fully integrated systems are not yet deployed given the lack of economic incentives.

Once a carbon regulatory system is in place, however, these technologies will be closely evaluated. Commercial adoption, however, is far from certain. Of paramount concern is whether the market price for carbon emission permits will be sufficient to justify investment in coal-based carbon capture and sequestration (CCS) systems. If carbon permit prices remain low and renewable energy sources, such as wind and solar, continue to benefit from subsidies and renewable portfolio standards, the risk is that incentives for technological progress on CCS would be limited. So low carbon pollution permit prices may be a double edge sword for coal, short-term preserving markets but long term discouraging future growth.

Another risk is that natural gas use in power generation will continue to expand. While significant shale gas discoveries may allow such expansion, natural gas prices are prone to spike, especially during periods of rising oil prices. Natural gas prices over the long run move with oil prices but do exhibit significant departures from heat equivalent parity with oil due to natural gas supply and demand imbalances.

While the reserves of coal and natural gas world wide are ample, there is growing concern that world supplies of light sweet crude oil likely will reach a peak sometime before 2050. This is of particular concern as the Chinese and other Asian economies enjoy rising levels of affluence and with this a growing desire for mobility. Regardless of current balances between physical supplies of crude oil and demand that may currently imply abundance, a scarcity premium may have become a permanent component of oil prices.

Finding a cost effective and environmentally acceptable substitute for liquid petroleum fuels will be a key challenge for the world economy and a significant opportunity for PRB coal producers, either through direct manufacturing of liquid fuels from coal or indirectly through the production of electricity for plug-in electric vehicles. The demonstrated success of PRB producers in providing high volumes of low-cost coal and the ingenuity of coal users to adapt to changing environmental standards and market conditions are sound reasons to remain optimistic about future prospects for PRB coal.

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Appendix A: Estimates Spending in Millions By Category & State

Category	AK	AL	AR	AZ	CA	CO	CT	DC	FL	GA
Administration	0.00	0.00	0.00	0.02	0.07	2.91	0.00	0.07	0.74	0.32
Chemicals	0.00	0.00	0.00	0.18	0.01	0.13	0.00	0.00	3.22	0.00
Communication products & services	0.00	0.13	0.00	0.18	0.00	0.76	0.01	0.00	0.17	0.00
Consulting & contractors	0.00	0.00	0.00	2.15	3.69	26.59	0.12	0.08	29.28	1.31
Drill parts and service	0.00	0.04	0.00	0.01	0.00	0.54	0.00	0.00	0.01	0.01
Electrical supplies and services	0.00	1.88	0.00	0.63	0.18	3.40	0.00	0.00	1.36	0.10
Explosives	0.00	81.73	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Freight expenses	0.00	0.43	2.22	0.07	0.02	1.87	0.00	0.01	0.75	5.22
Fuel supplies and services	0.00	0.00	0.00	0.05	0.08	0.86	0.00	0.00	0.01	0.00
Industrial supplies & equipment	0.00	16.20	0.00	6.00	4.09	11.93	0.01	0.00	19.91	4.79
Lubricants	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Operating, repair and rentals	0.00	49.73	0.01	6.15	3.30	63.42	0.01	0.00	2.66	8.25
Other	0.00	0.00	0.00	0.14	0.23	2.79	0.02	0.00	0.53	1.09
Safety & health	0.00	0.70	0.00	0.02	0.73	0.26	0.02	0.00	2.66	0.00
Support services & equipment	0.00	0.03	0.00	1.74	9.26	5.40	0.05	0.00	0.00	0.09
Taxes, fees and royalties	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tires	1.02	0.00	4.40	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Welding	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Wire rope	0.00	0.04	0.66	0.08	0.00	0.06	0.08	0.00	2.78	0.01

State	IA	ID	IL	IN	KS	KY	LA	MA	MD	MI
Administration	0.00	0.25	0.74	0.47	0.01	0.09	0.00	0.00	0.00	1.21
Chemicals	0.00	0.00	0.09	0.50	0.00	0.16	0.00	0.00	0.00	0.00
Communication products & services	0.00	0.00	0.14	0.00	0.94	0.03	0.00	0.00	0.04	0.08
Consulting & contractors	0.22	0.03	19.31	0.09	0.00	0.02	0.02	0.01	0.01	0.00
Drill parts and service	0.00	0.00	0.00	0.60	0.00	0.02	0.00	0.00	0.00	0.00
Electrical supplies and services	1.44	0.02	0.87	0.95	0.02	0.00	0.00	0.00	0.00	0.63
Explosives	0.00	0.00	0.00	0.03	0.00	0.23	0.01	0.00	0.00	0.00
Freight expenses	0.03	0.29	105.30	4.51	0.35	0.18	0.00	0.03	0.00	0.01
Fuel supplies and services	0.00	0.00	16.16	0.40	0.00	0.00	0.00	0.00	0.00	0.00
Industrial supplies & equipment	0.61	0.31	11.10	5.08	0.15	0.98	0.04	0.01	0.03	0.05
Lubricants	0.00	0.00	4.76	0.17	0.00	0.00	0.00	0.03	0.01	0.00
Operating, repair and rentals	0.15	11.94	19.48	9.46	0.18	0.19	0.04	0.56	0.00	0.02
Other	0.00	0.05	0.03	0.53	0.14	0.03	0.05	0.00	0.00	1.79
Safety & health	0.01	0.00	0.07	0.67	0.00	0.00	0.00	0.00	0.00	0.00
Support services & equipment	0.22	0.03	0.47	0.17	0.08	0.09	0.00	0.72	0.03	0.73
Taxes, fees and royalties	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tires	2.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Welding	0.00	0.20	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wire rope	0.00	0.00	0.01	0.04	1.92	0.00	0.00	0.00	0.00	0.00

Appendix A (continued)

State	MN	MO	MS	MT	NC	ND	NE	NH	NJ	NM	NV	NY
Administration	0.00	0.61	0.00	0.30	0.00	0.01	0.04	0.00	0.00	0.00	0.26	0.01
Chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Communication products	0.10	0.06	0.00	0.11	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.02
Consulting & contractors	1.37	2.95	0.00	0.56	1.01	0.09	0.05	0.05	0.53	0.01	0.00	0.02
Drill parts and service	0.19	0.02	0.00	0.05	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Electrical supplies and services	0.04	0.12	0.00	0.64	0.10	1.54	0.07	0.00	1.81	0.54	0.00	0.05
Explosives	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Freight expenses	4.17	0.11	0.00	5.64	0.00	0.08	1.78	0.00	0.00	1.60	0.01	0.00
Fuel supplies and services	3.10	0.00	0.00	0.88	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Industrial supplies & equipment	26.46	3.60	0.02	26.66	0.01	1.38	0.13	0.09	0.70	0.04	0.48	0.35
Lubricants	0.54	0.23	0.00	0.91	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00
Operating, repair and rentals	5.97	6.38	0.00	8.57	0.08	0.01	0.38	0.00	0.01	0.00	0.64	0.64
Other	6.34	0.01	0.00	0.04	0.11	0.01	0.09	0.00	0.03	0.00	0.02	0.00
Safety & health	0.00	0.06	0.00	0.41	0.00	0.63	0.00	0.00	0.00	0.00	0.06	0.00
Support services & equipment	2.70	1.09	0.00	1.24	0.00	0.41	0.01	0.01	1.54	0.00	0.03	1.00
Taxes, fees and royalties	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tires	0.00	0.06	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Welding	0.00	0.00	0.00	0.21	0.00	0.03	0.00	0.00	0.00	0.27	0.00	0.00
Wire rope	0.00	0.21	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.01	0.00

State	OH	OK	OR	PA	RI	SC	SD	TN	TX	UT
Administration	0.03	0.00	0.06	0.10	0.00	0.00	0.35	0.00	0.10	0.03
Chemicals	0.00	0.00	0.00	0.94	0.00	0.00	0.02	0.00	0.41	2.17
Communication products & services	0.08	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.81	0.05
Consulting & contractors	3.11	0.00	5.42	8.90	0.00	0.00	0.69	0.08	1.49	5.30
Drill parts and service	0.00	0.00	0.03	0.21	0.00	0.00	0.14	0.00	2.55	7.10
Electrical supplies and services	0.11	1.09	0.22	2.95	0.05	0.01	0.56	0.00	0.38	1.75
Explosives	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Freight expenses	0.04	0.09	0.31	0.80	0.01	0.08	0.49	0.25	4.66	5.20
Fuel supplies and services	0.17	0.00	0.00	120.50	0.00	0.00	0.60	5.50	154.11	160.15
Industrial supplies & equipment	1.73	0.72	0.96	7.24	0.00	1.11	6.35	0.57	22.31	37.12
Lubricants	0.66	0.00	0.00	0.05	0.00	0.00	0.00	0.00	7.36	0.00
Operating, repair and rentals	2.85	0.00	0.15	4.26	0.00	7.03	13.69	0.99	15.94	9.26
Other	0.05	0.00	0.01	0.06	0.00	0.00	0.18	0.00	0.13	0.24
Safety & health	0.02	0.00	0.02	0.11	0.00	0.00	0.10	0.00	3.45	0.03
Support services & equipment	0.15	0.53	0.04	0.75	0.00	0.00	0.62	0.60	13.58	2.25
Taxes, fees and royalties	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tires	0.00	0.00	0.00	0.00	0.00	14.13	19.22	9.42	0.42	0.60
Welding	0.15	0.00	0.00	0.05	0.00	0.00	0.15	0.00	1.38	0.04
Wire rope	0.45	0.00	0.00	6.45	0.00	0.00	0.00	0.00	0.53	0.33

Appendix A (continued)

State	VA	WA	WI	WV	WY
Administration	0.00	0.00	0.39	0.00	4.46
Chemicals	0.00	0.00	0.00	0.00	0.75
Communication products & services	0.00	0.00	0.10	0.00	2.81
Consulting & contractors	0.03	2.05	0.16	0.06	56.54
Drill parts and service	0.00	0.35	0.00	0.10	5.33
Electrical supplies and services	0.04	0.14	0.03	0.06	35.06
Explosives	0.00	0.01	0.00	0.14	0.13
Freight expenses	0.96	2.49	1.65	0.08	56.96
Fuel supplies and services	0.00	0.05	0.00	0.00	75.75
Industrial supplies & equipment	0.32	3.80	18.31	0.06	212.30
Lubricants	0.00	0.00	0.01	0.00	22.65
Operating, repair and rentals	1.32	10.35	21.79	1.95	161.27
Other	0.01	0.03	0.00	0.29	15.77
Safety & health	0.03	0.00	0.05	0.06	3.96
Support services & equipment	0.05	1.37	6.60	0.47	35.58
Taxes, fees and royalties	0.00	0.00	0.00	0.00	0.00
Tires	0.11	2.28	4.63	0.00	8.03
Welding	0.00	0.00	0.53	0.00	1.94
Wire rope	0.00	0.00	0.00	0.00	2.17