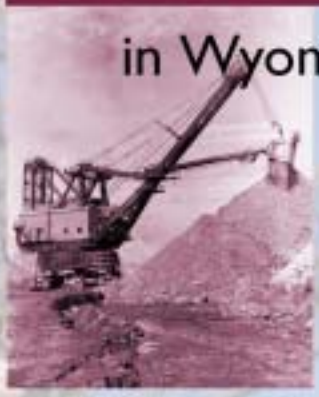
Economic TRENDS in Wyoming's Mineral Sector: COAL



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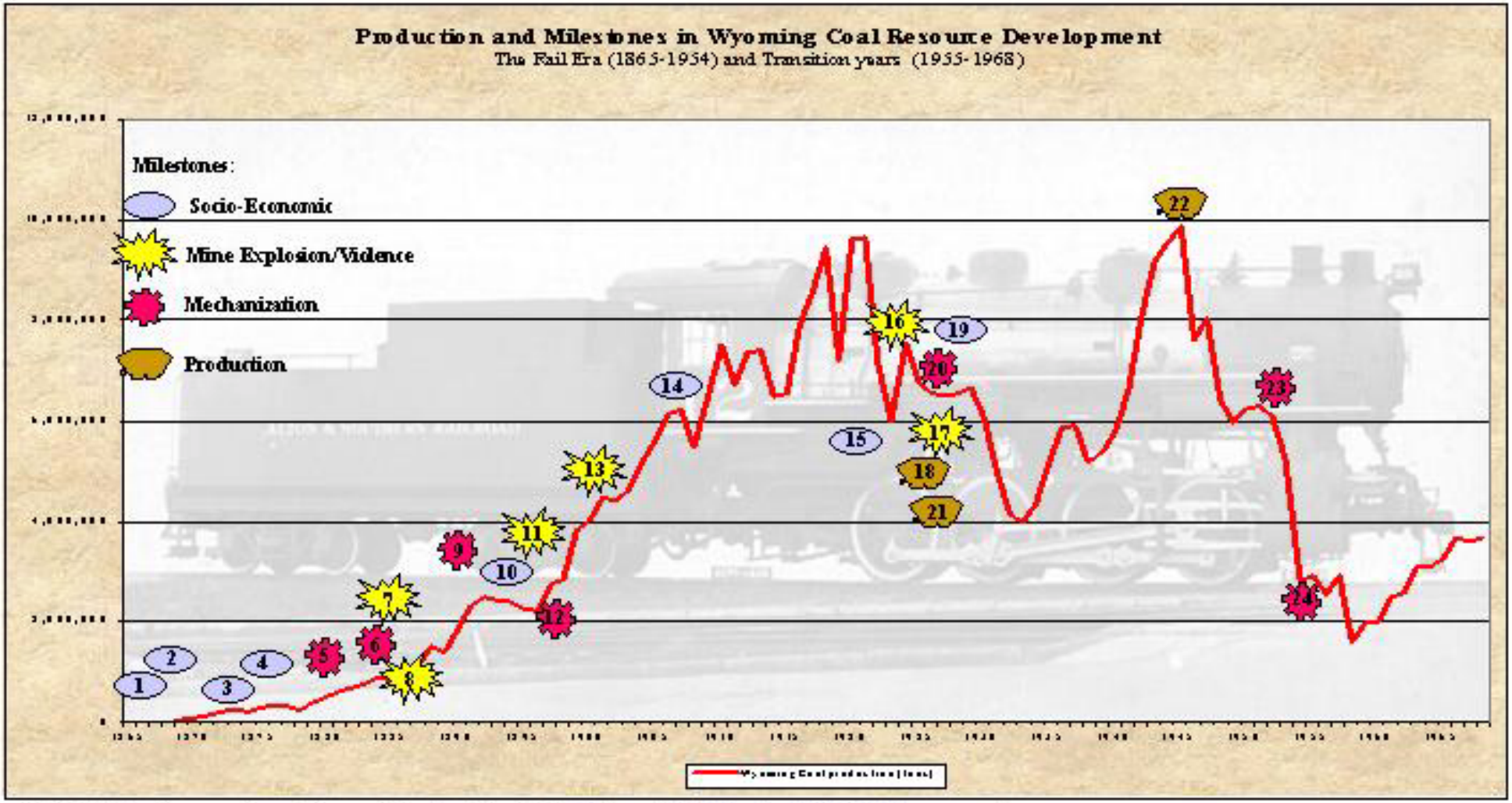


1. 1867-Union Pacific enters what would become Wyoming, laying track for the transcontinental railroad.
2. 1868- Carbon, Wyoming's first coal town founded. Also, Rock Springs mine No. 1 opened.
3. 1874-Jay Gould elected to U.P. board of Directors. Seizes control of Wyoming Coal Company mines and starts importing Chinese laborers.
4. 1877-Sioux chief Crazy Horse surrenders and Federal Government removes Indians to reservations. N.E. Wyoming opens to white settlement.
5. 1881-Telephones installed in Rock Springs No. 1 and 2.
6. 1882-First cutting and drilling machines introduced to Rock Springs No. 4 mine.
7. 1885-Rock Springs Chinese Massacre. 28 Chinese killed by mob violence. Troops dispatched to quell violence.
8. 1886-Mine explosion in Almy No. 4 kills 13. First laws protecting miners pass. Mine Inspectors office created.
9. 1892-First electric mine locomotive in U.S." the Charlie Smith" introduced at Rock Springs.
10. 1893-Nationwide economic depression forces bankruptcy of Union Pacific and Northern Pacific railroads.
11. 1895-Red mine No. 5 explosion at Almy kills 61. Wyoming's 3rd worst mine disaster.
12. About 1902-Shortwall automatic miner installed in Rock Springs U.P. No. 2 mine.
13. 1903-Hanna No. mine explosion kills 169. Wyoming's worst mine explosion.
14. 1907-Union Pacific mines union ize. 8 hour day comes to Wyoming mines.
15. 1922- 5 month UMWA strike shows that Wyoming mine workers had support of national union.
16. 1923-Frontier No. 1 mine explodes killing 99. Wyoming's second worst mine disaster.
17. 1924-Sublet No. 5 mine explodes killing 39.
18. 1924-USGS reports Peerless mine (east of Gillette as Wyoming's 1st surface mine.
19. 1925-Wyoming Legislature passes laws regulating mine safety.
20. 1926-70% of U.S. coal mined by machinery.
21. 1925- Wyodak-1st large surface mine opens near Gillette.
22. Peak production for WWII still dominated by underground mining.
23. 96% of all coal removed mechanically.
24. U.P. completes "dieselization" of its locomotive fleet.

The story of economic development in Wyoming would not be complete without coal. Economic growth and settlement patterns in the state mirrored coal production for almost a century. Today, coal is still a major contributor to Wyoming's economy, contributing over $300 million to state and local governments in 2000 alone and over 4,000 high- paying jobs.

The coal industry's involvement in Wyoming can be divided into two distinct time periods with a short transition between. Each of these eras is defined as much by the usage of the coal mined as by the method of mining. In the Rail Era, coal was primarily mined from underground mines for use as fuel for the railroads. In the Energy Era, coal is primarily produced from surface mines and mostly shipped via rail to power plants in Wyoming and many other states to generate electricity. Railroads played a significant role then and now.

This report uses the historical context of the development of Wyoming's coal industry to explore the impact on the state's economy, current trends in the industry, as well as future growth.

The Rail Era (1865-1954)

The roots of coal production in Wyoming go back before the Rail Era to the early frontier history of the region. The writings of early explorers show that they had an interest in the development potential of the region. Russell Osborne, a trapper, noted in his journal in 1835 that "rich beds of iron and bituminous coal" could be found near what would become Cody. The legendary trapper and guide, Jim Bridger, set up a trading post in 1843 on Black's Fork in southwestern Wyoming, using coal taken from nearby outcroppings in his forge and for heat (Gardner and Flores, 1989).

The concept of a transcontinental railroad arrived almost as soon as locomotives were invented, but securing a route was much more difficult. Secretary of War Jefferson Davis was in charge of a series of surveys for different routes across the country in 1853. However, these were of little value since they were hastily conducted, and Davis' bias as a southerner made him partial to a southern route through Texas to southern California. The Civil War ensured that a northern route would be chosen, but construction had to wait for the end of the war and detailed surveys. A route that followed the Oregon Trail seemed natural, but in Wyoming the route deviated from the historic trail to take advantage of the terrain and coal deposits located in southern Wyoming (Gardner and Flores, 1989). Railroads were in the process of converting from wood to coal in the 1860s. The higher BTU (British Thermal Unit) value of coal over wood allowed for construction of larger engines with more horsepower.

In 1867, the railroad's arrival in what would later become the State of Wyoming brought the first true permanent settlements to the territory. Prior to the railroad, the only settlements were Fort Laramie, Fort Bridger and a few scattered outposts of military and trading activity. Carbon,

the first coal town in Wyoming, was founded in 1868, north of the Medicine Bow Mountains; it survived until 1902. The Wyoming Coal and Mining Company opened Rock Springs's No.1 mine later that same year. The railroad was a transportation artery through which people, technology, and the ideas of nineteenth-century America flowed into the region. Most people in Wyoming at that time were employed in some way to serve the needs of the railroad, which meant operation, maintenance, and repair of locomotives, track and buildings as well as provisioning. Most of all, it meant coal. Since coal fueled the railroad that brought most commodities into the state, coal was the critical element and the raison d'être of most early Wyoming towns.

The remote location, harsh climate and the need to quickly increase production forced mining companies to help miners find places to live. Early coal towns such as Carbon and Rock Springs had a number of "dugouts" where miners lived in holes dug in creek banks. Later on, the companies built dormitories and eventually whole towns for miners. Company towns became a fixture, not only in Wyoming, but in other areas of the country where coal was mined.

This was partly due to the profit potential of the company town to the company. The company had a captive audience and the means of transportation, so it could set prices for everything from soap to lumber. Miners were required to buy at the company store on pain of dismissal and were often paid in "scrip," credit good only at the company store. The Union Pacific actively recruited family men as miners because they were a "better class of men and more mouths to feed so the company is a gainer all around" (Gardner and Flores, 1989).

The Union Pacific railroad was the first and largest of the railroads to come through Wyoming. The railroad controlled coal production in southern Wyoming for nearly a century. The Chicago and Northwestern Railway entered Wyoming in 1886 and reached Casper by 1888. The Chicago, Burlington and Quincy Railroad entered Wyoming in 1887 and built track through northeastern Wyoming. Northeastern Wyoming was Indian Territory until 1877 when Chief Crazy Horse was captured and the Indians were moved to reservations.

The potential for coal production in northeastern Wyoming had long been recognized. Henry Englemann, a geologist on a road-building survey in 1856, noted that the value of the coal beds "would be enormous if they were in a cultivable country; but as it is, they are probably of no use, unless a railroad were to be constructed

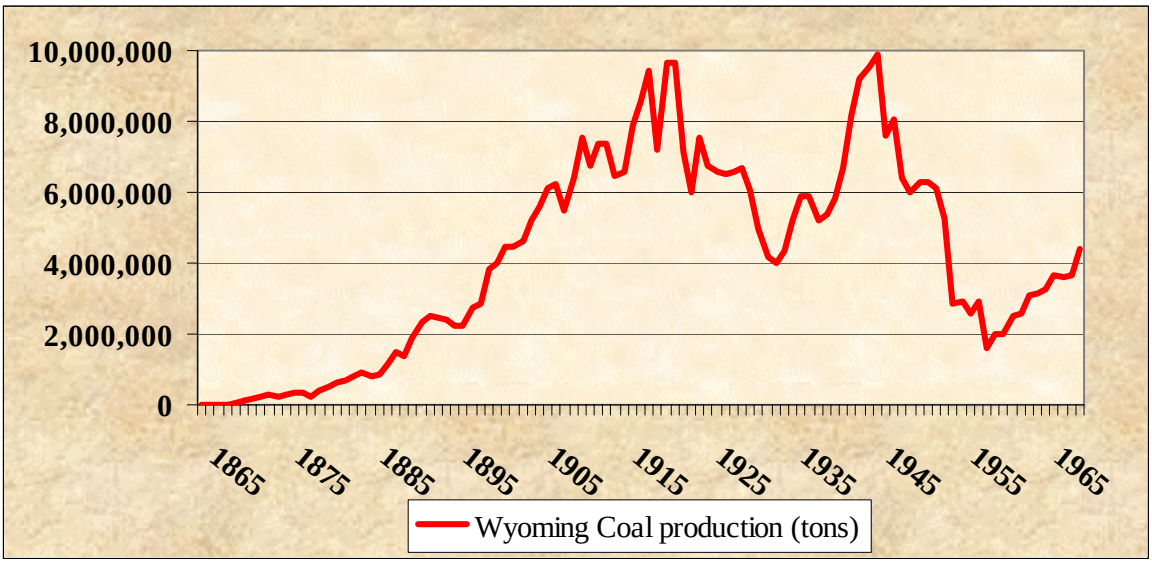
through the country, and require them for fuel" (Gardner and Flores, 1989). Mr. Englemann's estimate of the value proved correct, though it would take over a century for the full impact to be realized. Coal production grew faster in northeastern Wyoming than in southern Wyoming even though it arrived later. The first mines opened in Glenrock in 1883. Buffalo's Buffalo Fuel Company No. 1 mine opened in 1888. The Antelope and Jumbo mines in Cambria (north of present day Newcastle) opened in 1889, and had an annual production of 366,944 tons by 1892 (Gardner and Flores, 1989).

Wyoming coal production trended upwards from the entry of the railroads until the year following World War I (1919) (Figure 1). Coal was the cornerstone of economic growth as coal companies actively recruited miners to come to the company towns. Wyoming's population grew 200 percent from 1880 to 1890 largely due to coal. Nationwide, 70,000 miles of track were laid in that same decade. Additionally, the advent of the telephone and the initial push of electrification in America made copper very much in demand. Anaconda Copper purchased mines in Diamondville in 1898 to supply coal to its Butte, Montana, smelter. Coal production increased 221 percent between 1895 and the post-war peak of 1919.

Wyoming's oil industry was in its infancy in 1890 and did not really take off until after 1908. The Census of 1920 reports that in 1919 there were two and a half times as many employees in the coal industry as the oil and gas industry (7,091 versus 2,167), and that coal mining made up 73.1 percent of mining sector employment. Yet, in a sign of things to come, oil's value of production was slightly ahead of coal (Commerce, 1920).

The 1920s were a decade of profound societal change on many fronts. These changes had important implications for the structure of Wyoming's economy. The changeover from coal to oil by U.S. Navy vessels, the widespread introduction of internal combustion engines, and the high

Figure 1. Coal production, Wyoming (1865-1969).

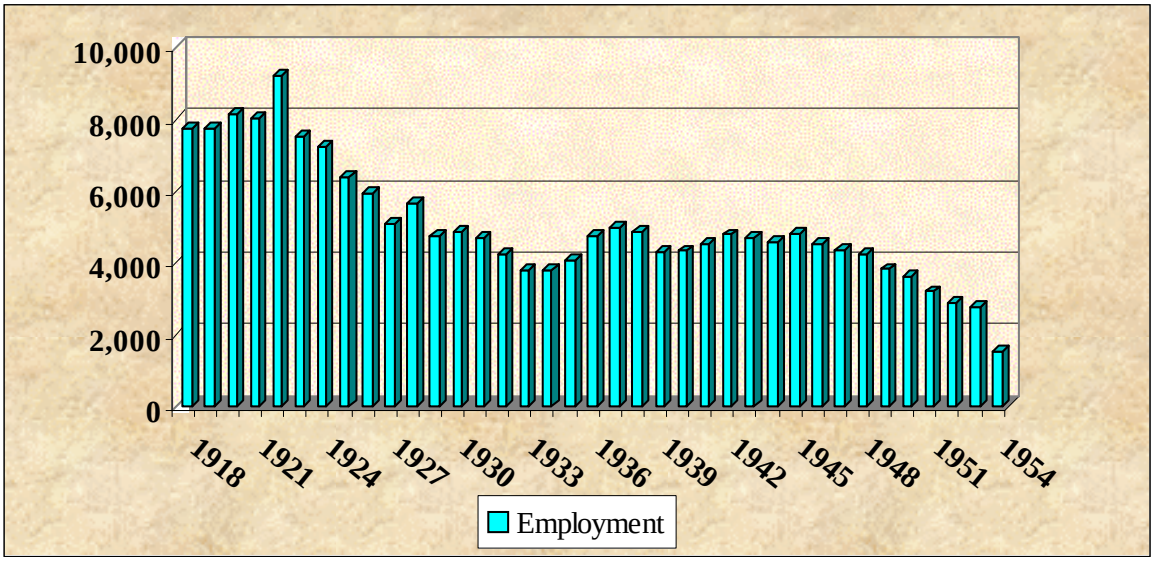


Source: WY Department of Commerce, 1995 and State Inspector of Mines of Wyoming, 2000

level of wartime coal production created severe oversupply conditions for coal. Post-war labor movements encouraged workers to demand more from the companies. This in turn pressed companies, concerned with work stoppages and profit margins, to turn increasingly to mechanization to solve labor problems. Yet mechanization required a more skilled class of worker to operate more complicated machinery; those workers, though fewer in number, had to struggle to get higher pay and safer working environments from the company. The results were strikes and layoffs as companies tried to maintain economic viability and workers tried to gain concessions and assert their rights. Coal production dipped steeply; by 1929, production was at the same level as a quarter century earlier. The crash on Wall Street signaled the start of the Great Depression that pushed down production even further and increased layoffs. In 1933, fewer than four million tons of coal were mined, Wyoming's lowest coal production year since the turn of the century.

World War II was the swan song for coal in the Rail Era, ensuring the survival of steam power (both coal and oil fired) for a time. Coal production peaked in 1945 at almost 9.8 million tons, while employment stood at 4,814, similar to the 1930 level. The inroads of mechanization in the industry allowed a record level of production without a correspondingly large number of employees. The majority of coal mined in Wyoming in the 1940s was used as fuel for locomotives. Diesel locomotives made their debut in the 1930s and were seen by many to be the wave of the future. In the recession that followed the war and the subsequent conversion of locomotives from steam to diesel, many thought that coal mining would disappear altogether.

Figure 2. Wyoming coal mining employment (1918-1954).



Source: State Inspector of Mines of Wyoming, 2000

Labor Relations, Mechanization and Technological Innovation

The development of Wyoming's coal industry was significantly impacted by factors from several disparate sources. The growing influence of labor movements and mechanization in the late nineteenth and early twentieth century had far-reaching effects on the industry.

Early coal miners enjoyed some degree of autonomy underground. "Company men" managed the mine, but a miner's wages depended on the amount of coal he mined. The miner supplied all his own tools, including the powder and fuses used to blast coal from the working face. The miner worked his own room and did not have much in the way of direct supervision. As the result of several deadly mine explosions, the mines started taking over some functions, such as blasting, for safety's sake. The individual miners' autonomy was slowly eroded as the company set more and more policy.

Wyoming's first coal miners were predominately from the British Isles. Britain's coal industry was considered preeminent in the nineteenth century, and there was a definite preference for British miners because they tended to be the most experienced and have an understanding of the latest mining technology (Gardner and Flores, 1989). As the need for miners grew, coal companies began hiring more immigrants from Scandinavia and eastern and central Europe, as well as black miners who had migrated west following the civil war. The Central Pacific Railway used Chinese immigrants to help build its half of the transcontinental railway, and the Chinese were found to be good workers.

In 1874, Jay Gould, a wealthy investor, was elected to the Union Pacific's board of directors. His election marked a change in business practices throughout the company that had long-lasting effects in Wyoming. Prior to 1874, the Wyoming Coal and Mining Company mined coal on land that had been granted to the Union Pacific by the government for building the railroad; Union Pacific had in effect contracted with Wyoming Coal to mine the railroad's own coal and sell it back to them. The day after Gould was elected to the Board of Directors, he abrogated the contract with Wyoming Coal and took over the mines. He proceeded to import the first Chinese miners from California to work in Rock Springs. European miners resented the presence of the Chinese and went on strike in November 1874. Gould replaced the Europeans with Chinese, offering the striking miners nothing more than transportation back to Omaha. Chinese miners saved the company 25 cents

per ton and were not inclined to organize (Gardner and Flores, 1989). Union Pacific's financial fortunes started to turn around, but the long-term effects were not so kind. The issue simmered for eleven years and then exploded in the Rock Springs Chinese Massacre of 1885.

Twenty-eight Chinese miners were killed by mob violence in Rock Springs on September 2, 1885, following a dispute over workings in the Union Pacific No. 6 mine. Territorial Governor F.E. Warren called in the army to protect the Chinese (and the mines). A significant outcome of the Chinese Massacre was more mechanization in mining. Charles Adams, president of the Union Pacific Railroad, claimed that it was in the company's interest to "have Rock Springs worked entirely by Chinese and machinery" (Gardner and Flores, 1989).

Mining was, in its day, at the forefront of the "hi-tech" frontier, and mechanization brought fundamental change to the way that coal was mined in Wyoming. The first cutting and drilling machines were introduced to Rock Springs in 1882 and telephones (only five years old) were installed in 1881. The white miners' biases toward unionization and the Chinese massacre helped push what was already a trend in the mechanization of production. Coal was fueling the industrialization of America, and companies that produced it cheaply were reaping the profits. 1902 saw the introduction of the "Charlie Smith," the first electric mine locomotive in the U.S., as well as the installation of a short wall automatic miner in Rock Springs No. 2 (Gardner and Flores, 1989). The automatic miner improved productivity because men no longer had to undercut and blast the coal seam by hand. Mechanization, though introduced early in the coal industry, took some time to filter into all the mines. Machinery mined 3 percent of Wyoming coal in 1900. By 1926, 70 percent was machinery mined, but mules could still be found in Wyoming mines into the 1930s (Gardner and Flores, 1989).

The history of labor unions in Wyoming could fill several volumes and will not be detailed here other than to note the importance of unionization and its impact on Wyoming's economy. By today's standards, early coal companies were clearly exploiting their workers. The influence of labor unions in Wyoming coal mining can be seen from its earliest beginnings. However the coal companies, particularly Union Pacific, were able to stave off unionization until 1907. The United Mine Workers of America (UMWA) was formed in 1890 by a coalition of previous labor organizations. They entered northern Wyoming coalfields in 1903 and the southern fields in 1907. One of the key factors of the union's success in organizing the UP mines was the fact that the UMWA allowed foreigners to join, particularly Japanese.

Previous attempts at organization had excluded diverse ethnicity. The eight-hour day became law in 1909 as a result of legislation by Wyoming's tenth legislature (Gardner and Flores, 1989). Unions became a firmly established fixture in Wyoming's coal industry, ensuring a voice for miners at the negotiating table.

The combined effects of mechanization, unionization and technological change can be seen in a graph of Wyoming coal production (Front piece and Figure 1). Newly industrialized America relied on coal for fuel through World War I. Dips in production in the 1890s and the early twentieth century were the result of national economic "crises," the forerunners of modern-day recessions. The production high right after World War I was the result of scaled-up production for the war effort. Demand for coal dropped after the war, due to a post-war recession. The drop was exacerbated by the advent of a new fuel, oil; petroleum usage increased 700 percent from 1900 to 1920 (Mackey, 1997). The U.S. Navy converted its fleet to oil, eliminating the need for coal, and the widespread use of internal combustion engines also cut into coal demand. With declining production, coal companies tried to decrease wages to maintain profitability, but the company and the UMWA could not agree on a wage rate. The UMWA called a nationwide strike in April 1922, which effectively shut down all of Wyoming's coal mines. The strike was settled by August, but production was significantly affected for the year.

The U.S. Geological Survey reported Wyoming's first surface mine in 1924. The Peerless mine was located east of Gillette, where 90-foot-thick coal beds were only 25 feet below the surface. Wyodak Coal opened Wyoming's first large surface mine near Gillette a year later. Surface mines produced 2,239 tons of coal per man per year (1925), more than twice the statewide average. The first surface mines used horse-drawn scrapers, called "fresnos," to remove the overburden (Gardner and Flores, 1989). Mechanization quickly took hold in this type of mining, but lack of demand for coal, especially the lower BTU coal of the Powder River Basin (PRB), kept production down. Even with increasing efficiency from mechanization, coal was a declining industry from the 1930s through the 1950s (with the exception of the war years) due to the lack of demand brought on by the increased use of oil.

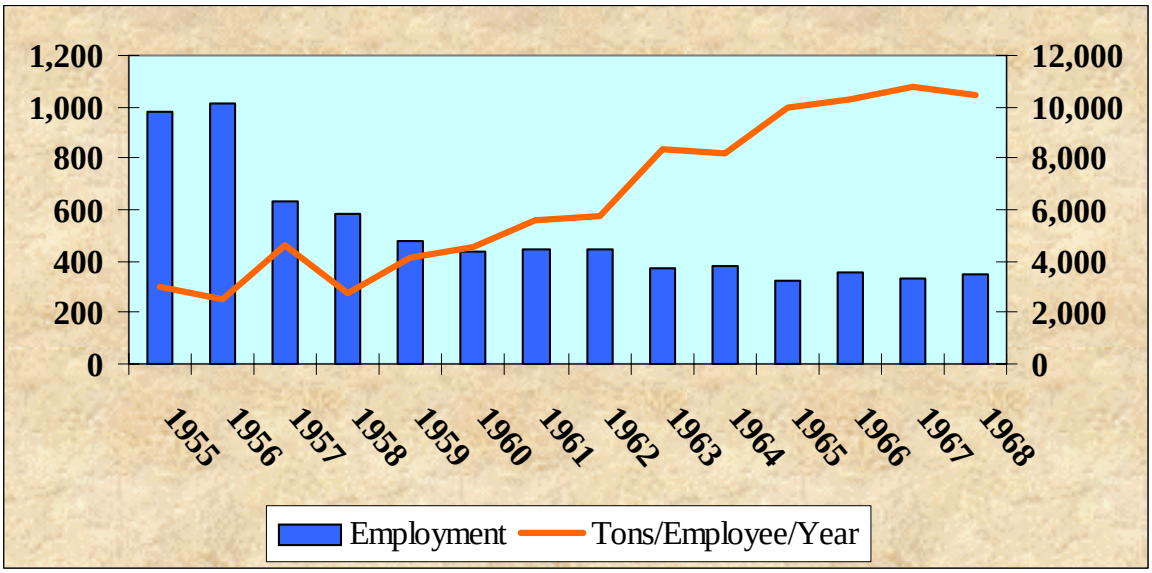
The Transition Years (1955-1968)

The Rail Era of coal in Wyoming ended in 1954 when the Union Pacific Railroad completed the "dieselization" of its locomotives. Coal production continued to slip until 1958 when only 1.6 million tons were mined. Employment (587 in 1958) continued downward until 1965, reaching a historical low of 327 employees (WY Employment, 2000). Underground mines closed throughout the 1950s, and the last Union Pacific coal mine in Wyoming closed in 1962. Surface mines outproduced underground mines for the first time in 1954. In 1958, the same year as the production low occurred, the first large power station, the Dave Johnston plant, was built near Glenrock. Coal production doubled between 1958 and 1965 even as employment slipped to historical lows (Figure 3). Increased mechanization at surface mines and the use of larger machinery made the productivity gains possible.

Another factor forcing change was the increase of federal regulatory pressure on industry. The Clean Air Act of 1963 and the Water Quality Act of 1965 gave the federal government enforcement power over air and water pollution. The Mine Health Safety Act of 1969 put into effect rock-dust controls that required significant financial outlays for underground mines. While protecting the miners, it made the economics of underground mining less appealing. The National Environmental Policy Act (NEPA), passed in 1969 and signed into law in 1970, had the most far-reaching implications, as it created the Environmental Protection Agency (EPA) to oversee environmental regulation and enforcement. This series of environmental legislative actions helped push industrial America to find cleaner, safer ways to do business.

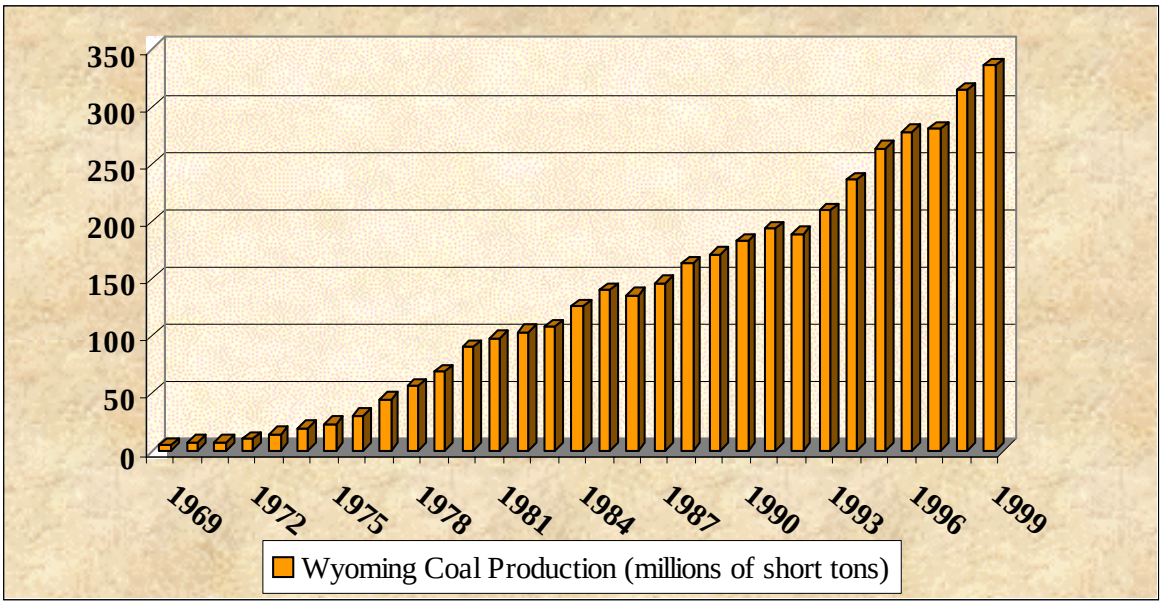
The new legislation required electrical generating plants to lower the amount of nitrogen oxide, sulfur oxide and particulate (ash) emitted to the atmosphere. This required the expensive addition of "scrubbers" on the stacks of power plants and / or

Figure 3. Employment and productivity in Wyoming's coal industry (1955-1968).



Source: State Inspector of Mines of Wyoming, 2000

Figure 4. Coal production, Wyoming (1969-2000).



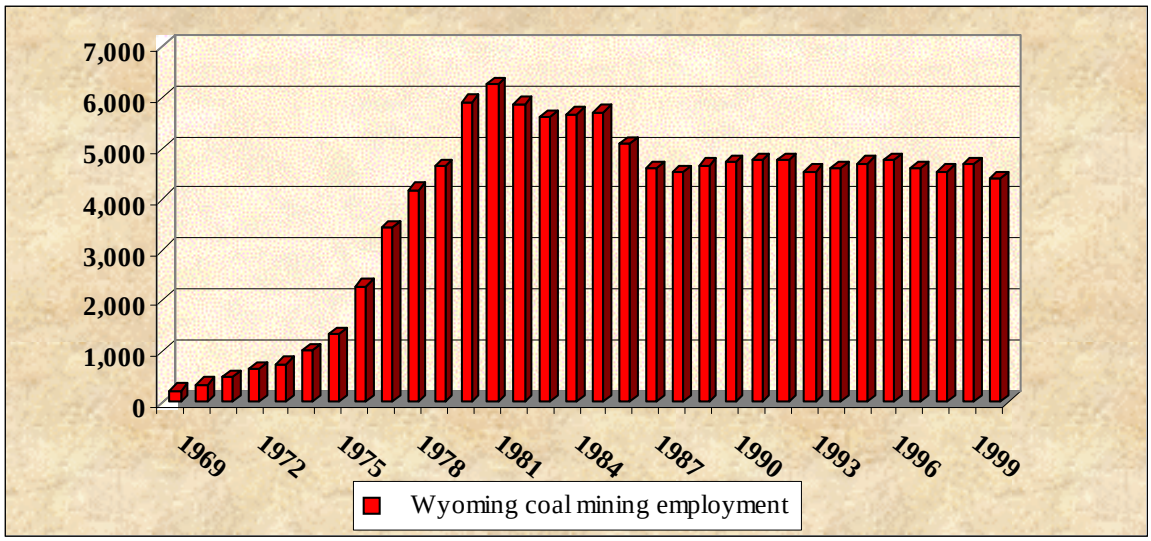
Source: WY Department of Commerce, 1995 and State Inspector of Mines of Wyoming, 2000

the use of a cleaner burning fuel. It quickly became obvious to the power-generating industry that Wyoming coal was a solution. Consequently, Wyoming coal was adopted by many utilities in the Midwest. This was due not only to the low sulfur content of the coal, but the fact that the transportation infrastructure (railroads) already existed. The stage was set for a new boom.

The Energy Era (1969-Present)

The Belle Ayr mine opened near Gillette in 1972. This was the first large non-captive (no power plant associated with it) surface mine in Wyoming. A year later, the Arab Oil Embargo awakened America to its dependence on foreign energy sources. Traditional petroleum companies responded by investing in Wyoming coal mines. This was an effort to expand and diversify their interests by becoming "energy companies" and obtaining a stable domestic resource base. Wyoming coal production in 1973 was already over 14 million tons (the peak during the Rail Era was 9.8 million tons in 1945), and Wyoming coal was being shipped to 17 states. Other mines soon opened in the Powder River Basin. Annual coal production soared from 4.4 million tons in 1969 to over 102 million tons by 1981, a 2,130 percent increase (Figure 4). Employment during the same period increased 1,243 percent from 448 to 6,015 (Figure 5). The 1970s were a period of explosive growth for Wyoming's coal industry, especially in the Powder River Basin.

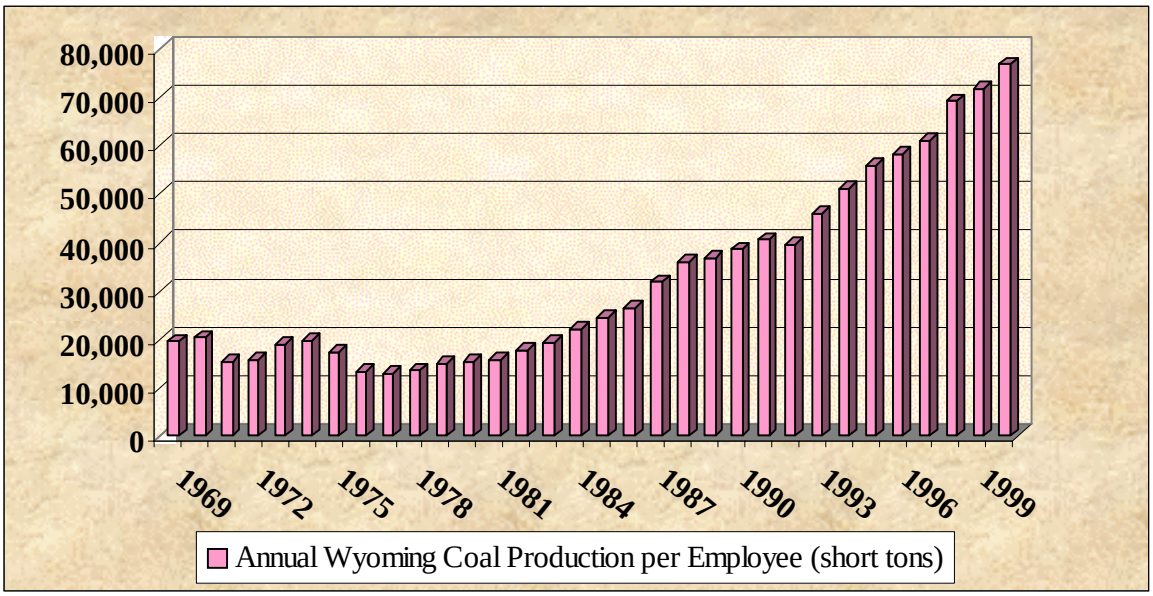
Figure 5. Employment, Wyoming coal mining, 1969-2000.



Source: State Inspector of Mines of Wyoming, 2000

The 1980s brought many changes for Wyoming's coal industry. By 1980, it was clear that the use of coal as fuel for power generation was going to increase still further. As the boom attracted more companies into the business, competition for contracts with utilities heated up. Competition also forced mines to search for more cost-effective extraction methods to maintain profit margins. This led to larger machinery, more mechanization, and layoffs. Wyoming coal industry employment in the Energy Era (starting in 1969) peaked in 1980 at 6,231, but employment started to level off as soon as it peaked. When the price of oil dropped in the mid-1980s, the economic downturn in the sector was exacerbated by the drive toward increased mechanization. Coal mining employment in Wyoming dropped 26.4 percent from 1981 to 1987 (Figure 5), and has stayed relatively unchanged since then. Production continued to increase throughout the period (Figure 4). Annual production for 2000 was over 338 million tons, surpassing 1999's record production by 2.4 million tons. Productivity improvements also continued. From 1969 to 2000, annual tons per employee increased 682 percent to 76,767 tons, showing that the trend toward increased mechanization continues (Figure 6).

Figure 6. Productivity, Wyoming coal mining, (1969-2000).



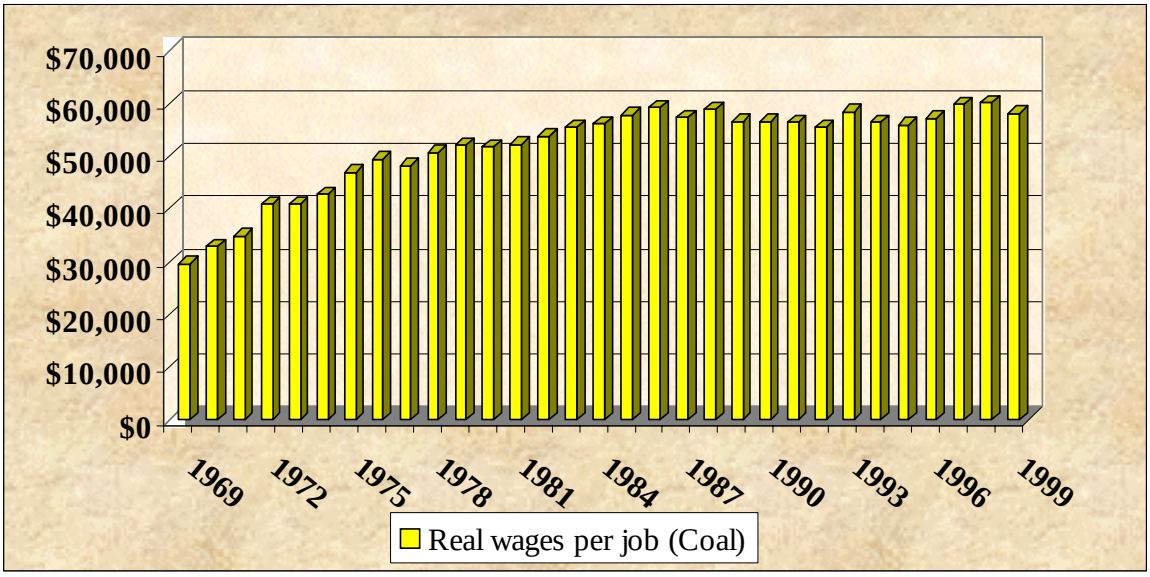
Source: State Inspector of Mines of Wyoming, 2000

With the drop in oil prices and the impacts of competition and mechanization in the coal industry, multinational petroleum companies were under severe pressure to cut costs to maintain profitability. This led them to exit the Wyoming coal industry in the 1990s. International mining corporations, with the specialization needed to make a profit, obtained interest in the mines and began a period of consolidation. Today's mines are often referred to not as a single mine, but as a mine "complex" encompassing the operations of mining, transportation and (in some cases) power generation. The Black Thunder mine complex, for example, produces coal at a rate of 2 tons per second with a BTU value greater than any oil field in the continental United States (Strook, 2001).

Mine wages represent an important source of income for some Wyoming communities. Table 1 shows the location of Wyoming's active coal mines and the number of employees at each mine. The PRB (Powder River Basin-Campbell, Converse, and Sheridan Counties) is the heart of Wyoming coal production today. Seventy two percent of coal industry employment and 88 percent of the state's coal production is in Campbell County.

The PRB, as a whole, accounts for 95 percent of the state's coal production and 79 percent of its coal industry employment. Real wages per job are shown in Figure 7. These values have been adjusted for inflation to 1999 dollars. Real wages increased 100.2 percent from 1969 to 1986. Since then there has been little change. The average wage per job in 1999 was $58,107.

Figure 7. Real wages per job, Wyoming coal industry (1969-2000).



Source: Department of Commerce, Bureau of Economic Analysis, 2001

Table 1. Active Wyoming coal mines 2000, by production.

Mine	County	Employees	Production (tons)
North Antelope/Rochelle Complex	Campbell	667	70,769,071
Black Thunder Mine	Campbell	560	60,101,578
Cordero Rojo Complex	Campbell	359	38,623,180
Jacobs Ranch Mine	Campbell	354	28,284,776
Caballo Mine	Campbell	281	25,596,000
Antelope Coal Mine	Converse	211	22,968,729
Eagle Butte Mine	Campbell	181	18,622,992
North Rochelle Mine	Campbell	224	17,187,000
Buckskin Mine	Campbell	168	15,833,179
Belle Ayr Mine	Campbell	249	15,016,000
Bridger Coal Company	Sweetwater	358	6,506,632
Coal Creek Mine	Campbell	70	4,190,148
Kemmerer Mine	Lincoln	270	3,725,983
Black Butte Coal Company	Sweetwater	144	3,453,105

Wyodak Mine	Campbell	43	3,050,325
Dry Fork Mine	Campbell	34	2,268,720
Shoshone Nr 1 **	Carbon	67	1,209,795
Dave Johnston Mine	Converse	64	631,126
Seminoe II	Carbon	46	402,783
Medicine Bow Mine	Carbon	48	372,615
Big Horn Coal Company	Sheridan	11	38,411
	Totals	4,409*	338,852,148

**Five employees at inactive mines not counted **Closed in 2000*

Source: Annual Report of the State Inspector of Mines of Wyoming, 2000.

Prices

The price of coal is a determining factor in the decision to mine or not to mine. As a commodity, coal has limited product differentiation from mine to mine across the nation. The production location cannot be moved; therefore, the coal must be transported to where it is to be used. Price is more often a function of demand for coal and the distance it must be transported rather than quality. One of the primary reasons the transcontinental railroad came through southern Wyoming was the close proximity to fuel resources.

In the early years, miners were paid by the ton, and the mines (or railroad as the case may be) set prices based on their costs or the market price of coal. Fluctuations in price were a major factor, determining not only the number of miners employed, but also whether the mine remained open or closed. As shown earlier in this report, mechanization and even the ethnicity of the miners themselves played roles in setting the price of coal. Additionally, since most coal during the rail era was used to power locomotives, coal from Utah and Colorado competed with Wyoming coal as a power source. Coal companies were (and are) under continuing pressure to reduce the cost of coal to stay competitive.

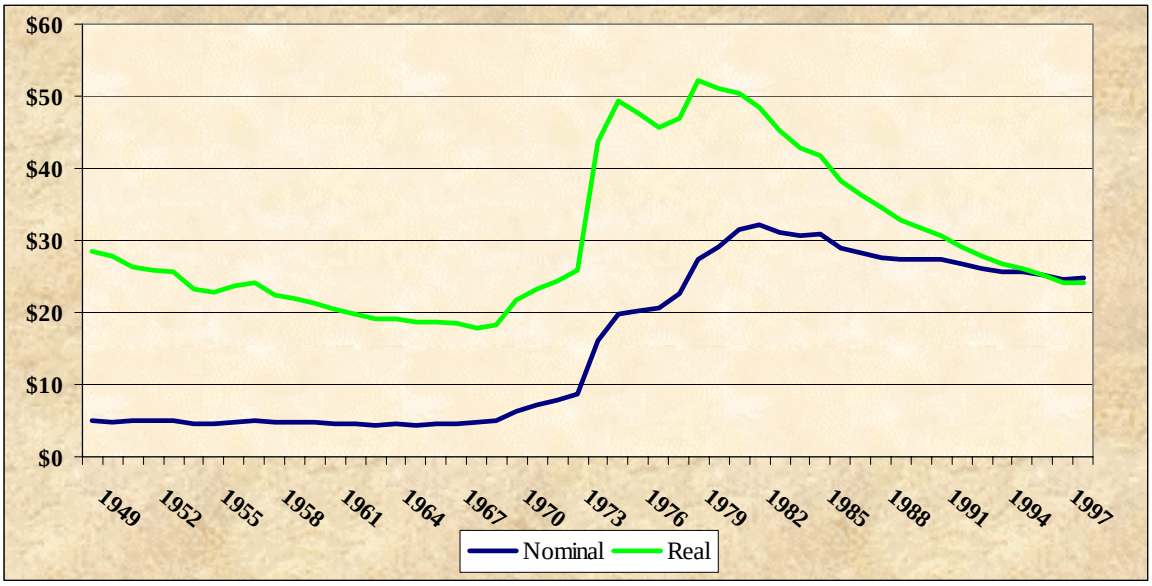
Railroads are the link between the two eras of coal mining in Wyoming. Railroads in the Rail Era brought people into the region to help settle the land in preparation for statehood. Coal's primary use was as fuel for the transportation industry (though

a significant amount was later used in smelters in the copper industry). Today, in the Energy Era, coal is mined on a massive scale, and productivity per worker is staggering when compared to the rail era (compare Figures 7 and 3). Railroads again play a key role in the industry, transporting Wyoming coal to power plants in other states and for export. An existing and efficient rail infrastructure was an important factor in the resurgence of the Wyoming coal industry in the early 1970s.

The competition among mines and between different fuel sources (coal versus natural gas) has pushed coal prices to lower and lower levels. Figure 9 shows the available data for U.S. average price of bituminous coal in both nominal and real (inflation adjusted to 1996) dollars (sub-bituminous prices are included to 1979). Bituminous coal is found mostly in southern Wyoming and has a higher heating value than the sub-bituminous coal found in the Powder River Basin (see text box, page 14). Railroads used bituminous coal for locomotives, but power plants are de-

signed to burn the cheaper, lower grade sub-bituminous coal for generating power. Price data for Wyoming sub-bituminous coal is only available since 1985 and nationally since 1979. The real price of coal, in Figure 9, declined during the transition years (1954-1968) even as the nominal price remained stagnant. Real value declined due to inflation as demand for coal declined. With the resurgence of coal in the Energy Era (1969-present), prices climbed. Real prices increased at a greater rate than nominal prices due to the higher level of inflation at the time. Coal companies could increase prices only so fast due to competition. The slow decline in prices

Figure 9. Average price per ton of bituminous coal U.S. (1949-1998).



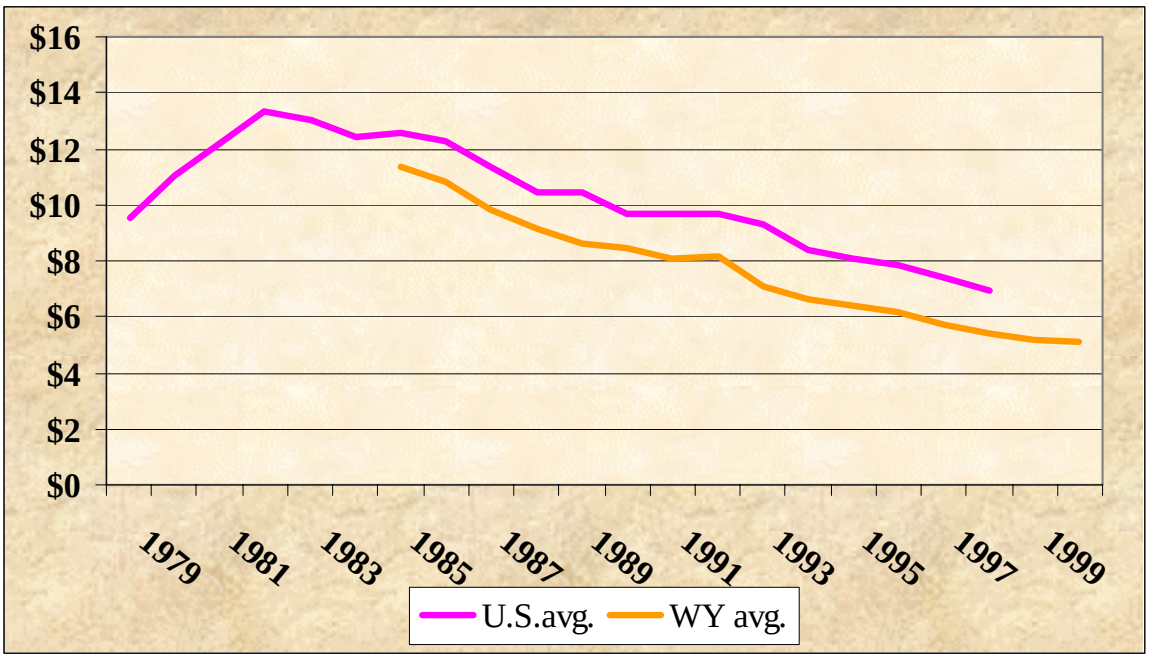
Source: Energy Information Administration, 2001

since the early 1980s is likely due not only to competition within the industry, but also to the increased use of natural gas to generate electricity.

Figure 10 shows the available price data for Wyoming sub-bituminous coal as well as the national average. Wyoming's price follows the national price trend but at a slightly lower level. The lower price is likely due to discounts and contracts associated with high-volume sales, as well as the fact that the lower BTU value of Wyoming coal and the distance to market mean that Wyoming coal must be aggressively priced to stay competitive. Wyoming has been the nation's number-one coal producer for the last 13 years, and is projected to remain so for the foreseeable future.

Contracts have become an important feature of the coal industry today. In the 1970s, when prices were rising steadily and worries that an oil shortage could threaten the United States, coal was seen as a stable domestic source of fuel. Many public utilities entered into long-term contracts to secure fuel at what they hoped would be a lower price over time. The average contract duration in 1979 was 21.4 years. Time has shown that the contracts were too long. Government regulation promoting cleaner power generation pushed utilities to use natural gas. As older, less environmentally friendly coal-fired plants were retired, natural gas plants replaced them. Coal companies, under intense pressure to cut costs, have continued to find efficiencies of size by enlarging machinery and cutting labor. Long-term contracts signed in the 1970s started to expire in the late 1990s; utilities negotiated new contracts at the current lower prices, and the length of contract has shortened to an average of 15.9 years. Encouraged by the trend in lower coal prices, utilities are choosing not to enter into longer-term contracts, betting instead that competition and increasing production efficiencies will keep prices low.

Figure 10. Average price per ton of sub-bituminous coal, Wyoming and U.S., (1979-2000)



Source: Energy Information Administration and Wyoming State Geologic Survey, 2001

Table 3. Coal Resources, Wyoming 2000.

Coal field	Coal rank	In place coal resources (millions of short tons)
Powder River	Sub-bituminous	578,162,000
Green River	Sub-bituminous / Hvb*	236,589,000
Wind River	Lignite / Hvb	81,007,000
Hanna / Rock Creek	Sub-bituminous / Hvb	26,390,000
Bighorn	Lignite / Hvb	23,491,000
Hams Fork	Sub-bituminous / Hvb	21,888,000
Other misc.	Sub-bituminous / Hvb	10,720,000
Total		978,247,000

Source: WSGS, IP-7, 2000. Hvb=high-volatile bituminous*

Source: Wyoming Department of Commerce, Energy Section, 1995 and Robert Lyman, WSGS

Coal ranking

Coal is ranked in order of its carbon content and thermal maturity, which in turn dictates its hardness and heating value (Table 3). Heating value is measured in BTUs*. The hardest coal is **anthracite**, which is not mined in Wyoming. Anthracite is primarily used in steel production. **Bituminous** coal is next lower in rank. It was formerly used to power steam locomotives, and in Wyoming was mined in the Hanna and Rock Springs and Newcastle fields. **Sub-bituminous** coal is less thermally mature than bituminous coal and is the fuel of choice for many of today's coal-fired utilities. It is plentiful and relatively inexpensive compared to other coals, thanks to thick deposits located close to the surface in the Powder River Basin. The lower sulfur content of Wyoming's sub-bituminous coal makes it especially attractive from an environmental standpoint. **Lignite,** the lowest grade of coal, has little value in today's market. Its use is mainly restricted to captive plants near deposits in Texas and North Dakota.

Table 3. Coal ranking

Name	Carbon (percent)	BTU content	Volatiles (percent)	Moisture (percent)
Anthracite	86-98	16,000-20,000	5	0
Bituminous	56-85	11,000-16,000	25	20
Sub-Bituminous	29-55	8,300-11,000	40	30
Lignite	10-30	4,000-8,300	50	40

* One BTU equals the amount of heat needed to raise the temperature of one pound of water, one-degree Fahrenheit.

Wyoming's coal resources

The majority of coal mined in Wyoming today is sub-bituminous coal from the Powder River Basin. Some is burned in captive generating plants at the mine, but most is loaded on rail cars and transported out of state. It is estimated that an average of sixty-five 13,000-ton trainloads of coal are shipped every day (Conference, 2000). This number is expected to increase over the next 10 years to 80 trains per day. This also means that 80 empty trains will have to arrive in the PRB to be filled every day. Each train consists of 110 to 115 cars plus three or four engines.

Table 3 shows Wyoming's coal resources by coal basin. The sub-bituminous resources of the Powder River Basin are twice the size of the next largest basin (Green River) and are closer to the surface. This means that Powder River coal has the lowest production cost and the longest resource life. Consequently, coal companies will continue locate in the Powder River Basin and will be more willing to invest in mines and infrastructure there.

Mineral Revenue

The economic importance of mineral extraction to the state of Wyoming cannot be understated. Wyoming's mining and minerals sector contributes more to Gross State Product (GSP) than any other sector of the economy. Minerals currently account for 31.39 percent of Wyoming's GSP, or over $5.5 billion (1997), and support approximately 15,790 full-time wage earners, or 9.76 percent of Wyoming's employment base (WY, DEA, 2000). The coal industry, included in the mining sector, employs 4,414 (2000) and accounts for 28 percent of mining sector employment (Commerce, 2000 and Mines, 2000).

Table 4 shows total mineral revenue to Wyoming state and county governments for the years 1999 and 2000. In 1999, the state legislature was grappling with a projected $200 million shortfall in its budget. Two years later, the surplus was projected at over $600 million. The difference came from the fact that gas and oil prices skyrocketed in 2000, and along with increasing coalbed methane production resulted in significant increases in all forms of mineral revenue. Coal prices, which had been declining, also showed strength with a few spot market sales reaching $14 per ton in May 2001. It is interesting to note that spot market spikes often make headlines in the media, but the spot market accounts for only about 20 percent of coal sales (Lyman, 2001).

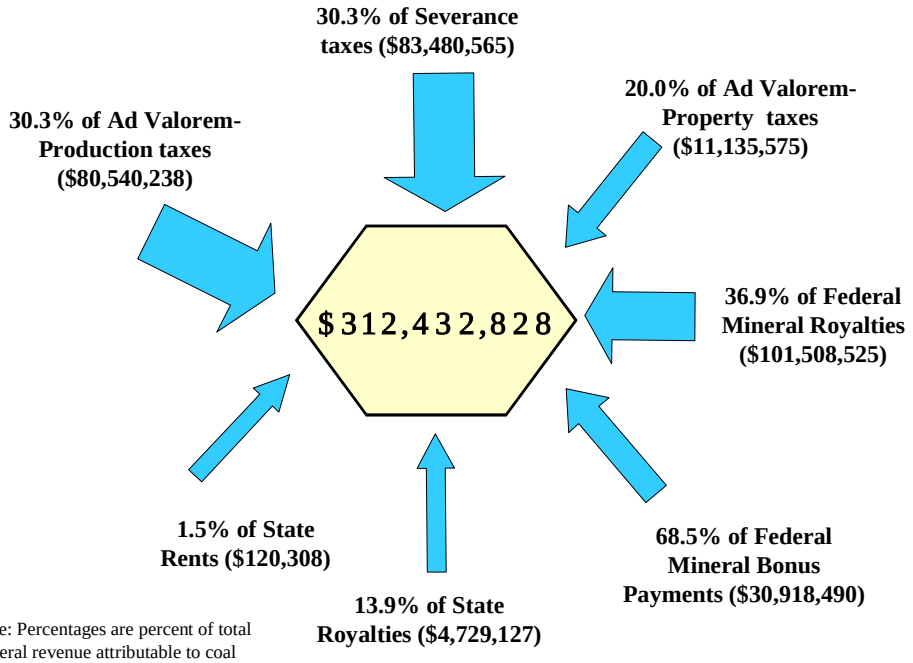
Table 4. Total mineral revenue to Wyoming state and local government, 1999 and 2000

	1999	2000	Change	Percent change
Ad valorem-production	$224,308,663	$265,433,379	$41,124,716	18.33
Severance taxes	$196,459,204	$275,122,976	$78,663,772	40.04
Federal mineral royalties	$198,657,100	$263,941,707	$65,284,607	32.86
Ad valorem-property	$47,816,041	$55,557,427	$7,741,386	16.19
Sales and use taxes	$28,800,218	$29,491,611	$691,393	2.40
State royalties	$27,720,888	$34,099,206	$6,378,318	23.01
Federal bonus payments	$32,371,984	$45,151,140	$12,779,156	39.48
State rent	$6,747,746	$8,434,827	$1,687,081	25.00
Total govt. revenue	$762,881,844	$977,232,273	$214,350,429	28.10
PWMTF interest	$107,285,509	$118,312,856	$11,027,346	10.28
AML reclamation grants	$23,815,989	$27,279,768	$3,463,779	14.54
Grand total mineral revenue	$893,983,342	$1,122,824,897	$228,841,555	25.60

Sources: WY Dept. of Revenue, U.S. Minerals Management Service, Equality State Almanac, WY Office of State Lands and Investments, WY DEQ, AML Division, U.S. Dept. of Interior, Bureau of Land Management.

Revenue from coal mining accounts for about 32 percent of total state mineral revenues (Figure 8). It is important to note that the sales and use tax and the AML (Abandon Mine Lands) reclamation grants values shown in Table 4 were not used in the calculation of coal's contributions, since it is not possible to break down that value by mineral. However, most of the AML reclamation grant money is attributable to coal with the remainder coming from trona. Figure 8 is therefore conservative but represents the authors' best estimates, given the data. The three largest revenue sources are severance taxes, ad valorem production taxes, and federal mineral royalties. Federal mineral bonus payments can vary widely from year to year; coal leases auctioned by the federal government are payable in installments over five years. Since large leases are typically valued over $100 million and the state receives one half of this, the state could receive in excess of $10 million per year for five years from a single large lease. However, it takes three to five years to complete a bid, based on the mine's plan. Wyoming coal mines today are averaging 15 years mineable reserves (before they would need to obtain a new lease). This keeps the number of these large leases small; there are currently only two under review, and payments from previous

Figure 8. Estimated revenue contributions of the coal industry to Wyoming state and county governments, 2000.



Note: Percentages are percent of total mineral revenue attributable to coal industry

leases will be complete by 2002 (Geonotes, 2000). Consequently, the federal mineral bonus payments from coal will shrink significantly unless new leases are approved. (For more information on mineral revenue see CES bulletin B-1112, Economic Trends in Wyoming's Mineral Sector: Gas and Oil).

The State of Wyoming has long been interested in a severance tax on coal. An initiative as far back as 1889 would have made this tax part of the first state constitution. However, industry opposition and market conditions were able to beat back legislation until 1969. By that time, "state government had to have more revenue and the alternatives, higher taxes or an income tax, were even more dangerous politically" (Gardner and Flores, 1989). The initial severance tax was one percent, but it was raised regularly through the 1970s; the current severance tax for surface coal is seven percent. Twenty-five percent of severance taxes go to the Permanent Wyoming Mineral Trust Fund (PWMTF), which acts like a savings account for the state. The balance in 2000 was over $1.6 billion, including $62 million in severance taxes added last year alone. The PWMTF earned over $100 million in interest and investment income in 2000. The principal from this account is not spent, but interest and investment income is distributed each year.

Future directions

Coal mining in Wyoming today has evolved into a highly automated, highly efficient, high-volume production process. Wyoming is the number-one coal producing state in the nation, supplying 31 percent of the country's coal (Lyman and

Hallberg, 2000). Wyoming mines produced over 338 million tons of coal in 2000 employing only 4,414 employees. Productivity is the highest on record at 76,768 tons per employee per year (Figure 7). This represents an increase of 6.99 percent over 1999 and a 293 percent increase since 1969. Shoshone Mine No. 1, the last underground coal mine in Wyoming, closed in 2000, and all Wyoming coal is now mined in surface mines, located mostly in Campbell, Converse, and Sweetwater Counties (Table 1).

The majority of Wyoming coal is transported by rail for use in electrical generating plants in other states. Some coal is "captive," used in a generating plant onsite or adjacent to the mine, such as the Naughton plant in Lincoln County, or the Wyodak plant in Campbell County. A very small amount of coal is trucked from mines for other uses. For example, University of Wyoming buildings are heated by coal-fired steam boilers with coal trucked from Hanna, and the Mountain Cement plant in Laramie trucks coal for its kilns.

Not everyone agrees on the future of coal. Its demise has been predicted before, only to have new demands for electricity bring it back stronger than ever. Increased mechanization in coal mining has caused employment in mines to decline even as production has soared. The employment outlook for the mining sector in Wyoming suggests it will remain stable through 2008 (Outlook, 2000). Improvements in transportation are expected to continue to keep prices depressed. One view holds that coal will gradually decrease in importance:

> "Although coal is projected to maintain its fuel cost advantage over both oil and natural gas, gas-fired generation is expected to be the most economical choice for construction of new power generation units in most situations, when capital, operating, and fuel costs are considered. Between 2005 and 2020, rising natural gas costs and nuclear retirements are projected to cause increasing demand for coal-fired base-load capacity" (EIA-Annual, 2001).

This suggests that as older nuclear and coal-fired units are retired, more cost-effective gas-fired units will replace them. As a result, the remaining coal-fired plants will be required to stay online longer and will be pushed to supply power at levels closer to their design capacity.

Another view has coal continuing to play a major role for the foreseeable future:

> "...rises in the cost of domestic natural gas are anticipated because of resource limitations. There are also likely to be significant increases in the price of imported petroleum. While continued growth in the use of renewable energy forms is expected, along with a poten-

> tial resurgence of nuclear power, there will be powerful economic driving forces for major and expanded use of coal over the next several decades, with concomitant pressures to reduce environmental impacts through improved technologies" (NRC, 1995).

This view holds that coal will expand its role due to economic forces and the demand for ever more electrical power.

The authors tend to side with the latter view. Coal will likely continue to hold a prominent place in the energy market. This is particularly true with regards to base-load generating capacity (base-load is the minimum steady state electrical load over a given period of time). According to the Department of Energy's Energy Information Administration, 56 percent of this country's electrical power comes from coal-fired plants. Existing plants and transportation infrastructure will most likely provide the best economic alternative to maintaining that capacity in the medium term. This view is not only supported by the Bush administration's proposed National Energy Policy, but the events of September 11, 2001, will most likely rekindle the desire for a secure, domestic source of energy. One thing is certain. Whatever the future of coal, Wyoming will be part of it. Its huge reserves of low-cost, low-sulfur coal are among the best in the country.

Summary

Early explorers in Wyoming recognized the economic potential of the coal deposits they encountered. Tapping these resources for locomotive fuel was only the beginning of economic development in the state, but the reality of the time was that coal mined in underground mines had a limited regional economic influence. As technology changed and fuel sources shifted from coal to oil, Wyoming underwent significant economic upheaval adapting to the new economics of oil extraction.

The resurgence of coal is tied to the developing technologies of long-distance transmission of electrical power, increased mechanization for ever-more efficient surface mining, and the low-sulfur properties of Wyoming coal itself. As the twenty-first century unfolds and the world looks for cleaner methods of power generation, many have predicted that coal will again become the fuel of the past. However,

Wyoming's vast coal reserves provide a clean, cheap, domestic source of fuel when combined with the latest technology. While the demand for electrical power seems ever increasing, predictions of the demise of coal may be premature.

Coal has been a powerful force in shaping economic development in Wyoming. From the earliest coal towns to today's hyper-efficient mine complexes, coal provides significant employment and hundreds of millions of dollars annually to state and local government. Wyoming's coal resources make it the likely beneficiary of any future use of the energy mineral beyond today's power generation needs.

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For more information on trends in Wyoming's economy visit the Wyoming Economic Atlas at http://agecon.uwyo.edu/EconDev.

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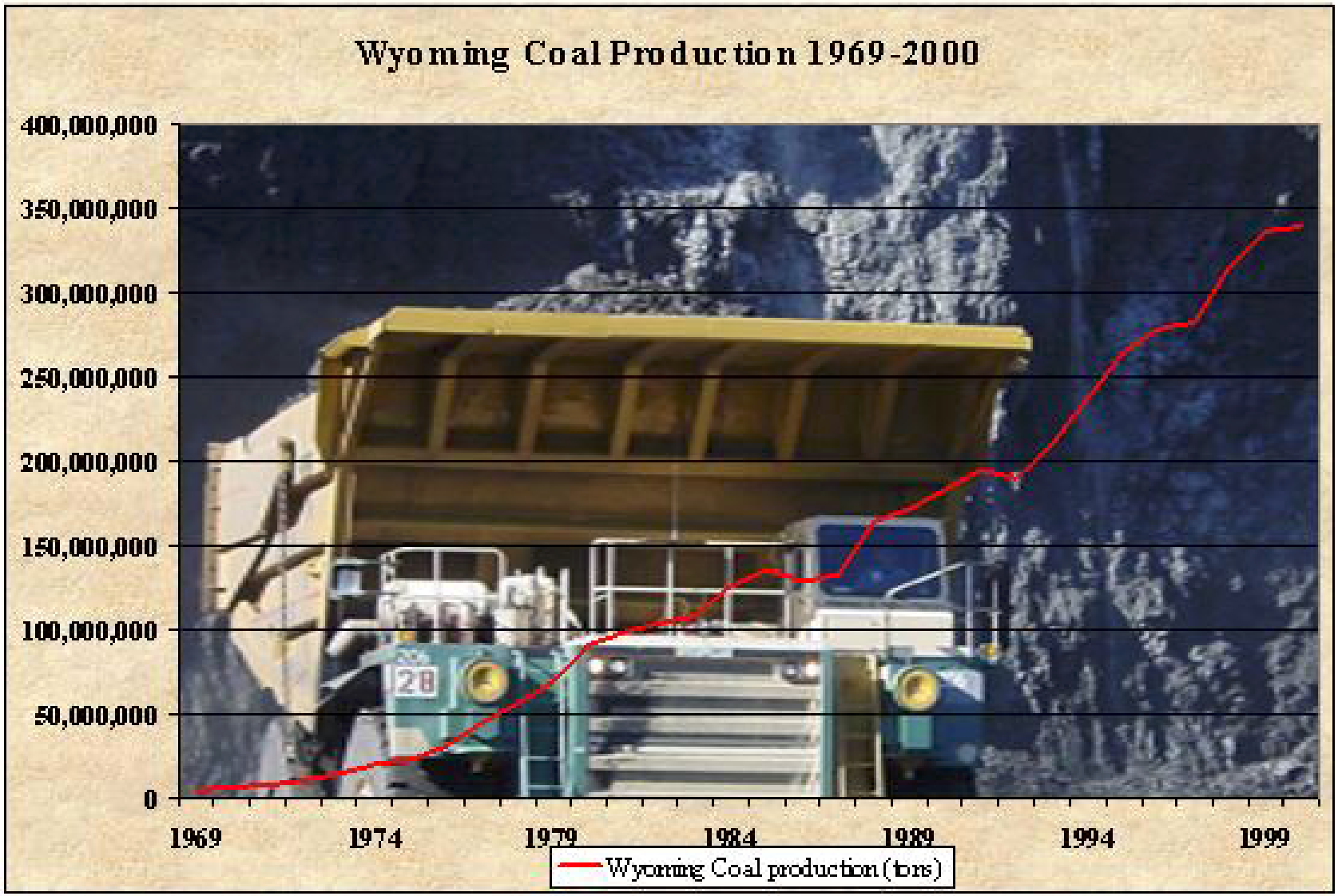
Wyoming Coal Production 1969-2000
400,000,000
350,000,000
300,000,000
250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
0
1969
1974
1979
1984
1989
1994
1999
Wyoming Coal production (tons)