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Coal:

Cheap and Abundant... Or Is It?

Why Americans Should Stop Assuming That The U.S. Has a 200-Year Supply of Coal

RAIN VISIB … H CARBON
DIOXIDE C … ACID RAIN
VISIBILITY I … P REMOVAL
SURFACE M … OLLUTANTS
MINING AC … ATES ACID
GASES COA … TS MINING
ACCIDENTS … ACID GASES
MOUNTAIN … OLLUTANTS
MINING AC … ATES ACID
GASES COA … HAZARDOUS
POLLUTANT … MERCURY
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Coal:

Cheap and Abundant... Or Is It?

Why Americans Should Stop Assuming That The U.S. Has a 200-Year Supply of Coal

Version 1.1 Issued February 2009
Corrections and updates to Leslie Glustrom at lglustrom@gmail.com or 303-245-8637

Dedication

This report is dedicated to the visionary, courageous and just-plain-fun activists in Clean Energy Action (www.cleanenergyaction.org) as well as to the determined clean energy activists around the world who will help lead our societies into the post-fossil fuel era.

Sole Responsibility

Leslie Glustrom takes full and sole responsibility for the contents of this report.

Acknowledgements

Anyone writing about coal in the 21st century owes a deep debt of gratitude to Barbara Freese for Coal: A Human History,[1] and to Jeff Goodell for Big Coal: The Dirty Secret Behind America's Energy Future,[2] as well as to the hard-working women and men in the Bureau of Land Management, United States Geologic Survey and the Department of Energy on whose work this report is largely based.

Note to the Reader

It is hard to write about coal without quickly becoming immersed in the seemingly endless environmental impacts of coal production and use, but the primary purpose of this report is to discuss the issue of whether the United States really has a "200 year supply" of economically accessible coal. While environmental issues are touched on in this report, it is not the purpose of this report to discuss these issues. For a summary of environmental and health impacts of our reliance on coal, the reader is referred to Appendix A.

Mine-Specific Analyses Recommended

The author would like to encourage any state or industry dependent on electricity from coal-fired power plants to undertake a mine-specific analysis of coal supplies for that state or industry. The author specifically encourages the state or industry to ask questions related to expected life span of any mines supplying coal to the state or industry and any geologic, economic, legal or transportation constraints that could face future mine expansion and to plan for the future accordingly.

Questions, Corrections and Updates

Questions, corrections or updates to the information in this report should be sent to Leslie Glustrom, lglustrom@gmail.com or 303-245-8637. If you do not receive a response, please call and send the message again as the volume of e-mail is often extensive.

Layout and Web Support

The author would like to thank Sarah Lake for her wonderful eye in laying out this report and Lili Francklyn for her web and public relations support.

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COAL: Cheap and Abundant: Or Is It?

Version 1.1. Released February 2009
Comments and Questions to Leslie Glustrom lglustrom@gmail.com 303-245-8637

ABSTRACT

Coal-fired power plants provide approximately 50% of the electricity in the United States. It has often been stated that coal is "cheap and abundant" and it is assumed that it will stay that way for at least the next century. A careful analysis of existing information on coal supplies suggests that United States coal supplies are much more constrained than is widely understood. Indeed, it appears that with existing mines playing out over the next 10-20 years and future mine expansions highly uncertain, the planning horizon for building alternative power production infrastructure is likely to be much shorter than previously thought.

A careful review of existing information on U.S. coal supplies demonstrates that:

1) The U.S. Energy Information Administration has repeatedly published data on coal "reserves" as though they include an assessment of economic recoverability when in actuality they did not. As a result, the often touted "200 year supply of U.S. coal" is not based on a realistic assessment of how much coal will actually be accessible.

2) The United States Geological Survey has developed a tool for assessing economic recoverability and published a series of reports showing that the amount of economically recoverable coal is a small fraction (e.g. less than 20%) of the original resource. The most recent USGS assessment of coal in the Gillette coal field of the Powder River Basin of Wyoming, the source of about 40% of U.S. coal, found that only 6% of the coal was economically accessible under the economic conditions at the time. Between 2002 and 2008, while coal costs were rising dramatically, the USGS reduced the amount of economically accessible coal in the Gillette coal field of the Powder River Basin from 23 billion tons to 10 billion tons.

3) The major mines in the Powder River Basin of Wyoming (e.g. the "Fort Knox" of U.S. coal) have less than a 20 year life span, and coal mines in other parts of the United States are also likely to be playing out in the next 20 years. Future coal mine expansions are highly uncertain as these expansions will face very serious geologic, economic, legal and transportation constraints. Importantly, the federal government owns essentially all of the coal in the western United States, and future coal mine expansions in western states will have to comply with a host of federal laws.

IN CONCLUSION, It appears that rather than having a "200 year supply of coal," the United States has a much shorter planning horizon for moving beyond coal-fired power plants. Depending on the resolution of geologic, economic, legal and transportation constraints facing future coal mine expansion, the planning horizon for moving beyond coal could be as short as 20-30 years.

I. INTRODUCTION—IS THE UNITED STATES THE SAUDI ARABIA OF COAL?

It is not clear who first referred to the United States as the "Saudi Arabia of Coal," but like other notable "facts," it seems to have been repeated so often that it is often taken for granted. From *Time* magazine and the *Christian Science Monitor,* to endless blog entries and statements of a Presidential candidate,[3] the belief in an almost endless supply of coal seems to have become part of the "conventional wisdom" in the United States.

Yet a closer look indicates that, like some other pieces of conventional wisdom that have often been repeated, this one does not bear up under closer scrutiny. The truth is that most of the coal in the United States is buried too deep to be accessible in large quantities. Importantly, coal is a solid, not a liquid or a gas, so its extraction is, in many ways, more difficult than that of oil or natural gas.

There have been a number of reports in recent years that have attempted to draw our attention to the fact that the amount of economically recoverable coal is much less than we have been told, but these reports have only been cursorily addressed in the popular media and the American public has almost never been told the true story. In the meantime, the cost of coal has begun to skyrocket, along with the other fossil fuels.

This report will provide background information on United States coal producing regions and will introduce the reader to a more thoughtful view of the supply, cost and accessibility of American coal and its implications for the speed at which the United States will need to be repowered.

Over 90% of the coal consumed in the United States is used for production of electricity,[4] and that will be the focus of this report. Indeed, it is the hope of the author that by taking a more careful look at coal supplies, we will be sure to leave enough coal for future generations to use in making steel and in other industrial applications that may require these highly concentrated forms of energy. Electricity can be produced in many different ways, but there may be uses of coal which are not easily replaced.

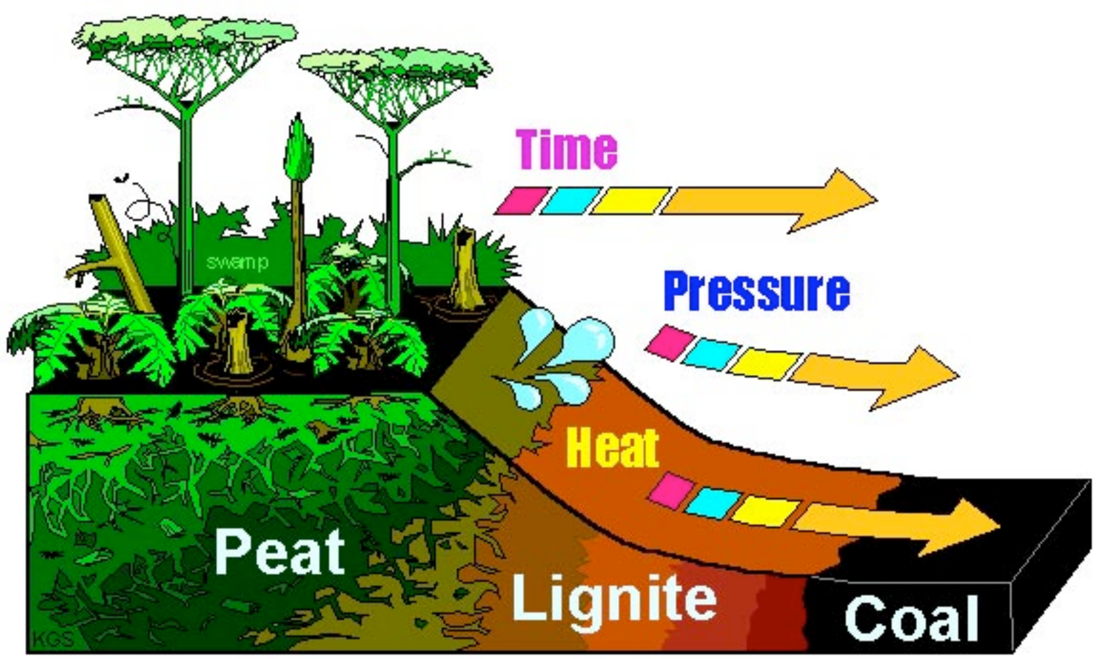
II. COAL—FORMATION, RANK AND CHEMISTRY

A. Formation of Coal

Coal is the result of dead plant material that has been buried under heat and pressure for millions of years.[5] Much of the coal in Europe and in eastern United States began its formation in the Carboniferous period from about 360 to 290 million years ago. Other coals were formed more recently, with coals in the Powder River Basin of Wyoming dating to the Paleocene Epoch from about 55-60 million years ago.[6]

Figure 1 below shows the general scheme for the formation of coal with plant material being buried under heat and pressure for long periods of time leading to the formation of coal.

Figure 1
General Schematic of the Formation of Coal
From http://www.minepermits.ky.gov/miningeducation/coal_formation.htm



B. Different Ranks of Coal

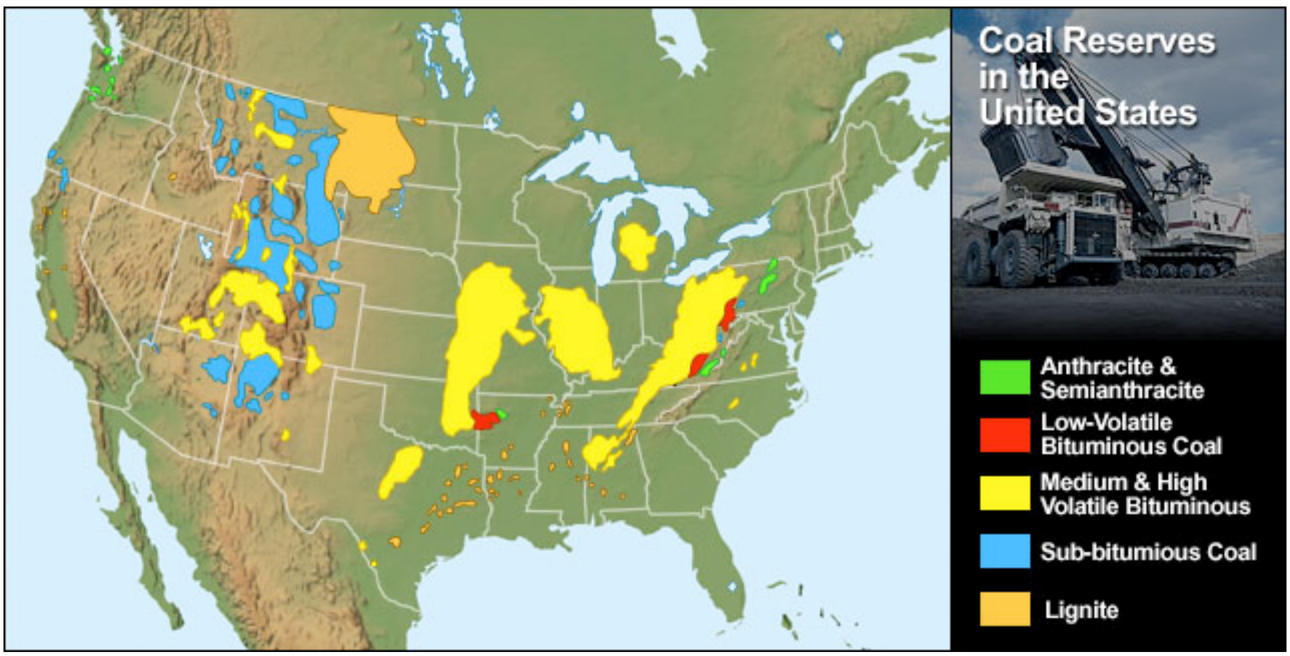
Not all coals were "created equal." Generally speaking, coals that were buried longer under heat and pressure have metamorphosed more thoroughly, driving out moisture and oxygen leaving these coals with a higher carbon and, therefore, heat content. As a result of the higher heat content, these coals are considered to be of higher quality. There are also many differences in the chemistry of coals including sulfur, chlorine and a host of other trace elements including mercury, arsenic, lead, uranium, thorium and selenium.

There are four broad categories of coals, with several subclasses in each category. The highest rank coal is anthracite, which has the highest heating content and the lowest ash and moisture content. After anthracite, coal ranks, in descending order, are bituminous, subbituminous and lignite—with each lower rank typically having lower heating value and often higher moisture and ash contents.

The formal definition of coal rank is given in the Standard Reference of the American Society of Testing and Materials (ASTM) D 388.[7] According to the ASTM Standard, higher rank coals are classified according to carbon content, while lower rank coals are classified according to British Thermal Unit ("BTU")[8] content. For example, anthracite coals have more than 92% carbon, while bituminous coals typically have in the range of 70-85% carbon. Subbituminous coals are ranked according to heat content with higher ranking coals having up to 11,500 BTUs per pound, while lower ranking subbituminous coals might only have 8300 BTUs per pound.[9] Lignite, the lowest rank of coal is classified as having less than 8,300 BTUs per pound.[10]

Figure 2 shows the location of various types of coal deposits in the United States.

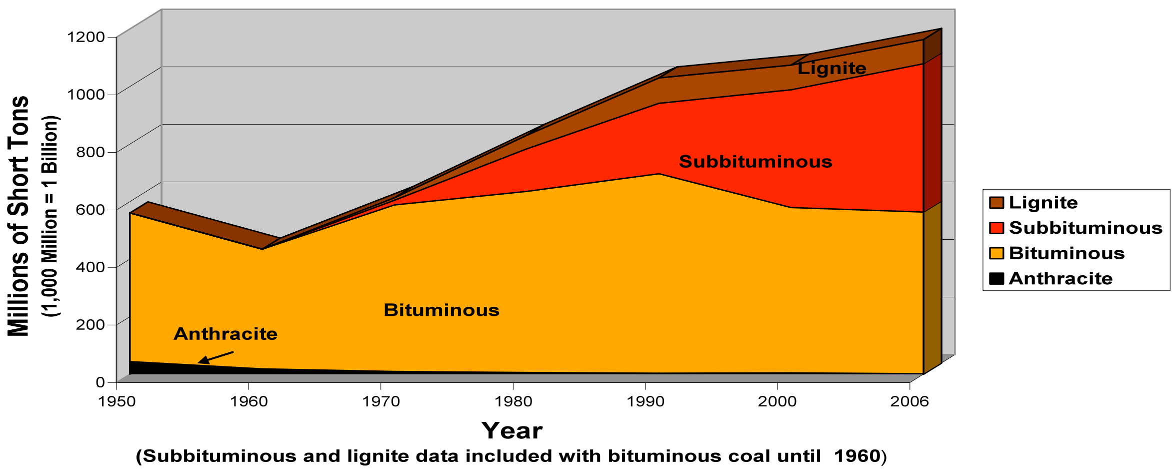
Figure 2
Coal Reserves in the United States
(From http://www.teachcoal.org/aboutcoal/articles/coalreserves.html)



From Figure 3, it is clear that the United States is no longer producing significant quantities of anthracite, the highest rank coal. The production of bituminous coal is falling while that of subbituminous coal is increasing. Indeed one calculation indicates that while volume of coal production in the United States has been increasing, on an energy content basis, United States coal production peaked in the 1990s because our production is increasingly reliant on the lower heat content subbituminous coals. [11]

Figure 3
Coal Production by Rank 1950-2006

Data from Energy Information Administration Annual Energy Outlook 2007 Table 7.2
http://www.eia.doe.gov/aer/coal.html



C. Coal Chemistry

Having been formed from living things, coal contains many trace elements including sulfur, mercury, chlorine, arsenic, lead, chromium, manganese, selenium, cobalt and many other hazardous pollutants that pose various emission and waste disposal problems.[12]

Each sample of coal will have a different chemical profile. While eastern coals typically have more sulfur than western coals, all coals have dozens of trace elements. When coal is combusted in power plants or other industrial applications, these trace elements will either be released to the air or concentrated in fly ash from the smokestack, bottom ash from the boiler, or in other streams of waste.[13]

III. COAL REGIONS IN THE UNITED STATES

A. Overview

Figure 4 and 5 show the relative importance of the key coal producing regions in the United States. While Western and Appalachian coal provided approximately equal amounts of coal a decade ago, since then production of coal from Appalachia has generally declined,[14] while production from the Western Region has increased.

Figure 4

Coal Production by Coal-Producing Region, 2007 (Million Short Tons and Percent Change from 2006)

Source: Energy Information Administration, http://www.eia.doe.gov/cneaf/coal/page/special/fig1.html

U.S. Total Production in 2007: 1,145.6 Million Short Tons (-1.5%)

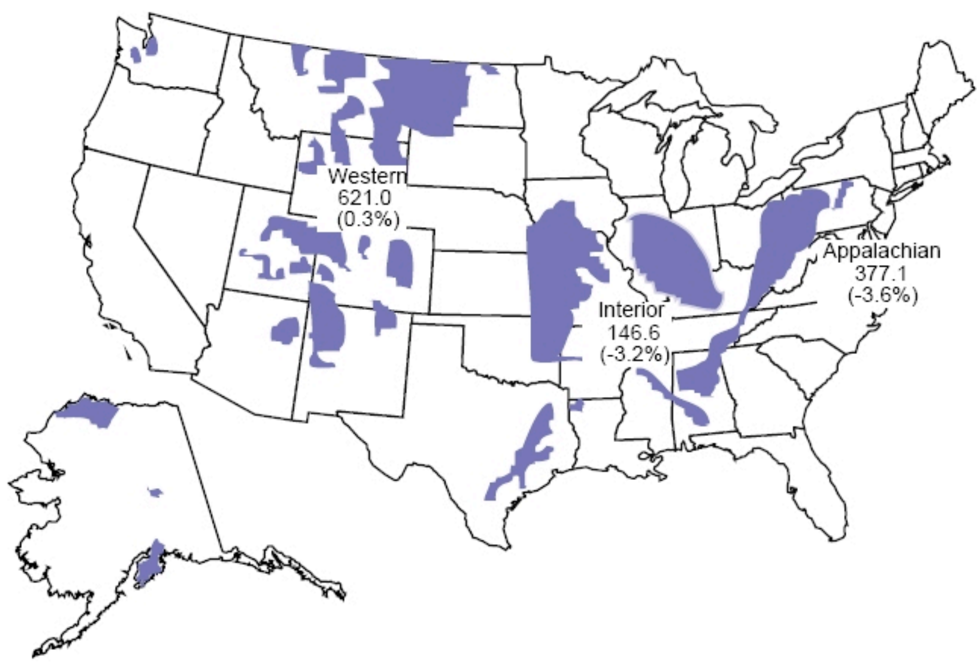
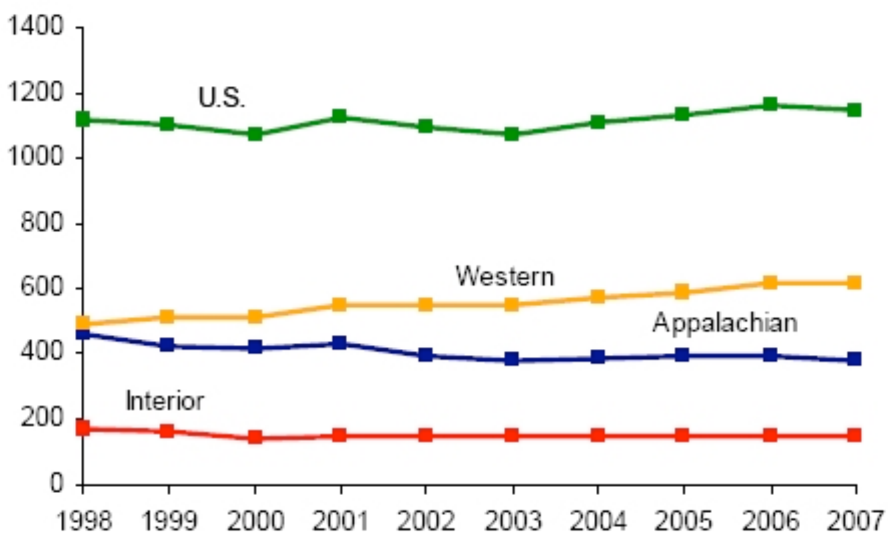


Figure 5

Coal Production by Region, 1998-2007
(Million Short Tons)
Source: Energy Information Administration
http://www.eia.doe.gov/cneaf/coal/page/special/fig2.html



B. Top Coal Producing States

Figure 6 shows the top 6 coal producing states in the United States. [15] These 6 states, Wyoming, West Virginia, Kentucky, Pennsylvania, Montana and Texas produced about 76% of the country's total coal production of about 1145.6 million short tons in 2007. [16]

Figure 6

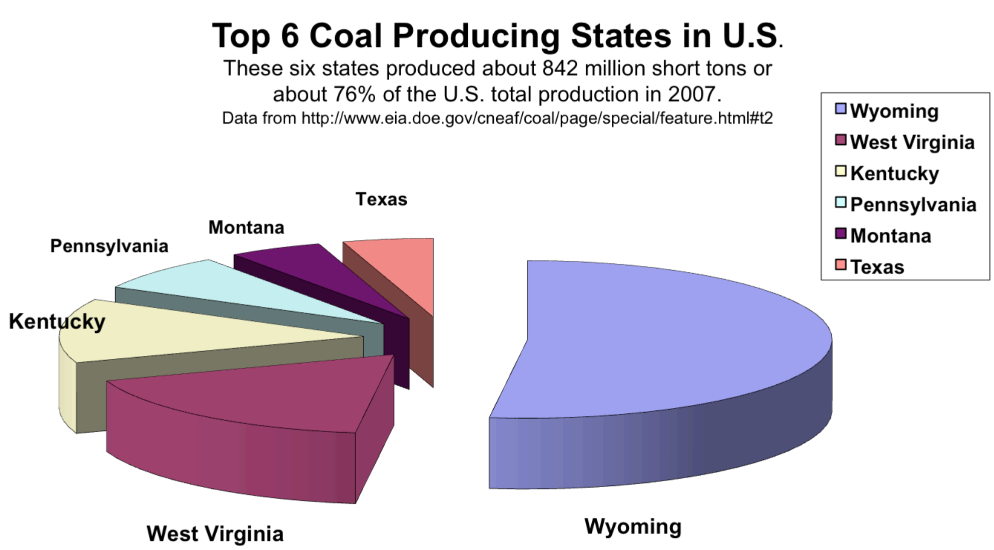


Table 1 shows the production of coal from the top 15 coal producing states in 2007. Wyoming was easily the single largest producer of coal in the United States. In 2007, Wyoming produced 453 million short tons, or almost three times as much coal as was produced in West Virginia, the second largest producer of coal at 153 million short tons, and almost four times as much as Kentucky, the third largest producer of coal at 115 million short tons.

What is the difference between the short ton, long ton, and metric tonne.

www.onlineconversion.com/faq_09.htm

The British ton is the long ton, which is 2240 pounds, and the U.S. ton is the short ton which is 2000 pounds.

Both tons are actually defined in the same way. One ton is equal to 20 hundredweight. It is just the definition of the hundredweight that differs between countries. In the U.S. there are 100 pounds in the hundredweight, and in Britain there are 112 pounds in the hundredweight. This causes the actual weight of the ton to differ between countries.

To distinguish between the two tons, the smaller U.S. ton is called short, while the larger British ton is called long.

There is also a third type of ton called the metric ton, equal to 1000 kilograms, or approximately 2204 pounds. The metric ton is officially called tonne. The SI standard calls it *tonne*, but the U.S. Government recommends calling it *metric ton.*

Table 1
Top 15 Coal Producing States—2007

Data from Table 2, U.S. Coal Supply and Demand: 2007 Review
http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2

Rank	State	Million Short Tons[17] 2007
1	Wyoming	453.6
2	West Virginia	153.2
3	Kentucky	115.0
4	Pennsylvania	65.0
5	Montana	43.4
6	Texas	41.9
7	Colorado	36.4
8	Indiana	35.0
9	Illinois	32.4
10	North Dakota	29.6
11	New Mexico	24.5
12	Utah	24.3
13	Ohio	22.6
14	Alabama	19.3
15	Arizona	8.0

As seen in Table 1, after the top 3 states, there are 12 states that all make much smaller contributions to the national total ranging from about 8 to 65 million short tons of coal produced in 2007. In addition, approximately an additional dozen states contribute very small quantities of coal, all having produced less than 10 million short tons in 2007. [18]

A brief description of each major coal-producing region follows.

C. Appalachian Region

The Appalachian Region is the second largest coal producing region in the United States after the Powder River Basin of Wyoming and Montana. The Energy Information Administration in the United States Department of Energy has designated a number of sub-regions in the Appalachian Region,[19] with the Central Appalachian region being the most important coal production region in the Eastern United States.

Central Appalachia

According to the Energy Information Administration, the Central Appalachia region includes parts of West Virginia, Kentucky, Tennessee and Virginia, with West Virginia being the largest producer of coal.[20]

Table 2
Key Coal Producing States of Central Appalachia

Data from: Energy Information Administration,
"U.S. Coal Supply and Demand: 2007 Review" Table 2 available at
http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2

Central Appalachia State	2007 Production of Coal (Million Short Tons)
West Virginia (Southern)	111.3
Kentucky (Eastern)	86.8
Virginia	25.3
Tennessee (Northern)	2.6*

* Northern Tennessee counties are grouped with Central Appalachia while southern Tennessee counties are grouped with Southern Appalachia. Total 2007 coal production in Tennessee was 2.6 million short tons.

West Virginia, now the second largest coal producing state in the U.S., reached 180 million short tons of production in 1998,[21] but has since fallen in production numbers and produced only 153 million short tons in 2007, as seen in Table 2. The southwest corner of West Virginia is home to many of the country's most productive bituminous coal mines, with Boone County alone producing over 32 million short tons in 2006. Of Boone County's production, approximately 13 million tons was produced using Mountain Top Removal (MTR) methods[22] in which the top of a mountain is removed and typically placed in an adjoining river valley in order to access the coal.

For much of the last half of the 20th century, Kentucky was the largest coal producing state in the country until 1988 when it was surpassed by Wyoming.[23] Kentucky (eastern and western combined) produced over 170 million short tons of coal in 1990,[24] but production since then has declined and in 2007, combined production in Kentucky (east and west) was only 115 million short tons, as shown in Table 1 listing the top 15 coal producing states.

Northern Appalachia

According to the Energy Information Administration, Northern Appalachia consists of Maryland, Ohio, Pennsylvania, and northern West Virginia.[25] Table 3 shows that Pennsylvania is the largest coal producing state in the Northern Appalachian region.

Table 3
Key Coal Producing States of Northern Appalachia

Data from: Energy Information Administration,
"U.S. Coal Supply and Demand: 2007 Review" Table 2 available at
http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2

Northern Appalachia State	2007 Production of Coal (Million Short Tons)
Pennsylvania	65.0
West Virginia (Northern)	42.0
Ohio	22.6
Maryland	2.3

Pennsylvania contains both bituminous and anthracite coal dating to the Pennsylvania geologic period of about 300 million years ago, but bituminous coal is now the predominant coal produced in the state. Only 1.6 million tons of anthracite coal were produced in 2007 while there were 63.5 million short tons of bituminous coal produced in the same year.[26] Pennsylvania was the top producer of coal in the United States in the early 1900s with production peaking in 1918 when the state produced an impressive 277 million short tons of coal.[27]

Northern West Virginia coal production is centered in Monongalia County on the border of Pennsylvania with over 11 million short tons produced in 2006, almost all of which came from underground mines.[28]

Ohio produced a little over 22 million short tons in 2007, down from a peak of over 50 million short tons in the late 1960s.[29] Much of the remaining Ohio coal has relatively high levels of sulfur,[30] which makes it less desirable for power plants that do not have sulfur controls.

Southern Appalachia

The Energy Information Administration applies the designation of "Southern Appalachia" to the coal producing states of Alabama and Tennessee.[31]

Table 4
Key Coal Producing States of Southern Appalachia
Data from: Energy Information Administration,

"U.S. Coal Supply and Demand: 2007 Review" Table 2 available at
http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2

Southern Appalachia State	2007 Production of Coal (Million Short Tons)
Alabama	19.3
Tennessee	2.6*

* Northern Tennessee counties are grouped with Central Appalachia while southern Tennessee counties are grouped with Southern Appalachia. Total 2007 coal production in Tennessee was 2.6 million short tons.

Alabama coal production peaked above 25 million short tons in the late 1980s and has since fallen to about 19 million short tons.[32] Alabama coal is relatively low sulfur, but there are not large amounts of reserves available.[33]

D. Interior Region

The Energy Information Administration includes Arkansas, Illinois, Indiana, Kansas, Louisiana, Mississippi, Missouri, Oklahoma, Texas, and Western Kentucky into what it designates the "Interior" coal producing region.[34]

Table 5
Key Coal Producing States of the Interior Region
Data from: Energy Information Administration,
"U.S. Coal Supply and Demand: 2007 Review" Table 2 available at
http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2

Interior State	2007 Production of Coal (Million Short Tons)
Texas	41.9
Indiana	35.0
Illinois	32.4
Kentucky (Western)	28.2
Mississippi	3.5
Louisiana	3.1
Oklahoma	1.6
Kansas	0.4
Missouri	0.2
Arkansas	0.1

Production of coal in Texas only began in earnest in the 1970s, during which time production climbed to over 50 million short tons.[35] Since 2000, coal production has fallen to its present level of a little less than 42 million short tons per year.

Indiana coal production is typically between 30 and 40 million short tons and has remained relatively steady since the 1980s. Much of the coal remaining in Indiana is high sulfur coal,[36] meaning it will be less desirable for power plants that do not have sulfur controls.

Illinois coal production has dropped to a little over 30 million short tons compared to a peaks of over 80 million short tons between 1910 and 1920 and production around 60 million short tons in the 1980s.[37] As with Indiana coal, Illinois coal is a high sulfur coal,[38] limiting its desirability for power plants that are not equipped with sulfur control equipment.

As can be seen from Table 2 showing coal production in the Central Appalachian states, about 75% of the 115 million short tons of coal produced in Kentucky in 2007 is mined from eastern Kentucky with western Kentucky producing about 28.2 million short tons, or a little less than 25% of Kentucky's total.

Production in all other states of the Interior Region is well under 10 million short tons per year.

E. Western Region

The United States Energy Information Administration classifies the Western Coal Producing Region as consisting of Alaska, Arizona, Colorado, Montana, New Mexico, North Dakota, Utah, Washington, and Wyoming.[39] Coal production figures for 2007 for the states in the Western Region are shown in Table 6.

Table 6
Key Coal Producing States of the Western Region

Data from: Energy Information Administration, "U.S. Coal Supply and Demand: 2007 Review" Table 2 available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2

Western State	2007 Production of Coal (Million Short Tons)
Wyoming	453.6
Montana	43.4
Colorado	36.4
North Dakota	29.6
New Mexico	24.5
Utah	24.3
Arizona	8.0
Alaska	1.3
Washington	0.0*

* Washington produced 2.6 million short tons in 2006, but none in 2007.

The Western Region is the largest volume coal-producing region in the United States and Wyoming is far and away the largest coal producing state in the Western Region—as well as for the United States as a whole. Significant production of coal in Wyoming began in the 1970s and has been rising steadily since that time. Recent studies on the availability of coal in Wyoming are discussed in detail below.

Montana coal mining, like that of Texas began in earnest in the 1970s and quickly ramped up to 30 to 40 million short tons per year. By 1997, Montana coal production exceeded 40 million tons and was 43.4 million tons in 2007.[40]

Colorado coal production began in the late 1800s, dropped in the middle of the 20th century and then began increasing in the 1980s and 1990s[41] with production generally increasing each year and peaking at 39.9 million tons of coal in 2004.[42] Currently, Colorado coal mining takes place in the Uinta basin where there are extensive deposits of relatively low sulfur bituminous coal with about two-thirds of the coal being exported out of state to power plants that are working to reduce sulfur emissions associated with the burning of higher sulfur coal from Appalachia or the Interior.[43]

North Dakota began significant mining of its lignite coal in the 1970s with production increasing to over 30 million tons in the 1980s.[44] Since then, production has remained relatively constant at about 30 million tons, with much of the lignite being used in local power or coal gasification plants.[45]

New Mexico, much like Colorado, began producing coal in the late 1800s and then after a significant drop off in the middle of the 20th century, began to ramp up production in the 1970s. During the 1990s and early 2000s production typically exceeded 25 million short tons, but in 2007, production dropped to 24.5 million short tons.

Utah's history of coal production mirrors that of Colorado and New Mexico with production below 10 million tons until the 1980s and then rapidly increasing production in the late 1900s[46] with production above 20 million tons after 2000.[47]

Arizona's coal production occurs on land leased from the Navajo and Hopi tribes with the coal being used to power two large coal plants in Nevada and Arizona. Production in 2007 dropped to 8 million tons of coal due in part to the closing of the Mohave coal plant in Nevada for failure to clean up sulfur pollution.[48]

While Alaska has considerable deposits of coal, it is presently only a small coal producing state at a little over 1 million short tons in 2007. Much of Alaska's coal lies on its north slope[49] and due to cost, transportation and infrastructure constraints it is not clear how much of it will be mined. Presently, essentially all of the coal mining in Alaska is done in the Usibelli mines south of Fairbanks that supply the Healy mine mouth coal plant and several cogeneration heat and electric power plants in Fairbanks.[50]

The Uinta and Powder River Basins of the Western Region

For many purposes, the Energy Information Administration has designated two key coal basins in the Western Coal Region. The Uinta Basin covers the counties of western Colorado and Utah.[51] The Powder River Basin includes the coal producing counties of Wyoming and Montana.[52] As seen below, the Energy Information Administration reports spot price information for the Uinta and Powder River Basin regions. Both of these Basins produce relatively low-sulfur coal, but Uinta Basin coal is bituminous and has higher heat content per pound than Powder River Basin coal which is subbituminous.[53]

F. Peak Coal Production in the Top Coal Producing States

Table 7
Approximate Year of Peak Production for Top 6 Coal States and Percentage Change in Production in 2007 Compared to 2006

Source of Data: Energy Information Administration Unless Otherwise Specified

Rank	State	Million Short Tons[54] 2007	Approximate Year of Peak Production	Percentage Change in Production 2007 Compared to 2006[55]
1	Wyoming	453.6	Not Known—See Text	+ 1.5 %
2	West Virginia	153.2	1997 [56]	+ 0.6%
3	Kentucky	115.0	1990 [57]	- 5.8%[58]
4	Pennsylvania	65.0	1918	- 1.5%
5	Montana	43.4	Not Known—See Text	+ 3.7%
6	Texas	41.9	Late 1980s[59]	- 7.9%

As can be seen from Table 7, four of the top six coal producing states had peak coal production before 2000. Only Wyoming and Montana are increasing their production and have not apparently reached their peak.

At this time, it is not known when Wyoming and Montana will reach their peak in coal production, but the government assessments of economically recoverable reserves in the Powder River Basin (which includes Wyoming and part of Montana), combined with an assessment of the remaining life span of existing Powder River Basin coal mines, will provide a framework for preparing such an assessment.

IV. TRENDS IN COAL COSTS

While coal costs paid by electric utilities or other industrial entities are typically confidential, a sense of coal costs can be obtained from government and other sources.

A. Spot Prices

Spot prices for coal are monitored by the US Energy Information Administration and archival data can be obtained from the EIA's Coal News and Market website.[60] When long term coal contracts begin to expire, utilities and other coal users are likely to be facing higher prices as reflected in the increasing spot price markets shown in Figures 7 to 9 covering spot prices for U.S. coal from July 2000 to January 2009.

Figure 7 shows spot prices for the major coal producing regions from July 2000 to July 2003. While there was some volatility during this period, spot prices for all the coal regions started and ended below $35 per ton.

Figure 7
Spot Prices for Coal July 2000-July 2003
Data from http://tonto.eia.doe.gov/FTPROOT/coal/newsmarket/coalmar030713.html

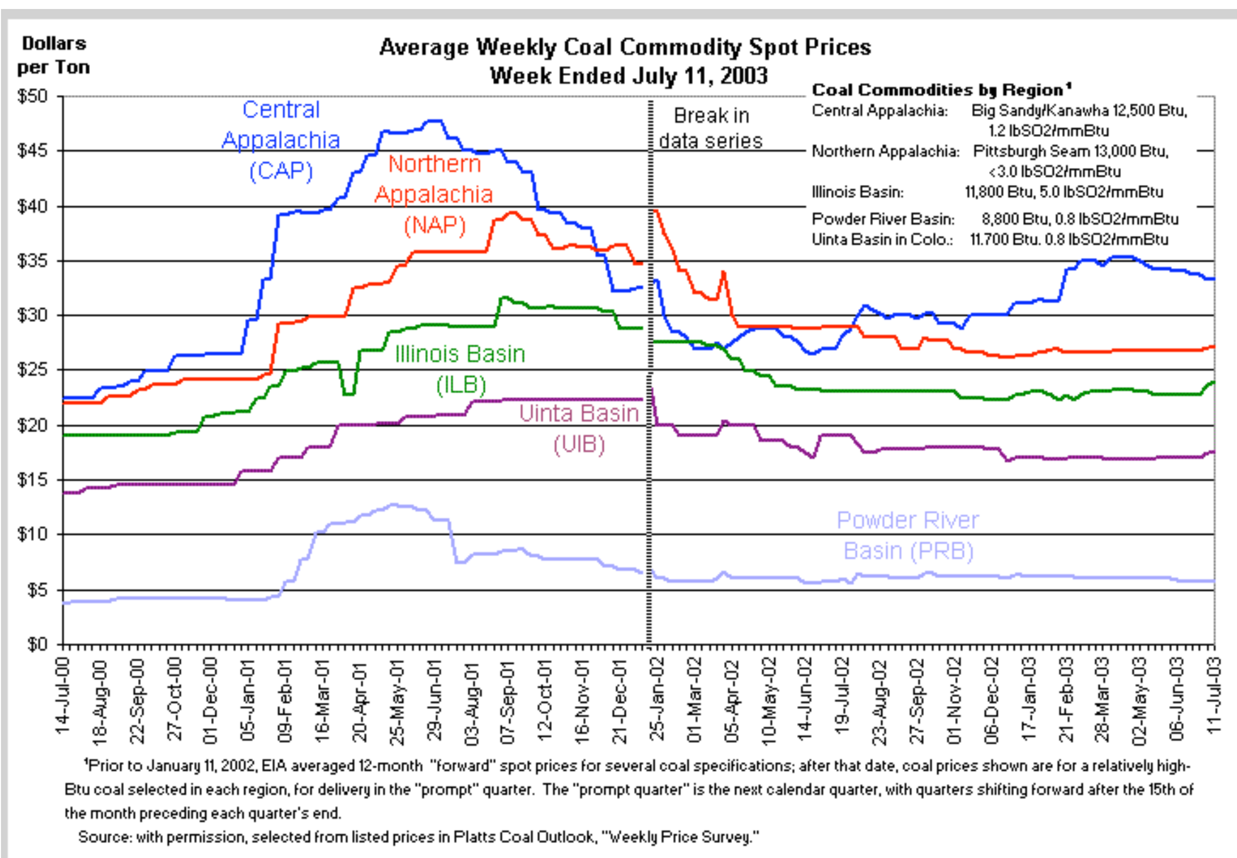


Figure 8 shows the spot prices for coal from the major coal producing regions from July 2003 until July 2006. During this period spot prices for coal from all the major regions increased sharply and ended substantially higher than they began. Note that in Figure 7 (covering the period July 2000 to July 2003), the top price on the vertical axis was $50 per ton, while in Figure 8 (covering the period July 2003 to July 2006) the vertical axis extends to $70 per ton.

Figure 8
Spot Prices for Coal July 2003-July 2006

Data from http://tonto.eia.doe.gov/FTPROOT/coal/newsmarket/coalmar060730.html

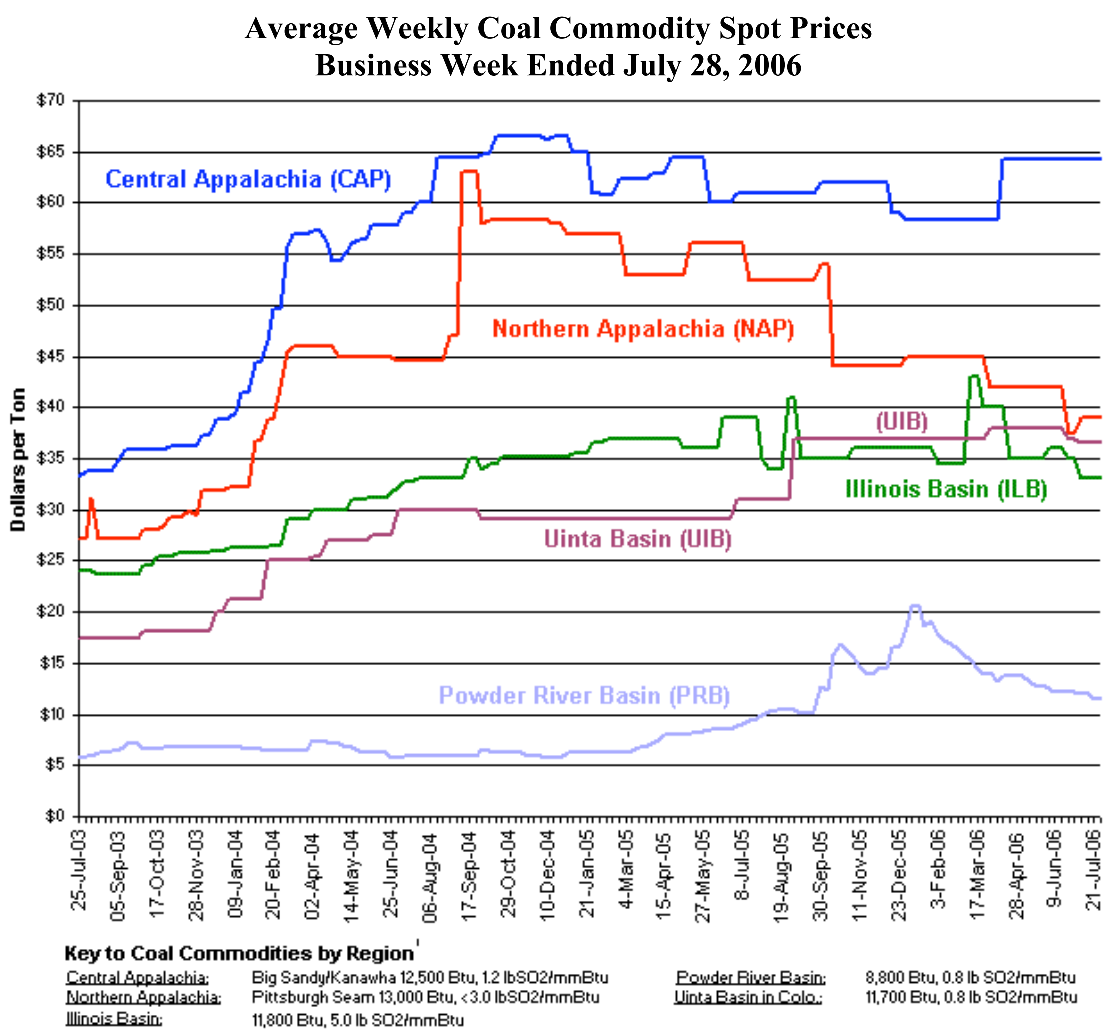


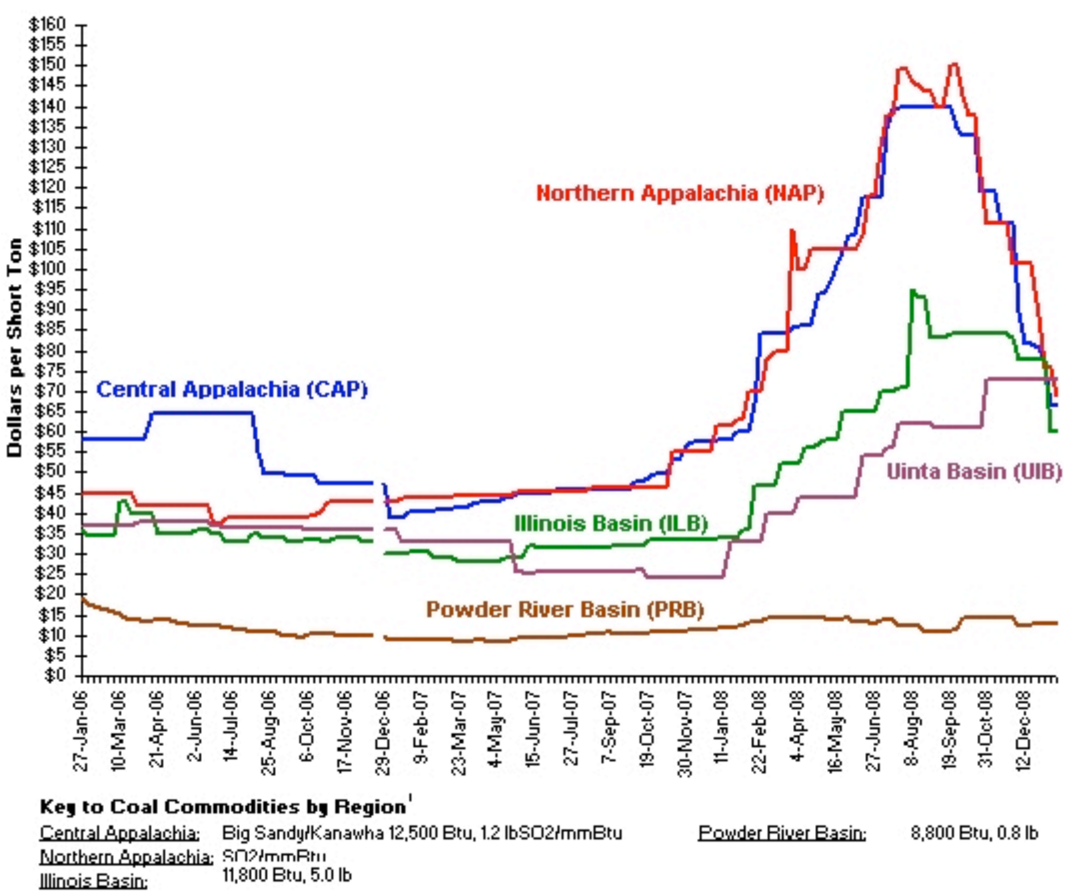
Figure 9 shows spot prices for coal from January 2006 through January 2009. Compared to Figure 7, it can be seen that the "stable" prices of 2006 and early 2007 are much higher than the "stable" prices of the early years of the 2000s. Note that Figure 7 has a maximum value on the vertical axis of $50 per ton while that maximum price on Figure 9 is $160 per ton. In addition, it can be seen that during 2008, spot coal prices increased dramatically. Powder River Basin coal is typically less expensive than other coals because it has a significantly lower heating content (as can be seen from the key to Figures 9) and because it involves significant transportation expense to get the coal to markets, as discussed further below.

Also, the Powder River Basin is subject to serious constraints on railroad traffic, in essence insulating Powder River Basin coal from some of the forces of demand and supply. Coal users can not just order more Powder River Basin coal and expect it to be delivered because the railroads out of the Powder River Basin are already utilized at close to or, at times, above their maximum capacity.[61]

Figure 9

Spot Prices for Coal January 2006-January 2009

Data from http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html

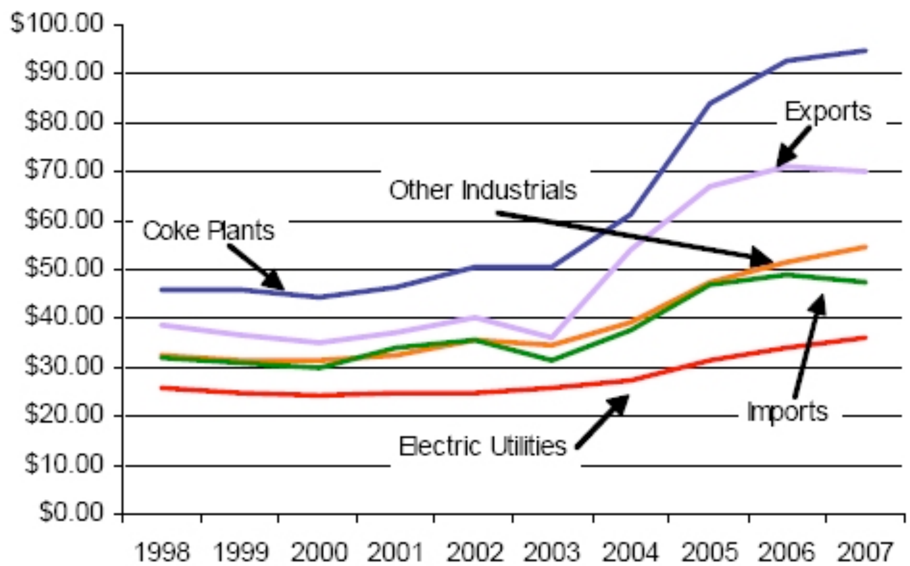


B. Delivered Prices

In addition to the increases in price seen in the spot market for coal, prices of delivered coal have also begun to rise as shown in Figure 10.

Figure 10
Delivered Coal Prices, 1998-2007
(Nominal Dollars per Short Ton)

Source: Energy Information Administration—"Coal Supply and Demand: 2007 Review"
http://www.eia.doe.gov/cneaf/coal/page/special/fig6.html



While all states experienced an increase in the price of coal delivered to electric utility plants in 2006 compared to 2005, several states had especially high increases as shown in Table 8.

Table 8
States Experiencing the Highest Price Increases in Average Price of Coal Delivered

2006 Compared to 2005

Source: Energy Information Administration
http://www.eia.doe.gov/cneaf/coal/page/acr/table34.html
(Note: As of January 31, 2009, the EIA had not yet published the 2007 data.)

State	Percentage Increase in Average Price of Coal Delivered to Electric Utility Plants 2005-2006
Montana	25.0%
Colorado	20.5%
Illinois	17.4%
Nevada	15.4%
Wisconsin	15.2%

As data is gathered for 2007 and 2008, it is likely that there will be additional increases in the cost of delivered coal due to both increased costs of production and transportation. (As this report went to press in January 2009, data on delivered coal prices for 2007 and 2008 were still not available.) While the prices of all fossil fuels are notoriously volatile, the geologic and transportation constraints discussed further below are likely to increase the cost of delivered coal.

An example of the coal cost increases experienced by one utility are seen in Table 9. Long-term coal contracts for Xcel, a utility serving several states including Minnesota and Colorado, began expiring in 2006,[62] and since that time Xcel's Colorado coal plants have seen dramatic increases in coal costs. (Data for Xcel's Minnesota coal plants is not available to the author.)

Table 9
Coal Cost Per MMBTU for
Xcel's Colorado Coal Plants 2005 and 2007[63]

(Data provided by Xcel and found in Attachment 42 to the Answer Testimony of Leslie Glustrom Docket 07A-447E at the Colorado Public Utilities Commission available from http://www.dora.state.co.us/PUC/DocketsDecisions/HighprofileDockets/07A-447E.htm.)

Xcel's Colorado Coal Plant	Coal Cost 2005 Cents/MMBTU	Coal Cost 2007 Cents/MMBTU	Percent Change 2005-2007	"One Year" Increase*
Arapahoe	101.77 cents/MMBTU	137.3 cents/MMBTU	34.9% Increase	17.45% Increase
Cameo	131.24 cents/MMBTU	162.98 cents/MMBTU	24.2% Increase	12.1% Increase
Cherokee	106.63 cents/MMBTU	141.76 cents/MMBTU	32.94% Increase	16.47% Increase
Comanche	76.64 cents/MMBTU	105.15 cents/MMBTU	37.20% Increase	18.6% Increase
Hayden	101.87 cents/MMBTU	156.71 cents/MMBTU	53.83% Increase	26.65% Increase
Pawnee	97.69 cents/MMBTU	101.53 cents/MMBTU	3.93% Increase	1.97% Increase
Valmont	149.81 cents/MMBTU	178.42 cents/MMBTU	19.10% Increase	9.55% Increase

* The "One-Year" increase is derived by dividing the 2005-2007 increase by 2. It is difficult to determine a uniform one-year increase because coal contracts for the different plants expire at different times and contracted coal prices are more of a "step" function rather than a smooth linear function since once a coal contract is signed then prices stay stable for a few years until the contract expires.

Actual prices paid for coal by a specific utility are not generally available, but a review of presentations made to investors by Peabody Energy, the world's largest private-sector coal company, can give an idea of coal price volatility and the trends that will influence future prices.[64] In December 2008, Peabody Energy noted the price increases shown in Table 10 for coal delivered one-year in the future and compared these price increases to the price decreases for other commodities.

Table 10
Commodity Price Changes Reported by Peabody Energy December 2008

See page 9 at Peabody Energy's Presentation to the FBR Investor Conference, December 2008
http://www.peabodyenergy.com/pdfs/2008%20FBR%20Capital%20Markets%20Conference%20Final.pdf .

Commodity	One Year Price Change
Coal from the Powder River Basin	+ 21%
Coal from Colorado	+143%
Coal from the Illinois Basin	+143%
Oil	-44%
Copper	-45%
Iron Ore	-52%

Peabody's presentation to the FBR Conference also detailed the supply constraints in the global coal market and why these constraints can be expected to lead to higher prices for coal in the coming months and years.[65]

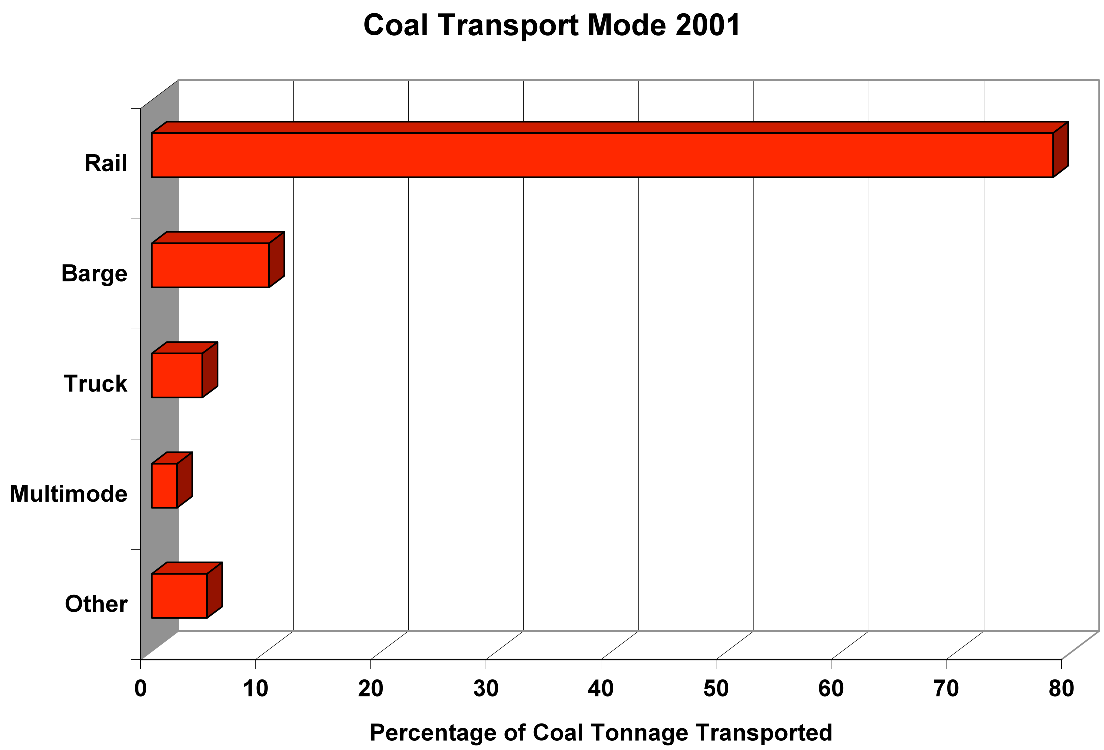
As with all fossil fuels, the price of coal is subject to complex forces of supply and demand and future prices are likely to be volatile and unpredictable as the United States and the world move into the post-fossil fuel world, but the evidence summarized above and the geologic constraints discussed below indicate that future increases in the price of coal are likely.

V. TRANSPORTATION OF COAL AND POTENTIAL FUTURE CONSTRAINTS

A. Rail--The Dominant Mode of Transport for Coal

The vast majority of coal travels from mine to power plant in the United States by rail. Figure 11 shows the percentage of coal transported by train (78.3%), barge (10.2%) and truck (4.4%) in 2001.[66] Also, a small percentage of coal was transported in a multiple modes (2.2%) and 4.8% was transported in "other," non-specified modes in 2001.

Figure 11
Transportation Modes for US Coal in 2001
Data from http://www.eia.doe.gov/cneaf/coal/page/trans/ratesntrends.html



Given the heavy reliance of US coal plants on Powder River Basin coal (See Figure 19), there is a corresponding heavy reliance on railroad traffic out of the Powder River Basin. This is shown in Figure 12 developed by the Oak Ridge National Laboratory.[67]

Figure 12
Oak Ridge National Laboratory Graphic on Railway Shipping Patterns for Coal

From http://rutledge.caltech.edu/; Original graphic on page 22 of 53 at http://www2.ku.edu/~kugis/gisday/2006/KU_GISDay2006_Harrison.pdf.

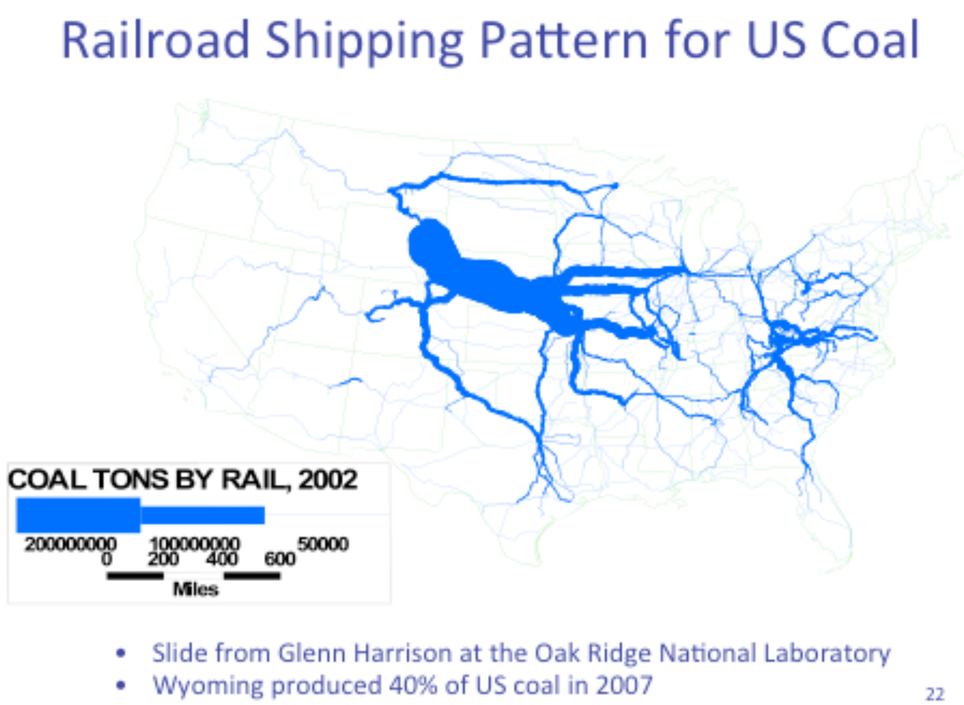


Figure 12 shows the extremely heavy coal traffic coming out of the Powder River Basin—a fact that makes sense in light of the large number of Midwestern coal plants that rely on Powder River Basin coal for their operation. Coal plants dependent on Powder River Basin coal are indicated by the large number of "red dots" in Figure 19 below. Moreover, as reserves of coal at eastern mines begin to deplete there is likely to be increased pressure on coal supplies from the Powder River Basin and the rail transport needed to deliver that coal. The extremely heavy coal traffic out of Wyoming is carried on the limited number of rail lines leading out of the Powder River Basin, creating a significant risk for disruption due to accidents or extreme weather events such as floods or tornadoes. Disruption of coal train traffic out of the Powder River Basin by two accidents in 2005 is discussed further below.

B. Freight Costs Can be a Significant Percentage of the Cost of Coal

Transportation costs for Midwestern and southern utilities that rely on Powder River Basin coal from Wyoming can be as much as two-thirds of the cost of the delivered coal. Energy Information Administration Data collected for 2001 is summarized in Table 11 showing coal freight rates from the Powder River Basin to other regions.

Table 11
Freight Costs for Coal Shipments from the Powder River Basin to Other Regions

Data from Tables 2.02 and 2.04 in the Energy Information Administration Coal Transportation Data Base, April 2004 available at http://www.eia.doe.gov/cneaf/coal/page/trans/ratesntrends.html

Coal Transport from the Powder River Basin to:	Transportation Cost as Percentage of Delivered Price (2001)	Cost Per Million BTU (British Thermal Units) (2001)	Average Number of Miles Travelled (2001)
East North Central	68.58%	$5.90	1,244 miles
West North Central	61.39%	$5.28	878 miles
West South Central	71.59%	$7.77	1,390 miles

The Energy Information Administration does not appear to have published more recent data than the 2001 data shown in Table 11. Many utilities have begun to renegotiate long term contracts for coal and coal transportation in recent years. These are leading to significant increases in both coal and transportation fees. In the case of the Public Service Company of Colorado, a part of Xcel Energy, long term coal contracts began expiring in 2006, and coal costs increased 30% between 2005 and 2006.[68]

C. Constraints in Rail Traffic Can Affect Coal Plant Reliability

Coal for electric power plants is typically delivered in "unit trains" of 100-130 cars with each car carrying 100 or more tons of coal each.[69] With a typical freight car length of 50-60 feet,[70] these trains can be a mile long or more. A large coal plant (e.g. > 1000 MW) might require a mile-long train of coal to be delivered almost every day. Smaller plants would require several mile-long trains a week. Coal plants typically retain a stockpile of 30-60 days,[71] but if there is a significant disruption in rail delivery, then coal plants may have to curtail production due to diminishing supplies of coal.

In 2005, there were two train derailments on the tracks leading out of the Powder River Basin and coal deliveries were significantly reduced, causing coal stockpiles to dwindle and forcing utilities to curtail their coal plants and replace the generation with more expensive natural-gas fired generating units. The cost to ratepayers nationwide in 2006 was projected to be more than $2 billion.[72] The cost to Xcel ratepayers in Colorado was close to $50 million.[73]

In September 2007, the consulting firm Cambridge Systematics completed a study for the Association of American Railroads entitled, "National Rail Freight Infrastructure Capacity and Investment Study."[74] The study concluded the following:

> This study estimates that an investment of $148 billion (in 2007 dollars) for infrastructure expansion over the next 28 years is required to keep pace with

> economic growth and meet the U.S. DOT's forecast demand. Of this amount, the Class I freight railroads' share is projected to be $135 billion and the short line and regional freight railroads' share is projected to be $13 billion. Without this investment, 30 percent of the rail miles in the primary corridors will be operating above capacity by 2035, causing severe congestion that will affect every region of the country and potentially shift freight to an already heavily congested highway system.[75]

Rail congestion out of the Powder River Basin is expected to be one of the corridors that will be affected if large investments are not made in rail infrastructure.[76] Given the country's strong reliance on Powder River Basin coal and the likelihood that this reliance will increase as coal mines in other regions deplete their reserves, these rail constraints could mean significant challenges for electric reliability in the United States.

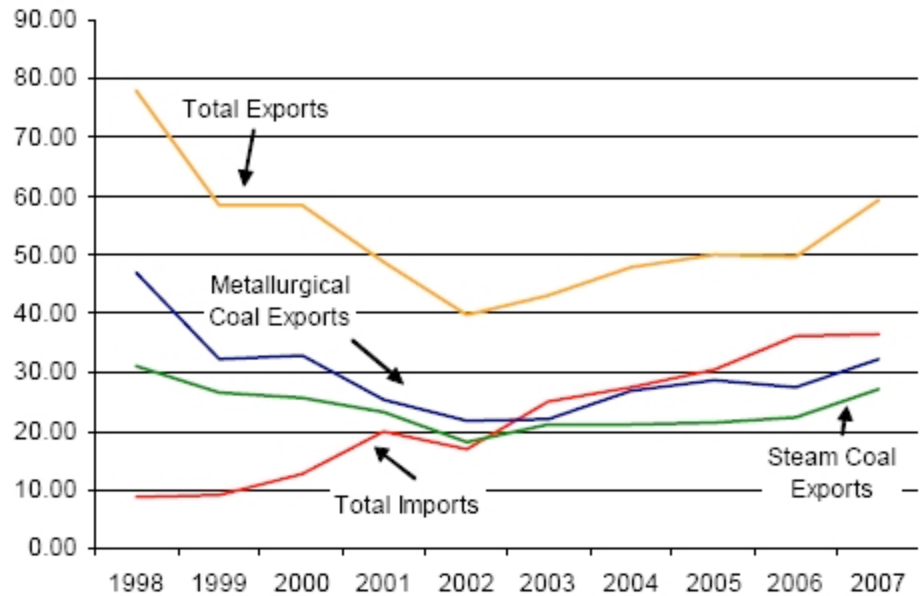
While there have been proposals for other railroads coming out of the Powder River Basin, it is not clear if these proposals will be able to clear the regulatory and financial requirements and actually be constructed. Two lines that have been proposed out of the Powder River Basin are the Tongue River Railroad running north into Montana and the DME (Dakota Minnesota & Eastern) line running east to Minnesota and the Midwest. Both lines have run into significant financial and regulatory hurdles and, as of the writing of this report, have not begun construction. As information on life span of the Powder River Basin mines becomes more widely understood, it is not clear that the railroad companies will be able to finance rail improvements for mines that will be facing significant geologic, economic and legal constraints on future expansion.

VI. COAL IMPORTS AND EXPORTS

Given the bulk nature of coal, the export and import market is a small fraction of coal production, but as world demand for coal increases both imports and exports are growing as shown in Figure 13 below.

Figure 13
U.S. Coal Exports and Imports 1998-2007
http://www.eia.doe.gov/cneaf/coal/page/special/fig8.html

(Million Short Tons)



VII. STUDIES OF COAL RESOURCES AND RESERVES

A. Introduction

When discussing coal supplies, the terms resources and reserves are used in a variety of contexts with a variety of meanings. Resources usually refers to the total amount of a resource, while reserves refer to resources that are technically and economically capable of being recovered, but different reports and different authors use differing definitions of these and other related terms.

To add to the confusion, the two U.S. agencies that provide the majority of the data on coal resources and reserves—the Energy Information Administration ("EIA") in the United States Department of Energy and the United States Geological Survey ("USGS") in the United States Department of the Interior use different terminology and report the data on coal resources in a different fashion. These differences will be explained below as various studies are summarized.

The key consideration is what coal resources are expected to be economically recoverable. As explained below, the Energy Information Administration in particular, appears to have reported coal reserves in a fashion that implied that the coal reserves were economically recoverable even though they hadn't assessed economic recoverability. As a result, the EIA's estimates of "200 years of coal supply or more" have been assumed to include an assessment of economic recoverability—when they did not.

EIA Publications Indicating a "200 Year Supply" of US Coal Are Not Well Founded

The primary source of confusion regarding the extent of U.S. coal supplies seems to be that the Energy Information Administration's estimates of "200 years of coal supply or more" have been assumed to include an assessment of economic recoverability—when they did not. When economic recoverability is assessed, the amount of available coal in the U.S. becomes a small fraction of the much vaunted "200 year supply."

Over the last decade, a growing number of USGS studies that have assessed economic recoverability have indicated that only a small fraction of the available coal in the United States is likely to be economically recoverable. As a result, it now appears that the EIA estimate of a "200 year supply of coal" in the United States was based on data that wasn't analyzed for economic recoverability. When economic recoverability is assessed, the amount of available coal becomes a small fraction of the often claimed "200 year supply."

Careful Examination of Long Term U.S. Coal Supplies Needed

Since the United States relies on an electric grid that is powered in large part by coal, it is the goal of this report to initiate a discussion of long term coal supplies and to suggest that elected officials, business leaders and citizens at all levels, need to take a close look at the amount of economically recoverable coal in the United States and begin to plan accordingly.

B. United States Coal Reserves in a Global Context

Statistical surveys repeatedly identify the United States as having the largest reserves of coal in the world. The BP Statistical Review of World Energy issued in June 2008 puts U.S. reserves at 242.7 billion tonnes of coal.[77] Table 12 below shows the top eight countries with respect to reserves of coal according to the 2008 BP Statistical Review of World Energy.

Table 12
"Proven Reserves" at the End of 2007 According to the BP Statistical Review of World Energy—Top 8 Countries June 2008

Available at www.bp.com

(While the report does not appear to state so, it appears that the "tonnes" being reported in the BP Statistical Review are metric tonnes or 2204 pounds.)

Country	Billions Tonnes Coal Reserves Reported by BP	Percentage of World Total of "Proved Reserves" of Coal
United States	242.7 Billion Tonnes	28.6%
Russian Federation	157 Billion Tonnes	18.5%
China	114.5 Billion Tonnes	13.5%
Australia	76.6 Billion Tonnes	9.0%
India	56.5 Billion Tonnes	6.7%
South Africa	48 Billion Tonnes	5.7%
Ukraine	33.8 Billion Tonnes	4.0%
Kazakhstan	31.3 Billion Tonnes	3.7%
Total Reported World	**847.5 Billion Tonnes**	**100%**

After Kazakhstan, all other countries are reported as having less than 10 billion tonnes of coal reserves.

The quality of the data reported by BP and shown in Table 12 are highly uncertain. As discussed in detail below, the amount of economically recoverable coal in the United States is much less than the "242.7 billion tonnes" reported by BP. Indeed, as noted by the Energy Watch Group of Germany, which recently analyzed global coal resources, "data quality of coal reserves and resources is poor, both on global and national levels. But there is no objective way to determine how reliable the available data actually are."[78]

Estimates of "Proved Reserves" at the International Level are Not Likely to Be Reliable

The quality of the data reported by BP and shown in Table 12 are highly uncertain. It is known from geologic studies that the amount of economically recoverable coal in the United States is much less than the "242.7 billion tonnes" reported by BP and as noted by the Energy Watch Group of Germany, "data quality of coal reserves and resources is poor, both on global and national levels."

Uncertainties regarding the reporting of "proved reserves" by BP are discussed further below.

C. Reported Reserves and Economic Recoverability

The problem with the BP Statistical Review, as with so many representations of US coal reserves, is that it appears to have used data on coal that it assumed included a determination of economic recoverability when they did not. The BP Statistical Review has a footnote on the Proved Reserves of Coal Table that states:

> **Proved reserves of coal--**Generally taken to be those quantities that geological and engineering information indicates with reasonable certainly can be recovered in the future from known deposits under existing economic and operating conditions.[79] (Emphasis added.)

Yet, importantly, it does not appear that the BP[80] Statistical Review actually evaluated the ability to recover the coal "under existing economic and operating conditions." The United States Geological Survey reports discussed below, indicate that when US coal resources are carefully assessed, only a small percentage of what has been taken to be coal "reserves" in the United States are likely to be economically accessible.

Since statistical reviews that are widely relied on, such as that of BP, appear to be based on estimates of US coal reserves that did not take economic accessibility into account, the error has continued to be perpetuated.

The unexamined claim that the United States has 200 or more years of coal is now widely repeated by everyone from classroom teachers to utility executives. For example, the CEO of Xcel Energy—presently one of the country's most progressive utilities—was recently quoted as saying, "Depending on whose estimate you believe, we have 200, 300, 400 years worth of coal."[81] Xcel is heavily dependent on coal, producing over 60% of its electricity in Colorado from coal[82] and yet its otherwise progressive CEO has, as so many others have also, blithely repeated what Big Coal author Jeff Goodell refers to as "the myth of eternal coal in America."[83]

The Concept of a "200 Year Supply" of Coal in the United States Appears to Be Based on an Inaccurate Assumption that Reported Reserves Are Economically Recoverable When They Are Not

The concept of "200 years of coal (or more)" gets repeated by journalists, teachers, policy makers, utility executives and even Presidential candidates—yet it is based on an inaccurate assumption that "reserves" will be economically accessible, while there is abundant evidence from detailed geologic surveys, including the ones discussed below, that only a small fraction of reserves will be economically accessible.

A more thoughtful assessment of United States coal supplies has been developing in a number of state and federal agencies including the United States Geologic Survey, the Bureau of Land Management and the State Geological Surveys. However to date, their studies have been either misread or ignored by the media, the public, business leaders, policy makers and even utilities that are heavily dependent on coal to provide electricity to their ratepayers.

Key studies on the availability of U.S. coal are summarized below.

A Measuring Stick for US Coal Consumption

In 2007, the United States produced about 1.1 billion short tons of coal according to the Energy Information Administration—so the "measuring stick" for assessing U.S. coal resources is approximately

1 billion short tons = Approximately 1 year supply for the U.S.

D. Historical Studies of U.S. Coal Supplies

A number of historical studies of US coal supplies exist, with several of the key studies summarized below.

Campbell and Parker 1909—
Coal Supply Constraints Predicted for the Early 21st Century

In February 1909, Marius R. Campbell and Edward W. Parker of the United States Geological Survey presented a paper at the New Haven meeting of the American Institute of Mining Engineers.[84] They noted that USGS geologists had worked in the six major coal producing regions that had been identified—regions that correspond closely to the regions still used by the U.S. Energy Information Administration.

Summarizing the data gathered by the field geologists, Campbell and Parker concluded that:

> … the quantity of coal contained within the known area of the United States when mining first began was 3,076,204,000,000 tons. Of this quantity a little less than two-thirds, or 1,922,979,000,000 is considered as coal that is easily accessible or minable under present conditions….[85]

At first glance 3,076,204,000,000—or over 3 trillion—tons of coal appeared to be an inexhaustible supply—and even the 1,922,279,000,000—or just under 2 trillion—tons of coal seemed more than adequate to fuel the American economy apparently "forever…" As Big Coal author, Jeff Goodell noted regarding the Campbell and Parker results, "This was music to the ears of early industrialists, of course, and went a long way toward establishing the dream of eternal coal in the American psyche."

Campbell and Parker were, however, much more thoughtful in their assessment than has been generally recognized. First they noted that approximately 530 billion tons of western coal was not likely to be "available," reducing the amount of coal to 1392,979,000,000 tons.[86] Then, Campbell and Parker estimated that mining had already exhausted 10,200,000,000 tons, leaving 1,382,780,000,000 tons of accessible and available coal.[87]

Finally, and most importantly, after considering first that "the drain on the supply" of coal had practically doubled each decade of the late 1800s, and second that at the time "for every ton of coal mined and sold half a ton is lost or wasted,"[88] Campbell and Parker concluded, "the 1,382,780,000,000 tons[89] available at the end of 1907 would be exhausted in 107 years, or by 2015 A.D."[90]

In a different calculation using an estimate based on 20 year averages of production by another researcher, Campbell and Parker noted that, "The result obtained by this method is that the easily accessible and available coal will be exhausted about the year 2027, and all coal by the middle of the next century."[91]

Even in 1909, Geologists Predicted Coal Supply Constraints in the Early 21st Century

Upon closer examination, the 1909 coal supply report by USGS scientists Campbell and Parker did not appear to support an endless supply of coal. Rather their analysis pointed to significant coal supply constraints at the beginning of the 21st century—a concept that has been lost on most Americans for much of the last century.

In commenting on the quality of their data, Campbell and Parker stated:

> It is recognized that the data upon which this curve has been constructed are few, and that the curve is correspondingly weak. However, in the above estimate all the data have been given which it is possible to use, and this estimate is believed to represent the best use that can be made of the data at hand.[92]

While the "data at hand" used by Campbell and Parker in their classic 1909 paper has been refined several times in the intervening century, the basic concept that even a trillion tons of coal won't last forever is one that has had a hard time taking hold in the American consciousness.

Campbell and Parker also discussed the increases in cost of coal that are likely to occur as accessible deposits are depleted. They stated it this way:

> Again, as soon as the end appears in sight, prices will rise and production diminish, and that progressively. This interference with the law of decreasing increase, produced by growing scarcity, will, of course, prolong the life of our

> coal-reserves, but at the same time will greatly hamper our industries dependent on this fuel.[93]

Reviewing the recent increases in spot prices for coal shown in Figures 7 through 9, provides present context to the thoughtful prediction of Campbell and Parker made almost a full century ago.

In 1909, USGS Scientists Campbell and Parker Anticipated the Coal Supply Constraints that Are Now Beginning to Become Apparent

In short, a careful reading of the 1909 Campbell and Parker paper indicates that rather than thoughtless promoters of the endless supply of American coal, these early geologists had already given thought to what would happen as coal supplies began to wane sometime after the beginning of the 21st century. Indeed, it appears these early 20th century geologists would have been very comfortable in the discussions of "Peak Oil," "Peak Coal" and "Peak Everything" that have begun to occur in the United States and throughout the world.[94]

Averitt 1974 Assessment of Coal Resources: Economic Accessibility Not Carefully Considered

In 1974, USGS geologist Paul Averitt refined the 1909 data of Campbell and Parker, reviewed studies done between 1909 and 1974, and provided extensive information on many aspects of coal and its production.[95] Averitt concluded that the United States "reserve base" was 434 billion tons,[96] a significant reduction from the over 1 trillion tons identified by Campbell and Parker.

While Averitt's report contains important and extensive information on coal and its production, he still did not do a detailed analysis of economic recoverability of United States coal.

Serious studies of economic recoverability of coal reserves did not begin until the U.S. Bureau of Mines, followed by the United States Geological Survey, undertook the studies summarized in detail below. Before summarizing the studies on economic accessibility of U.S. coal supplies, it is first important to consider the validity of the coal "reserve" data published by the Energy Information Administration.

E. EIA Coal Data--"Reserves" that Are Not "Reserves"

While the USGS has been busy developing detailed assessments of the economic availability of US coal resources, the Energy Information Administration ("EIA") has been collecting and publishing extensive data on coal production, use and "reserves." The EIA typically publishes data on the Demonstrated Reserve Base ("DRB"),[97] Estimated

Recoverable Reserves ("ERR"),[98] and Recoverable Reserves at Existing Mines. In theory, the Demonstrated Reserve Base includes a broad assessment of coal resources while the Estimated Recoverable Reserves is intended as an assessment of what is realistically recoverable. The full EIA definitions, cryptic as they are, are reproduced in the box below.

For example, in September 2008, EIA published Table 15 in the Annual Coal Report which reported the Demonstrated Reserve Base for US coal as 489 billion short tons—or over a 400 year supply. The same Table reported the US Estimated Recoverable Reserves as 262 billion short tons—or approximately a 250-year supply at existing rates of use. It appears that utility executives and others are relying on numbers such as these when they claim that the United States is "The Saudi Arabia of Coal." As explained below, however, these reserve numbers reported by the Energy Information Administration are highly unlikely to represent amounts of economically recoverable coal.

Energy Information Administration Definitions for Estimating Coal Reserves

Demonstrated reserve base (coal): A collective term for the sum of coal in both measured and indicated resource categories of reliability, representing 100 percent of the in-place coal in those categories as of a certain date. Includes beds of bituminous coal and anthracite 28 or more inches thick and beds of subbituminous coal 60 or more inches thick that can occur at depths of up to 1,000 feet. Includes beds of lignite 60 or more inches thick that can be surface mined. Also includes thinner and/or deeper beds that presently are being mined or for which there is evidence that they could be mined commercially at a given time. Represents that portion of the identified coal resource from which reserves are calculated.
From the EIA glossary--http://www.eia.doe.gov/glossary/glossary_d.htm

Recoverable reserves, estimated recoverable reserves (coal) : Reserve estimates (broad meaning) based on a demonstrated reserve base adjusted for assumed accessibility factors and recovery factors. The term is used by EIA to distinguish estimated recoverable reserves, which are derived without specific economic feasibility criteria by factoring (downward) from a demonstrated reserve base for one or more study areas or regions, from recoverable reserves at active mines, which are aggregated (upward) from reserve estimates reported by currently active, economically viable mines on Form EIA-7A

From the EIA glossary--http://www.eia.doe.gov/glossary/glossary_r.htm

The problem seems to be that the EIA has not been following the work of the USGS and has continued to publish information on coal "reserves" which appear to consider economic accessibility, when they, in fact, do not.

For example, the EIA routinely publishes data on "Estimated Recoverable Reserves,"[99] and states in a footnote to the table that :

> EIA's estimated recoverable reserves include the coal in the demonstrated reserve base considered recoverable after excluding coal estimated to be unavailable due to land use restrictions or currently uneconomically attractive for mining and after applying assumed mining recovery rates." [100]

This convoluted footnote implies that EIA's Estimated Recoverable Reserve numbers reflect assessments of economic recoverability. Yet, as will be seen in the discussion of the 1997 Assessment of Coal Resources below, it appears that EIA has been publishing coal "reserve" data as though they consider economic accessibility, when, in fact, they do not.

EIA 1997 Assessment of Coal Resources: Less Than 20 Years of Coal Reserves at Existing Mines

In 1997, the EIA published an update to their assessment of Coal Reserves Data.[101] Figure 14 is taken from the EIA 1997 Assessment and presents the EIA's estimates which are also summarized in Table 13.

EIA Publishes Coal Reserve Data as Though It Includes Economic Accessibility When it Does Not

As will be seen in the discussion of the 1997 Assessment of Coal Resources, it appears that EIA has been publishing coal "reserve" data as though they consider economic accessibility, when, in fact, they do not.

Table 13
Energy Information Administration
1997 Coal Reserves Data

Source: Energy Information Administration 1997 Coal Reserve Data Update available at http://www.eia.doe.gov/cneaf/coal/reserves/chapter1.html .

Category	Billion Short Tons
Recoverable Reserves at Active Mines	19.4
Estimated Recoverable Reserves	275.1
Demonstrated Reserve Base	507.7
Identified Resources	1,730.9
Total Resources (Identified and Undiscovered)	3,968.3

Using the approximation that the United States produces and consumes about 1 billion short tons per year, the reserve and resource data provided in 1997 by EIA would indicate that the United States has hundreds and perhaps thousands of years of coal. The "Total Resources" would translate to almost 4,000 years of coal while the Identified Resources would translate to about 1,700 years at existing rates of usage—if the coal could be recovered….The Demonstrated Reserve Base would translate to about 500 years of coal and the Estimated Recoverable Reserves would translate to 250 years of coal, or more.

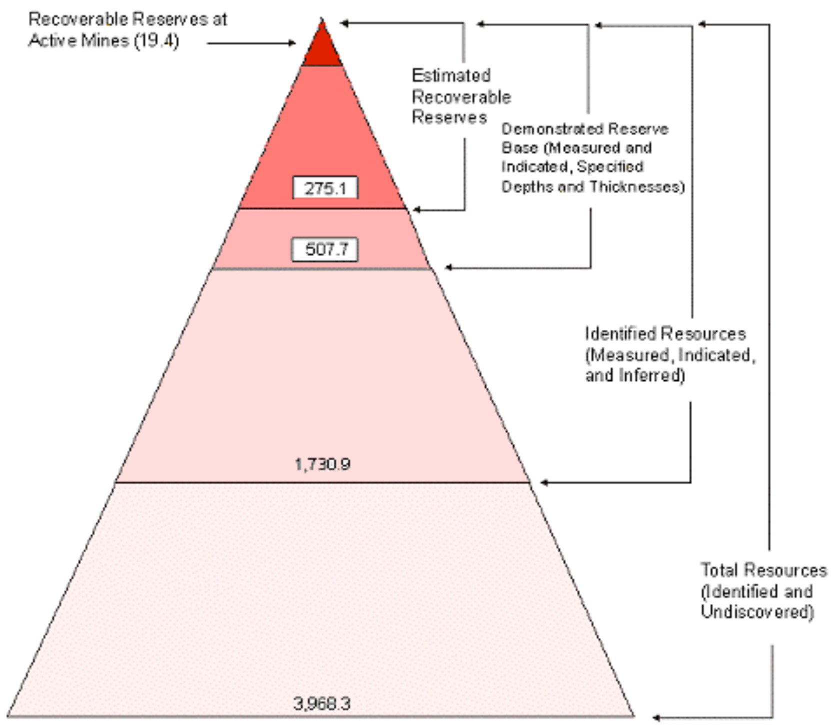
The number that is perhaps most important in the 1997 EIA Assessment is also the number that has had scant attention—and that is the number at the tip of the triangle or "Recoverable Reserves at Active Mines" which in 1997 was set at 19.4 billion short tons—or about 19 years of coal reserves.

In short, most Americans have focused on the base of the triangle in Figure 14 while ignoring the tip of the triangle. Yet it is the tip of the triangle—or about 19 years of recoverable reserves at active mines (as of 1997)—that represents coal that has a significant probability of being recoverable. Future mining of the rest of this country's coal will depend on a multitude of geologic, economic, environmental, legal and transportation considerations.

Figure 14
EIA 1997 Delineation of U.S. Coal Resources and Reserves

Figure 2 found at http://www.eia.doe.gov/cneaf/coal/reserves/chapter1.html

Figure 2. Delineation of U.S. Coal Resources and Reserves



Notes: Resources and reserves data are in billion short tons. Darker shading in the diagram corresponds to greater relative data reliability. The estimated recoverable reserves depicted near the top of the diagram assume that the 19 billion short tons of recoverable reserves at active mines reported by mine operators to the Energy Information Administration (EIA) are part of the same body of resource data. This diagram portrays the theoretical relationships of data magnitude and reliability among coal resource data. All numbers are subject to revision with changes in knowledge of coal resource data.

Sources: The DRB estimate was compiled by the EIA as of January 1, 1997. Estimated recoverable reserves were compiled in EIA's Coal Reserves Data Base (CRDB) program. Recoverable reserves at active mines were reported in EIA's Coal Industry Annual, 1996. Identified resources and total resources are estimates as of January 1, 1974, compiled and published by the U.S. Geological Survey in Coal Resources of the United States, January 1, 1974.

In 1997 EIA Reported That Recoverable Reserves at Active Mines Were Less Than 20 Years—But This Was Given Scant Attention

The number that is perhaps most important in the 1997 EIA Assessment is also the number that has had scant attention—and that is the number at the tip of the triangle, or "Recoverable Reserves at Active Mines" which was set at 19.4 billion short tons—or about 19 years of coal reserves at existing rates of usage—in 1997.

EIA Acknowledges That "Reserves" Aren't "Reserves" and that EIA Data Does Not Consider Economic Accessibility

It appears that much of the confusion about the quantity of economically recoverable coal in the United States can be traced to the Energy Information Administration's reporting of "reserves" as though they include an estimate of economic recoverability when in fact they do not.

For example, in the 1997 EIA Coal Reserve Data report, EIA makes the following statement.

> The usual understanding of the term "reserves" as referring to quantities that can be recovered at a sustainable profit **cannot** technically be extended to EIA's estimated recoverable reserves because economic and engineering data to project mining and development costs and coal resource market values are not available.[102] (Emphasis added.)

It appears that the source of much of the misunderstanding about American coal supplies can be traced to how the EIA has used the term "reserves"—which is widely understood to include an assessment of economic recoverability—while at the same time EIA acknowledges that they do not have the "economic and engineering data to project mining and development costs…."[103]

In 1997, EIA Acknowledged That It Didn't Have the Data to Determine Which Coal "Reserves" Were Economically Recoverable

As a result of the EIA practice of publishing reserve data as though they included economic recoverability when they did not, many Americans have been misled into assuming that the United States has 200 years of reasonably accessible coal when the truth appears to be very different. Studies over that last two decades by the United States Geological Survey which have not been widely reported or discussed, present a very different picture.

F. The National Coal Resource Assessment—Economic Accessibility Begins to Be Assessed

After Averitt issued his assessment in 1974,[104] the United States Geological Survey and the US Bureau of Mines in conjunction with several state Geological Surveys began an updated assessment of the country's coal resources in terms of both quality and quantity. The studies published by the National Coal Resource Assessment ("NCRA") are available online.[105] Several of the USGS studies discussed below grew out of the efforts of the National Coal Resource Assessment.

G. Studies of Appalachian Coal

Beginning in the 1980s, the United States Geological Survey began a series of studies designed to determine the amount of coal that "might realistically be available for production after environmental and technological restraints are considered."[106]

For example, the USGS and Bureau of Mines studied the Matewan quadrangle in eastern Kentucky. The results of the study, as summarized in Figure 17 of US Bureau of Mines Circular 9368, conclude that at $30 per ton, approximately 22 % of the original coal resource would be economically recoverable. [107]

Throughout the 1990s, the USGS continued to study the economic recoverability of coal resources in a number of Appalachian states. The results were summarized in US Geological Survey Professional Paper 1625-C. The USGS summarized these studies of coal availability and recoverability for the Appalachian states like this:

> The USGS and State geological surveys of Pennsylvania, West Virginia, Ohio, Kentucky, and Virginia have completed 32 1:24,000-scale coal availability studies and 25 coal recoverability studies and concluded that only a fraction of the original coal resource can be extracted and marketed economically under current conditions given social and technological restrictions.[108]

Overall, the USGS concluded that on average the amount of economically recoverable coal in the 32 study areas in the Northern and Central Appalachian regions was only 11%.[109]

In the 1990s the USGS Found That On Average Only 11 % of the Coal in 32 Northern and Central Appalachian Study Areas Was Economically Recoverable

After studying 32 coal producing regions of Northern and Central Appalachia in the 1990s, the USGS concluded that "The amount of coal that can be extracted and marketed at current break-even costs range from less than 1 to 43 percent of the original resource and averages 11 percent."
(See "Chapter J—U.S.G.S. Professional Paper 1625-C')

H. Studies of Powder River Basin Coal

In 1902, Wyoming's Secretary of State Fenimore Chatterton was quoted as saying, "Coal? Wyoming has enough to run the forges of Vulcan, weld every tie that binds, drive every wheel, change the North Pole into a tropical region or smelt all hell!"[110] Chatterton's claim appears hauntingly prophetic as the climate scientists report that the summer Arctic Ice is melting three decades earlier than expected.[111] Nonetheless, a century later, recent geologic assessments indicate that only a small fraction of Wyoming's coal reserves are likely to be economically accessible.

The accessibility of Powder River Basin coal is critical because the other large coal producing states appear to have already passed their peak production as shown in Table 7. Also, Figure 5 shows that while Appalachian coal production has been declining since 1998, Western coal production (primarily Wyoming and Montana) has been increasing and the trend is expected to continue.[112] As the United States relies increasingly on western coal—and Powder River Basin coal in particular—the recent studies of the United States Geological Survey on the accessibility of Powder River Basin coal gain increasing importance.

As mines play out in other parts of the country, it appears that many utilities believe they will be able to tap into the "200 year supply" of coal in the Powder River Basin. In light of the studies from the United States Geological Survey summarized below and the expected life spans of most Powder River Basin existing mines of under 20 years, it is not clear that reliance on a "200 year supply" of Powder River Basin coal is well placed. Furthermore, it can be expected that expansions of existing mines in the Powder River Basin are likely to be geologically, economically and legally difficult.

2002 USGS Report: 17% of Coal in the Gillette Coal Field of the Powder River Basin Expected to Be Economically Accessible

In 2002, the United States Geological Survey issued Open File Report 2002-0180 entitled "Evaluation of Economically Extractable Coal Resources in the Gillette Coal Field, Powder River Basin, Wyoming."[113] The Gillette coal field is the country's largest single coal field, producing approximately 40% of the country's coal supply.[114]

Reliance on a "200 Year Supply" of Powder River Basin Coal Does Not Appear to be Wise.

As mines play out in other parts of the country, it appears that many utilities believe they will be able to tap into the "200 year supply" of coal in the Powder River Basin. In light of the studies from the United States Geological Survey summarized below and expected life spans of most existing Powder River Basin mines of under 20 years, it is not clear that reliance on a "200 year supply" of Powder River Basin coal is well placed. Furthermore, it can be expected that future expansions of existing mines are likely to be geologically, economically and legally difficult.

The report examined the question of availability and economic accessibility of coal in the Gillette coal field and noted:

> Mining production costs, current mining machinery and methods, coal transport to the market place, present and near future market conditions, and the gross calorific value, ash yield and sulfur content of the available coal are all factors that influence the amount of coal that can be mined at a profit.[115]
>
> Specifically, the USGS noted that:
>
> The cost to produce coal is directly related to the amount of rock material that must be moved in mining, and the relation between the amount of rock material to be moved and the amount of coal that will be produced.[116]

The ratio of "waste rock to coal" is also referred to as the "stripping ratio." A stripping ratio of 2:1 means that two tons of rock would have to be moved to get to a ton of coal. As stripping ratios increase, the amount of economically recoverable coal drops dramatically due to the cost of moving the large amount of rock that lies over the coal. In the Powder River Basin, much of the coal lies beneath a stripping ratio of greater than 5:1.[117]

After considering a variety of constraints and issues related to economic recoverability including the issue of stripping ratio, the USGS estimated that 17% or about 23 billion tons of the original 136 billion tons of coal in the Gillette coal field of the Powder River Basin would be economically recoverable at then current conditions.[118]

Soon after the 2002 publication of USGS Open File Report 2002-0180, the USGS began to update the assessment of economically recoverable coal in the Gillette Coalfield using both better data on the coal beds and improved computerized assessment tools. The USGS released the results of the updated assessment in August 2008 as Open File Report 2008-1202 discussed further below.

2008 USGS Report 2008-1202
Much of the Coal in the Gillette Coal Field of the Powder River Basin is Not Expected to Be Economically Accessible

The rapid development of coal bed methane throughout Wyoming as well as in the Gillette Coal Field allowed the United States Geological Survey to do a much more detailed assessment of the coal resources in the Gillette coal field than was possible for the 2002 USGS report discussed above.

The results of the 2008 updated assessment are contained in a 92 MB report known as USGS Open-File Report 2008-1202, entitled, "Assessment of Coal Geology, Resources, and Reserves in the Gillette Coalfield, Powder River Basin, Wyoming." The updated assessment was released in August 2008 and can be found online at http://pubs.usgs.gov/of/2008/1202/ .[119]

The Abstract of the 2008 USGS Report 2008-1202 on the Gillette coal field of the Powder River Basin is reproduced for convenience below. As can be seen, with increased data, (and despite including one more coal bed in 2008) the economically recoverable coal reserves available in the Gillette coal field were reduced from 17% and 23 billion tons in 2002 to 6% and 10.1 billion tons in 2008.[120]

At a Time When Coal Prices Were Increasing Dramatically, Reports Showed the Amount of Economically Accessible Coal in the Gillette Coal Field to be 10.1 Billion Tons in 2008, Reduced from 23 Billion Tons in 2002.

The Abstract of the 2008 USGS Report 2008-1202 on the Gillette coalfield of the Powder River Basin is reproduced for convenience below. As can be seen, with increased data, the economically recoverable coal reserves available in the Gillette coal field were reduced from 17% and 23 billion tons in 2002 to 6% and 10.1 billion tons in 2008

Open-File Report 2008-1202

Available from http://pubs.usgs.gov/of/2008/1202/

Assessment of Coal Geology, Resources, and Reserves in the Gillette Coalfield, Powder River Basin, Wyoming

By James A. Luppens, David C. Scott, Jon E. Haacke, Lee M. Osmonson, Timothy J. Rohrbacher, and Margaret S. Ellis

ABSTRACT

The Gillette coalfield, within the Powder River Basin in east-central Wyoming, is the most prolific coalfield in the United States. In 2006, production from the coalfield totaled over 431 million short tons of coal, which represented over 37 percent of the Nation's total yearly production. The Anderson and Canyon coal beds in the Gillette coalfield contain some of the largest deposits of low-sulfur subbituminous coal in the world. By utilizing the abundance of new data from recent coal bed methane development in the Powder River Basin, this study represents the most comprehensive evaluation of coal resources and reserves in the Gillette coalfield to date. Eleven coal beds were evaluated to determine the in-place coal resources. Six of the eleven coal beds were evaluated for reserve potential given current technology, economic factors, and restrictions to mining. These restrictions included the presence of railroads, a Federal interstate highway, cities, a gas plant, and alluvial valley floors. Other restrictions, such as thickness of overburden, thickness of coal beds, and areas of burned coal were also considered.

> The total original coal resource in the Gillette coalfield for all eleven coal beds assessed, and no restrictions applied, was calculated to be 201 billion short tons. Available coal resources, which are part of the original coal resource that is accessible for potential mine development after subtracting all restrictions, are about 164 billion short tons (81 percent of the original coal resource).
>
> Recoverable coal, which is the portion of available coal remaining after subtracting mining and processing losses, was determined for a stripping ratio of 10:1 or less. After mining and processing losses were subtracted, a total of 77 billion short tons of coal were calculated (48 percent of the original coal resource).
>
> **Coal reserves are the portion of the recoverable coal that can be mined, processed, and marketed at a profit at the time of the economic evaluation. With a discounted cash flow at 8 percent rate of return, the coal reserves estimate for the Gillette coalfield is10.1 billion short tons of coal (6 percent of the original resource total) for the 6 coal beds evaluated.**
>
> (Emphasis added. Report available from http://pubs.usgs.gov/of/2008/1202/)

The 10.1 billion tons of economically accessible coal noted in USGS 2008-1202 would last about 22 years at the present rates of production of approximately 454 million tons of coal per year.[121] This estimate of economic coal reserves assumes that all of the 10.1 billion tons is accessed and the production of coal from the Powder River Basin doesn't change. Both of these assumptions are rather questionable as there are significant legal and economic issues related to coal mine operation and expansion. Also, as mines play out in other parts of the country, an increasing percentage of the country's coal is likely to come from the Powder River Basin. Issues related to the amount of coal that could become available at an increased price are discussed further below.

Predictions about Future Coal Supply are Difficult, But Relying on a "200 Year Supply" of Coal in the Powder River Basin Does Not Appear to Be Wise

Given uncertainties about our economy, our future reliance on coal for production of electricity and the future of mines in other regions in the country, it is difficult to make projections about the future life span of coal in the Powder River Basin, but it is clear that relying on a "200 year supply" of coal from the Powder River Basin does not appear to be wise since the most recent USGS assessment found in USGS 2008-1202 found that only a small percentage of the available coal is expected to be economically recoverable.

One of the key questions about USGS 2008-1202 is what will happen to the amount of economically accessible coal if the price of coal increases. This issue will be discussed further below after first introducing the reader to key sections of the report.

With over 92 MB of information, USGS 2008-1202 can appear daunting. Moreover, the report cannot be purchased in paper copy. It has to be downloaded and printed out.[122] The boxes below identify the key pages and summarize the main findings of USGS 2008-1202 to help the reader get started.

Key Pages of USGS 2008-1202

Assessment of Coal Geology, Resources, and Reserves in the Gillette Coalfield, Powder River Basin, Wyoming

Available at http://pubs.usgs.gov/of/2008/1202/

- Pages i-viii—Cover Page, Table of Contents and List of Figures and Tables
- Pages 1-32—Abstract and text describing the report methodology
- Figures 1 and 5—Geologic map and map showing drill hole locations in the Gillette field
- Figures 34-36—Key maps for the Anderson coal bed—the largest coal bed in the study
- Figures 40-42—Key maps for the Canyon coal bed—the second largest coal bed
- Figures 60-68—Figures summarizing the key findings of the report
- Tables 1-13—Tables summarizing all the findings of the report

Stripping Ratio—A Key Determinant of Economic Accessibility For Coal Supplies

A stripping ratio indicates the number of tons of rock that have to be moved to get to a ton of coal. A stripping ratio of 3:1 would mean three tons of rock need to be moved to get to a ton of coal. The rock can include overburden (above the coal), interburden (between the coal beds) and partings (rock within the coal bed). As stripping ratios increase in a coal bed, it can be expected that production costs for the coal will increase. In calculations done in USGS 2008-1202, when stripping ratio increases by a factor of 2, from 1:3 to 1:6, the equipment and staffing needs increase by a factor of 5.5.

(See page 25 of USGS 2008-1202).

Reading Guide for USGS 2008-1202—Assessment of Coal Geology, Resources, and Reserves in the Gillette Coalfield, Powder River Basin, Wyoming

The key concepts of USGS 2008-1202 can be gotten by referring to the following pages—presented in a recommended order of reviewing:

- **The Abstract** notes that the amount of economically recoverable coal estimated at the time of the publication of USGS 2008-1202 is 6% of the original resource or 10.1 billion tons. (Note that this is 6% of the 164 billion tons of "available" coal resource.")
- **Pages 1-32** are the text describing the report and the process of determining economic recoverability for the coal in the Gillette coal field. The discussion of economic recoverability begins on page 22. As noted on page 25, costs increase significantly as overburden and stripping ratios increase. A stripping ratio indicates the number of tons of rock that have to be moved to get to a ton of coal. A stripping ratio of 3:1 would mean three tons of rock need to be moved to get to a ton of coal. The rock can include overburden (above the coal), interburden (between the coal beds) and partings (rock within the coal bed). In the example discussed on page 25, when stripping ratio increases by a factor of 2 from 1:3 to 1:6, the equipment and staffing needs increase by a factor of 5.5. This is an example of the economic challenges and resulting production cost increases that will face future coal mine expansion.
- **Figure 65** shows the relative size of the various coal beds. The Anderson coal bed is the largest with 84.8 billion short tons of the original 201 billion short tons. The Canyon coal bed is the second largest with 36.7 billion short tons. The Smith coal bed is third largest with 26.6 billion short tons. These quantities do not consider restrictions or economic accessibility.
- **Figures 34 and 35** show coal bed thickness and overburden for the Anderson coal bed.
- **Figures 40 and 41** show coal bed thickness and overburden for the Canyon coal bed.
- **Figure 61** shows the effect of surface restrictions on coal bed accessibility as coal bed depth increases. As the coal bed depth increases, an increasing amount of coal resource becomes unavailable due to the need to construct terraced mine benches.
- **Figure 62** shows the stripping ratios for the coal beds that were evaluated. It is clear that stripping ratios will be increasing as Powder River Basin mines expand from east to west.
- **Figure 63** shows the ownership pattern for coal in the Powder River Basin with the vast majority of the coal being owned by the federal government.
- **Figures 67 and 68** show the economically accessible coal supplies in the assessed coal beds of the Gillette coal field. Figure 67 shows 10 billion short tons and Figure 68 shows 6% of coal available at a sales price of $10.47.
- **Figure 66** shows a composite "cost curve" for coal resources in the Gillette coal field of the Powder River Basin coal field. This cost curve is discussed further below.
- **Tables 1-13** summarize the results of the USGS 2008-1202 assessment in relatively accessible table format.

After consideration of the restrictions to coal mining and issues of economic recoverability, the USGS concluded that only 10.1 billion tons of coal in the evaluated coal beds of the Gillette coal field (or 6% of the original resource) would be economically recoverable at the time of the economic evaluation done for USGS 2008-1202. This is shown in Figure 15, which shows Figure 68 in USGS 2008-1202. The issue of how changes in price for the coal could change the amount of economically recoverable coal is discussed further below.

Figure 15
Economic Recoverability of Coal for the Gillette Coal Field, Powder River Basin, Wyoming Percentage Basis—USGS 2008-1202
From http://pubs.usgs.gov/of/2008/1202/

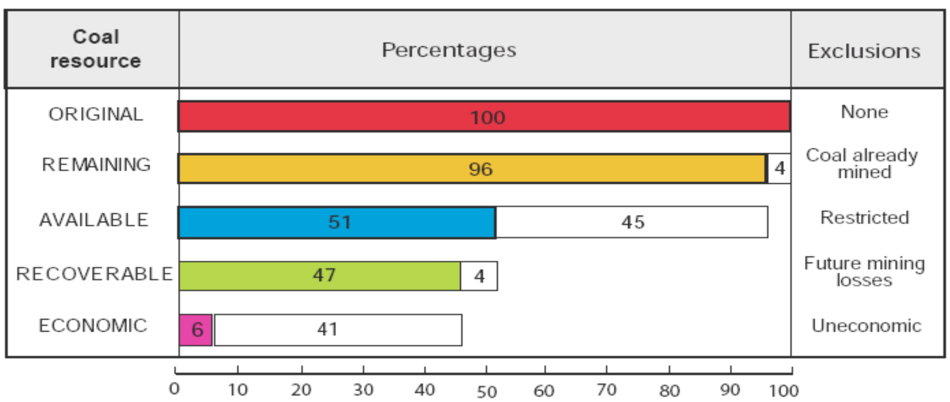


Figure 68. Bar graph showing Gillette coalfield coal resource analysis results for the six coal beds from figure 67, reported as percentages of original resources (at sales price of $10.47 as of January, 2007). Percent of remaining resources are shown in colored bars; excluded resources from the previous category are shown in white bars.

USGS 2008-1202 Concludes that 10.1 Billion Tons or 6% of the Original Resource Was Economically Recoverable at the Time of the Economic Evaluation

After consideration of the restrictions to coal mining and issues of economic recoverability, the USGS concluded that only 10.1 billion tons of coal in the evaluated coal beds of the Gillette coal field (or 6% of the original resource) would be economically recoverable at the time of the economic evaluation done for USGS 2008-1202. (Note that the 6% is 6% of the 164 billion short tons of available coal.) The issue of how much coal could become economically recoverable under different economic assumptions is discussed further below.

**The 2008 USGS Cost Curve for the Gillette Coal Field—
Issues to Consider With Respect to Figure 66 in USGS 2008-1202**

The USGS begins to address the issue of how much coal could become available as the price of coal increases in Figure 66 of USGS 2008-1202. Figure 66 presents a composite "cost curve" for coal in the Gillette coal field of the Powder River Basin and is reproduced below in Figure 16.[123]

As seen in Figure 16 below, Figure 66 from USGS 2008-1202 shows the number of tons of coal on the horizontal axis and the sales price for coal on the vertical axis. It shows 77 billion (i.e. 77,000 million) short tons of coal as potentially available at sales prices up to $60 per ton, 18.5 billion tons available at a sales price of $14 per ton and 10.1 billion tons available at a sales price of $10.47 a ton.

Figure 16
The USGS Cost Curve for Coal in the Gillette Coal Field from USGS 0208-1202

Figure 66 from http://pubs.usgs.gov/of/2008/1202/

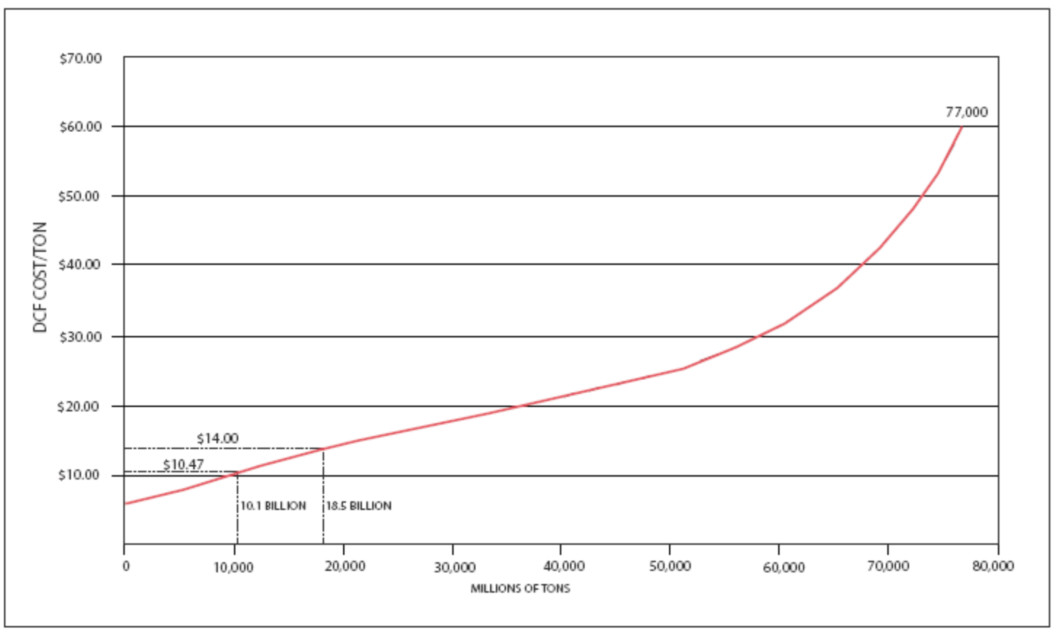


Figure 66. Cost curve showing reserve estimates at $10.47/ton (as of January, 2007) and $14.00/ton (as of March, 2008) for the Gillette coalfield.

While Figure 66 in USGS 2008-1202[124] represents a large step forward from Energy Information Administration publications, which present coal reserve data as though they have been analyzed for economic recoverability when they have not, there are still a number of issues to consider when reviewing the USGS cost curve in Figure 66. Key issues to consider with respect to Figure 66 are summarized in the box below and discussed in further detail below that.

Key Issues to Consider When Reviewing the Cost Curve in Figure 66 of USGS 2008-1202

- Increasing coal costs are likely to increase coal production costs; this is not accounted for in Figure 66
- Coal production occurs in a step-wise, mine-specific fashion, not as a smooth curve as implied by Figure 66
- Legal challenges to coal mine expansion are likely to become significant; this is not accounted for in Figure 66
- It is not clear that the costs of reclamation have completely accounted for increasing costs due to increased stripping ratios.

Key issues to be considered when interpreting Figure 66 in USGS 2008-1202 are described in more detail below.

Figure 66 in USGS 2008-1202 Fails to Account for the Effect of Increasing Coal Costs on Coal Production Costs

The cost curve in Figure 66 of USGS 2008-1202 assumes the cost of producing the coal stays the same while the purchase price of coal increases.[125] On page 32 of USGS 2008-1202, the report describes Figure 66 stating, “This reserves estimate will change depending on changes in current sales prices (assuming mining costs remained steady) as shown in the cost curve figure 66.”[126] Assuming that sales prices will increase without increasing mining (“production”) costs is a questionable assumption since it takes large amounts of electricity and diesel fuel, including coal-based electricity, to mine coal.

In real life, it appears unlikely that sales price of coal will increase without increasing production costs, so the utility of Figure 66 in the real world—while a large improvement over unfounded EIA claims about coal reserves—is questionable. The authors have recognized this issue and have suggested that “reserve studies should be adjusted periodically using the most recent data and reassessed utilizing the most current recovery technology and economics.”[127]

As noted above, increasing coal prices do not necessarily increase economically recoverable reserve estimates. From 2002 until 2008, the price of Powder River Basin coal increased steadily (See Figures 7 through 9), but the USGS reduced the amount of economically recoverable coal in the Powder River Basin from 23 billion short tons[128] in 2002 to 10.1 billion short tons in 2008 as reported in USGS 2008-1202.[129]

By failing to recognize the interdependent relationship between the cost of coal and the production costs for mining coal, Figure 66 in USGS 2008-1202 appears to have significantly overestimated the amount of coal that will be mined under real life economic constraints.

Figure 66 in USGS 2008-1202 Fails to Properly Account for the Fact That Coal Production Occurs in a in a Step-Wise Fashion—Not the Smooth Fashion Implied in Figure 66

The cost curve in Figure 66 of USGS 2008-1202 is a smooth "composite" curve of reserve estimates for the Gillette coal field. This assumes that coal production can occur in a smooth, continuous fashion, assuming that the next increments of coal that become available as the sales price increases can be easily accessed no matter how far apart they occur in the Gillette coal field. In real life, of course, coal is mined in coal mines which are discrete operations working in a defined location. If the next economic coal reserves are not located in an existing coal mine, then it is unlikely they will be mined in the smooth manner implied by Figure 66.

For example, a quick glance at Figures 40 and 41 in USGS 2008-1202 will show that most of the coal in the Canyon coal bed is located a long distance from the major mines in the Gillette coal field and the coal is buried below hundreds of feet of overburden. As a result, it is unclear who would finance new coal mines to access the coal in the Canyon coal bed. About 18.5 billion tons or approximately 24% of the 77 billion tons shown in Figure 66 is from the Canyon coal bed,[130] yet it is unclear how much, if any, of the coal in the Canyon bed will ultimately be mined given the depth of the coal and its distance away from the largest mines in the Gillette coal field.

By failing to consider the real life constraints on mining and the opening of new mines, it appears that Figure 66 in USGS 2008-1202 may have significantly overestimated the amount of coal that is likely to be mined in the Gillette coal field.

Figure 66 in USGS Fails to Consider Potential Legal Challenges to Leasing Federal Coal in the Powder River Basin

Figure 66 in USGS 2008-1202 shows a smooth cost curve implying an ease of production that does not consider the significant legal and permitting issues surrounding coal mine expansion. Figure 63 in USGS 2008-1202 shown in Figure 18 shows that the vast majority of the coal in the Gillette coal field is owned by the federal government. Federal ownership of the western coal resources resulted from a series of Congressional

Acts in the early 1900s.[131] As a result of the federal ownership of the coal, coal mine expansions in the Powder River Basin are accompanied by extensive permitting and legal processes, as discussed further below.

Given the widespread concern about global climate change and the role of coal in increasing atmospheric and oceanic concentrations of carbon dioxide, assuming that coal mine expansions will occur without significant legal opposition appears to be a questionable assumption.

By failing to consider the potential for legal challenges to the leasing of federal coal in the Powder River Basin, Figure 66 in USGS 2008-1202 appears to have presented an optimistic view of the amount of coal that is likely to be recovered from the Gillette coal field.

Figure 66 May Have Overestimated the Amount of Economically Recoverable Coal by Underestimating Mine Reclamation Expenses

As stripping ratios increase, it can be expected that reclamation costs will increase because more dirt will have to be moved back into the mining pit for reclamation. It is not clear that the increasing cost of reclamation with increasing stripping ratio has been fully considered in creating Figure 66 in USGS 2008-1202. Reclamation costs have been treated as proprietary by the mines and the USGS, and at this point it is not clear exactly how these reclamation costs have been modified to reflect increasing stripping ratios for Figure 66.[132]

The USGS CoalVal Model Should Provide Further Information Regarding Assumptions Used to Determine Economic Recoverability of Coal in the Gillette Coal Field

Further information on the interplay between stripping ratios, coal price and economic availability of coal in the Gillette coal field of the Powder River Basin should be available when the model used by the USGS to determine economic accessibility, known as CoalVal[133] is made available to the public. An overview of the CoalVal model and the relationship between increasing stripping ratio and the cost of mining coal is found on pages 23-25 of USGS 2008-1202. The USGS has stated that the CoalVal model should be released for public use in 2009.[134]

While considering the possible effect of increasing price on the economic availability of coal in the Powder River Basin, it is worth noting that at a time when the price of Powder River Basin coal was increasing rapidly (e.g. see Figures 7 through 9 for increases in spot prices of Powder River Basin coal), the USGS, using better data reduced the amount of economically available coal in the Gillette coal field from 23 billion tons in 2002,[135] to 10 billion short tons in 2008.[136]

Figure 17

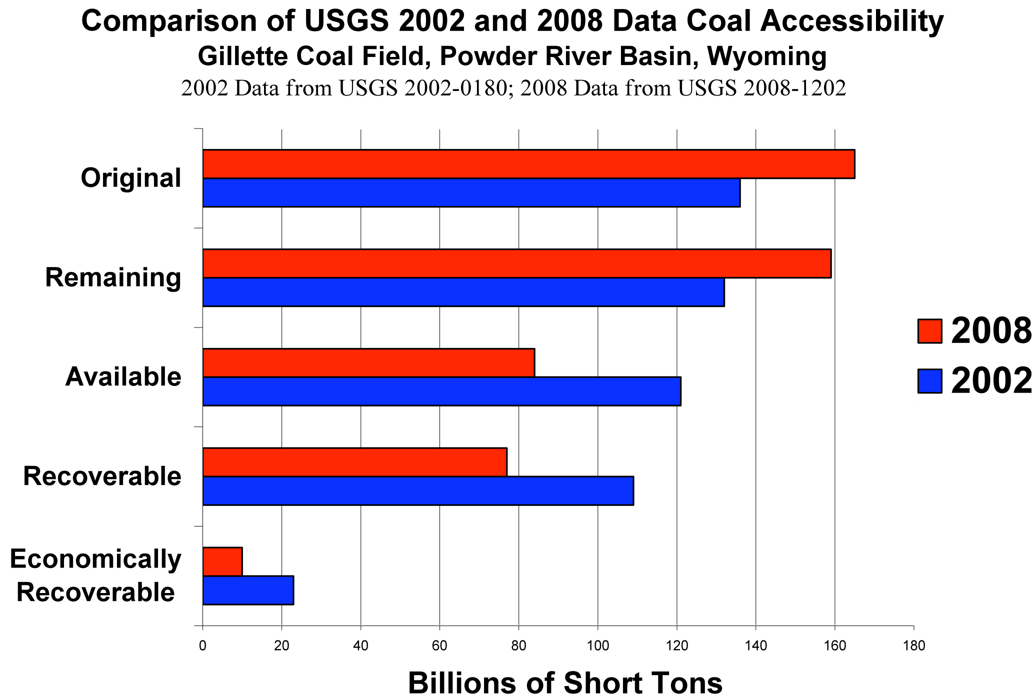


Figure 17 shows that between 2002 and 2008, despite the large increases in spot prices for Powder River Basin coal and the fact that the 2008 assessment began with a larger quantity of coal, the USGS found that the amount of economically recoverable coal in the Powder River Basin decreased from 23 billion tons in 2002 to 10.1 billion tons in 2008. This is the opposite of the result that would be expected. If price goes up, then the amount of economically recoverable coal should also increase. This did not happen because the improved data used in the 2008 data significantly reduced the amount of coal that was economically available.

While the USGS analysis of economically recoverable coal in USGS 2008-1202 provides much more information on economic recoverability than the "Estimated Recoverable Reserve" data published by the EIA, the USGS data still fails to consider key issues related to economic and legal constraints on coal mine expansion. It appears, therefore, that the best way to assess future coal supplies is on a mine-specific basis.

Information on the expected life span for mines in the Powder River Basin is discussed in further detail below. Data on expected life for coal mines in other coal producing regions will be discussed after discussing the life expectancy of the Powder River Basin mines.

Geologic, Economic and Legal Constraints are Likely to Limit Future Mine Expansions

In light of the many geologic, economic, environmental and legal considerations that will attend coal mine expansions, the amount of the coal in the United States that will actually be recovered is highly uncertain. Perhaps the most important information is the amount of recoverable reserves at active mines given the large number of uncertainties regarding future coal mine expansion. Available information on the expected life span of existing mines in the Powder River Basin, the largest single source of coal in the United States, is discussed further below.

VIII. LIFE SPANS OF EXISTING COAL MINES

A. Life Spans of Existing Powder River Basin Coal Mines

There are presently 13 mines in the Gillette coal field of the Powder River Basin. These mines are shown in many of the Figures of USGS 2008-1202 and can be seen in Figure 18, showing ownership of coal in the Gillette coalfield of the Powder River Basin in Wyoming.

As can be seen from Figure 18, most of the coal in the Powder River Basin is owned by the federal government, in accordance with a series of acts passed by Congress in the early 1900s.[137] Upon being granted statehood, there were typically two sections of coal-bearing lands per township granted to the state from the federal government. These two sections, shown in blue in Figure 18, are typically referred to as “school sections,” because they were to be used to fund the state school system.[138]

Figure 18
Ownership of Coal in the Gillette Coalfield in the Powder River Basin, Wyoming

Figure 63 from USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202/

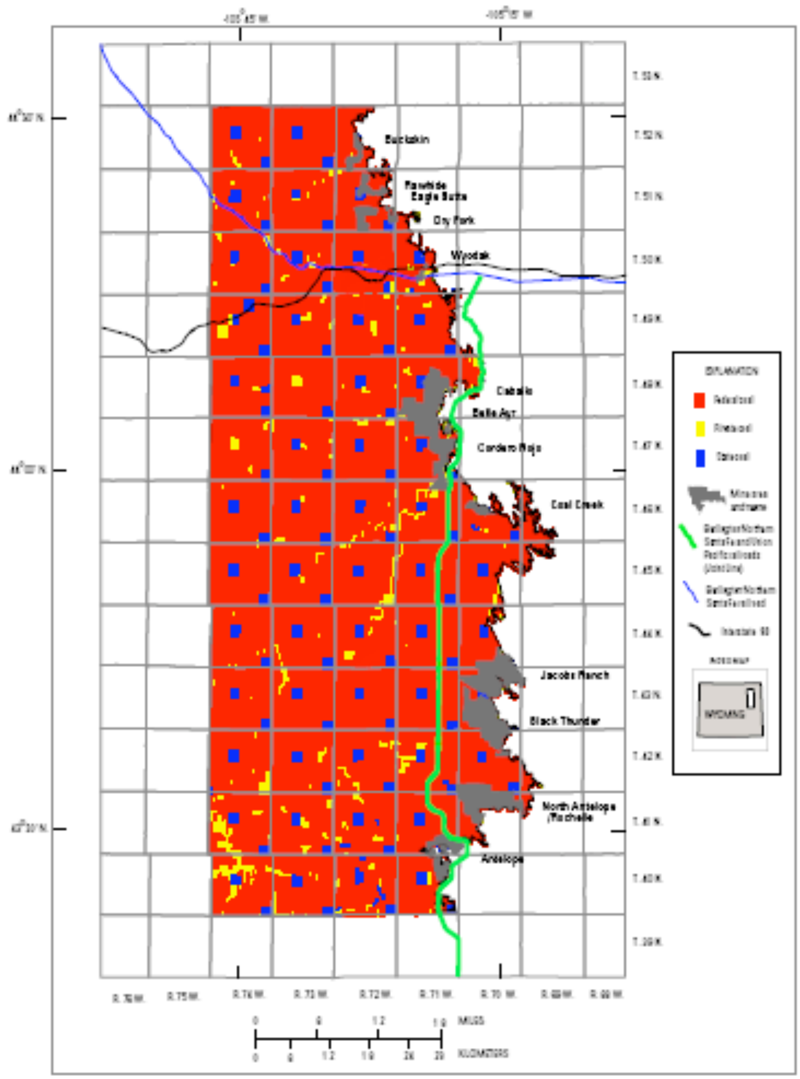


Figure 63. Map showing coal ownership in the Gillette coalfield, Wyoming.

Many of the major mines in the Powder River Basin have 10-15 years of life span remaining (at current rates of production) and are presently applying to lease more of the federally owned coal in hopes of mine expansion. The application to lease more federal coal is accompanied by the preparation of an Environmental Impact Statement ("EIS") prepared by the Bureau of Land Management ("BLM") in the United States Department of the Interior. These Bureau of Land Management EISs provide estimates of existing life span for the Powder River Basin mines as well as the expected life span extensions if the lease of federal coal is approved and the mine expansion is approved by the State of Wyoming.

Publicly available information on current and potential life span for the 13 mines in the Gillette coal field of the Powder River Basin is presented in Table 14 below.

Table 14

Existing and Potential Life Span for Powder River Basin Mines, Gillette Coal Field, Wyoming

Name of Mine (From North to South in the Gillette Coal Field of the Powder River Basin)	**Approx Production Per Year** (mm tons = million tons)	**Expected Life Span at Existing Rate of Production** (Post 2008)	**Lease Approved in Years at Existing Production Rates**	**Lease Applied For in Years at Existing Production Rates**	**Life Span Assuming Any Requested Expansions are Approved and Implemented**
Buckskin Mine	**25 mm tons**[139]	**5.4 yrs**[140]	**5.6 yrs**[141]	**NA**	**11 yrs**
Rawhide Mine	**24 mm tons**[142]	**> 20 yrs**[143]	**NA**	**NA**	**>20 yrs**
Eagle Butte Mine	**25 mm tons**[144]	**10.6 yrs**[145]	**8.1-9.2 yrs**[146]	**NA**	**18.7-19.8 yrs**
Dry Fork Mine	**15 mm tons**[147]	**> 20 yrs**[148]	**NA**	**NA**	**> 20 yrs**
Wyodak Mine	**12 mm tons**[149]	**> 20 yrs**[150]	**NA**	**NA**	**> 20 yrs**
Caballo Mine	**37.8 mm tons**[151]	**14.4 yrs**[152]	**NA**	**2.2-2.6 yrs**[153]	**16.2-17.0 yrs**
Belle Ayr Mine	**30.0 mm tons**[154]	**7.3 yrs**[155]	**NA**	**5.0-6.8 yrs**[156]	**12.3-13.9 yrs**
Cordero Rojo Mine	**46.3 mm tons**[157]	**10.4 yrs**[158]	**NA**	**9.4-10.3 yrs**[159]	**19.8-20.7 yrs**
Coal Creek Mine	**13.4 mm tons**[160]	**15.2 yrs**[161]	**NA**	**4.3 yrs**[162]	**19.5 yrs**
Jacobs Ranch Mine	**39.9 mm tons**[163]	**< 10 yrs**[164]	**NA**	**Approx. 23 yrs**[165]	**Approx. 33 yrs**
Black Thunder Mine	**92.2 mm tons**[166]	**< 10 yrs**[167]	**NA**	**Approx. 10 yrs**[168]	**Approx. 20 yrs**
North Antelope Rochelle Mine	**89.7 mm tons**[169]	**< 10 yrs**[170]	**NA**	**Approx. 6 yrs**[171]	**Approx. 16 yrs**
Antelope Mine	**36 mm tons**[172]	**9 yrs**[173]	**NA**	**9-13 yrs**[174]	**18-22 yrs**

As can be seen from Table 14, while some of the smaller mines in the Powder River Basin have a current or expected life span of more than 20 years, most of the major mines in the Powder River Basin have less than 15 years of current life and if requested coal leases and mine expansions are approved, their life spans will still typically be less than 20 years. Twenty years is not a very long time when talking about planning horizons for electric utility infrastructure.

Current Life Span of Most Major Powder River Basin Mines is Less Than 15 Years—If Leases and Mine Expansions are Approved, then Life Spans Could be Extended to About 20 Years. Future expansions beyond that are likely to be geologically, economically and legally challenging.

B. Life Spans of Coal Mines in Other Coal-Producing Regions

Appalachian Coal Mines

The life expectancy of Appalachian [175]coal mines is difficult to determine as the coal is typically owned by the coal mines and detailed information is proprietary. Nonetheless, two pieces of publicly available information can provide an indication of possible life spans for Appalachian mines. The Energy Information Administration publishes coal production by state on an annual basis[176] as well as information on recoverable reserves at producing mines by state as reported by the mines.[177] The information on annual production and recoverable reserves at producing mines can be combined to produce a ratio of reserves to production as shown in Table 15 below for Appalachian states producing more than 15 million tons per year.

Table 15
Annual Production, Recoverable Reserves at Existing Mines and Ratio of Reserves to Production for Key Appalachian States

Information from http://www.eia.doe.gov/cneaf/coal/page/special/feature.html (Table 2) and http://www.eia.doe.gov/cneaf/coal/page/acr/table15.pdf
See text for discussion.

State	2003 Production[178] (mm tons = million short tons)	2007 Production[179] (mm tons = million short tons)	Recoverable Reserves at Producing Mines[180] (mm tons = million short tons)	Ratio of Recoverable Reserves at Producing Mines to 2007 Production
Alabama	20.1 mm tons	19.3 mm tons	327 mm tons	16.94 years
Kentucky--Eastern	91.3 mm tons	86.8 mm tons	669 mm tons	7.71 years
Ohio	22.0 mm tons	22.6 mm tons	333 mm tons	14.73 years
Pennsylvania	63.7 mm tons	65.0 mm tons	532 mm tons	8.18 years
Virginia	31.6 mm tons	25.3 mm tons	256 mm tons	10.12 years
West Virginia	139.7 mm tons	153.2 mm tons	1,828 mm tons	11.93 years

Life Spans of Existing Coal Mines – Interior Region

The ratio of Recoverable Reserves at Producing Mines to 2007 Production in Table 15 assumes that a) all recoverable reserves have been reported and that b) all recoverable reserves can be recovered without losses. It is unclear how accurate these assumptions are and it is also unknown whether existing mines have expansion plans and at what stage any such plans might be in. Further analysis is recommended by any entity reliant on coal from Appalachian mines.

Interior Coal Mines

The life expectancy of Interior[181] coal mines is difficult to determine as the coal is typically owned by the coal mines and detailed information is proprietary. Nonetheless, two pieces of publicly available information can provide an indication of possible life spans for Interior coal mines. The Energy Information Administration publishes coal production by state on an annual basis[182] as well as information on recoverable reserves at producing mines by state as reported by the mines.[183] The information on annual production and recoverable reserves at producing mines can be combined to produce a ratio of reserves to production as shown in Table 16 below for Interior states producing more than 15 million tons per year.

Table 16
Annual Production, Recoverable Reserves at Existing Mines and Ratio of Reserves to Production for Key Interior States

Information from http://www.eia.doe.gov/cneaf/coal/page/special/feature.html (Table 2) and http://www.eia.doe.gov/cneaf/coal/page/acr/table15.pdf
See text for discussion.

State	2003 Production[184] (mm tons = million short tons)	2007 Production[185] (mm tons = million short tons)	Recoverable Reserves at Producing Mines[186] (mm tons = million short tons)	Ratio of Recoverable Reserves at Producing Mines to 2007 Production
Illinois	31.6 mm tons	32.4 mm tons	1,286 mm tons	39.7 years
Indiana	35.4 mm tons	35.0 mm tons	401 mm tons	11.46 years
Kentucky-Western	21.5 mm tons	28.2 mm tons	513 mm tons	18.19 years
Texas	47.5 mm tons	41.9 mm tons	737 mm tons	17.59 years

The ratio of Recoverable Reserves at Producing Mines to 2007 Production in Table 16 assumes that a) all recoverable reserves have been reported and that b) all recoverable reserves can be recovered without losses. It is unclear how accurate these assumptions are and it is also unknown whether existing mines have expansion plans and at what stage any such plans might be in. Further analysis is recommended by any entity reliant on coal from Interior mines.

Western Coal Mines (Other Than Wyoming)

The life expectancy of Western [187] coal mines in states other than Wyoming is difficult to determine as detailed information on the mines is proprietary. Nonetheless, two pieces of publicly available information can provide an indication of possible life spans for Western coal mines outside of Wyoming. The Energy Information Administration publishes coal production by state on an annual basis[188] as well as information on recoverable reserves at producing mines by state as reported by the mines.[189] The information on annual production and recoverable reserves at producing mines can be combined to produce a ratio of reserves to production as shown in Table 17 for Western states (other than Wyoming) producing more than 10 million tons per year. For life spans of current mines in the Gillette coal field of the Powder River Basin in Wyoming, see Table 14.

Table 17
Annual Production, Recoverable Reserves at Existing Mines and Ratio of Reserves to Production for Key Western States (Other Than Wyoming)

Information from http://www.eia.doe.gov/cneaf/coal/page/special/feature.html (Table 2) and http://www.eia.doe.gov/cneaf/coal/page/acr/table15.pdf
See text for discussion.

State	2003 Production[190] (mm tons = million short tons)	2007 Production[191] (mm tons = million short tons)	Recoverable Reserves at Producing Mines[192] (mm tons = million short tons)	Ratio of Recoverable Reserves at Producing Mines to 2007 Production
Arizona	12.1 mm tons	8.0 mm tons	Withheld from EIA	Unknown
Colorado	35.8 mm tons	36.4 mm tons	328 mm tons	9.01 years
Montana	37.0 mm tons	43.4 mm tons	1,251 mm tons	28.82 years
New Mexico	26.4 mm tons	24.5 mm tons	483 mm tons	19.71 years
North Dakota	30.8 mm tons	29.6 mm tons	1,252 mm tons	42.30 years
Utah	23.1 mm tons	24.3 mm tons	211 mm tons	8.68 years

The ratio of Recoverable Reserves at Producing Mines to 2007 Production in Table 17 assumes that a) all recoverable reserves have been reported and that b) all recoverable reserves can be recovered without losses. It is unclear how accurate these assumptions are and it is also unknown whether existing mines have expansion plans and at what stage any such plans might be in. Further analysis is recommended by any entity reliant on coal from Western mines.

Although both Montana and North Dakota have a reserve-to-production ratio of over 20 years, neither state is a large producer of coal. Montana's 43.4 million tons of coal produced in 2007 is less than 10% of the 453.6 million tons of coal produced in Wyoming in the same year. North Dakota only produced 29.6 million tons of coal in 2007 and the coal is lignite, the lowest quality of coal. Neither Montana nor North Dakota will be able to provide significant quantities of coal in the future without massive investments in new mines and railroad lines to move the coal.

While mine-specific data was not easily accessible for most western states, the Colorado Geologic Survey has published the "Colorado Coal Directory, 2005."[193] In 2005, most of the Colorado mines surveyed in this publication reported 10 to 20 years of reserves or less. Since three years have passed since the reporting of these reserves, the reserves remaining at this point can be expected to be less than reported in 2005. In 2005, the "Colowyo" mine reported about 25 years of reserves and the Deserado mine reported

24 years of reserves. These were the largest reported reserves for Colorado mines producing more than a million tons per year.[194] Once again, the accuracy of these numbers is not known and more detailed mine-specific analyses are recommended.

While the United States Geological Survey intends to publish an assessment of economically recoverable coal in the central and northern parts of the Powder River Basin (including Montana),[195] it is not clear if or when new mines and the necessary rail lines in these areas will be proposed, permitted and opened.

The Reserve to Production Ratio is Typically Less than 20 Years for Most Coal Producing States—More Investigation is Strongly Suggested

Data published by the Energy Information Administration on Reported Reserves at Producing Mines and Annual Production Rate gives a "Reserves to Production" ratio of less than 20 years for most coal-producing states. While the reserve-to-production ratio for a few states such as Montana or North Dakota exceeds 20 years, neither of these states is a large producer of coal and increased production will not be possible without massive investments in new mines and railroad lines. A mine-specific investigation of future coal supplies by any entity relying on United States coal is strongly suggested.

With much of the United States dependent on coal for electricity, it is strongly suggested that utilities, industries, regulators, elected officials and concerned citizens begin to ask serious questions about the coal mines that are supporting the coal plants in their state and to investigate potential future geologic, economic and legal constraints to the expansion of these mines.

Questions to Ask on Long-Term Coal Supply Constraints

Any state, utility or industry reliant on coal supplies is encouraged to begin investigating long-term coal supplies for their region.

Questions related to long term coal supplies that should be asked include:

1) What mines are supporting the power plants in my state or region?
2) What is the expected life span of these mines?
3) What expansion plans do these mines have?
4) What geologic, economic or legal constraints might exist to future mine expansion?
5) What plans, if any, does my utility, industry or state need to make in the face of possible long-term constraints on coal supply?

IX. OTHER RECENT REPORTS DISCUSSING U.S. COAL SUPPLIES

In addition to the information from the Energy Information Administration and the United States Geological Survey summarized in previous sections, there have been a number of other reports published in recent years that have begun to question the common belief that U.S. coal will continue to be cheap and abundant for the next century. These reports are summarized below.

A. Global Energy Decisions 2006 "Can Coal Deliver?" Report

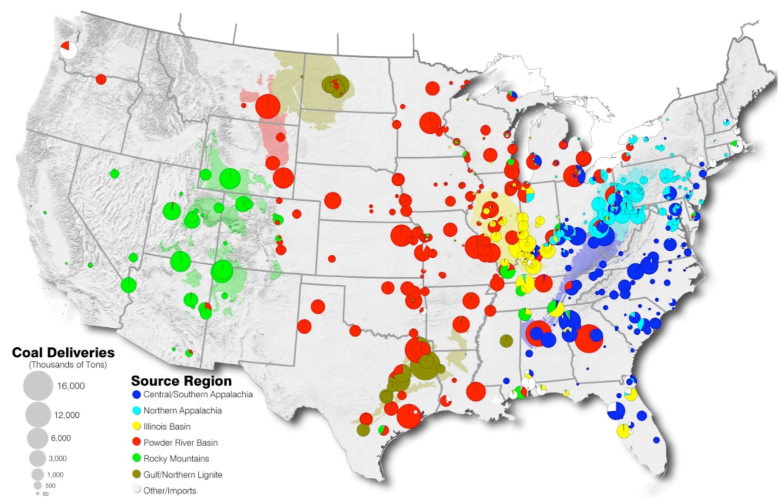
In late 2006, the consulting firm Global Energy Decisions issued a report entitled "Can Coal Deliver?" The full report included a mine-specific database for all the major coal mines in this country and cost $15,500. An eight page summary is available online.[196] This report pointed out that the amount of economically recoverable coal is much less than the full amount of reported reserves and that many geologic, legal and economic constraints would constrain future United States' coal supplies.[197] In short, the report questioned the ability of US coal supplies to support the high coal growth scenario that was being pursued from 2002-2007.

The "Can Coal Deliver?" report included the diagram shown in Figure 19 below, showing coal deliveries by source of the coal and size of the delivery to power plants throughout the United States. The color of the dots corresponds to the origin of the coal and the size of the dots indicates the size of the annual coal shipments. The color code for the dots is as follows:

- Dark Blue—Southern Appalachian Coal
- Light Blue—Northern Appalachian Coal
- Yellow—Illinois Basin Coal
- Red—Powder River Basin Coal
- Bright Green—Rocky Mountain Coal
- Olive Green—Lignite From the Gulf or North Dakota

Permission has been obtained to use this figure from the consulting firm Ventyx which took over Global Energy Decisions.[198]

Figure 19
Coal Delivery by Source of Coal—Ventyx Diagram
Used by permission of Ventyx—From "Can Coal Deliver?"



The dots on the Ventyx coal delivery diagram in Figure 19 give an indication of which states are dependent on coal from the various coal producing regions of the country---and also of the importance coal presently plays in electricity production in the United States.

Figure 19 shows that a large number of coal plants in the Midwest are fully reliant on Powder River Basin coal—and presumably they are assuming that there is a "200 year supply of coal" in the Powder River Basin. The operators of these plants are encouraged to undertake a detailed assessment of their long-term coal supplies and begin to plan accordingly. A detailed assessment of long term coal supplies is also recommended for coal plants reliant on other sources of coal (e.g. Appalachian, Indiana/Illinois, Rocky Mountain and Gulf and North Dakota lignite), as these coal plants should not just assume that they will be able to switch to Powder River Basin coal if their regional coal mines play out. As shown in Table 14 and discussed in the text, the major mines in the Powder River Basin have less than a 20 year life span and future expansions will be subject to very serious geologic, economic and legal constraints.

B. Energy Watch Group March 2007

In March 2007, a group of independent scientists and experts, gathered together by German member of Parliament Hans-Josef Fell, published a report entitled, "Coal" Resources and Future Production." The authors summarized the paper as follows in the Executive Summary:

> This paper attempts to give a comprehensive view of global coal resources and past and current coal production based on a critical analysis of available statistics. This analysis is then used to provide an outlook on the possible coal production in the coming decades. **The result of the analysis is that there is probably much less coal left to be burnt than most people think.**[199] (Emphasis added.)

After reviewing reserve data for key coal producing countries, the Energy Watch Group authors concluded that, "A closer look at the historical reserve assessments raises doubts regarding the quality of reserve assessments."[200]

With respect to United States coal supplies, the Energy Watch Group report noted that while coal production volumes have been increasing, the quality and heat content of the mined coal has been decreasing. The Energy Watch Group therefore concluded with respect to US coal production:

> Since 1970 lower quality subbituminous and low quality lignite have been contributing rising volumes. The growing share of lower quality coal is the reason why total [US] coal production in terms of energy content peaked in 1998….[201]

The conclusion of the Energy Watch Group on the energy content of coal depends on the assumptions used for the energy content of the various ranks of coal (e.g. bituminous, subbituminous etc.) A different set of assumptions about energy content could lead to a different conclusion on the timing of the peak of US coal production on an energy content basis. Nonetheless, the fundamental point is that what matters with respect to coal production is the energy content, not the volume, of the coal and that as higher quality coals are depleted, higher volumes of mined (but lower quality) coal may not be able to make up for the loss of energy content. In short, while the date of the peak is uncertain, peak coal, on an energy content basis, is much more imminent in the U.S. than is widely thought.

C. National Academy of Sciences 2007 Report

In 2007, The National Academy of Science ("NAS") issued a book-length report on coal entitled Coal: Research and Development to Support National Energy Policy.[202] The NAS study reviewed a wide range of issues related to the use of coal in the United States including assessments of future coal use and supply, environmental issues involved with the future production and use of coal as well as the research and development needs associated with future use of coal.

With respect to reported assessments of coal reserves, the NAS report stated the following:

> …there is no question that sufficient minable coal is available to meet the nation's coal needs through 2030. Looking further into the future, there is probably

> sufficient coal to meet the nation's needs for more than 100 years at current production levels. However, it is not possible to confirm that there is a sufficient supply of coal for the next 250 years as is often asserted.[203]

While it can be seen that the NAS Committee was beginning to question the claim of a "250 year supply of coal," it is not clear that the Committee considered issues related to the geologic, economic and legal constraints on future mine expansion. As discussed throughout this present report, the constraints to future coal mine expansion are likely to be significant and it is highly questionable whether the U.S. truly does have 100 years of geologically, economically and legally accessible coal as asserted by the NAS report.

D. Inventory of Federal Coal Resources August 2007

In 2007, the US Departments of Energy, Interior and Agriculture collaborated on a report entitled, "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development."[204] The report was issued in compliance with the Energy Policy Act of 2005, P.L. 109-58 §437 and was intended to conduct an inventory of coal resources underlying federal lands, and to identify the extent and nature of any restrictions on the development of coal resources on those lands. The report chose to focus on the Powder River Basin region because it contains the most federally-owned coal and because it is the region with the most complete datasets.[205]

Key points made by the report include:

- **Compliance with Federal Laws to Lease Federal Coal:** "All Federal coal must be included in a land use plan prior to leasing. These coal leases, including all those issued with standard lease terms, are subject to full compliance with all laws and regulations. These laws establish the restrictions and impediments encompassed in this Inventory and include, but are not limited to, the National Environmental Policy Act, Clean Water Act, Clean Air Act, Endangered Species Act, Surface Mining Control and Reclamation Act, Federal Coal Leasing Amendments Act of 1976, Mineral Leasing Act of 1920, and National Historic Preservation Act." (page vi)[206]

- **Only a Small Fraction of Powder River Basin Coal is Presently Under Lease and Available for Development:** Of the over 550 billion short tons of federally owned coal in the Powder River Basin,[207] only about 11.6 billion tons has presently been leased after completing the land use planning and legal requirements for leasing of federal coal.[208]

- **Approximately 70% of the Federal Coal is of Low Development Interest Because it Is Deeper than a 10:1 Stripping Ratio:** As shown in Figures 20 and 21, both taken from the 2007 Inventory of Federal Coal Resources, most of the coal in the Powder River Basin is buried under hundreds of feet of

> overburden and is highly unlikely to be mined. When the stripping ratio becomes greater than 10:1 then these coals are of low current development interest and are not likely to be surface mined.[209] Approximately 70% of the coal (see blue striped areas in Figure 21) in the Powder River Basin is not expected to be surface mined.[210] While it is uncertain how much of the coal that lies below a stripping ratio of 10:1 can be accessed, it is likely to be at costs that far exceed those for surface mining and it is highly unlikely that coal buried below a 10:1 stripping ratio can be mined in volumes matching the present volumes that are removed from the surface mines in the Powder River Basin (See Table14.)

Figure 20 shows the "basin" (or "bowl-like") nature of the Powder River Basin. The coal in the Powder River Basin originated approximately 55-60 million years ago[211] and the "basin" has filled with dirt in the intervening years. As can be seen in Figure 20, the coal on the eastern edge of the Powder River Basin, where the existing mines are presently located, was covered by 50-200 feet of overburden. As the existing mines expand from east to west, then the overburden will be increasing and production costs for the coal are likely to also increase as more dirt will have to be moved (and then moved back to reclaim the mine) to access the coal.

One example of increasing overburden can be seen in the case of the West Antelope II expansion proposed for the Antelope Mine on the southern edge of the Gillette coal field in the Powder River Basin (see Table 14 and Figure 18). The proposed expansion to the Antelope Mine would add 9-13 years to the life of the existing mine (See Table 14), but the coal accessed in the proposed expansion would be buried much deeper and the seams would be thinner than the existing seams.

Table 18 provides the overburden and seam thickness for the existing Antelope Mine and the proposed West Antelope II expansion area. Overburden increases from an average of 122 feet in the existing mine to 260-280 feet in the expansion area, while coal seam thickness decreases from an average of 86 feet in the existing mine to 50-60 feet in the expansion area. Both the increasing overburden and the decreasing coal seam thickness are likely to increase production costs for the coal mined from the expansion area.

Table 18
Increasing Overburden and Decreasing Coal Seam Thickness
Antelope Coal Mine, Powder River Basin, Wyoming

Source: Page 3-8 in the "Final Environmental Impact Statement for the West Antelope II Coal Lease Application WYW 163340," Wyoming State Office, Bureau of Land Management available at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/West_Antelope_II.html

	Existing Antelope Mine	Antelope II Proposed Expansion
Average Overburden Above the Coal[212]	122 Feet of Overburden	260-280 Feet of Overburden
Average Coal Seam Thickness[213]	86 Feet Thick	50-60 Feet Thick

As can be seen in Figure 20, most of the coal in the Powder River Basin (see the yellows, oranges and reds) rests under 400 or more feet of overburden. As a result, this coal is not likely to be surface accessible as shown by the blue striped area in Figure 21. Figure 21 provides a visual representation of the fact that most of the coal in the Powder River Basin will not be economically accessible as presented in the USGS 2008-1202 report discussed at length above.

Figure 20
Overburden Thickness Above the Coal in the Powder River Basin of Wyoming and Montana

Source: "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development," page 25, available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf

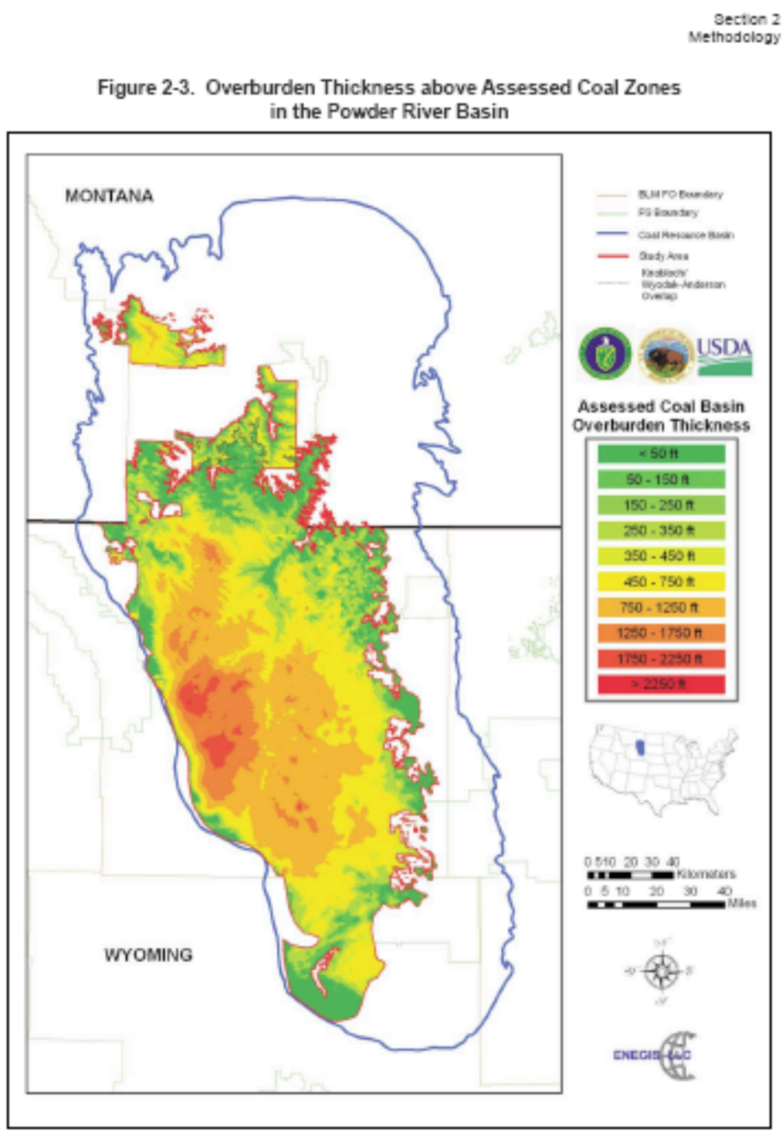
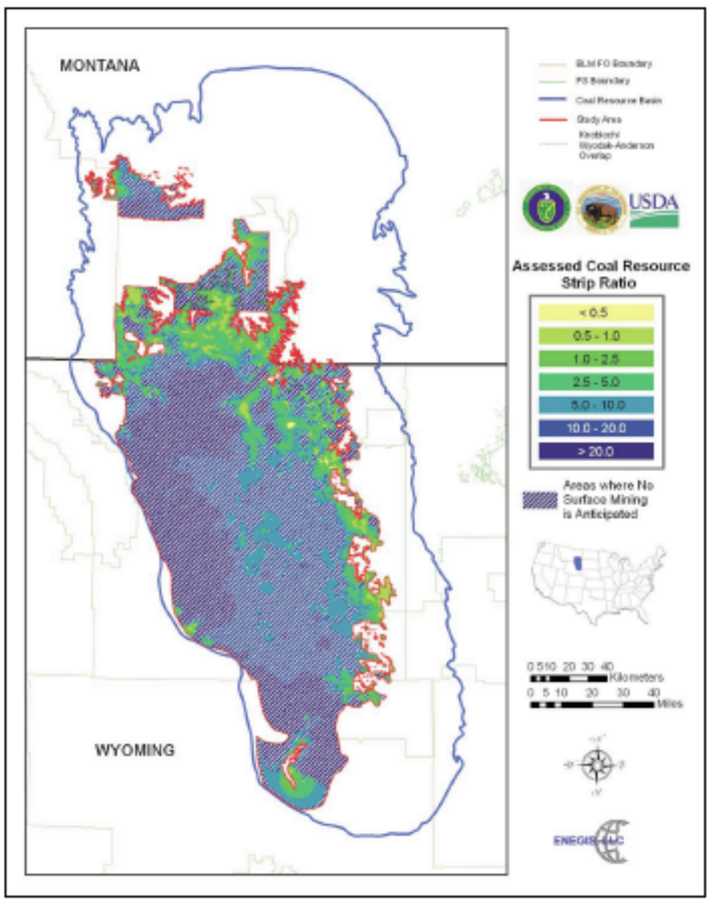


Figure 21
Coal Resources Not Expected to be Surface Mined in the Powder River Basin of Wyoming and Montana

Source: "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development," page 33, available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf

Section 2
Methodology

Figure 2-6. Resources beyond Conventional Surface Mining Technology in the Powder River Basin



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E. Professor David Rutledge, CalTech—Coal Depletion Rates

Professor David Rutledge of the Division of Engineering and Applied Science at CalTech University has conducted a study of depletion rates for oil and coal using methods based on those of M. King Hubbard who, in 1956 with remarkable accuracy, predicted peak oil production for the United States. Using techniques similar to Hubbard, Professor Rutledge has predicted the amounts of coal available around the world.[214] He concludes that there is much less coal likely to be mined than has been previously suggested. Professor Rutledge's analyses depend on reported production statistics for a region and do not substantially address mine-specific geologic, economic or legal constraints.

X. COAL SUPPLY ISSUES IN OTHER COUNTRIES

A detailed analysis of world-wide coal supply is beyond the scope of this report. The reader is referred for more information to the 2007 Energy Watch Group report on worldwide coal resources,[215] and the analysis by CalTech Professor David Rutledge on coal production depletion rates around the world.[216] Also the BP Statistical Review of World Energy publishes a table that it entitles, "Proved Reserves at end 2007."[217] The top 8 countries listed by BP for "proved coal reserves" are shown in Table 12 above. As discussed at length in this paper as well as in the Energy Watch Group report,[218] it is extremely questionable whether these "proved reserves" actually exist and whether they can be produced in an economic fashion.

The BP Statistical Review Reported "Proved Reserves" are Highly Questionable.

The "Proved Reserves" reported by the BP Statistical Review of World Energy are highly questionable as it appears that they have merely reported "reserve" estimates from countries without assessing them for economic recoverability. As discussed at length in this paper, the "reserves" published by the Energy Information Administration (and reported by BP) have not been assessed for economic recoverability. It is similarly questionable whether the reserves reported by other countries have been assessed for economic recoverability.

In one rather ominous sign of potential world constraints on coal supplies, Peabody Energy Corporation reported in July 2008 that there were 60 coal plants sitting idle in China for lack of a coal supply.[219] In a December 2008 presentation to investors, Peabody summarized the supply constraints on coal supply around the world.[220] Given the significant geologic, economic, legal and transportation constraints facing future coal supplies, it is the goal of this paper to encourage the United States and the world to begin to take a more sober look at potential constraints on future coal supplies and begin to plan accordingly.

XI. CONCLUSION

Careful examination of publicly available data shows that the United States has much less accessible coal than has oft been stated. Most coal-producing states have reported reserves at existing mines of less than 20 years and plans for future coal mine expansion are uncertain for geologic, economic and legal reasons.

In the western US, most of the coal is owned by the Federal government and future coal mine expansions will require compliance with approximately a dozen environmental laws. Importantly, most of the coal in the Powder River Basin of Wyoming and Montana (presently the source of over 40% of US coal production) is buried too deeply to be surface accessible and it is uncertain if this coal will ever be produced in large quantities. The major existing mines in the Gillette coal field of the Powder River Basin of Wyoming typically have less than 20 years of expected life and future expansions are uncertain for geologic, economic and legal reasons.

It appears that rather than having a "200 year supply of coal," the United States has a much shorter planning horizon for moving beyond coal-fired power plants. Depending on the resolution of geologic, economic and legal constraints to future coal mine expansion, the planning horizon could be as short as 20-30 years.

Endnotes

All websites accessed late 2008 or early 2009.

Due to the complexity of the references used for this report, every effort has been made to make each reference "self-contained," or at least easily decipherable, in order to ease the burden on the reader that is trying to track down the source of information used in this report.

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[1] Barbara Freese, Coal: A Human History, Penguin Books (2004) ISBN 0-7382-0400-5
[2] Jeff Goodell, Big Coal: The Dirty Secret Behind America's Energy Future, Houghton Mifflin, New York (2006) ISBN -13: 978-0-618-31940-4
[3] For Time magazine see "Is Coal Golden," (*Time,* October 2, 2006); for the Christian Science Monitor, see "Why coal rich US is seeing record imports," (*CS Monitor,* July 10, 2006) and for use of "Saudi Arabia of Coal" by a Presidential candidate see Flathead Beacon "Exclusive: Obama, Clinton Make Closing Arguments as Montana Primary Looms," May 29, 2008. The New York Times used the phrase "Saudi Arabia of Coal" in the multimedia presentation available at http://www.nytimes.com/2006/05/28/business/28coal.html?pagewanted=3&_r=1 .
[4] See Table 1 in "U.S. Coal Supply and Demand: 2007 Review," by Fred Freme, U.S. Energy Information Administration, available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html
[5] See Freese Coal: A Human History, pages 17-21, for a vivid description of the formation of Carboniferous coals from the monstrous *lepidodendron* and *sigillaria* trees and giant ferns. Sketches and a discussion of the trees and bushes thought to make up Pennsylvania coal can be found on pages 10-14 of "Coal in Pennsylvania," by William E. Edmunds (2002) found at http://www.dcnr.state.pa.us/topogeo/education/coal/es7.pdf.
[6] See http://www.wsgs.uwyo.edu/coalweb/swamp/swamps.aspx
[7] See for example, Annual Book of ASTM Standards 2006, Volume 05.06, Standard D388-05—Standard Classification of Coals by Rank—available in many engineering or large public libraries. Also available for purchase on line at http://webstore.ansi.org/FindStandards.aspx?SearchString=D388-05&SearchOption=1&PageNum=0
[8] A BTU or British Thermal Unit is a measure of heat. One BTU is enough heat to raise the temperature of one pound of water by 1 degree Fahrenheit.
[9] The National Academy of Sciences also notes that "differences in the moisture content and hearing values among different coal types affect CO2 emissions upon combustion, with higher-rank bituminous coals producing 7 to 14 percent lower emissions than subbituminous coals on a net calorific value basis." See page 62 in Coal: Research and Development to Support National Energy Policy, National Research Council of the National Academy of Sciences, National Academies Press, 2007, available at http://www.nap.edu/catalog.php?record_id=11977 .
[10] See ASTM "Standard Classification of Coals by Rank,", Designation D388-05 available in many science and engineering libraries or purchased on line at http://www.astm.org/Standards/D388.htm .
[11] See "Coal: Resources and Future Production," Report EWG -01/07 by the Energy Watch Group available at http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf. Calculations of energy content depend on assumptions made about energy content of the various ranks of coal. The key point is that the United States is seeing declining production of higher rank and higher energy content coals declining while volume of lower rank and lower energy content coals is increasing. With lower rank coals, it takes a larger volume to produce the same number of BTUs.
[12] See for example, "Beyond Mercury: How the Fine Print of the Bush Administration Plan Means More Arsenic, Dioxin, Lead and other Toxic Air Pollution," by Clear the Air and available at http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Global_warming/env_beyond_mercury_0804.pdf
[13] For more information on hazardous pollutants included in coal combustion wastes see the Environmental Protection Agency website on coal combustion wastes at http://www.epa.gov/osw/nonhaz/industrial/special/fossil/index.htm. For a discussion of the increased

concentration of heavy metals such as arsenic and selenium in the ash produced by coal plants with mercury controls see "Characterization of Mercury-Enriched Coal Combustion Residues from Electric Utilities Using Enhanced Sorbents for Mercury Control," at http://www.epa.gov/nrmrl/pubs/600r06008/600r06008.pdf . For a discussion of the EPA's failed efforts to regulate disposal of coal combustion waste, see the testimony of Lisa Evans, Project Attorney, Earthjustice before the Subcommittee on Energy and Mineral Resources of the United States House of Representatives, June 10, 2008 available at http://www.earthjustice.org/library/legal_docs/evans-testimony-emrsubcom.pdf .

[14] With the rise of a global market for coal, Appalachian coal has begun to be exported from East Coast ports, leading to some recent increases in production of coal from Appalachia. See http://www.eia.doe.gov/cneaf/coal/quarterly/qcr_sum.html . As noted in the Quarterly Coal Report for 2008-Q2, "with less new capacity available to be brought on line in the region and with many accessible coal seams already mined, this resurgence of Appalachian coal is unlikely to continue indefinitely."

[15] Data on top 12 coal producing states from Table 2 of "U.S. Coal Supply and Demand: 2007 Review," by the U.S. Energy Information Administration available from http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2 .

[16] See Table 2 at http://www.eia.doe.gov/cneaf/coal/page/special/fig2.html

[17] A short ton is 2000 pounds as compared to a metric ton which equates to 2204 pounds or about 10% bigger. The British long tonne is 2240 pounds.

[18] See Table 2 of "U.S. Coal Supply and Demand: 2007 Review," by the U.S. Energy Information Administration available from http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2 .

[19] See the definition of "Coal Producing Regions" at http://www.eia.doe.gov/glossary/glossary_c.htm

[20] See the definition of "Coal Producing Regions" at http://www.eia.doe.gov/glossary/glossary_c.htm

[21] See page 14 in the West Virginia Coal Association's 2006 Coal Facts report available at http://www.wvcoal.com/docs/coalfacts_07.pdf .

[22] See page 10 in the West Virginia Coal Association's 2006 Coal Facts report available at http://www.wvcoal.com/docs/coalfacts_07.pdf .

[23] See page 5 in "Kentucky Coal Facts—2007-2008 Pocket Guide," available at http://www.kentuckycoal.org/documents/CoalFacts08.pdf .

[24] See the Energy Information Administration Kentucky coal statistics available at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/ky.htm

[25] See the definition of "Coal Producing Regions" at http://www.eia.doe.gov/glossary/glossary_c.htm

[26] See Table 2 of "U.S. Coal Supply and Demand: 2007 Review," by the U.S. Energy Information Administration available from http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2 .

[27] See the Energy Information Administration State Profile for Pennsylvania available at http://www.eia.doe.gov/cneaf/coal/st_coal_pdf/0576w.pdf .

[28] See page 10 in the West Virginia Coal Association's 2006 Coal Facts report available at http://www.wvcoal.com/docs/coalfacts_07.pdf .

[29] See the Energy Information Administration Ohio Profile of Historical Coal Production available at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/oh.htm .

[30] See http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/oh4p1.html .

[31] See the definition of "Coal Producing Regions" at http://www.eia.doe.gov/glossary/glossary_c.htm

[32] See the Energy Information Administration State Profile for Alabama at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/al.htm .

[33] See Energy Information Administration State Profile for Alabama at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/al4p1.html .

[34] See the definition of "Coal Producing Regions" at http://www.eia.doe.gov/glossary/glossary_c.htm

[35] See Energy Information Administration State Profile for Texas at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/tx.htm

[36] See Energy Information Administration State Profile for Indiana at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/in4p1.html .

[37] See the Energy Information Administration Illinois Profile and Historical Coal Production at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/il.htm .

[38] See http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/il4p1.html .

[39] See the definition of "Coal Producing Regions" at http://www.eia.doe.gov/glossary/glossary_c.htm

[40] See the Energy Information Administration State Coal Profile: Montana available at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/mt.htm .
[41] See Energy Information Administration State Coal Profile: Colorado available at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/co.htm .
[42] See Table 2 of "U.S. Coal Supply and Demand: 2007 Review," by the U.S. Energy Information Administration available from http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2 .
[43] See "Colorado Coal Directory, 2005," by Christopher J. Carroll, Colorado Geologic Survey, Information Series 71, Denver, Colorado (2005) available for purchase from http://dnr.state.co.us/geostore/ProductInfo.aspx?productid=IS-71 .
[44] See Energy Information Administration State Coal Profile: North Dakota available at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/nd.htm
[45] See https://www.dmr.nd.gov/ndgs/Mineral/nd_coal.asp .
[46] See Energy Administration State Profile: Utah available at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/ut.htm .
[47] See Table 2 of "U.S. Coal Supply and Demand: 2007 Review," by the U.S. Energy Information Administration available from http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2 .
[48] See http://www.sce.com/PowerandEnvironment/PowerGeneration/MohaveGenerationStation/
[49] See the Energy Information Administration State Coal Profile: Alaska available at http://www.eia.doe.gov/cneaf/coal/st_coal_pdf/0576e.pdf .
[50] See the Energy Information Administration State Coal Profile: Alaska available at http://www.eia.doe.gov/cneaf/coal/st_coal_pdf/0576e.pdf See also http://www.dnr.state.ak.us/mlw/mining/coal/index.htm .
[51] See the definition of "Coal Producing Regions" at http://www.eia.doe.gov/glossary/glossary_c.htm .
[52] See the definition of "Coal Producing Regions" at http://www.eia.doe.gov/glossary/glossary_c.htm .
[53] See Coal News and Market reports at http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html .
[54] A short ton is 2000 pounds as compared to a metric ton which equates to 2204 pounds or about 10% bigger. The British or "long" tonne is just a bit bigger than the metric ton at 2240 pounds.
[55] See Table 2 of "U.S. Coal Supply and Demand: 2007 Review," by the U.S. Energy Information Administration available from http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2
[56] See page 14 in the West Virginia Coal Association's 2006 Coal Facts report available at http://www.wvcoal.com/docs/coalfacts_07.pdf .
[57] See page 5 in "Kentucky Coal Facts—2007-2008 Pocket Guide" available at http://www.kentuckycoal.org/documents/CoalFacts08.pdf .
[58] Combined total for Kentucky fell from 120.8 million tons in 2006 to 115.0 million tons in 2007 according to Table 2 of "U.S. Coal Supply and Demand: 2007 Review," by the U.S. Energy Information Administration available from http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2
[59] See Energy Information Administration State Profile for Texas at http://www.eia.doe.gov/cneaf/coal/statepro/imagemap/tx.htm
[60] See the Coal and Market News Archive at http://www.eia.doe.gov/cneaf/coal/page/coalnews/cnmarchive.html
[61] See for example the discussions of railroad constraints in http://tonto.eia.doe.gov/FTPROOT/coal/newsmarket/coalmar050121.html and http://tonto.eia.doe.gov/FTPROOT/coal/newsmarket/coalmar050211.html .
[62] For example, see slide 25 of 30 in Xcel Energy presentation to MidWest Investor Meetings May 31 and June 1, 2005 at http://library.corporate-ir.net/library/89/894/89458/items/153806/xel_0605.pdf .
[63] Data from Attachment 42 to the Answer Testimony of Leslie Glustrom Docket 07A-447E at the Colorado Public Utilities Commission available from http://www.dora.state.co.us/PUC/DocketsDecisions/HighprofileDockets/07A-447E.htm .
[64] See the December 2008 Peabody Energy Presentation to the FBR Investor Conference available at http://www.peabodyenergy.com/pdfs/2008%20FBR%20Capital%20Markets%20Conference%20Final.pdf
[65] See the December 2008 Peabody Energy Presentation to the FBR Investor Conference available at http://www.peabodyenergy.com/pdfs/2008%20FBR%20Capital%20Markets%20Conference%20Final.pdf .
[66] See Table 2.08 at the EIA Coal Transportation Rate Database, April 2004 available at http://www.eia.doe.gov/cneaf/coal/page/trans/ratesntrends.html .

[67] See presentation on Geographic Information Systems by Glenn Harrison , Oak Ridge National Laboratory at http://www2.ku.edu/~kugis/gisday/2006/KU_GISDay2006_Harrison.pdf . The figure is taken from the Powerpoint presentation entitled "Hubbert's Peak, the Coal Question and Climate Change," of Professor Dave Rutledge, CalTech University available at http://rutledge.caltech.edu/.
[68] See Attachment 31 to the Answer Testimony of Leslie Glustrom in Docket 07A-447E at the Colorado Public Utilities Commission submitted April 28, 2008.
[69] See page 3 in David Wilks Testimony to the Committee on Energy and Natural Resources of the US Senate on May 25, 2006, available at http://www.cleanenergyaction.org/documents/coal_supplies/Exhibit%201-060525%20Testimony%20of%20David%20Wilks%20of%20Xcel%20Before%20US%20Senate.pdf
[70] See typical freight car dimensions at http://www.csx.com/?fuseaction=customers.search_car&n=Typical%20Boxcar%20Dimensions .
[71] See page 4 in David Wilks Testimony to the Committee on Energy and Natural Resources of the US Senate on May 25, 2006, available at http://www.cleanenergyaction.org/documents/coal_supplies/Exhibit%201-060525%20Testimony%20of%20David%20Wilks%20of%20Xcel%20Before%20US%20Senate.pdf .
[72] See page 6 in David Wilks Testimony to the Committee on Energy and Natural Resources of the US Senate on May 25, 2006, available at http://www.cleanenergyaction.org/documents/coal_supplies/Exhibit%201-060525%20Testimony%20of%20David%20Wilks%20of%20Xcel%20Before%20US%20Senate.pdf .
[73] See Exhibit 118 (Discovery Response RUC 2-10) in Docket 06S-234EG at the Colorado Public Utilities Commission.
[74] See "National Rail Freight Infrastructure Capacity and Investment Study," dated September 2007 available at http://www.aar.org/~/media/Files/National_CAP_Study_docs/natl_freight_capacity_study.ashx
[75] See pages ES-1 and ES-2 in the "National Rail Freight Infrastructure Capacity and Investment Study," dated September 2007 available at http://www.aar.org/~/media/Files/National_CAP_Study_docs/natl_freight_capacity_study.ashx .
[76] See page 5-5 in the "National Rail Freight Infrastructure Capacity and Investment Study," dated September 2007 available at http://www.aar.org/~/media/Files/National_CAP_Study_docs/natl_freight_capacity_study.ashx .
[77] See "Coal Proved Reserves at End 2007" in BP Statistical Review of World Energy June 2008 at http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/downloads/pdf/statistical_review_of_world_energy_full_review_2008.pdf .
[78] See page 4 of "Coal: Resources and Future Production," by the Energy Watch Group, March 2007 at http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf .
[79] Footnote to "Coal Proved Reserves at End 2007" in BP Statistical Review of World Energy June 2008 at http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/downloads/pdf/statistical_review_of_world_energy_full_review_2008.pdf
[80] "BP" was formerly known as "British Petroleum," but know uses the acronym to refer to "Beyond Petroleum." See a history of BP at http://www.bp.com/sectiongenericarticle.do?categoryId=9014445&contentId=7027526 and of BP's logo http://www.bp.com/sectiongenericarticle.do?categoryId=9014508&contentId=7027677 .
[81] See "Xcel Chief Touts Solar and Wind But a Long Future with Coal," *Colorado Biz Today,* October 1, 2008 available at http://www.cobizmag.com/articles.asp?id=2355 .
[82] See page 2-53 in Xcel's Colorado Resource Plan submitted November 15, 2007available at http://www.xcelenergy.com/Company/About_Energy_and_Rates/Resource%20and%20Renewable%20Energy%20Plans/Pages/2007_Colorado_Resource_Plan.aspx
[83] See page 8 in Jeff Goodell's Big Coal: The Dirty Secret Behind America's Energy Future, Houghton Mifflin (2006).
[84] Marius Campbell and Edward Parker presented a paper entitled, "The Coal Fields of the United States" at the February 1909 meeting of the American Institute of Mining Engineers in New Haven, Connecticut The paper can be found on pages 253-260 of the 1909 Transactions of the American Institute of Mining Engineers, Vol. XL which was published by the Institute in 1910. The 1909 Transactions have been

digitized by Google Books and is available online at http://books.google.com/books?id=HFQMAAAAYAAJ&pg=PA163&lpg=PA163&dq=marius+campbell+coall&source=web&ots=DCTAKlMxk8&sig=0XD9L46L2dQ0Mx1hFpLp0cVHLbY&hl=en&sa=X&oi=book_result&resnum=1&ct=result#PPA1,M1 . (Hereafter, "Campbell and Parker, 1909")

[85] Campbell and Parker, 1909, page 254
[86] Campbell and Parker, 1909, page 254
[87] Campbell and Parker, 1909, page 256
[88] Campbell and Parker, 1909, page 256
[89] Campbell and Parker, 1909, pages 254-258
[90] Campbell and Parker, 1909, page 258
[91] Campbell and Parker, 1909, page 258
[92] Campbell and Parker, 1909, page 258
[93] Campbell and Parker, 1909, page 259
[94] See the Association for the Study of Peak Oil and Gas website at http://www.peakoil.net/, the discussion of "Peak Coal" in "Coal: Resources and Future Production," from the Energy Watch Group and available from http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf and Richard Heinberg's Peak Everything: Waking Up to the Century of Declines, New Society Publishers, 2007.
[95] Averitt, Paul, 1975, "Coal resources of the United States, January 1, 1974,"U.S. Geological Survey Bulletin 1412, 131 p. While this study does not appear to be on line, it is likely to be available in University libraries or may be purchased from booksellers through an online search.
[96] See Averitt, 1975, page 1.
[97] See definition of Demonstrated Reserve Base at http://www.eia.doe.gov/glossary/glossary_d.htm
[98] See definition of Estimated Recoverable Reserves under "Recoverable Reserves" at http://www.eia.doe.gov/glossary/glossary_r.htm
[99] EIA data on coal is available at http://www.eia.doe.gov/fuelcoal.html . Data on Estimated Recoverable Reserves is available in Table 15 of the Annual Coal Report. The Annual Coal Report is at http://www.eia.doe.gov/cneaf/coal/page/acr/acr_sum.html while Table 15 is at http://www.eia.doe.gov/cneaf/coal/page/acr/table15.html .
[100] See the footnote on Table 15 at http://www.eia.doe.gov/cneaf/coal/page/acr/table15.html .
[101] See "EIA Coal Reserves Data-1997" at http://www.eia.doe.gov/cneaf/coal/reserves/chapter1.html
[102] See page 1 of EIA Coal Reserves Data 1997 at http://www.eia.doe.gov/cneaf/coal/reserves/chapter1.html
[103] See page 1 of EIA Coal Reserves Data 1997 at http://www.eia.doe.gov/cneaf/coal/reserves/chapter1.html
[104] Averitt, Paul, 1975, "Coal resources of the United States, January 1, 1974,"U.S. Geological Survey Bulletin 1412, 131 p. While this study does not appear to be on line, it is likely to be available in University libraries or may be purchased from booksellers through an online search.
[105] Several National Coal Resource Assessment studies are available at http://energy.er.usgs.gov/coal_quality/coal_quality_pubs_data.html .
[106] See US Bureau of Mines Circular 9368 at http://pubs.usgs.gov/usbmic/ic-9368/intro.htm .
[107] See US Bureau of Mines Circular 9368 at http://pubs.usgs.gov/usbmic/ic-9368/intro.htm .
[108] See page A-4 of USGS Professional Paper 1625-C at http://pubs.usgs.gov/pp/p1625c/CHAPTER_A/CHAPTER_A.pdf .
[109] See the Abstract of USGS Professional Paper 1625-C, Chapter J, available at http://pubs.usgs.gov/pp/p1625c/CHAPTER_J/CHAPTER_J.pdf .

[110] Quote from Wyoming Secretary of State Fenimore Chatterton is quoted on page 4 in Jeff Goodell's Big Coal: The Dirty Secret Behind America's Energy Future, Houghton Mifflin (2006).The Chatterton quote is also used in "2 Industry Leaders Bet on Coal but Split on Cleaner Approach," New York Times, May 28, 2006 available at http://www.nytimes.com/2006/05/28/business/28coal.html .

[111] See "Arctic Sea Ice Decline: Faster Than Forecast," Julienne Stroeve et al., *Geophysical Research Letters,* Volume 34, L09501, May 1, 2007, "Arctic Sea Ice Extent Plummets in 2007," Julienne Stroeve et al., *EOS Transactions of the American Geophysical Union,* Volume 89, pages 13-14, January 8, 2008, and "Arctic Sea Ice Down to Second-Lowest Extent; Likely Record-Low Volume ," Press Release from the

National Snow and Ice Data Center, October 2, 2008 available at http://nsidc.org/news/press/20081002_seaice_pressrelease.html
[112] See EIA Annual Energy Outlook for coal at http://www.eia.doe.gov/oiaf/aeo/pdf/trend_5.pdf
[113] The USGS has taken Open File Report 2002-0180 off of its website, but the report is available at *http://www.cleanenergyaction.org/documents/coal_supplies/USGS_PowderRiver_supplies02-180%202002.pdf* . The full cite for the report is USGS ***2002OFR2002-180 "Evaluation of economically extractable coal resources in the Gillette Coal Field, Powder River Basin, Wyoming*** " Ellis, Margaret S.; Molnia, Carol L.; Osmonson, Lee M.; Ochs, Allan M.; Rohrbacher, Timothy J.; Mercier, Tracy; Roberts, Laura N. R. The website http://pubs.usgs.gov/of/2002/ofr-02-0180/ states, "This report is presently being revised. The revised version will be made available as soon as possible, at this same URL."
[114] See page 1 in Luppens, J. A., Scott, D. C., Haacke, J. E., Osmonson, L. M., Rohrbacher, T. J., and Ellis, M. S., 2008, Assessment of Coal Geology, Resources, and Reserves in the Gillette Coalfield, Powder River Basin, Wyoming: U.S. Geological Survey Open-File Report 2008-1202, 127 p. available at http://pubs.usgs.gov/of/2008/1202/ . In 2007, Wyoming produced about 39 % of the country's coal according to Table 2 in "U.S. Coal Supply and Demand: 2007 Review" by Fred Freme, U.S. Energy Information Administration available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html#t2 .
[115] See page 5 of USGS 2002-0180 available at ***http://www.cleanenergyaction.org/documents/coal_supplies/USGS_PowderRiver_supplies02-180%202002.pdf***
[116] See page 40 of USGS 2002-0180 available at ***http://www.cleanenergyaction.org/documents/coal_supplies/USGS_PowderRiver_supplies02-180%202002.pdf***
[117] See pages 40-41 of USGS 2002-0180 available at ***http://www.cleanenergyaction.org/documents/coal_supplies/USGS_PowderRiver_supplies02-180%202002.pdf***
[118] See page 43 of USGS 2002-0180 available at ***http://www.cleanenergyaction.org/documents/coal_supplies/USGS_PowderRiver_supplies02-180%202002.pdf***
[119] Luppens, J. A., Scott, D. C., Haacke, J. E., Osmonson, L. M., Rohrbacher, T. J., and Ellis, M. S., 2008, Assessment of Coal Geology, Resources, and Reserves in the Gillette Coalfield, Powder River Basin, Wyoming: U.S. Geological Survey Open-File Report 2008-1202, 127 p. available at http://pubs.usgs.gov/of/2008/1202/ .
[120] See Abstract of USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202/ .
[121] In 2007, Wyoming produced about 454 million tons. Assuming this all came from the Gillette coal field, then 10.1 billion tons would last about 22 years at that rate of production.
[122] USGS 2008-1202 is not available for purchase according to a personal communication with USGS lead author Jim Luppens, November 14, 2008.
[123] See the discussion of Figure 66 on page 30, as well as the background on pages 27-29 of USGS 2008-1202 found at http://pubs.usgs.gov/of/2008/1202/ .
[124] USGS 2008-1202 assessing coal resources and reserves in the Gillette coal field of the Powder River Basin of Wyoming can be found at http://pubs.usgs.gov/of/2008/1202/.
[125] See pages 28, 30 and 32 in USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202/ discussing the fact that Figure 66 assumes that production costs remain constant while sales prices change.
[126] See page 32 in USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202/ .
[127] See page 31 in USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202/ .
[128] For the 2002 estimate of 23 billion short tons of economically recoverable coal in the Gillette coal field see page 43 in USGS Open File Report 2002-0180 available at *http://www.cleanenergyaction.org/documents/coal_supplies/USGS_PowderRiver_supplies02-180%202002.pdf* .
[129] See figure 67 in USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202/.
[130] See Table 10 in USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202/
[131] See pages 87-90 of Averitt, Paul, 1975, "Coal resources of the United States, January 1, 1974,"U.S. Geological Survey Bulletin 1412. While this study does not appear to be available on line, it may be found in University libraries or may be purchased from booksellers from an online search.
[132] Personal communication with Jim Luppens, Project Chief, US Coal Assessment, United States Geological Survey, November 25, 2008.
[133] See pages 23-25 in USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202/ for a discussion of the CoalVal model for mining costs.

[134] Personal communication with Jim Luppens, Project Chief, US Coal Assessment, United States Geological Survey November 2008.
[135] See page 43 of USGS 2002-0180 available at ***http://www.cleanenergyaction.org/documents/coal_supplies/USGS_PowderRiver_supplies02-180%202002.pdf***
[136] See the Abstract and Figure 67 in USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202/ .
[137] See page 87 in Averitt, Paul, 1975, "Coal resources of the United States, January 1, 1974,"U.S. Geological Survey Bulletin 1412. While this study does not appear to be on line, it is likely to be available in University libraries or may be purchased from booksellers through an online search.
[138] See page 89 in Averitt, Paul, 1975, "Coal resources of the United States, January 1, 1974,"U.S. Geological Survey Bulletin 1412. While this study does not appear to be on line, it is likely to be available in University libraries or may be purchased from booksellers through an online search.
[139] See page ES-7 in Final Environmental Impact Statement for the West Hay Creek coal Lease Application available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/whay.html
[140] See page ES-7 in Final Environmental Impact Statement for the West Hay Creek coal Lease Application available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/whay.html
[141] See page ES-7 in Final Environmental Impact Statement for the West Hay Creek coal Lease Application available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/whay.html
[142] See 2004 mine production permitted capacities for Powder River Basin mines at http://www.blm.gov/wy/st/en/programs/energy/Coal_Resources/PRB_Coal/deq_aqd.html.
[143] Personal communication, Mike Karbs, Bureau of Land Management, Casper, Wyoming
[144] See page ES-9 in Final Environmental Impact Statement for the Eagle Butte West Coal Lease Application available from the Casper office of the Wyoming Bureau of Land Management or at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/cfodocs/eaglebuttewestcoal/feis.Par.79934.File.dat/02abst-exsumm.pdf .
[145] See page ES-9 in Final Environmental Impact Statement for the Eagle Butte West Coal Lease Application available from the Casper office of the Wyoming Bureau of Land Management or at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/cfodocs/eaglebuttewestcoal/feis.Par.79934.File.dat/02abst-exsumm.pdf .
[146] See page ES-9 and ES-10 in Final Environmental Impact Statement for the Eagle Butte West Coal Lease Application available from the Casper office of the Wyoming Bureau of Land Management or at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/cfodocs/eaglebuttewestcoal/feis.Par.79934.File.dat/02abst-exsumm.pdf
[147] See 2004 mine production permitted capacities for Powder River Basin mines at http://www.blm.gov/wy/st/en/programs/energy/Coal_Resources/PRB_Coal/deq_aqd.html.
[148] Personal communication, Mike Karbs, Bureau of Land Management, Casper, Wyoming
[149] See 2004 mine production permitted capacities for Powder River Basin mines at http://www.blm.gov/wy/st/en/programs/energy/Coal_Resources/PRB_Coal/deq_aqd.html
[150] Personal communication, Mike Karbs, Bureau of Land Management, Casper, Wyoming
[151] See page ES-15 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[152]See page ES-15 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[153] See page ES-15 and ES-16 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[154] See page ES-11 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[155] See page ES-11 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html

[156] See page ES-11 and ES-12 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[157] See page ES-16 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[158] See page ES-16 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[159] See page ES-16 and ES-17 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[160] See page ES-13 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[161] See page ES-13 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[162] See page ES-13 in "Draft Environmental Impact Statement for the South Gillette Area Coal Lease Applications," available from the Bureau of Land Management, Casper, Wyoming office or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/south_gillette.html
[163] See 72 Federal Register 36476-36478 "Notice of Intent to Prepare an Environmental Impact Statement (EIS) and Notice of Public Meeting on Four Federal Coal Lease Applications in the Decertified Powder River Federal Coal Production Region, WY" (July 3, 2007) at page 36477.
[164] Private communication with Sarah Bucklin, Bureau of Land Management, Casper, Wyoming, November 2008
[165] See 72 Federal Register 36476-36478 "Notice of Intent to Prepare an Environmental Impact Statement (EIS) and Notice of Public Meeting on Four Federal Coal Lease Applications in the Decertified Powder River Federal Coal Production Region, WY" (July 3, 2007) at page 36477.
[166] See 72 Federal Register 36476-36478 "Notice of Intent to Prepare an Environmental Impact Statement (EIS) and Notice of Public Meeting on Four Federal Coal Lease Applications in the Decertified Powder River Federal Coal Production Region, WY" (July 3, 2007) at page 36477.
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[168] See 72 Federal Register 36476-36478 "Notice of Intent to Prepare an Environmental Impact Statement (EIS) and Notice of Public Meeting on Four Federal Coal Lease Applications in the Decertified Powder River Federal Coal Production Region, WY" (July 3, 2007) at page 36477.
[169] See 72 Federal Register 36476-36478 "Notice of Intent to Prepare an Environmental Impact Statement (EIS) and Notice of Public Meeting on Four Federal Coal Lease Applications in the Decertified Powder River Federal Coal Production Region, WY" (July 3, 2007) at page 36478.
[170] Private communication with Sarah Bucklin, Bureau of Land Management, Casper, Wyoming, November 2008
[171] See 72 Federal Register 36476-36478 "Notice of Intent to Prepare an Environmental Impact Statement (EIS) and Notice of Public Meeting on Four Federal Coal Lease Applications in the Decertified Powder River Federal Coal Production Region, WY" (July 3, 2007) at page 36478.
[172] See page ES-7, "Final Environmental Impact Statement for the West Antelope II Coal Lease Application," available from the Bureau of Land Management, Casper, Wyoming or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/West_Antelope_II.html
[173] See page ES-7, "Final Environmental Impact Statement for the West Antelope II Coal Lease Application," available from the Bureau of Land Management, Casper, Wyoming or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/West_Antelope_II.html
[174] See page ES-7 and ES-8, "Final Environmental Impact Statement for the West Antelope II Coal Lease Application," available from the Bureau of Land Management, Casper, Wyoming or at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/West_Antelope_II.html

[175] Appalachian states are as defined by the Energy Information Administration. See for example Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html .
[176] See for example, Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html .
[177] See Table 15 "Recoverable Coal Reserves at Producing Mines, Estimated Recoverable Reserves, and Demonstrated Reserve Base by Mining Method," Energy Information Administration 2007 Annual Coal Report at http://www.eia.doe.gov/cneaf/coal/page/acr/table15.html .
[178] See for example, Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html .
[179] See for example, Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html
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[181] Interior coal states are as defined by the Energy Information Administration. See for example Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html .
[182] See for example, Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html .
[183] See Table 15 "Recoverable Coal Reserves at Producing Mines, Estimated Recoverable Reserves, and Demonstrated Reserve Base by Mining Method," Energy Information Administration 2007 Annual Coal Report at http://www.eia.doe.gov/cneaf/coal/page/acr/table15.html .
[184] See for example, Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html .
[185] See for example, Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html
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[188] See for example, Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html .
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[190] See for example, Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html .
[191] See for example, Table 2 on page 5 of 15 in "U.S. Coal Supply and Demand: 2007 Review," available at http://www.eia.doe.gov/cneaf/coal/page/special/feature.html
[192] See Table 15 "Recoverable Coal Reserves at Producing Mines, Estimated Recoverable Reserves, and Demonstrated Reserve Base by Mining Method," Energy Information Administration 2007 Annual Coal Report at http://www.eia.doe.gov/cneaf/coal/page/acr/table15.html .
[193] See "Colorado Coal Directory, 2005" by Christopher J. Carroll, Colorado Geologic Survey, Department of Natural Resources as part of Information Series 71 available at http://dnr.state.co.us/geostore/ProductInfo.aspx?productid=IS-71 .
[194] See "Colorado Coal Directory, 2005" by Christopher J. Carroll, Colorado Geologic Survey, Department of Natural Resources as part of Information Series 71 available at http://dnr.state.co.us/geostore/ProductInfo.aspx?productid=IS-71 .
[195] Personal communication with Jim Luppens, U.S. Coal Assessment, United States Geological Survey November 2008
[196]The eight page summary of the "Can Coal Deliver?" report is available at http://www.globalenergy.com/BR06/BR06_Can_Coal_Deliver.pdf

[197] Colorado based Clean Energy Action purchased a copy of the approximately 200 page Executive Summary of the report from Global Energy Decisions and has a single paper copy of the report. Copies of the report can not be provided without the written consent of Global Energy Decisions, which is now part of Ventyx http://www1.ventyx.com/index.asp .
[198] Permission to use the coal delivery diagram was granted by Ms. Mary Boyd of Ventyx in an e-mail to Leslie Glustrom dated November 11, 2008.
[199] See page 4 of 47 in the Energy Watch Group report "Coal: Resources and Future Production," available at http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf .
[200] See page 10 of 47 in the Energy Watch Group report "Coal: Resources and Future Production," available at http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf .
[201] See page 30 of 47 in the Energy Watch Group report "Coal: Resources and Future Production," available at http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf .
[202] See Coal: Research and Development to Support National Energy Policy, National Academies Press, Washington, DC (2007) ISBN 978-0-309-11022-8 Available for free download at www.nap.edu with the direct link being http://www.nap.edu/catalog.php?record_id=11977 .
[203] See page 44 in Coal: Research and Development to Support National Energy Policy, National Academies Press, Washington, DC (2007) ISBN 978-0-309-11022-8 Available for free download at www.nap.edu with the direct link being http://www.nap.edu/catalog.php?record_id=11977 .
[204] See "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development," issued in Compliance with the Energy Policy Act of 2005, P.L. 109-58 §437 available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf .
[205] See pages v and vi in "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development," issued in Compliance with the Energy Policy Act of 2005, P.L. 109-58 §437 available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf .
[206] See page vi in "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development," issued in Compliance with the Energy Policy Act of 2005, P.L. 109-58 §437 available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf .
[207] See page vi in "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development," issued in Compliance with the Energy Policy Act of 2005, P.L. 109-58 §437 available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf .
[208] See page viii and Table ES-2 on page x in "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development," issued in Compliance with the Energy Policy Act of 2005, P.L. 109-58 §437 available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf .
[209] See pages ix, 25 and 33 in "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development," issued in Compliance with the Energy Policy Act of 2005, P.L. 109-58 §437 available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf .
[210] See page ix, 25 and 33 in in "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development," issued in Compliance with the Energy Policy Act of 2005, P.L. 109-58 §437 available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf .
[211] See http://www.wsgs.uwyo.edu/coalweb/swamp/swamps.aspx .
[212] See page 3-8 in "Final Environmental Impact Statement for the West Antelope II Coal Lease Application WYW 163340" Bureau of Land Management, Wyoming State Office-Casper Field Office available at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/West_Antelope_II.html
[213] See page 3-8 in "Final Environmental Impact Statement for the West Antelope II Coal Lease Application WYW 163340" Bureau of Land Management, Wyoming State Office-Casper Field Office available at http://www.blm.gov/wy/st/en/info/NEPA/cfodocs/West_Antelope_II.html
[214] See "Hubbert's Peak, the Coal Question and Climate Change," Powerpoint and Excel workbooks posted at http://rutledge.caltech.edu/ .
[215] See the Energy Watch Group report "Coal: Resources and Future Production," available at http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf .
[216] See "Hubbert's Peak, the Coal Question and Climate Change," Powerpoint and Excel workbooks posted at http://rutledge.caltech.edu/ .

[217] See page 32 in the BP Statistical Review of World Energy June 2008 available at http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/downloads/pdf/statistical_review_of_world_energy_full_review_2008.pdf .

[218] See the Energy Watch Group report "Coal: Resources and Future Production," available at http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf .

[219] See Peabody Energy Corporation's Securities and Exchange Commission ("SEC") 8-K report filed on July 23, 2008 available at http://phx.corporate-ir.net/phoenix.zhtml?c=129849&p=irol-sec&secCat01.2_rs=31&secCat01.2_rc=10

[220] See slide 9 in the Peabody Presentation to Investors at http://www.peabodyenergy.com/pdfs/2008%20FBR%20Capital%20Markets%20Conference%20Final.pdf .