

# Consensus Coal Production Forecast for West Virginia 2009-2030

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Protection  
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## Executive Summary

West Virginia's coal production rebounded from 139.7 million tons in 2003 to 158.0 million tons in 2008. This recent trend of coal production growth in the state will not continue into 2009. According to data currently published by the Energy Information Administration (EIA), coal production in the state is down 7.8 percent through the first six months of 2009 compared to 2008. The fall in production in 2009 follows the dramatic decrease in spot prices and the decrease in demand for electricity as a result of the current economic recession. West Virginia coal mining jobs have increased from about 15,000 in 2000 to more than 21,000 by September 2008.

The updated consensus coal production forecast described in this report calls for state production to decline by 11.3 percent in 2009 to 140.2 million tons. During the 2010-2014 period, state coal production gradually increases to the 150 million ton level, as electric power plants respond to tighter emission restrictions (SO<sub>2</sub> and NO<sub>x</sub> restrictions under the Clean Air Interstate Rule (CAIR)) through massive investment in scrubbing capacity. These investments are expected to increase the demand for higher-sulfur coals produced in the northern part of the state. This growth in coal production is expected to end by 2015 with production gradually decreasing to 130.2 million tons by 2030.

The updated forecast calls for significantly less coal production in the state than envisioned in the consensus forecast produced in 2006, primarily from the decreased demand as a result of the current national recession. The updated consensus forecast reflects the improved state coal production observed during the last two years as demand and prices increased. It also reflects dramatically lower growth in real GDP as the recession was not included the base cases in 2006 and has been much more severe than expected. The updated consensus coal forecast also includes the effects of the American Recovery and Reinvestment Act (ARRA) that was designed to increase investment in energy efficiency and renewable energy.

Risks to the updated coal production forecast include continued risks to U.S. and world economic growth. If the economic recession continues or recovers slower than expected, this will further reduce the demand for energy and thus the demand for coal. Further, coal faces competition from other sources, namely natural gas, and increasingly renewable. Of course the largest risks to the forecast are from the numerous environmental and regulatory uncertainties that exist. The continued issues regarding 404 mine permits and the delays that have occurred in getting these permits approved have the potential to limit coal production (and may already have), especially in the southern part of the state. The various environmental regulations that may be imposed on coal mining or the use of coal, including the currently proposed cap and trade on CO<sub>2</sub> emissions, would have a large negative effect on coal production.

There are possible upside risks to the forecast as well. Advanced coal technologies that address environmental concerns have the potential to increase production above the forecast provided. Three coal-to-liquids (CTL) plants have been proposed in West Virginia, two of these plants are

still moving forward with their plans. If these plants come online, this would increase the demand for West Virginia coal and could spur production above currently forecasted levels.

This report proceeds as follows: the Recent Developments section describes in more detail updated trends in coal production, prices, employment, and productivity; the updated consensus coal production forecast for West Virginia is summarized next; followed by an update risks section. Appendix I contains the details of the construction of the consensus forecast and Appendix II summarizes each of the updated component forecasts individually.

## **Recent Developments**

with Hossein Radmard, Graduate Research Assistant

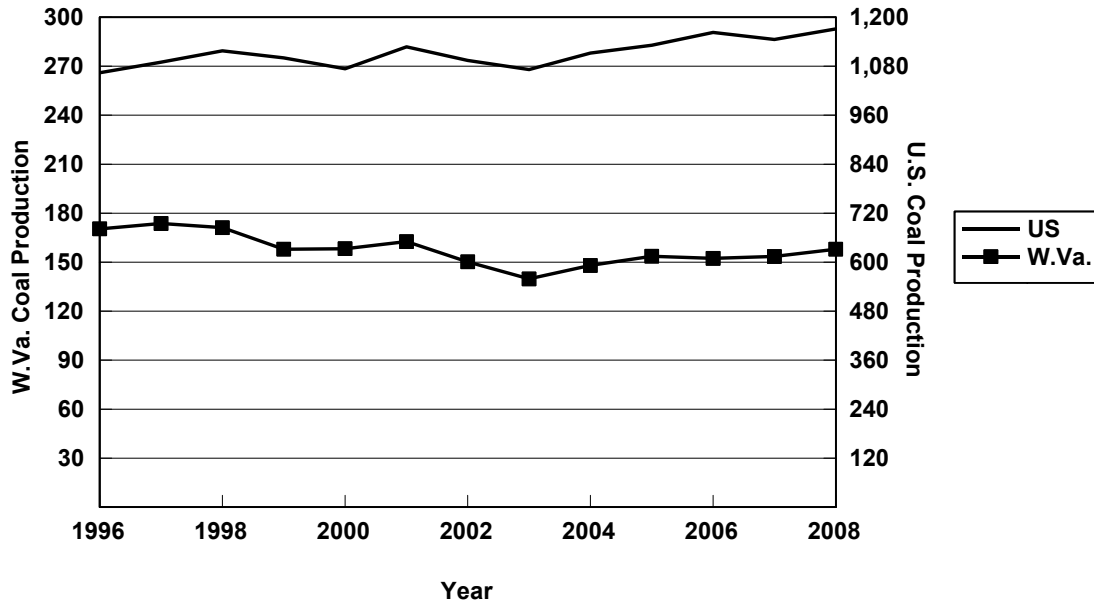
### **Coal Production**

National coal production reached a new high in 2008 at 1,171 million tons, up 2.2 percent from 2007. Since 1996, when national production was 1,064 million tons, coal production has increased an average of 0.8 percent annually. The growth in coal production during this time was due to strong growth in western coal production (2.6 percent average annual rate) and declines in eastern coal production (-1.1 percent average annual rate). While historically coal production has been dominated by eastern producers, production from western coal producers surpassed production from eastern coal producers in 1999. In 2008, coal produced west of the Mississippi accounted for 58 percent of total U.S. production.

West Virginia coal production peaked in 1997 at 173.7 million tons. From 1997 to 2003, production in West Virginia declined an average of 3.6 percent per year, reaching a low in 2003 with 139.8 million tons produced. Since 2003, coal production in the state has increased an average of 2.5 percent. Coal production in the state increased 2.9 percent in 2008 to 158.0 million tons (Figure 1).

West Virginia's share of U.S coal production, while down from the 15.6 percent average in the 1990s, has increase the last two years. West Virginia coal producers accounted for 13.5 percent of total U.S. production in 2008.

**Figure 1**  
**Annual Coal Production**  
**W.Va. and U.S.**  
(Million Short Tons)

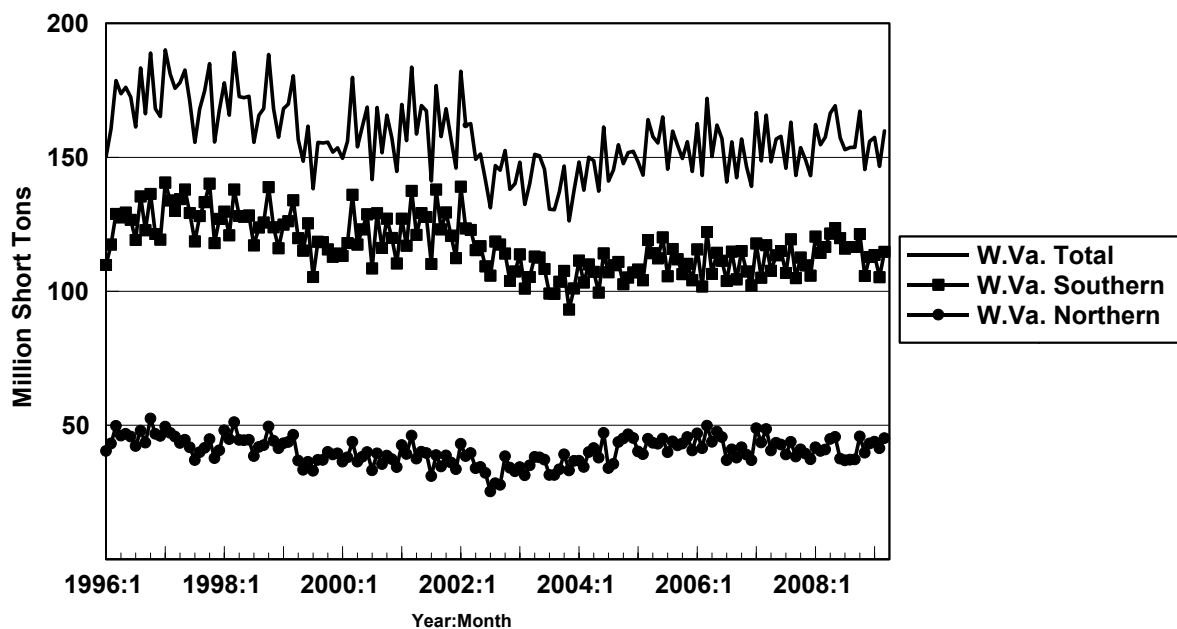


Source: Energy Information Administration

West Virginia coal production is often divided into two regions – northern West Virginia and southern West Virginia. It is useful to look at trends for the regions since the Energy Information Administration (EIA), the major source of energy data for the U.S., places northern West Virginia in the northern Appalachia region and southern West Virginia in the central Appalachia region. In addition, the coal and associated mines in these two areas vary greatly and can be affected differently by market conditions and regulations.

Figure 2 shows the monthly coal production for northern West Virginia and southern West Virginia, as well as for total state production, from January 1996 through March 2009. Southern West Virginia’s share of total state production, after reaching 77.3 percent of total state production in 2002, was 74.1 percent in 2008. While preliminary data for 2009 shows that southern West Virginia’s share of total state production has declined to 71.7 percent, production changes in this region continue to dominate total state production.

**Figure 2**  
**W.Va. Monthly Coal Production by Region**  
 (Non-seasonally Adjusted, Annualized in Million Tons)



Source: Energy Information Administration

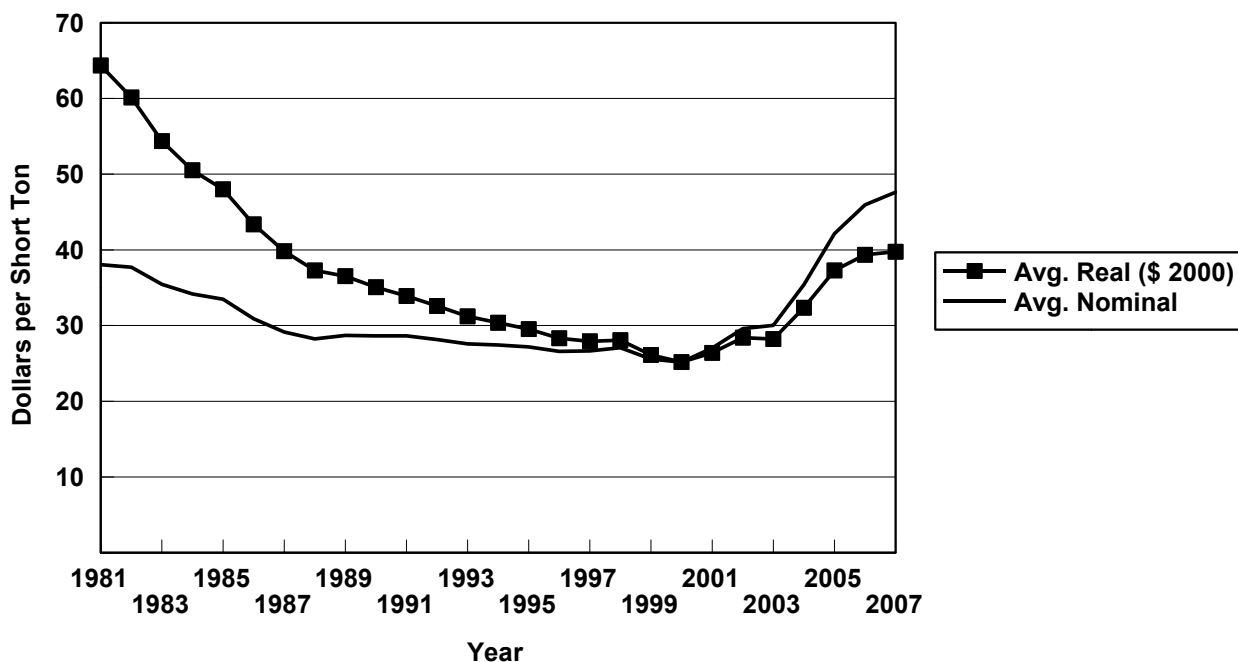
### Coal Prices

The average mine price of West Virginia coal rebounded significantly after 2000. Before then, there had been a constant decline in the price. In 1981, the average mine price was \$38.05 per short ton while in 2000 the average mine price was \$25.17 per short ton, as illustrated in the figure3. Nominal prices reached \$47.63 in 2007, nearly double the price in 2000. Based on EIA definitions, the mine price is the price available to the open market, consumers and companies, excluding the cost of foresight, shipping, and insurance. As Figure 3 shows, the real price of West Virginia coal (adjusted for inflation) reached nearly \$40 per ton in 2007, higher than any year in the past two decades.



**Figure 3**  
**Average Mine Price of W.Va. Coal**

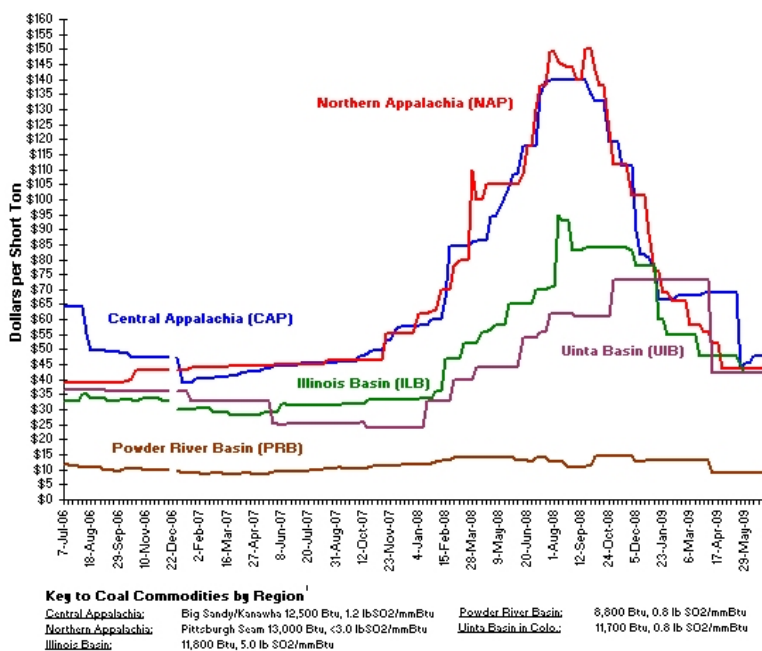
(Nominal and Real Dollars per Short Ton)



Source: Energy Information Administration  
 Bureau of Economic Analysis

Figure 4 shows monthly coal spot prices for the Central and Northern Appalachian regions since July 2006. The spot price for coal in the Central Appalachian region, which includes southern West Virginia, shows a drastic increase from \$65 per ton in July 2006 to \$140 per ton in September 2008. Spot prices fell sharply since then to \$50 per ton in recent days. The spot price for Northern Appalachian coal also saw a dramatic increase in 2007 and 2008, peaking at \$150 per ton before falling to \$45 per ton.

**Figure 4**  
**Average Weekly Coal Commodity Spot Prices**  
**Business Week Ended March 29, 2009**



Source: Energy Information Administration

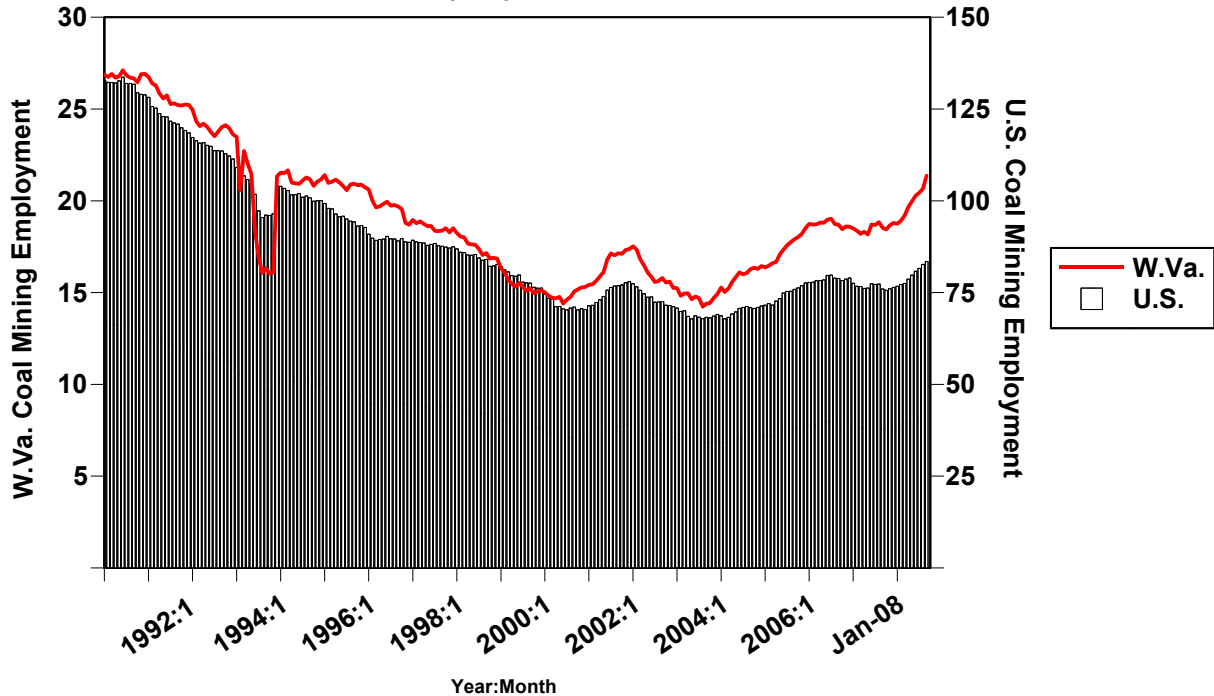
EIA continues to attribute the spike in coal prices to a large number of factors, including the influence of regulatory issues (and associated permitting delays) related to mountaintop removal/valley fill techniques, the diminishing of readily mineable reserves, temporary mine closure due to fires, accidents, and safety issues, diminishing rail capacity to handle western coal, higher natural gas prices, rising gasoline prices, international factors like falling value of the U.S. dollar(which makes U.S. exports more competitive), and strong international demand (as China devotes its coal resources to internal use).

### Coal Mining Employment

As illustrated in Figure 5, West Virginia coal mining employment declined significantly through the 1990's. A drop of 11,883 employees can be seen from 26,808 in 1990 to 14,925 in 2000. After 2000 until recent years coal mining employment in West Virginia has been cycling between 15,000 and 21,000 with an upward trend in last four years. The average employment in 2007 was 18,518. West Virginia coal mining employment was 21,369 as of September 2008.

## Figure 5 Coal Mining Employment W.Va. and U.S.

(Non-seasonally Adjusted, In Thousands)



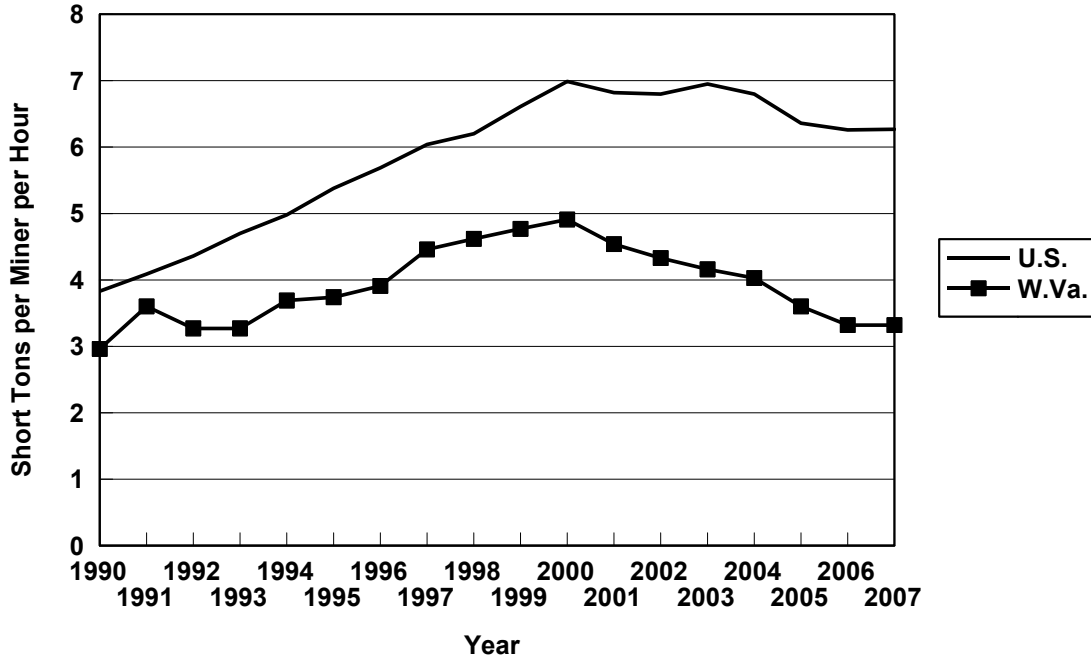
Source: Bureau of Labor Statistics

### Coal Productivity

EIA defines coal productivity as the number of short tons of coal per miner per hour. By this definition, as Figure 6 illustrates, national annual productivity in coal mining has increased from 4 tons per miner per hour in 1990 to 7 tons per miner per hour in 2000. Since 2000, national productivity has gradually declined to 6.3 tons per miner per hour. West Virginia coal mining productivity also increased through the 1990s reaching 4.9 tons per miner per hour in 2000 before falling to 3.3 tons per miner per hour for 2006 and 2007.

## Figure 6 Annual Productivity W.Va. and U.S.

(Short Tons of Coal per Miner per Hour)

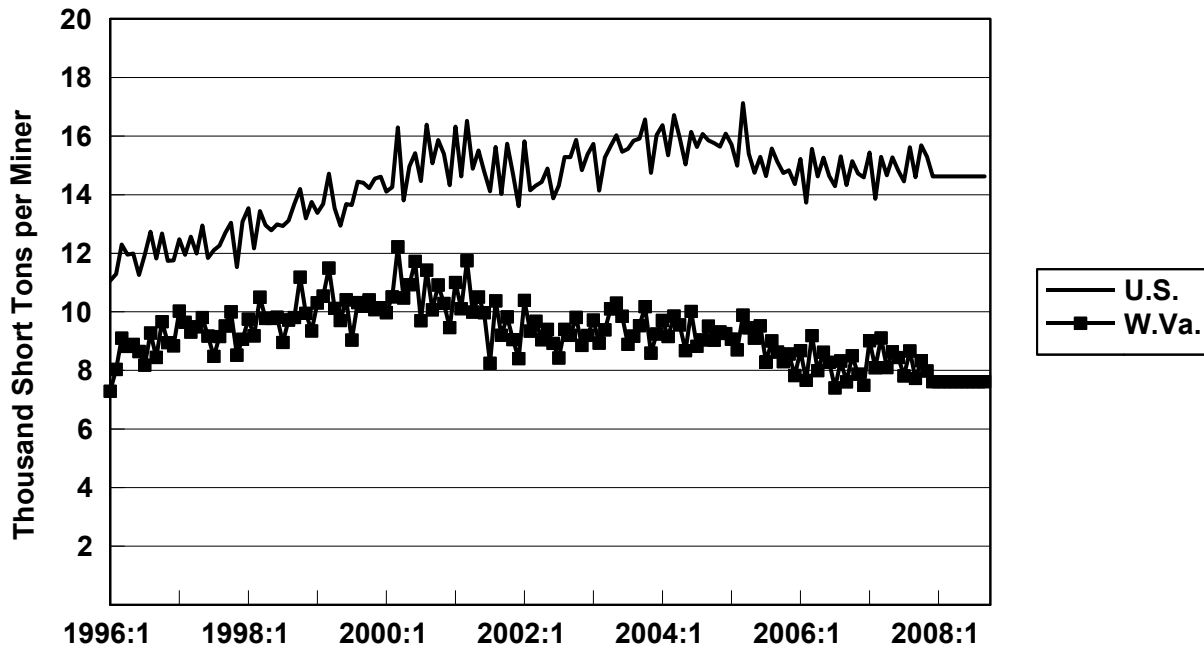


Source: Energy Information Administration

Figure 7 shows monthly coal productivity for West Virginia and the U.S. measured in short tons per miner (not per hour). The monthly productivity for West Virginia peaked in March 2000 at over 12 thousand tons per miner. Since that time productivity has decreased, falling to 7.6 thousand tons per miner by the end of 2008, the same level as in 1996. As easily mineable reserves are depleted, this trend is expected to continue.

# Figure 7 Monthly Productivity W.Va. and U.S.

(Coal Production Annualized in Thousand Short Tons per Miner)



Source: Energy Information Administration  
Bureau of Labor Statistics

## **Consensus Coal Production Forecast for West Virginia**

The updated consensus coal production forecast for the state was constructed by computing a weighted average of four forecasts of coal production growth rates from three forecast providers. The weights used to compute the weighted average were derived from an updated analysis of relative forecast accuracy. See Appendix I for a detailed explanation of the forecast evaluation procedure and the weights used to combine the forecasts.

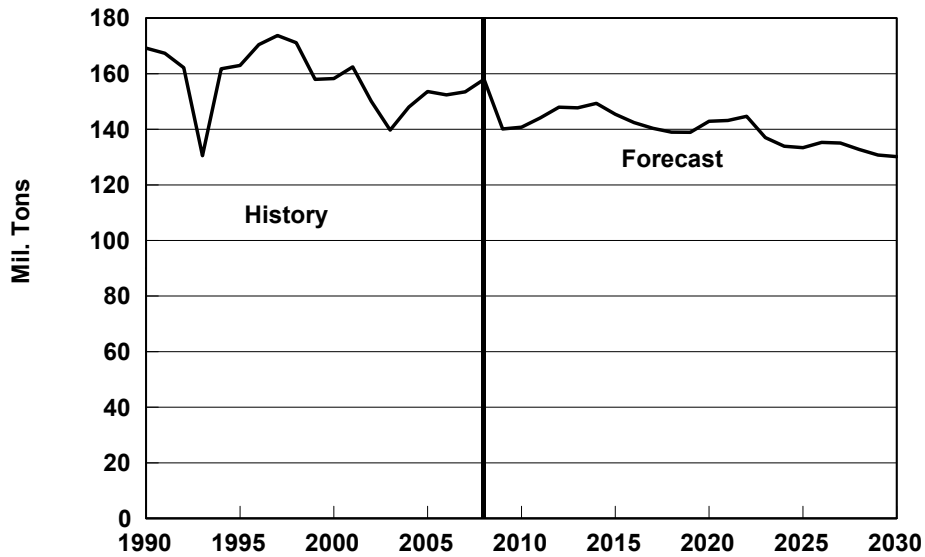
The individual forecasts used to compute the consensus forecast come from the Energy Information Administration (2 forecasts), Wood Mackenzie, and the Bureau of Business and Economic Research at West Virginia University. See Appendix II for summaries of each individual forecast.

Forecasts were chosen to include a wide variety of modeling strategies and forecasts. These forecasts vary from a short-run forecast (five years ahead) designed to capture business cycle influences on state coal production to long-run forecasts derived from firm-level modeling exercises. The forecasts were produced between November 2008 and May 2009.

The updated consensus forecast, summarized in Figure 8 and Table 1, calls for West Virginia coal production to drop sharply from the 158 million tons produced in 2008 to just over 140 million tons in 2009, an 11.3 percent decrease in production. Coal production in the state is 7.8 percent lower in the first six months of 2009 as compared to the first six months of 2008, indicating the production declines will be more severe in the second half of this year. Production gradually recovers over the next 5 years as the economy comes out of the current recession and begins what most expect to be a slow recovery. Production is forecast to peak in 2014 at 149.3 million tons before gradually falling to 130.2 million tons by 2030.

While statewide production is forecast to increase from 2010 to 2014 before declining, the effects are expected to vary widely between northern and southern West Virginia. There are many emission restrictions that may be imposed and some of these will affect southern West Virginia coal production more severely. The Clean Air Interstate Rule (CAIR) Phase I NO<sub>x</sub> caps become effective in 2009, while Phase I caps for SO<sub>2</sub> become effective in 2010. More stringent Phase II limits for both become effective in 2015. The Clean Air Mercury Rule (CAMR) was vacated by the courts in February 2008, but numerous states have their own mercury mitigation laws in place and several states are planning to enact new laws or are going to modify their existing laws since the CAMR has not been enacted. As coal-fired power plants install flue gas desulfurization (FGD) equipment, demand for higher sulfur coals produced in the northern part of the state increases. The depletion of low-cost reserves in the southern part of the state leads to increased mining costs that can make the southern West Virginia too expensive for the market.

**Figure 8**  
**W.Va. Consensus Forecast**  
**Coal Production**



**Table 1**  
**W.Va. Coal Production**  
**Consensus Forecast**  
**(Millions of Tons)**

Actual							
	2003	2004	2005	2006	2007	2008	Ann.Gr.(%)
<b>W.Va. Coal Production</b>	139.7	148.0	153.7	152.4	153.5	158.0	2.5
Forecast							
	2009	2010	2011	2012	2013	2014	Ann.Gr.(%)
<b>W.Va. Coal Production</b>	140.2	140.8	144.1	148.0	147.7	149.3	1.3
Forecast							
	2015	2016	2017	2018	2019	2020	Ann.Gr.(%)
<b>W.Va. Coal Production</b>	145.4	142.4	140.3	139.0	138.9	142.9	-0.4
Forecast							
	2021	2022	2023	2024	2025	2026	Ann.Gr.(%)
<b>W.Va. Coal Production</b>	143.2	144.7	137.0	133.9	133.4	135.3	-1.1
Forecast							
	2027	2028	2029	2030			Ann.Gr.(%)
<b>W.Va. Coal Production</b>	135.0	132.8	130.7	130.2			-1.2

## Risks to the Forecast

Predictions or forecasts of the future are inherently risky. Nearly every forecast will have some margin of error, especially if they forecast very far into the future. An important part of using and understanding forecasts is to consider a few likely ways in which they may turn out to be incorrect.

All of the forecasts used in this study rely on a forecast of U.S. economic growth, typically summarized by expected real gross domestic product (GDP) growth. EIA uses economic forecasts produced by IHS Global Insight to generate its projections. The West Virginia University Bureau of Business and Economic Research forecast also uses the HIS Global Insight macroeconomic outlook as an input into its coal production forecast. Wood Mackenzie produces its own estimate of real GDP growth.

The EIA forecast called for real GDP growth to average 2.4 percent during the 2007-2030 period. Real GDP growth was forecast to be 1.3 percent, -2.7 percent, and 2.0 percent in 2008, 2009, and 2010, respectively. The WVU Bureau of Business and Economic Research forecast called for real GDP growth to average 2.2 percent per year during the 2008-2013 period with growth of 1.5 percent and 0.2 percent for 2008 and 2009, respectively. The Wood Mackenzie forecast called for real GDP growth to average 2.2 percent during the 2007-2030 period. Real GDP growth was forecast to be 1.1 percent, -2.9 percent, and 0.3 percent in 2008, 2009, and 2010, respectively.

The latest forecast of real GDP by HIS Global Insight shows growth of 1.1 percent, -2.8 percent, and 1.5 percent in 2008, 2009, and 2010, respectively, indicating slower growth than estimates used to produce the initial individual forecasts. If real GDP growth turns out to be stronger (weaker) than expected, then we should expect the coal production forecasts to fall short (above) of actual estimates.

In addition, it is important to remember that West Virginia coals will increasingly compete in a global marketplace, with some coal produced in the state exported to countries around the world and with foreign-produced coals imported into the U.S. This implies that future coal production will depend not only on U.S. economic growth but also in part on worldwide economic growth. This was highlighted by developments in the market for metallurgical coal in 2008, where surging demand spurred price increases. Stronger (weaker) than expected worldwide economic growth has the potential to generate stronger (slower) coal production in the state.

EIA produces two alternative economic growth scenarios: high growth and low growth. These scenarios were not updated in April when the reference case was updated. In the high-growth scenario, EIA assumes an average annual real GDP growth rate of 3.0 percent per year during the forecast period (compared to 2.5 percent in their original reference case). The faster economic growth generates stronger demand for coal. Growth in northern Appalachia coal production rises by an average of 0.1 percentage points per year above the March 2009 reference case (0.8 percent above the revised reference case). Central Appalachia coal production growth (or decline in this



case) is higher (slower production losses) by an average of 0.1 percentage points per year above the March 2009 reference case (unchanged compared to the revised reference case).

In the low-growth scenario, EIA assumes an average annual real GDP growth rate of 1.8 percent per year during the forecast period (compared to 2.5 percent in their original reference case and 2.4 percent in their revised reference case). The slower economic growth generates weaker demand for coal. Growth in northern Appalachia coal production declines by an average of 0.4 percentage points per year **below** the March 2009 reference case (0.3 percent **above** the revised reference case). Central Appalachia coal production growth (or decline in this case) is lower (faster production losses) by an average of 0.2 percentage points per year compared to the March 2009 reference case (0.3 percent lower than the revised reference case).

Of course the largest risks to the forecast are from the numerous environmental and regulatory uncertainties that exist. The continued pressure from anti-mining groups to limit or eliminate surface mining, particularly mountaintop mining are a very real threat. The court battles over 404 mine permits and the delays that have occurred in getting these permits approved have the potential to (and may already have) limit coal production, especially in the southern part of the state. The various environment regulations that have been discussed, including the currently proposed cap and trade on CO<sub>2</sub> emissions in the American Clean Energy and Security Act (ACESA) of 2009, would have a large negative effect on national coal production.

EIA released an analysis of the effects of the ACESA on August 4<sup>th</sup>, 2009. EIA's analysis of the ACESA includes a "Basic Case" as well as 10 alternative cases that vary one or more of the assumptions used in the Basic Case. While EIA does not provide detailed coal production forecasts in its report, total Appalachian coal production is provided. EIA's analysis forecasts a 28.7 percent decrease in Appalachian coal production by 2030 in the Basic Case. The assumptions used in the 10 alternative cases all result in decreases in forecasted Appalachian coal production in 2030 compared to the Reference Case (no ACESA scenario). Five of the alternative cases have coal production declining by less than that forecast in the Basic Case, while the other 5 cases have coal production declining by more than that forecast in the Basis Case. Forecasts of Appalachian coal production in 2030 with the ACESA range from -13.1 percent to -69.4 percent of production in 2030 without the ACESA.

There are possible upside risks to the forecast as well. Advanced coal technologies that address the environmental concerns have the potential to increase production above the forecast provided. Three coal-to-liquids (CTL) plants have been proposed in West Virginia, two of these plants are still moving forward with their plans. If these plants come online, this would increase the demand for West Virginia coal and could spur production above currently forecast levels.

# Appendix I

## Assessment of Forecast Accuracy and Forecast Weights

A forecast is a prediction about the future. In the simplest terms, evaluating a forecast means comparing forecast values to actual realizations. In theory, this is simple; in practice, it gets complicated. The purpose of this appendix is to systematically compare coal production forecasts from EIA, Wood Mackenzie (which now includes Hill & Associates), and West Virginia University Bureau of Business and Economic Research, to actual realizations and summarize the results.

Keep in mind that most forecasts differ from what we eventually observe. It is a fact of life that the future is uncertain and economic models cannot fully surmount that. In addition, the current economic situation is uncertain. Even preliminary production data are released at least one month after the fact and sometimes take years to become "final." Thus, we find ourselves in the position of evaluating what the future may bring, while in possession of only incomplete information about what has just happened. Indeed, this uncertainty contributes to the importance of timely analysis of current trends and forecasting.

### Comparing Forecasts to Actual Values

#### *Forecast Horizon*

To summarize the forecasting performance of the models, we focus on forecasts that are one, two, three, and four years ahead. Now, what is the meaning of a one-year-ahead forecast? A practical example using an actual forecast from the BBER West Virginia State Econometric Model will be used to illustrate basic concepts. This model is used twice per year to forecast the state economy.

In the fall of 2007, the BBER used its econometric model to generate an annual forecast of West Virginia coal production. In the fall of 2007, we knew that coal production in West Virginia was about 152 million tons in 2006 and we had six months of coal production data for 2007. In the fall of 2007, a one-year-ahead forecast of state coal production from the BBER West Virginia Econometric Model was for annual production in 2007 (the model predicted that state coal production would be 152 million tons). Similarly, a two-year-ahead forecast was for 153 million tons for 2008, and so on. In a similar fashion, each forecast from the BBER West Virginia Econometric Model generates forecasts of coal production one, two, three, four, and up to 10 years ahead.

#### *Forecast Difference*

To measure how a forecast differs from the actual results, at each forecast horizon, we will use the term "forecast difference." A forecast difference is measured simply as a forecast value minus

the actual value. A percentage forecast difference is just the forecast difference divided by the actual value, multiplied by 100, as shown in the equations below,

$$\text{Forecast Difference}_t = \text{Forecast}_t - \text{Actual}_t$$

$$\text{Percent Forecast Difference}_t = \frac{\text{Forecast Difference}_t}{\text{Actual}_t} \times 100 = \frac{\text{Forecast}_t - \text{Actual}_t}{\text{Actual}_t} \times 100$$

Thus, a positive forecast difference tells us that the forecast exceeds the current estimate, whereas a negative difference tells that the forecast falls short of the current estimate. Specifically, the one-year-ahead forecast difference for the West Virginia coal production forecast produced in the spring of 2007 was -2 million tons (the actual value for 2007 turned out to be 154 million tons). The one-year-ahead percent forecast difference for this forecast was +1.3 percent.

For each forecast provider, I report the average percentage forecast differences for all available forecasts at the four forecast horizons (a measure of the bias of the forecasts). Since the forecast difference from each release could be positive or negative, an average of forecast differences will allow positive forecast differences to be canceled by negative forecast differences.

However, a forecast accuracy measure based on a simple average of positive and negative forecast differences is not sufficient. In order to see why, suppose we are comparing the one-step-ahead forecast accuracy of two models, each of which has produced two forecasts. Suppose that for model 1, the percent forecast differences are +1 percent and -1 percent. Thus, the average percent forecast difference is 0.0 percent. Suppose that for model 2, the percent forecast differences are +10 percent and -10 percent. The average percent forecast difference for model 2 is 0.0 percent as well. It is obvious, however, that model 1 has produced the superior forecasts, coming closer to actual values each time. (The forecast from model 1 is more efficient in the sense that its variance around the actual value is lower.) We can account for this issue by averaging the absolute percent differences for each model. Thus, for model 1 the average absolute percent difference is 1 percent, while for model 2 the average is 10 percent.

## **Evaluating the Internal Accuracy of Coal Production Forecasts**

Table 2 shows the ability of forecast providers to predict the coal production level of their chosen geography (Northern Appalachia, Central Appalachia, or West Virginia) and coal type (steam coal or all coal). The table shows the average percentage forecast differences as well as average absolute percentage forecast differences, by forecast horizon, for each forecast provider. In each case, the target variable corresponds to the variable forecasted. For example, EIA generates coal production forecasts for Northern Appalachia. In order to evaluate the performance of this forecast, we compare forecast coal production for Northern Appalachia to actual coal production for Northern Appalachia. The results of this analysis tell us about the performance of each forecast providers model, relative to the geography/coal-type they are trying to predict.

The table summarizes the type of coal production forecasted, the geography forecasted, as well as the number of one-step-ahead forecasts available from each forecast provider. A larger number of forecasts available for evaluation tends to make the average forecast differences a more robust indicator of overall forecast performance. The number of forecasts available ranges from 13 for West Virginia University to two for Wood Mackenzie. All forecasts evaluated were produced during the 1998 to 2007 period.

At the one-year-ahead horizon, average absolute percentage differences range from 3.08 percent to 9.32 percent. At the four-year-ahead horizon, average absolute percentage differences range from 6.89 percent to 15.83 percent. As the table shows, forecast differences rise with the length of the forecast horizon. This is a standard result in forecast evaluation and arises because of the increasing uncertainty associated with forecasts at longer horizons.

Overall, forecast differences tend to be a bit smaller for the EIA and West Virginia University forecasts. This arises in part from the model structures and data used by these agencies. Each of these forecasts relies on published historical data, which are then combined with statistical techniques designed to capitalize on key historical correlations found within the data.

Wood Mackenzie employs a very different methodology, which focuses on firm-level modeling of the economic decisions made by energy producers and coal producers. Thus, the coal production forecasts from each of these models are dominated by demand for steam coal. Further, these models do not attempt to capture and extrapolate current trends in any way. Thus, they are not tied to published estimates of steam coal production.

**Table 2**  
**Internal Forecast Performance by Forecast Geography and Coal Type**  
**Average Percentage Differences and Average Absolute Percentage Differences**

Forecast Provider Forecast Geography	Coal Type	One Step Forecasts	Average Percentage Differences*				Average Absolute Percentage Differences			
			One	Two	Three	Four	One	Two	Three	Four
<b>Energy Information Admin.</b>										
Northern Appalachian Region	All	12	3.61	7.54	10.92	15.83	6.69	9.23	12.43	15.83
Central Appalachian Region	All	12	-2.00	-0.94	1.94	3.64	3.08	6.29	7.83	6.89
<b>Hill &amp; Associates</b>										
West Virginia	Steam	2	9.32	9.83	18.95	NA	9.32	9.83	18.95	NA
<b>West Virginia University</b>										
West Virginia	All	18	0.40	4.28	5.86	5.09	4.07	6.55	7.42	8.81

\*Positive (negative) values indicate over (under) prediction on average.

NA is Not Available. The Hill & Associates and Marshall University models have not produced enough West Virginia forecasts to be evaluated four years ahead.

**Forecasts Evaluated:**

EIA: Annual Energy Outlook 1997-2003

Global Insight: U.S. Energy Outlook 1998-2001

Hill & Associates: U.S. Steam Coal Outlook 1998-1999, 2001-2002

Marshall University: Mountain State Clean Water Trust Fund, 2001

West Virginia University: West Virginia Economic Outlook 1998-2008, Mid-Year Review 1999, 2001, Long-Term Forecast 1998, 2000, 2002, 2004, 2006

## Evaluating the Accuracy of Coal Production Forecasts for West Virginia Coal Production

The analysis so far tells us a great deal about the relative performance of the forecasts we will combine. However, our ultimate goal is to produce a forecast for West Virginia coal production, by combining forecasts for West Virginia coal production, West Virginia steam coal production,

and Northern (and Central) Appalachian coal production. Since EIA generates forecasts for geographies which extend beyond West Virginia's borders and Wood Mackenzie only forecasts steam coal production, we need to evaluate the ability of these forecasts to predict West Virginia total coal production.

To evaluate these forecasts we will compare forecast coal production **growth rates** from each provider to actual West Virginia coal production **growth rates**. The forecast growth rates are computed using exactly the same coal production forecasts evaluated above. We follow the same procedure as above, except that we focus on forecast differences only and do not compute percentage forecast differences.

The results of this exercise are presented in Table 3 below. The average forecast differences provide information on how close forecast growth rates are to actual West Virginia coal production growth rates. For instance, to construct the one-step-ahead forecast differences for Northern Appalachian coal production (from EIA), we compare the forecast growth rate Northern Appalachian coal production (one step ahead) to the actual West Virginia coal production growth rate. The results of this analysis tell us how useful the EIA forecasts of Northern Appalachia coal production are in forecasting West Virginia coal production. As shown in the table, average growth rate differences for the Northern Appalachian forecast from EIA were 2.39 percent. This means that on average, the one-year-ahead forecast of the Northern Appalachian coal production growth rate was 2.39 percentage points above the actual West Virginia coal production growth rate.

Table 3  
Forecast Performance with Respect to the W.Va. Coal Production Growth Rate  
Average and Average Absolute Growth Rate Differences in Percent

Forecast Provider Forecast Geography	Coal Type	One Step Forecasts	Average Growth Rate Differences* Annual Steps Ahead				Average Absolute Growth Rate Differences Annual Steps Ahead				
			One	Two	Three	Four	One	Two	Three	Four	Average
<b>Energy Information Admin.</b>											
Northern Appalachian Region	All	12	2.39	4.26	2.27	4.67	4.12	5.49	6.04	6.33	5.49
Central Appalachian Region	All	12	-3.06	0.20	1.24	0.33	4.12	5.36	4.57	3.59	4.41
<b>Hill &amp; Associates</b>											
West Virginia	Steam	5	3.54	0.38	1.47	-0.87	4.85	2.43	4.81	4.69	4.03
<b>West Virginia University</b>											
West Virginia	All	18	0.58	3.65	1.33	-1.08	2.92	4.47	3.71	4.20	3.82

Growth rate differences show the difference between the predicted growth rate (for each geography and coal type) and the West Virginia coal production growth rate.

\*Positive (negative) values indicate over (under) prediction on average.

NA is Not Available. The Hill & Associates and Marshall University models have not produced enough forecasts to be evaluated at four years ahead.

**Forecasts Evaluated:**

EIA: Annual Energy Outlook 1997-2008

Hill & Associates: U.S. Steam Coal Outlook 2001-2005

West Virginia University: West Virginia Economic Outlook 1998-2008, Mid-Year Review 1999, 2001, Long-Term Forecast 1998, 2000, 2002, 2004, 2006

As the table shows, the results are generally similar to the internal forecast evaluation results. The forecast differences rise as the forecast horizon rises, as is usually the case. At the one-year-ahead horizon, average absolute growth rate differences range from 2.92 percent to 4.85 percent. At the four-year-ahead horizon, average absolute growth rate differences range from 3.59 percent to 6.33 percent. Overall, the forecast differences are, in general, lower for the forecasts produced by West Virginia University and Wood Mackenzie than for those produced by EIA. The average absolute growth rate differences (averaged across forecast horizons) are used to construct the weights required to compute the final West Virginia coal production forecast.

## Construction of the Consensus Forecast

The West Virginia consensus coal production forecast is constructed as the linear combination of seven coal production forecasts from five forecast providers (following Granger (1989)). This linear combination amounts to computing a weighted average of the forecast growth rates, where the weights are computed as functions of average absolute forecast differences. The average absolute forecast differences are drawn from Table 3 above and are the average across the four forecast horizons.

The forecast of the growth rate for West Virginia coal production in year (t) is computed as follows:

$$\text{West Virginia Coal Production Growth Rate}_t = \sum_i \omega_i * \text{Coal Production Growth Rate}_{i,t},$$

where i indexes the seven forecasts to be combined and  $\omega_i$  is the weight applied to the coal production growth rate for forecast i.

The weights ( $\omega_i$ ) are constructed from the average absolute growth rate differences (averaged across horizons) shown in Table 3. They are constructed as follows:

$$\omega_i = \frac{1/d_i}{\sum_i 1/d_i},$$

where  $d_i$  is the average absolute growth rate forecast difference (averaged across horizons). Thus, by definition, the weights sum to 1.0 and the forecast provider with the smallest (largest) average absolute growth rate differences gets the largest (smallest) weight in the combined forecast.

Using this formula and the data from Table 3, the weights ( $\omega_i$ ) used to combine forecasts are shown in Table 4.

**Table 4**  
**Weights Used to Combine**  
**Coal Production Growth Rate Forecasts**

<b>Forecast Provider</b>		<b>Last Year</b>
Geography	<b>Weight (<math>\omega_i</math>)*</b>	<b>Forecast</b>
<b>Energy Information Admin.</b>		
Northern Appalachian Region	0.20	2030
Central Appalachian Region	0.25	2030
<b>Hill &amp; Associates</b>		
West Virginia	0.27	2030
<b>West Virginia University</b>		
West Virginia	0.28	2013

\*These are the weights when all forecasts are available. When forecast data for a provider are exhausted the weights are re-adjusted to sum to one for the remaining forecasts.

Finally, the consensus forecast for West Virginia coal production growth rates generate forecast coal production levels using the following:

$$\text{W.Va. Coal Production Level}_t = \text{W.Va. Coal Production Level}_{t-1} * (1 + \text{W.Va. Coal Production Growth Rate}_t).$$

## Appendix II

### Summary of Component Forecasts

#### Energy Information Agency

Publication: Annual Energy Outlook 2009

Publication Date: March 2009 (Updated April 2009)

Coal Type: All

Geography: Northern Appalachia, Central Appalachia<sup>1</sup>

Forecast Horizon: 2008-2030

#### Assumptions:

##### *Macroeconomic Growth:*

U.S. real GDP growth at an average of 2.4 percent per year during the 2007-2030 period. Rate varies slightly from year to year and is based on the HIS Global Insight February 2009 macroeconomic forecast. Real GDP growth in the near term is much lower. Real GDP increases by 1.3 percent in 2008 and decreases by 2.7 percent in 2009 before recovering in 2010 with 2.0 percent growth.

##### *Environmental:*

The March 2009 forecasts were based on current laws and regulations in effect before November 5, 2008. The updated April 2009 forecasts (the forecasts used to produce the consensus forecast) included provisions of the American Recovery and Reinvestment Act (ARRA) as well as reinstatement of the Clean Air Interstate Rule (CAIR) and the updated Corporate Average Fuel Economy (CAFE) standards for model year 2011. For CAIR, NO<sub>x</sub> Phase I caps become effective in 2009, while Phase I caps for SO<sub>2</sub> become effective in 2010. More stringent Phase II limits for both become effective in 2015. The Clean Air Mercury Rule (CAMR) was vacated by the courts

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<sup>1</sup> Northern Appalachia includes Pennsylvania, Maryland, Ohio, and Northern West Virginia.

Northern West Virginia includes all mines in the following counties (formerly defined as Coal-Producing Districts 1, 3, & 6): Barbour, Brooke, Braxton, Calhoun, Doddridge, Gilmer, Grant, Hancock, Harrison, Jackson, Lewis, Marion, Marshall, Mineral, Monongalia, Ohio, Pleasants, Preston, Randolph, Ritchie, Roane, Taylor, Tucker, Tyler, Upshur, Webster, Wetzell, Wirt, and Wood.

Central Appalachia includes Southern West Virginia, Virginia, Eastern Kentucky, Northern Tennessee. Southern West Virginia includes all mines in the following counties (formerly defined as Coal-Producing Districts 7 & 8): Boone, Cabell, Clay, Fayette, Greenbrier, Kanawha, Lincoln, Logan, Mason, McDowell, Mercer, Mingo, Nicholas, Pocahontas, Putnam, Raleigh, Summers, Wayne, and Wyoming.



in February 2008 and thus was not modeled. Nearly half of the states had their own mercury mitigation laws in place and several states were planning to enact new laws or were going to modify their existing laws. These state rules were approximated and modeled to produce the EIA forecast. A national carbon cap and trade program is not modeled in the reference case, however the Regional Greenhouse Gas Initiative (RGGI), which includes 10 northeastern states, is modeled. Given the generous emissions budgets, the effect of the RGGI is minimal.

#### *Natural Gas Prices:*

The lower 48 wellhead price of natural gas is projected to rise by 1 percent per year, from \$6.39 per mcf in 2007 to \$8.01 per mcf in 2030 in 2007 dollars.

#### *Electricity Growth:*

Electricity sales are forecast to grow an average of 0.8 percent per year through 2030. While electricity generation from coal increases from 2007-2030, coal's share of electricity generation decreases from 48.6 percent in 2007 to 45.7 percent in 2030.

#### *Coal Mining Productivity:*

National coal mining productivity declines at an annual average rate of 0.2 percent per year during the 2007-2030. Coal mining productivity in northern Appalachia decreases 0.3 percent per year, while productivity in central Appalachia decreases 1.0 percent per year during the 2007-2030 period. This is attributed to higher stripping ratios and the additional labor needed to maintain underground mines, which offsets productivity gains from improved equipment and technology. Productivity is expected to diminish in some eastern mines as operations move from mature coal fields to more marginal reserve areas. In addition, regulatory restrictions on surface mines and fragmentation of underground reserves limit productivity gains in the Appalachia.

### **Summary Coal Production Forecast for Central and Northern Appalachia.**

The EIA forecast for Central and Northern Appalachian coal production is summarized in Table 5. The forecast calls for Central Appalachian coal production to decline from 229 million tons per year in 2008 to 144 million tons by 2030. This decline is due to decreased demand due to the recession, tightening (and uncertain) environmental regulations, depletion of easily mineable reserves (i.e. lower cost reserves), and the ability of existing coal-fired power plants to use higher sulfur coal as they are retrofitted with flue gas desulfurization (FGD) equipment.

Northern Appalachia coal production is forecast to decrease from 141 million tons in 2008 to 135 million tons in 2010 as a result of the current recession. Production quickly rebounds as power plants install FGD equipment that makes the use of the region's higher sulfur coal more attractive. Northern Appalachia coal production is forecast to be 165 million tons by 2030.

**Table 5**  
**EIA Forecast**  
**Regional Coal Production**  
**Annual Energy Outlook 2009 (Updated)**  
**(Millions of Tons)**

	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>Ann.Gr.(%)</b>
<b>Central Appalachia</b>	226.7	228.7	208.2	203.6	202.8	198.5	-2.6
<b>Northern Appalachia</b>	132.3	140.8	136.0	135.1	136.0	147.1	2.1
<b>Central + Northern</b>	359.0	369.5	344.2	338.7	338.7	345.6	-0.8
	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>Ann.Gr.(%)</b>
<b>Central Appalachia</b>	185.8	168.9	165.1	163.2	163.9	164.4	-2.4
<b>Northern Appalachia</b>	154.6	163.1	158.9	153.3	150.0	144.8	-1.3
<b>Central + Northern</b>	340.5	332.0	324.0	316.5	314.0	309.2	-1.9
	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>	<b>2024</b>	<b>Ann.Gr.(%)</b>
<b>Central Appalachia</b>	162.3	163.0	159.7	160.0	158.5	156.6	-0.7
<b>Northern Appalachia</b>	151.5	151.7	153.0	151.7	152.4	153.4	0.2
<b>Central + Northern</b>	313.8	314.7	312.7	311.7	310.9	310.0	-0.2
	<b>2025</b>	<b>2026</b>	<b>2027</b>	<b>2028</b>	<b>2029</b>	<b>2030</b>	<b>Ann.Gr.(%)</b>
<b>Central Appalachia</b>	155.2	154.1	154.0	149.3	146.3	144.2	-1.8
<b>Northern Appalachia</b>	155.4	159.6	157.1	157.1	160.8	165.3	1.5
<b>Central + Northern</b>	310.6	313.7	311.1	306.5	307.1	309.5	-0.1

## **Wood Mackenzie**

Publication: Long Term US Thermal Coal Outlook

Publication Date: May 2009

Coal Type: Steam Coal only

Geography: State of West Virginia, Northern West Virginia, Southern West Virginia

Forecast Horizon: 2009-2030

### **Assumptions:**

#### *Macroeconomic Growth:*

U.S. real GDP growth at an average of 2.2 percent per year during the 2007-2030 period. Real GDP growth in the near term is much lower with growth expected to stabilize at 2.6 percent after 2015. Real GDP increases by 1.1 percent in 2008 and decreases by 2.9 percent in 2009 before recovering slightly in 2010 with 0.3 percent growth.

#### *Environmental:*

Wood Mackenzie includes the Clean Air Interstate Rule (CAIR) beginning in 2009 for SO<sub>2</sub> and NO<sub>x</sub>. Given the current ruling on the Clean Air Mercury Rule (CAMR) it is not modeled, however mercury emissions are assumed to be regulated by a combination of Maximum Achievable Control Technology (MACT) and state specific initiatives. The Regional Greenhouse Gas Initiative (RGGI), a cap and trade program including 10 states, is also modeled.

#### *Natural Gas Prices:*

Natural gas prices (Henry Hub) increase from \$4.5/mmBTU in 2009 to \$78/mmBTU by 2030.

#### *Electricity:*

Wood Mackenzie assumes electricity demand declines from 2009 to 2010 before increasing through 2013 by 1.5-2.5 percent. Electricity demand declines slightly through 2030, stabilizing at 1-2 percent growth for most regions.

#### *Coal Mining Productivity:*

Productivity growth is assumed to increase at an average of 1 percent per year on a mine-by-mine basis for northern Appalachia, while declining an average of 2 percent per year for central Appalachia during the forecast.

## Summary Steam Coal Production Forecast for West Virginia

The Wood Mackenzie forecast for West Virginia steam coal production is summarized in Table 6 below. Wood Mackenzie expects West Virginia steam coal production to decrease to 73 million tons by 2030. Southern West Virginia steam coal production trends down during the forecast, this is likely due to the increased mining costs of the region as more marginal reserves must be mined. According to Wood Mackenzie, Central Appalachian high quality coal (a region which includes southern West Virginia) are not good enough for a plant to avoid scrubbing costs after SO<sub>2</sub> limits are reduced. As more plants have to scrub with the lower limits, they will opt for much less expensive mid-sulfur or high-sulfur coal instead of using compliance or near-compliance coal in their scrubbed boilers. Mountaintop mining regulation and permitting issues continue to be a challenge for coal producers in the region.

The trend for northern West Virginia coal production is different. Utilities with FGD equipment installed begin to choose the lower cost high-sulfur coal in the region. The growth in northern West Virginia coal production is also facilitated by the proximity to major population centers with excellent transportation options.

<b>Table 6</b>							
<b>Wood Mackenzie Forecast</b>							
<b>W.Va. Steam Coal Production</b>							
<b>Long Term US Thermal Coal Outlook</b>							
<b>(Millions of Tons)</b>							
	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>Ann.Gr.(%)</b>
<b>Northern W.Va.</b>	42.9	49.1	52.4	52.9	54.1	57.5	6.0
<b>Southern W.Va.</b>	50.9	46.6	44.0	41.2	37.4	38.2	-5.6
<b>W.Va. Total</b>	93.8	95.7	96.4	94.1	91.5	95.7	0.4
	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>Ann.Gr.(%)</b>
<b>Northern W.Va.</b>	56.3	55.8	58.0	59.8	61.9	68.1	3.9
<b>Southern W.Va.</b>	34.1	32.8	28.2	26.2	22.1	24.9	-6.1
<b>W.Va. Total</b>	90.3	88.7	86.2	86.0	84.0	93.0	0.6
	<b>2021</b>	<b>2022</b>	<b>2023</b>	<b>2024</b>	<b>2025</b>	<b>2026</b>	<b>Ann.Gr.(%)</b>
<b>Northern W.Va.</b>	70.6	70.2	59.9	53.2	54.1	56.2	-4.5
<b>Southern W.Va.</b>	20.9	24.3	21.9	24.2	22.3	22.1	1.1
<b>W.Va. Total</b>	91.6	94.5	81.7	77.4	76.4	78.3	-3.1
	<b>2027</b>	<b>2028</b>	<b>2029</b>	<b>2030</b>			<b>Ann.Gr.(%)</b>
<b>Northern W.Va.</b>	57.6	56.4	53.9	53.3			-3.3
<b>Southern W.Va.</b>	21.2	21.1	20.6	19.8			-1.4
<b>W.Va. Total</b>	78.8	77.5	74.5	73.1			-2.8

## **West Virginia University BBER**

Publication: West Virginia Economic Outlook 2009

Publication Date: November 2008

Coal Type: All

Geography: State of West Virginia

Forecast Horizon: 2008-2013

### **Assumptions:**

#### *Macroeconomic Growth:*

The West Virginia forecast is based on a national forecast, produced by Global Insight, Inc., completed in October 2008. That forecast calls for the U.S. economy to fall into recession in 2008. That reduces real GDP growth to 1.5 percent in 2008 and 0.2 percent in 2009. The forecast calls for growth to rebound in 2010 and continue through 2013. Real GDP growth is forecast to average 2.2 percent per year from 2008-2013.

#### *Environmental:*

Laws on the books at the time of the forecast are observed.

#### *Natural Gas Prices:*

After rising strongly again in 2008, natural gas prices (as measured by the Henry Hub cash market price) are forecast to drop slightly in 2009, before rebounding during the 2010-2013 period. Overall, natural gas prices are expected to remain near or above 2008 levels through 2013.

#### *Electricity:*

Electricity sales to consumers is forecast to grow by 1.0 percent per year through 2013. Coal's share of electric utility fuel use falls from 48.2 percent in 2008 to 47.6 percent by 2013.

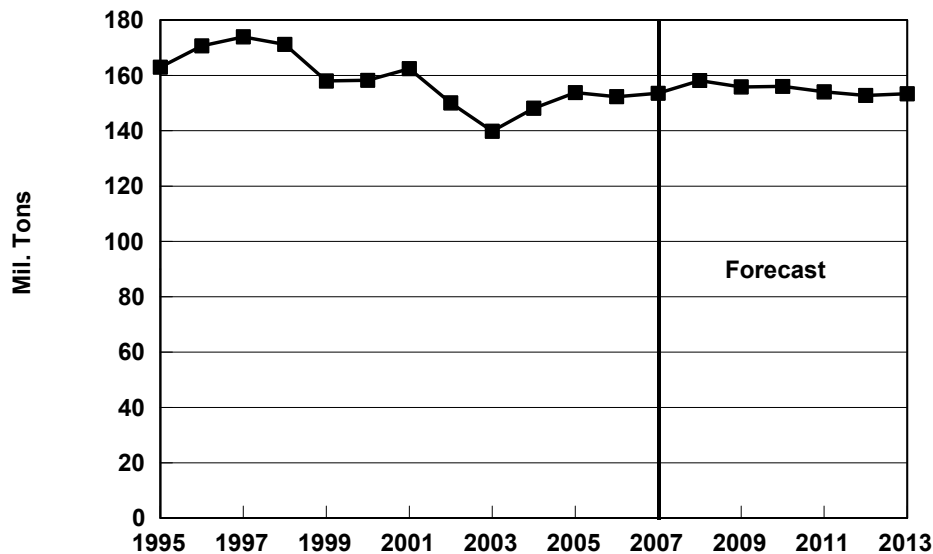
#### *Mining Productivity (includes coal, natural gas, and petroleum mining):*

After falling during the 2008-2009 period, mining productivity growth is expected to rise 2.5 percent per year through 2013. This is a bit faster than mining productivity growth during the 1990s (at 2.2 percent per year).

## Summary Coal Production Forecast for West Virginia

The WVU BBER forecast for West Virginia coal production is summarized in Figure 9 and Table 7. The forecast calls for coal production to fall from 2008 levels (about 158 million tons) to 156 million tons during 2009-2010, as the global recession diminishes demand. Coal production stabilizes around 153 million tons during 2011-2013 as production gains in the northern West Virginia coal fields are offset by production declines in the southern part of the state.

**Figure 9**  
**West Virginia University BBER Forecast**  
**W.Va. Coal Production**  
 West Virginia Economic Outlook 2009



**Table 7**  
**West Virginia University BBER Forecast**  
**W.Va. Coal Production**  
 West Virginia Economic Outlook 2009  
 (Millions of Tons)

	Actual						Ann.Gr.(%)
	2002	2003	2004	2005	2006	2007	
<b>West Virginia</b>	150.0	139.8	148.1	153.8	152.3	153.6	0.5
	Forecast						Ann.Gr.(%)
	2008	2009	2010	2011	2012	2013	
<b>West Virginia</b>	158.1	155.8	156.1	154.0	152.8	153.4	-0.6

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