Consensus Coal
Production Forecast
for West Virginia

Prepared for the
West Virginia Department of Environmental Protection
Office of Special Reclamation

By

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May 2004

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Executive Summary

West Virginia’s coal production has declined during the last six years, falling from 173.7 million tons per year in 1997 to 138.4 million tons per year in 2003. Part of the coal production decline can be traced to regulatory issues that impacted the industry during the period. The combination of regulatory issues and strong energy demand, along with rising natural gas prices, forced coal prices upward significantly during 2000-2001. This produced a slight increase in coal production, which proved to be short lived, as the state and national economies slipped into recession in early 2001. This reduced energy demand in general, and demand for coal as well.

The consensus forecast documented in this report calls for West Virginia coal production to remain stable in the 140 million tons per year range until nearly 2010, when increasingly stringent environmental restrictions on power plant emissions come into effect. For most of the next decade (2010-2020), state coal production trends down toward the 130 million tons per year range, as electricity generators switch to coal with more favorable emissions impacts. However, gradual investments over time by power producers, in emission reduction technologies, eventually result in increased coal production activity in West Virginia, with coal production expected to return to the 150 million tons per year level by 2025.

However, there are risks to this forecast, with both favorable and unfavorable impacts. First, all of the forecasts contained in the consensus outlook rely on assumptions regarding future economic growth and the future price of natural gas. To the extent that these underlying assumptions are too optimistic or pessimistic, so too will be the forecast for state coal production. Second, the industry faces regulatory risks related to clean air and water concerns. Increasing regulatory burdens beyond those incorporated into the component forecasts would be likely to change the evolution of state coal production over time and certain types of regulatory changes could negatively impact state production.

Finally, coal prices have recently spiked upward again, with spot prices for specific grades of Northern Appalachian coal over $45 per ton (over $55 per ton for selected Central Appalachian grades, see Figure 4 below). The Energy Information Administration (EIA) attributes the recent 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 closures due to fires, accidents, and safety issues, diminishing rail capacity to handle western coal, higher natural gas prices, rising gasoline prices, and international factors like the 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).

The durability and production impact of the current price spike are currently the subject of active debate. To the extent that factors related to rising demand for coal dominate, there is the potential for stronger coal production in the near future. To the extent that adverse supply shocks dominate, there is the potential for little or no production response.

This report proceeds as follows: the Recent Developments section describes in more detail recent trends in coal production, prices, employment, and productivity; the consensus coal production forecast for West Virginia is summarized next; and the following section describes some of the relevant risks to the forecast. Appendix I contains the details of the construction of the consensus forecast and Appendix II summarizes each of the component forecasts individually.
Recent Developments
with Abhijit Pradeep, Graduate Research Assistant

Coal Production
National coal production has fluctuated around the 1,100 million tons mark since 1996, as Figure 1 indicates, while coal production in West Virginia has steadily declined from a high of 173.7 million tons reached in 1997. After peaking in 2001 at 1,127.7 million tons, national production fell to 1,094.2 million tons in 2002 and further decreased to an annual average of around 1,069.5 million tons in 2003. There has been a similar trend in West Virginia coal production since 2001 as it steadily decreased from 162.6 to 138.4 million tons between 2001 and 2003.

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

Annual coal production in West Virginia has declined during the last eight years falling from 170.4 million tons in 1996 to about 138 million tons in 2003, as Figure 2 below shows. Average coal production was stable around 171 million tons from 1996 to almost the first quarter of 1999. Production then fell by 14 million tons during the latter half of 1999. The level of production was relatively stable through 2001 with an average annual production of around 160 million tons. Coal Production once again fell in 2002 to 150.2 million tons and averaged 138.4 million tons in 2003.
Figure 2 also shows coal production in northern and southern region of West Virginia. The share of southern coal production has been around 75 percent of the state’s total production. Average annual coal production for this region fell by 21 tons, from 124.5 million tons to 103.5 million tons between 1996 and 2003, which is a 2.6 percent per year decline. The decline in coal production in the northern region was smaller at about 10 million tons between 1996 and 2003, but the percentage fall in production was 3.8 percent per year.

**Coal Prices**

There has been a steady decline in the average mine price of West Virginia coal during the last 19 years, with the price falling from $38.05 per ton in 1981 to $25.37 in 2000, as Figure 3 shows. EIA defines mine price as the price paid at the mining operation site, free on board that is, excluding freight, shipping, and insurance costs. The trend changed after 2000 when average nominal coal prices increased from $27.03 in 2001 to $29.59 per ton in 2002, as spiking natural gas prices increased demand for coal. The figure also shows the real West Virginia coal price, in 2000 dollars, which takes inflation into account. As Figure 3 indicates, real inflation-adjusted prices for West Virginia coal have declined more drastically than nominal prices, falling by almost 40 percent from 1980 to 2000.
Figure 3
Average Mine Price of W.Va. Coal
(Nominal and Real Dollars per Ton)

Figure 4 illustrates the latest monthly trends in coal commodity spot prices in Northern and Central Appalachian regions. The price of Central Appalachian coal rapidly declined in 2001 until it reached its lowest of around $27 in the first three months of 2002. Coal price steadily increased to around $36 per short ton by the end of 2003 before shooting up to the $55 range in the first few months of 2004. Northern Appalachian coal prices had a peak of almost $40 per short ton in the beginning of 2002, after which it declined and stabilized at around $27 per short ton for the rest of 2002 and 2003. Northern Appalachian coal prices began to rise again in 2003 and reached the $45 per short ton range by early 2004.

EIA attributes the recent 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 closures due to fires, accidents, and safety issues, diminishing rail capacity to handle western coal, higher natural gas prices, rising gasoline prices, and international factors like the 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 in West Virginia as well as the United States has declined during the past 13 years. West Virginia’s coal employment fell from an annual average of 26,808 in 1990 to 15,566 in 2003. Coal employment increased during 2001 and 2002, as coal prices surged upward, before falling to 15,566 by 2003. As Figure 5 shows, national coal-mining employment has a similar trend, and it fell from an annual average of 136,033 in 1990 to 70,416 by 2003.
Coal Productivity

Coal productivity has increased rapidly and steadily in both West Virginia and the U.S. during the last 12 years. Figure 6 shows the national and state’s annual productivity, which is the amount of coal produced per miner hour. West Virginia’s coal productivity increased more than one and a half times from 2.9 tons in 1990 to 4.9 in 2000, after which it dropped to 4.3 tons by 2002, as hiring increased but overall coal production did not rise as fast. National coal productivity increased from 3.8 tons in 1990 to 7.0 in 2000. Productivity stabilized at 6.8 tons between 2000 and 2002.
Figure 6
Annual Productivity
W.Va. and U.S.
(Tons of Coal per Miner per Hour)

Figure 7 shows the most recent coal productivity data, computed coal production per mining job. These estimates suggest that productivity growth has not yet returned to growth rates posted during the 1990s.
Figure 7
Monthly Productivity
W.Va. and U.S.
(Tons of Coal Produced per Miner)
Consensus Coal Production Forecast for West Virginia

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

The forecasts used to compute the consensus outlook come from the Energy Information Administration, Global Insight, Inc., Hill & Associates, the Center for Business and Economic Research at Marshall University, 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. All but one of the forecasts (the Marshall University forecast was produced in 2001) were generated during 2003 and thus they do not incorporate the possible effects of recent increases in coal prices.

The consensus coal production forecast calls for West Virginia coal production to fall slightly during the forecast period (2004-2025). During the 1998-2003 period, state coal production averaged 156.4 million tons per year, according to data from EIA. The forecast calls for production to fall to the 150 million tons per year range by 2025, as Figure 8 and Table 1 show. This forecast of rough stability in state coal production contrasts with forecasts of growth for national coal production, due to rising demand for electricity. Western coal producers are thus expected to increase their share of national production during the forecast period.
While the forecast calls for coal production in 2025 to be only slightly below the average levels achieved during the last five years, there is a dramatic decline and rebound expected during the forecast period. In particular, after stabilizing in the neighborhood of 140 million tons per year during the 2004-2009 period, production falls to the 130 million tons per year level during the 2010-2015 period, as environmental restrictions imposed on electricity producers are expected to tighten.

These environmental restrictions (on sulfur dioxide (SO$_2$) and nitrogen oxide (NO$_x$) emissions) drive down demand for the higher sulfur coal produced in the state, as electricity producers initially respond by seeking out coal which generates lower emission levels. Eventually, electricity producers respond to these tightening environmental restrictions by investing in emission-control technologies which permit them to burn coal with higher sulfur content. This expected response eventually generates increasing demand for coal produced in West Virginia.
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Risks to the Forecast

Most forecasts differ from actual events (once they finally transpire). 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 coal production forecasts evaluated in this document and used in the construction of the consensus coal production forecast were generated during (or in the case of the Marshall University forecast, before) 2003. Thus they do not incorporate the possible impacts of the recent increases in coal prices. To the extent that recent price increases reflect increased demand for coal (whether from rising U.S. and worldwide economic growth or from higher natural gas prices), they have the potential to spur more investment and production industry-wide (and also in West Virginia). However, to the extent that recent price increases reflect increasing costs (or reduced desire to invest due to regulatory risk), they will be less likely to generate increasing production in the future.

Further, all of the forecasts used in this study rely on a forecast of U.S. economic growth, typically summarized by expected real GDP growth. Overall real GDP growth forecasts range from 2.2 percent to 3.0 percent per year for the longer-term outlooks. However, 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 has recently been highlighted by developments in the market for metallurgical coal, where surging demand has spurred price increases, and it implies that stronger than expected worldwide economic growth has the potential to generate stronger coal production in the state. Keep in mind that the opposite is also true, in that slower than expected worldwide growth may generate slower growth in state coal production.

None of the forecast providers compute simulations for West Virginia (or Northern and Central Appalachia, for that matter) coal production based on alternative economic growth scenarios. EIA comes the closest by publishing simulations of Appalachian coal production based on two alternative economic growth scenarios: high growth and low growth.

In the high-growth scenario, EIA assumes an average annual real GDP growth rate of 3.5 percent per year during the forecast period (compared to 3.0 percent in their reference case). Faster economic growth generates stronger demand for electricity and its growth rate rises from 1.8 percent per year under the reference case to 2.0 percent per year in the high-growth scenario.

Stronger demand for electricity, in turn, generates stronger demand for coal. Growth in U.S. coal production rises from 1.5 percent per year under the reference case to 1.6 percent per year in the high-growth scenario. This translates into faster growth for Appalachian production as well, with production rising by 0.5 percent per year in the high-growth scenario, compared to 0.1 percent per year in the reference case. EIA does not publish coal production for Appalachian sub-regions under alternative scenarios.
In the EIA low-growth scenario, real GDP growth averages 2.4 percent per year, 1.1 percent per year slower than under high-growth assumptions. This generates significantly slower electricity demand, which grows by just 1.5 percent per year. This translates into significantly slower coal production growth nationally, at 1.1 percent per year, while Appalachian production falls at an annual rate of -0.3 percent per year.

While none of the forecast providers forecast coal production for West Virginia under alternative economic growth scenarios, it is very likely that state coal production will respond to overall national economic growth. Faster (slower) than expected national growth will tend to generate higher (lower) than expected levels of state coal production.

In electricity generation, coal faces competition from natural gas. However, none of the forecast providers generate alternative coal production forecasts based on alternative natural gas price scenarios. It should be noted however, that relative fuel prices matter, and that, in general, higher (lower) than expected natural gas prices have the potential to generate higher (lower) than expected coal production.

In addition to economic growth (and fuel competition) risks to the forecast, there are also risks related to environmental regulation. The Hill & Associates forecast includes two alternative environmental regulation scenarios, with forecasts for West Virginia steam coal production.

The first alternative scenario is modeled on the Clear Skies Initiative as introduced in Congress. This simulation assumes the 19+2 state SIP Call for NOx (with regional trading), additional SO$_2$ limitations in 2010 (and another reduction in the SO$_2$ limit in 2018), limitations on Mercury beginning in 2010 (with an additional limit reduction in 2018), and no CO$_2$ limits.

The impact of these restrictions is to reduce coal production beyond their baseline steam coal outlook for the state, as the Clear Skies line in Figure 9 shows. The additional restrictions on SO$_2$ and Mercury in 2010 and 2018 drive state coal production down and mute the rebound expected near the end of the forecast. The rebound is still there, due to the impact of power plant investments in emission reduction technologies, which make the state’s higher sulfur coal more competitive.
The second alternative forecast reflects Senator Carper’s CAP 2002 proposal. This scenario assumes the implementation of the 19+2 state SIP Call in 2005, with a 1.7 million tons nationwide NOx limit in 2012. It also imposes additional restrictions on SO2 emissions in 2008, 2012, and 2015, as well as more stringent limits (than Clear Skies) on Mercury emissions in 2008 and 2012. Finally, CAP 2002 imposes CO2 limits of 2.6 billion tons in 2008 and 2.3 billion in 2012.

The relative impacts of this scenario are shown by the CAP 2002 line in Figure 9. The CO2 limits have particularly severe impacts on state (and national) coal production, with large drops in 2008 and 2012. Indeed, under these assumptions, state steam coal production drops below 20 million tons by the end of the forecast period.

A further environmental risk to the forecast is the possible restriction of mountaintop mining practices. This scenario has been studied in a short-run context by the Center for Business and Economic Research at Marshall University (The Fiscal Implications of Judicially Imposed Surface Mining Restrictions in West Virginia, 2001). Their estimate of the impact of permitting restrictions designed to protect intermittent and perennial streams suggests that the impact on state coal production would be severe. They estimate that state coal production would fall by 41.1 million tons within five years of the imposition of restrictions. This amounts to an estimated drop in state coal production of 27.6 percent.
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, Global Insight, Hill & Associates, Marshall University Center for Business and Economic Research, 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 spring of 2002, the BBER used its econometric model to generate an annual forecast of West Virginia coal production. In the spring of 2002, we knew that coal production in West Virginia was 160 million tons in 2001 and we had a couple of months of coal production data for 2002. In the spring of 2002, a one-year-ahead forecast of state coal production from the BBER West Virginia Econometric Model was for annual production in 2002 (the model predicted that state coal production would be 154 million tons). Similarly, a two-year-ahead forecast was for 156 million tons for 2003, 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. Thus, since the BBER model is used to produce two forecasts each year, we will have several forecasts at each forecast horizon (one year ahead, two years ahead, etc.).

Forecast Difference

To measure how a forecast differs from the actual results, at each forecast horizon, I 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,
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 2002 was +3 million tons (the actual value for 2002 turned out to be 151 million tons). The one-year-ahead percent forecast difference for this forecast was +2.0 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 10 for West Virginia University to one for Marshall University. All forecasts evaluated were produced during the 1998 to 2002 period.

At the one-year-ahead horizon, average absolute percentage differences range from 0.63 percent to 9.72 percent. At the four-year-ahead horizon, average absolute percentage differences range
from 7.96 percent to 38.94 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, Marshall University, 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.

Global Insight and Hill & Associates employ 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. In the case of the Global Insight forecasts, their estimates of the actual level of steam coal production have changed significantly from their published forecast in 1998 to their latest forecast (published in 2003). Thus, a large share of their forecast difference stems from a change in their estimated level of past steam coal production. Their view of history has settled down during the last two years, which suggests that their latest forecasts should track better.

### Table 2

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

**Forecasts Evaluated:**

### 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 seven 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, Northern (and Central) Appalachian coal production, and Northern (and Central) Appalachian steam coal production. Since two of the five forecast providers generate forecasts for geographies which extend beyond West Virginia’s borders (EIA, Global Insight) or which forecast only steam coal production (Global Insight, Hill & Associates), 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. I follow the same procedure as above, except that I 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), I compare the forecast growth rate Northern Appalachian coal production (one step ahead) to the actual West Virginia coal production 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 -0.49 percent. This means that on average, the one-year-ahead forecast of the Northern Appalachian coal production growth rate was 0.49 percentage points below the actual West Virginia coal production growth rate.

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 0.63 percent to 10.29 percent. At the four-year-ahead horizon, average absolute growth rate differences range from 4.05 percent to 8.89 percent. Overall, the forecast differences are, in general, lower for the forecasts produced by Marshall University, and West Virginia University, than they are for EIA, Global Insight and Hill & Associates. 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:

\[ \text{West Virginia Coal Production Growth Rate}_t = \sum_i \omega_i \times \text{Coal Production Growth Rate}_{i,t}, \]

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:

\[ \omega_i = \frac{1}{\sum_i 1/d_i}, \]

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. Note that the weight for the Hill & Associates forecast is computed from their forecast differences averaged across their three geographies.
Table 4
Weights Used to Combine
Coal Production Growth Rate Forecasts

<table>
<thead>
<tr>
<th>Forecast Provider</th>
<th>Geography</th>
<th>Weight (ωi)*</th>
<th>Last Year Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Information Admin.</td>
<td>Northern Appalachian Region</td>
<td>0.12</td>
<td>2025</td>
</tr>
<tr>
<td></td>
<td>Central Appalachian Region</td>
<td>0.17</td>
<td>2025</td>
</tr>
<tr>
<td>Global Insight</td>
<td>Northern Appalachian Region</td>
<td>0.10</td>
<td>2030</td>
</tr>
<tr>
<td></td>
<td>Central Appalachian Region</td>
<td>0.11</td>
<td>2030</td>
</tr>
<tr>
<td>Hill &amp; Associates</td>
<td>Average Across Geographies</td>
<td>0.13</td>
<td>2021</td>
</tr>
<tr>
<td>Marshall University</td>
<td>West Virginia</td>
<td>0.21</td>
<td>2030</td>
</tr>
<tr>
<td>West Virginia University</td>
<td>West Virginia</td>
<td>0.16</td>
<td>2008</td>
</tr>
</tbody>
</table>

*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:

\[
\text{W.Va. Coal Production Level}_{t+1} = \text{W.Va. Coal Production Level}_{t} \times (1 + \text{W.Va. Coal Production Growth Rate}_{t}).
\]
Appendix II

Summary of Component Forecasts

Energy Information Administration
Publication: Annual Energy Outlook 2004
Coal Type: All
Geography: Northern Appalachia, Central Appalachia¹
Forecast Horizon: 2003-2025

Assumptions:

Macroeconomic Growth:
U.S. real GDP growth at an average of 3.0 percent per year during the 2002-2025 period. Rate varies slightly from year to year.

Environmental:
Those environmental restrictions that are fully spelled out in law or regulation are included. Electricity producers comply with CAAA90, by meeting SO₂ emissions limits of 9.48 million tons per year from 2001 through 2009, and 8.95 million tons by 2010. Electricity producers in the 19 states and the District of Columbia, for which emissions limits have been finalized, comply with EPA regulations regarding NOₓ emissions. With regard to deregulation, EIA notes those states that have deregulated and those that have partially deregulated, but does not forecast future deregulation decisions.

Natural Gas Prices:
Real natural gas prices to electricity generators are projected to rise by 1.2 percent per year, from $3.77 per MBtu in 2002 to $4.92 per MBtu in 2025 in 2002 dollars.

Electricity Growth:
Electricity sales are forecast to grow an average of 1.8 percent per year through 2025. Coal’s share of electricity generation rises slightly from about 50 percent in 2003 to 52 percent by 2025.

¹ 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, Wetzel, 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.
Coal Mining Productivity:
Growth in coal mining productivity declines from an annual average rate of 5.9 percent per year during the 1980-2002 period to 1.3 percent during the 2003-2025 period. This is attributed to increasing strip ratios, thinner coal seams and lower coal yields, longer trucking hauls, and tougher permitting standards.

Summary Coal Production Forecast for Central and Northern Appalachia.

The EIA forecast for Central and Northern Appalachian coal production is summarized in Figure 10 and Table 5. The forecast calls for Central Appalachian coal production to gradually trend down from the 220 million tons per year range in 2003 to the 206 million tons level by 2025. This decline is likely due to tightening environmental regulations and competition from western coal production of lower sulfur coal.

In contrast, Northern Appalachia coal production remains steady in the 160-180 million tons range through 2016 and then rises steadily to the 200 million tons level by 2025. This increase likely stems from the impact of gradual additions to emission abatement technology, that tends to make the use of higher sulfur coal more attractive.

Figure 10
EIA Forecast
Regional Coal Production
Annual Energy Outlook 2004

Northern Appalachia includes Pennsylvania, Maryland, Ohio, and Northern W.Va.
Central Appalachia includes Southern W.Va., Virginia, Eastern Kentucky, and Northern Tennessee.
Table 5
EIA Forecast
Regional Coal Production
Annual Energy Outlook 2004
(Millions of Tons)

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<thead>
<tr>
<th>Year</th>
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<th>Northern Appalachia</th>
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<td>220.8</td>
<td>152.9</td>
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<td>2004</td>
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<td>2006</td>
<td>230.1</td>
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<td>2007</td>
<td>226.1</td>
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</tr>
<tr>
<td>2008</td>
<td>224.0</td>
<td>173.0</td>
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<td>0.3</td>
<td>2.5</td>
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<td>171.1</td>
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<td>176.2</td>
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<td>2011</td>
<td>215.9</td>
<td>178.3</td>
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<td>2012</td>
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<td>2013</td>
<td>208.4</td>
<td>170.2</td>
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<td>2014</td>
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<td>-0.3</td>
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<td>218.4</td>
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<td>2016</td>
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<td>171.9</td>
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<td>2017</td>
<td>212.2</td>
<td>168.9</td>
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<td>2018</td>
<td>212.1</td>
<td>175.8</td>
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<td>2019</td>
<td>210.5</td>
<td>179.2</td>
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<tr>
<td>2020</td>
<td>205.7</td>
<td>184.9</td>
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<td>Ann.Gr. (%)</td>
<td>-1.2</td>
<td>2.4</td>
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<th>Year</th>
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<td>2021</td>
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<td>2022</td>
<td>211.2</td>
<td>191.3</td>
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<td>2023</td>
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<td>195.4</td>
</tr>
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<td>2024</td>
<td>209.4</td>
<td>198.3</td>
</tr>
<tr>
<td>2025</td>
<td>206.3</td>
<td>201.5</td>
</tr>
<tr>
<td>Ann.Gr. (%)</td>
<td>-0.2</td>
<td>1.8</td>
</tr>
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</table>
Global Insight, Inc.
Coal Type: Steam Coal only
Geography: Central Appalachia, Northern Appalachia
Forecast Horizon: 2003-2030

Assumptions:

Macroeconomic Growth:
U.S. real GDP growth at 2.8 percent per year during forecast period.

Environmental:
The Global Insight forecast assumes the implementation only of known environmental policy. Electricity producers comply with current regulations by meeting SO2 emissions limits of 11.02 million tons per year from 2001 through 2013, and 8.95 million tons from 2014-2030. States comply with the SIP call in 2004, but there are no new restrictions on NOx or mercury during the forecast period. The Global Insight forecast assumes no global warming policy is enacted.

Natural Gas Prices:
Natural gas prices, Henry Hub spot prices measured in constant 2002 dollars per MBtu, drift down from $5.78 in 2003 to $3.47 by 2007 and then settle into the $3.57 to $4.09 dollar range during the 2010 to 2030 period.

Electricity:
Electricity generation (net energy for load) is forecast to grow by 1.7 percent per year from 2003-2030. Coal’s share of electricity generation remains in the 50-51 percent range from 2003 to 2030.

Coal Mining Productivity:
Productivity is expected to continue rising during the forecast, which generates moderate declines in coal prices during the forecast.

Summary Steam Coal Production Forecast for Central and Northern Appalachia.

Figure 11 and Table 6 summarize the Global Insight forecast for steam coal production for Central and Northern Appalachia. The forecast calls for Central Appalachia steam coal production to drop from the 200 million tons per year range down to the 165 million tons range by 2010, before recovering at rising back to the 200 million tons range by 2030. The production declines through 2015 are driven by tightening environmental restrictions and by competitive pressures from low sulfur coal produced in the West, while production is forecast to bounce back
in the longer term as tight natural gas supplies and higher natural gas prices favor coal fuels for electricity generation.

Coal production in Northern Appalachia rises from about 130 million tons in 2003 to 150 million tons by 2010, and continues to rise to over 200 million tons per year by the end of the forecast. The gradual increase in production of Northern Appalachia steam coal is influenced both by the relative price of natural gas and also by the continued expected investment in pollution control equipment, which tends to make the higher sulfur coal found in the region more competitive.

Figure 11
Global Insight Forecast
Regional Steam Coal Production
U.S. Energy Outlook 2003

Northern Appalachia includes Pennsylvania, Maryland, Ohio, and Northern W.Va. Central Appalachia includes Southern W.Va., Virginia, Eastern Kentucky, and Northern Tennessee.
Table 6  
Global Insight Forecast  
Regional Steam Coal Production  
U.S. Energy Outlook 2003  
(Millions of Tons)

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<td>215.7</td>
<td>188.6</td>
<td>187.6</td>
<td>189.4</td>
<td>190.6</td>
<td>185.6</td>
<td>-3.0</td>
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<td>Northern Appalachia</td>
<td>132.0</td>
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<td>135.6</td>
<td>134.7</td>
<td>136.1</td>
<td>142.3</td>
<td>1.5</td>
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<table>
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<td>165.7</td>
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<td>154.0</td>
<td>157.0</td>
<td>0.8</td>
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<td>2.0</td>
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<tr>
<td>Northern Appalachia</td>
<td>171.8</td>
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<td>177.4</td>
<td>179.6</td>
<td>181.6</td>
<td>191.4</td>
<td>2.2</td>
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<table>
<thead>
<tr>
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<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>Ann.Gr.(%)</th>
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<tbody>
<tr>
<td>Central Appalachia</td>
<td>184.6</td>
<td>188.3</td>
<td>191.9</td>
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<td>199.8</td>
<td>1.6</td>
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<tr>
<td>Northern Appalachia</td>
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<td>195.3</td>
<td>197.4</td>
<td>199.4</td>
<td>207.0</td>
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<thead>
<tr>
<th></th>
<th>2027</th>
<th>2028</th>
<th>2029</th>
<th>2030</th>
<th>Ann.Gr.(%)</th>
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<tbody>
<tr>
<td>Central Appalachia</td>
<td>203.5</td>
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<td>Northern Appalachia</td>
<td>211.7</td>
<td>213.9</td>
<td>217.1</td>
<td>220.1</td>
<td>1.3</td>
</tr>
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</table>
**Hill & Associates**

Publication: The Outlook for U.S. Steam Coal Long-Term Forecast 2003-2022  
Coal Type: Steam Coal only  
Geography: State of West Virginia, Northern West Virginia, Southern West Virginia  
Forecast Horizon: 2003-2022

**Assumptions:**

*Macroeconomic Growth:*  
U.S. real GDP growth at 2.8 percent per year during forecast period.

*Environmental:*  
National Ambient Air Quality Standards. 19+2 State SIP Call for NOx (including portions of Georgia and Missouri), including EPA’s March 1998 revisions to the state-by-state Btu growth projections, but with an effective date of 2005. For plants inside the 11-state OTC region, we used the more stringent of the OTC NOx step-down or the 21-State SIP Call limit. SO2 limit equal to 50 percent of CAAA Phase 2 levels, becoming effective in 2010. No Mercury limits. No CO2 limits.

*Natural Gas Prices:*  

*Electricity:*  
Electricity generation (net energy for load) is forecast to grow by 2.7 percent per year from 2003-2022. Coal’s share of electricity generation drops from the 50 percent range in 2003 to near 30 percent by 2022.

*Coal Mining Productivity:*  
Productivity is flat in 2003 for both the Northern Appalachian and Central Appalachian regions, before rising to 2 percent and 1 percent, respectively, in 2004. Productivity growth is 2 percent for both regions for the remainder of the forecast.

**Summary Steam Coal Production Forecast for West Virginia**

The Hill & Associates forecast for West Virginia steam coal production is summarized in Figure 12 and Table 7 below. Hill & Associates expect West Virginia steam coal production to remain stable in the neighborhood of 145 million tons until 2010, when more strict regulations regarding SO2 are assumed to come into effect, and then to trend down to the 100 million tons level in 2016, when production rebounds strongly to the 160 million tons range.
As the figure shows, southern West Virginia steam coal production trends down during the forecast, this is likely due to the declining reserve base for high quality coal in the area, particularly reserves with favorable geologic conditions for low mining costs. According to Hill & Associates, Central Appalachian high quality coal (a region which includes southern West Virginia) are not good enough for a plant to avoid scrubbing costs after SO2 limits are cut in half or even lower. 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.

The trend for northern West Virginia coal production is totally different. This is driven by the shift to higher-sulfur coal once scrubbers have been installed at generating plants, in order to meet increasingly stringent environmental restrictions.

Finally, Hill & Associates’ model calls for a large drop in production in 2021. This is, as Hill & Associates readily admit, a “modeling glitch” driven by their use of reserves listed in state mining permit applications when they originally build their model. According to Hill & Associates, in many cases, the coal producer simply lists enough reserves to satisfy his 20-year mine plan in the permit application (instead of the true geologic reserves).

**Figure 12**

Hill & Associates Forecast
W.Va. Steam Coal Production

Outlook for U.S. Steam Coal
Long-Term Forecast To 2022

---

W.Va. Total
Northern W.Va. Coal
Southern W.Va. Coal
### Table 7

Hill & Associates Forecast

W.Va. Steam Coal Production

Outlook for U.S. Steam Coal: Long-Term Forecast to 2022

(Millions of Tons)

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>Ann.Gr. (%)</th>
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<td>Northern W.Va.</td>
<td>91.4</td>
<td>91.4</td>
<td>93.0</td>
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<td>78.8</td>
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<td>Central W.Va.</td>
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<td>60.5</td>
<td>64.4</td>
<td>70.9</td>
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<tr>
<td>W.Va. Total</td>
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<td>142.2</td>
<td>148.8</td>
<td>149.6</td>
<td>143.2</td>
<td>145.5</td>
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<td>W.Va. Total</td>
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Marshall University CBER
Publication: Mountain State Clean Water Trust Fund
Coal Type: All
Geography: State of West Virginia
Forecast Horizon: 2003-2030

Assumptions:

Macroeconomic Growth:
The forecast model directly uses the forecast for total Appalachian coal production during the 1998 to 2020 period published in the Annual Energy Outlook 2000 by EIA. This forecast calls for Appalachian production to fall from 470 million tons in 1998 to 385 million tons by 2020, an average annual decline of -0.9 percent per year. Within the EIA model, real GDP growth is forecast to average 2.2 percent per year through 2020.

Environmental:
The forecast assumes no additional restrictions on West Virginia surface mining operations. It embodies environmental assumptions used in the Annual Energy Outlook 2000. EIA assumes that Federal, State, and local environmental regulations on the books as of July 1, 1999 are observed. This includes restructuring in electricity generation to improve competition, phased reductions in SO₂ and NOx emissions by electricity generators required by the Clean Air Act Amendments of 1990. EIA does not include restrictions related to the NOx SIP Call in this forecast. EIA does include some elements, related to energy combustion and/or CO₂, of the Climate Change Action Plan developed by the Clinton Administration.

Natural Gas Prices:
From the Annual Energy Outlook 2000, real natural gas prices to electricity generators are projected to rise by 1.6 percent per year, from $2.34 per MBtu in 1998 to $3.33 per MBtu in 2020 in 1998 dollars.

Electricity Growth:
In the Annual Energy Outlook 2000, electricity sales are forecast to grow by 1.4 percent per year through 2020. Coal’s share of electricity generation rises slightly from 53.3 percent in 1998 to 55.4 percent by 2020.

Coal Mining Productivity:
After rising by 6.7 percent per year from 1978 to 1998, the Annual Energy Outlook 2000 calls for coal mining productivity growth to slow to 2.3 percent per year.
Summary Coal Production Forecast for West Virginia

The MU EIA/CBER forecast, summarized in Figure 13 and Table 8, calls for West Virginia coal production to remain stable near 160 million tons until 2010, when production begins to drop toward the 140 million tons mark, which it reaches in 2018. Production then remains in the 140 range through the remainder of the forecast. The forecast likely reflects the expected impact of tougher environmental standards and gradually increasing environmental remediation technology. Tougher environmental standards drive production down starting in 2010, as low sulfur coal produced in the West increase competitive pressures. Coal production stabilizes by 2020 as increasing use of scrubbing technology makes higher sulfur coal a bit more competitive.
### Table 8
Marshall University CBER Forecast
W.Va. Coal Production
Mountain State Clean Water Trust Fund Report
(Millions of Tons)

<table>
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<th>2030</th>
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<th>Ann.Gr.(%)</th>
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<tbody>
<tr>
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<td>138.5</td>
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<td>-0.4</td>
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Assumptions:

Macroeconomic Growth:

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

Natural Gas Prices:
After rising strongly in 2003, natural gas prices (as measured by the producer price index) are forecast to gradually decline to levels last seen in 2002 (by 2006) and then to gradually rise through 2008. Even with the gradual price increases through 2008, the producer price index is forecast to remain below 2003 levels.

Electricity:
Electricity sales are forecast to grow by 2.8 percent per year through 2008. Coal’s share of electric utility fuel use falls from 50 percent in 2003 to 47.1 percent by 2008.

Coal Mining Productivity:
After falling during the 2002-2003 period, coal mining productivity growth is expected to accelerate and average 3.0 percent per year through 2008. However, this rate is well below the average rate posted during the 1990s, when coal mining productivity growth averaged 5.4 percent per year.

Summary Coal Production Forecast for West Virginia

The WVU BBER forecast for West Virginia coal production is summarized in Figure 14 and Table 9. The forecast calls for coal production to remain near 2003 levels (about 140 million tons) as stronger national growth, which increases demand for electricity, is counterbalanced by an expected short-run drop in the share of electricity generated from coal. The forecast also
reflects the rising competitive pressures faced by state coal producers from rivals in the U.S. and abroad.

**Figure 14**

West Virginia University BBER Forecast
W.Va. Coal Production
West Virginia Economic Outlook 2004

**Table 9**
West Virginia University BBER Forecast
W.Va. Coal Production
West Virginia Economic Outlook 2004
(Millions of Tons)

<table>
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<tr>
<th></th>
<th>2003</th>
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<th>2008 Ann.Gr. (%)</th>
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References


