# Consensus Coal Production Forecast for West Virginia: 2015

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CBER
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# Consensus Coal Production Forecast for West Virginia: 2015

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# Consensus Coal Production Forecast for West Virginia: 2015

## Introduction

The West Virginia Consensus Coal Production Forecast is a combined production forecast comprised of four component forecasts. A consensus approach to forecasting seeks the "wisdom of crowds" in producing an expectation for output from the coal industry (Armstrong 2001). The Consensus Forecast is used in planning analysis to provide the best expectation of tax revenues to be collected for mandatory reclamation activities conducted through the Special Reclamation Fund and the Special Reclamation Water Trust Fund.

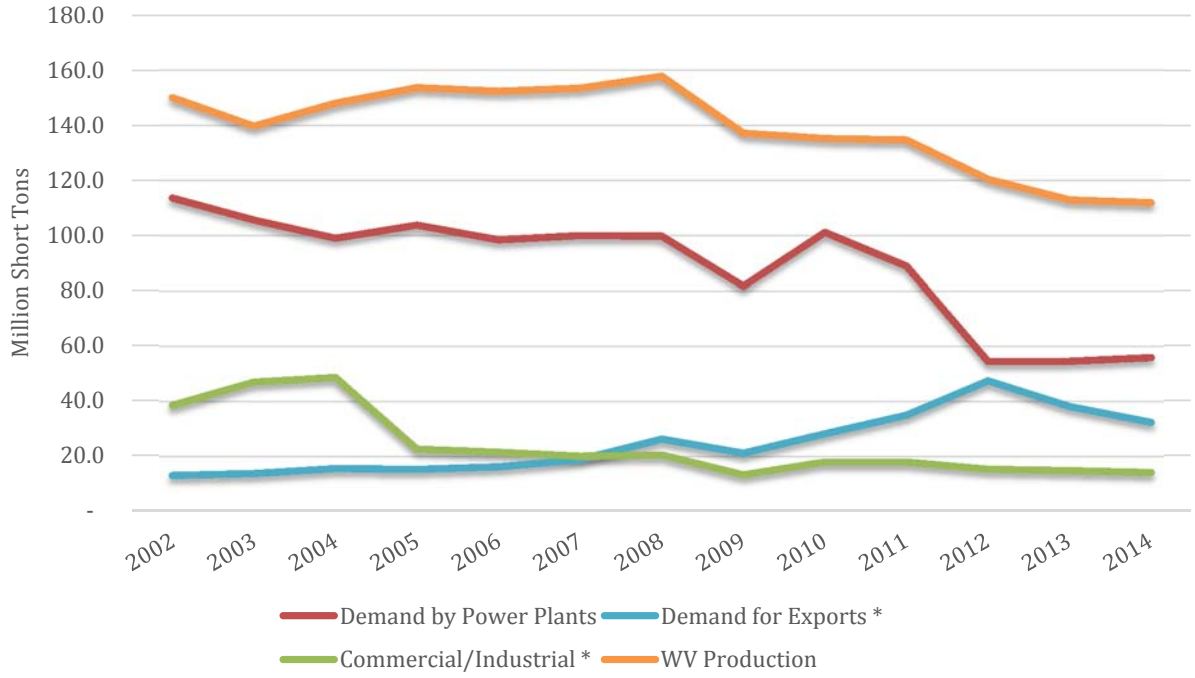
This report describes recent historical coal production trends for the State of West Virginia including the individual industries that comprise the major segments of demand. Each of the component forecasts used to form the Consensus Forecast is then described, with information about assumptions and resulting projected levels of production for West Virginia. The process used to produce the Consensus is also described, including the weightings applied to each of the component forecasts. The West Virginia Consensus Coal Production Forecast is calculated for the years 2015 through 2035.

## Overview

West Virginia coal production for 2014 was around 112 million tons (EIA 2014),[1] a decline of about one percent from the 113 million tons produced in 2013. This decline reflects various trends and events within the coal industry's primary markets: power generation, exports and industrial demand. Recent demand trends with preliminary and estimated sector-level data for 2014 are shown below.

[1] 111.9 million tons is the Energy Information Administration's revised 2014 production value based on the final 2014 value published by MSHA (clean coal production reported on MSHA Form 7000-2). The West Virginia Office of Miner's Health, Safety and Training reports 2014 production of 122.6 million tons, but this is not exclusively clean coal which is the final production volume.

**Figure 1: Historical West Virginia Coal Production and Components of Demand**



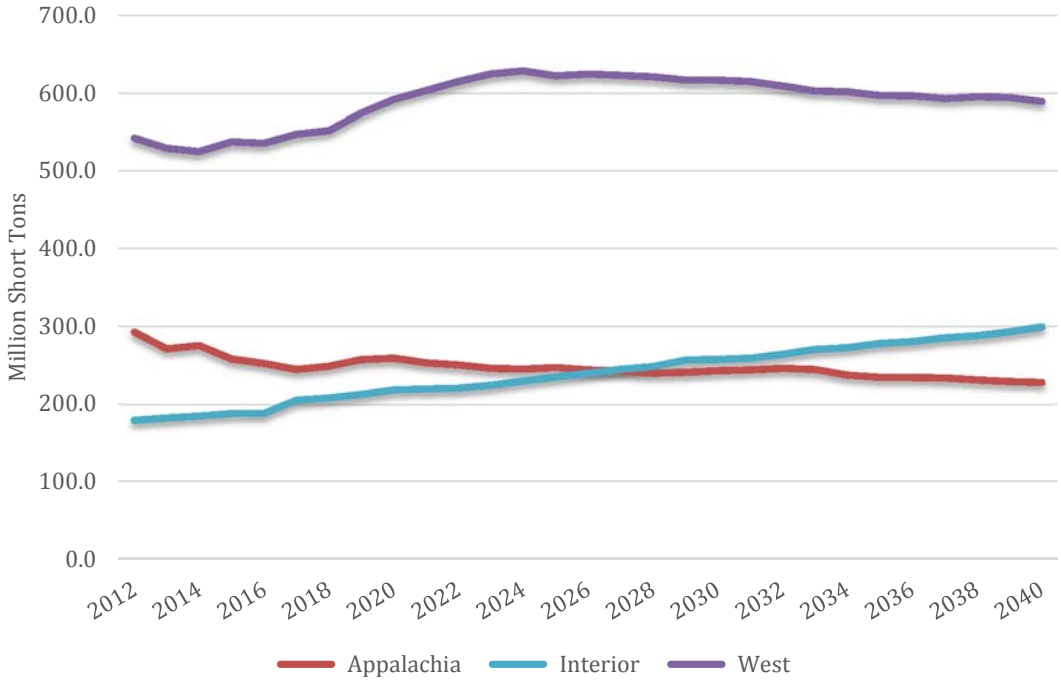

Source: (EIA 2015). Asterisked (*) 2014 volumes estimated by MU CBER. Other 2014 figures are preliminary by EIA.

Future demand for West Virginia coal depends on several variables including the price(s) paid by gas-fired electrical generators for natural gas in the region, the longevity and annual capacity factors of the coal-fired power plants that will continue to burn coal from the State, the rate of economic growth of countries that import West Virginia coal and the nature of compliance with existing and pending environmental regulations.

The Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2015 base case model forecasts Appalachian coal production to decline steadily through 2040, with some stability in the 2017 to 2020 time period. As shown in the following figure, Interior[2] coal production is projected to increase and to surpass Appalachian production in the mid-2020s.

[2] Arkansas, Illinois, Indiana, Iowa, Kansas, Western Kentucky, Louisiana, Mississippi, Missouri, Oklahoma, and Texas.

**Figure 2: EIA Forecasted Coal Production, by Region**



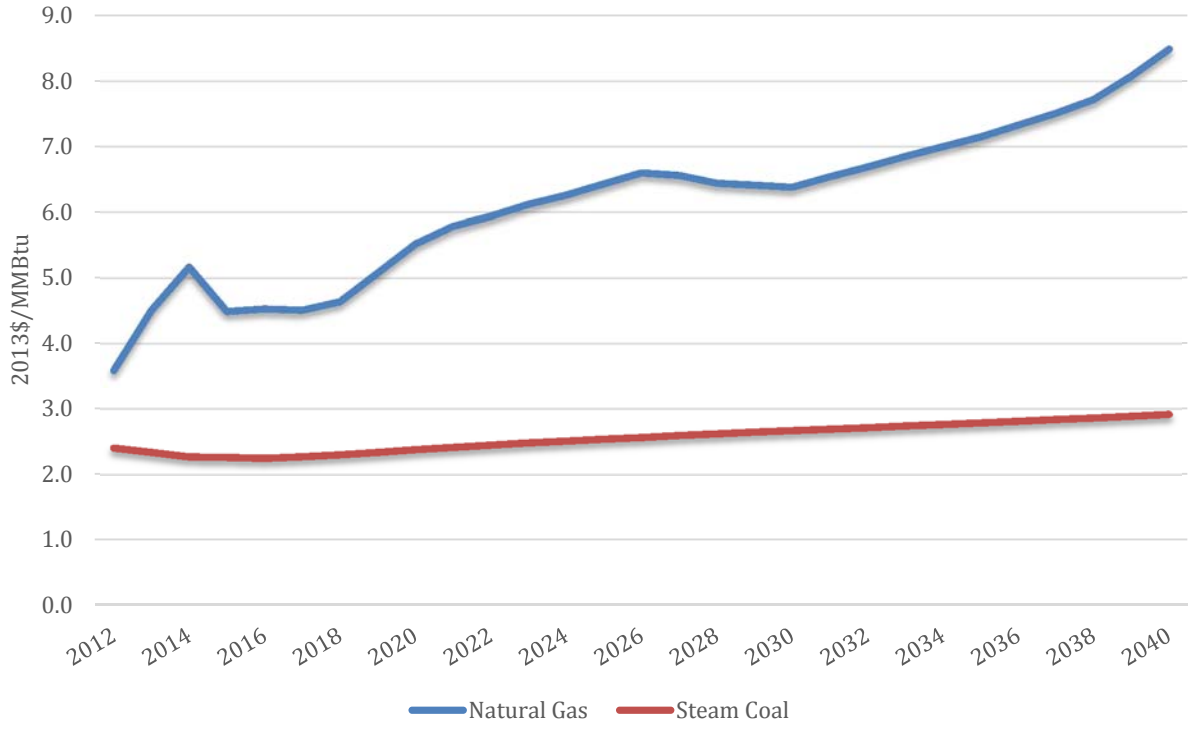

Source: (EIA 2015)

## The Electricity Sector

Preliminary power plant fuel receipts data for 2014 published by the EIA indicates that demand for West Virginia-produced coal by the electricity sector increased slightly in 2014, to about 55.6 million tons, compared to about 55 million tons in 2013 (EIA 2015). Natural gas prices rose in 2014, with the average U.S. price for the electric power sector increasing to $5.19/mcf from $4.49/mcf in 2014 (EIA 2015).

The price of natural gas affects utilization of coal-fired power plants, and thus the amount of coal burned by those plants. Higher natural gas prices in 2014 made coal-fired generation somewhat more competitive than in 2013. In its AEO 2015 Reference Case analysis, the EIA continues to project gas prices delivered to the power generation sector to increase at a faster rate than coal prices.

**Figure 3: Forecasted Natural Gas & Coal Prices to Electricity Sector**

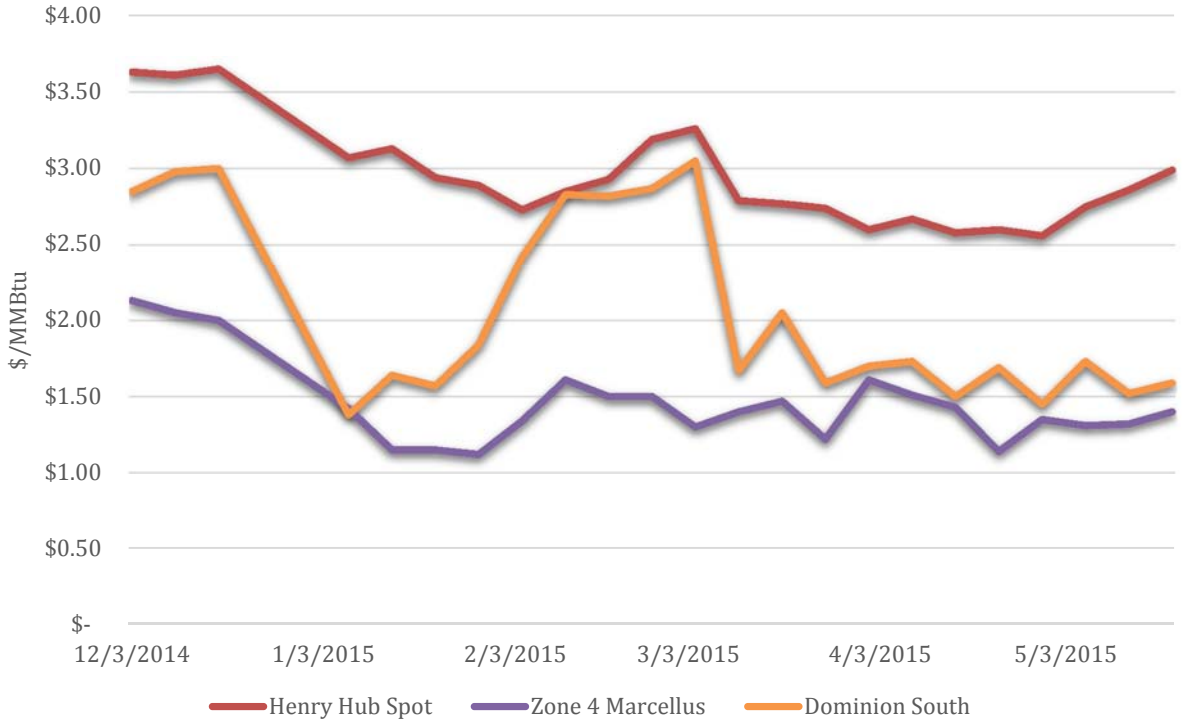



Source: (EIA 2015)

Although the expectation remains that a rise in the relative price of natural gas will moderate declines in coal demand, abundant gas production from the Marcellus play has resulted in particularly low gas prices in the Marcellus area. West Virginia coal competes in the same electricity market as Marcellus gas and is thus impacted by these prices.

Marcellus-area prices frequently trade at a discount to the Henry Hub price, the national benchmark for natural gas. Figure 3 below shows some recent prices for Zone 4 Marcellus gas, a hub in northeast Pennsylvania, and Dominion South, a hub in southwest Pennsylvania. Both of these sub-regions have recently traded at one-half of the Henry Hub price. Other Marcellus hubs, on pipeline systems with the ability to reject Gulf Coast gas, trade at higher prices closer to Henry Hub as noted by EIA's *Today in Energy* (EIA 2014). The continuing build out of pipelines in the region will allow more gas to get to market. These expansions, along with pending activation of the Cove Point LNG export terminal in 2017 (Dominion 2015) and possible reversal of pipelines that have historically brought gas to the northeast, will change the pricing dynamic of regional gas.

**Figure 4: Select Marcellus Area vs. Henry Hub Gas Prices**




Source: (EIA 2014 and 2015)

Coal-fired power plants in the eastern U.S. continue to close in order to comply with Environmental Protection Agency (EPA) air quality regulations. Closures to date in 2015 have included the Phil Sporn, Kanawha River and Kammer power plants in West Virginia (Appalachian Power Closes 3 West Virginia coal-fired plants 2015). The units at these plants were built in the 1950s and originally had a combined nameplate capacity of around 2,300 MW (EIA 2015).

As it is customary to only simulate the impact of existing rules, the potential impact of the EPA's proposed Clean Power Plan is not considered in any of the component forecasts that make of the West Virginia Consensus Forecast. Other policy changes, such as the June 2015 remand of the EPA MATS rule by the U.S. Supreme Court, are also not incorporated.

EIA analysis of the Clean Power Plan projects resulting declines in consumption of coal for power generation, although the decline only continues through 2024, with lower overall levels of demand through 2040. After 2024, demand for coal-fired generation is projected to rise due to increased demand for electricity, rising natural gas prices and increased renewable capacity, which causes higher utilization of existing coal plants. The southeastern United States region is projected to account for 75% (117 million tons) of the total decline in demand for coal in 2040 compared to the AEO2015 Reference case (EIA

2015). Appalachian coal production in the Base Policy case is 46 million tons (19%) lower by 2024 compared to its Annual Energy Outlook (AEO) 2015 Reference case.

West Virginia University's (WVU) Bureau for Business and Economic Research (BBER) projects an 18 percent decline in production, with the majority of that decline from Northern West Virginia mines due to the concentration of that production for the power gen market (West Virginia University BBER 2015).

According to the EPA, the final Clean Power Plan rule will be released in summer of 2015. States then have one to three years to submit compliance plans, depending on whether a single-state or multi-state approach is utilized and if an extension if requested. The beginning of the CPP compliance period is proposed for summer of 2020 (EPA 2015).

## The Industrial Sector

As shown in Figure 1 (page 5) demand for coal by the industrial sector (coke plants and self-generating manufacturers, including coal-fired combined heat and power plants) continues a slow and steady decline. EIA's national-level projections still forecast only a slight decline in industrial demand for coal through 2040, at an annualized rate of 0.1 percent, although overall energy consumption by the sector is projected to grow at a rate of 0.7 percent per year (EIA 2015). All the decline is projected to be from reduced demand from domestic coke plants, with growth in coal usage expected from other industrial users. However, due to announced conversions to natural gas as a primary fuel source by some self-generating customers of West Virginia coal it is still possible that industrial demand for West Virginia coal could decline more quickly than the nation.

Domestic demand for coke continues to shrink as imports capture a growing share of the U.S. steel market. According to data published by the U.S. Department of Commerce International Trade Administration (ITA) imports of steel mill products reached a high of four million metric tons in October 2014 and January 2015, double the maximum levels seen in 2009 (ITA 2015). In addition, unit value for U.S. imports of steel products have been declining since 2011, which suppresses domestic prices. These trends are believed to be caused by excess capacity in the global steel industry, especially in Asia, which has led to overproduction and surges of exports (Stewart, et al. 2014).

## Exports

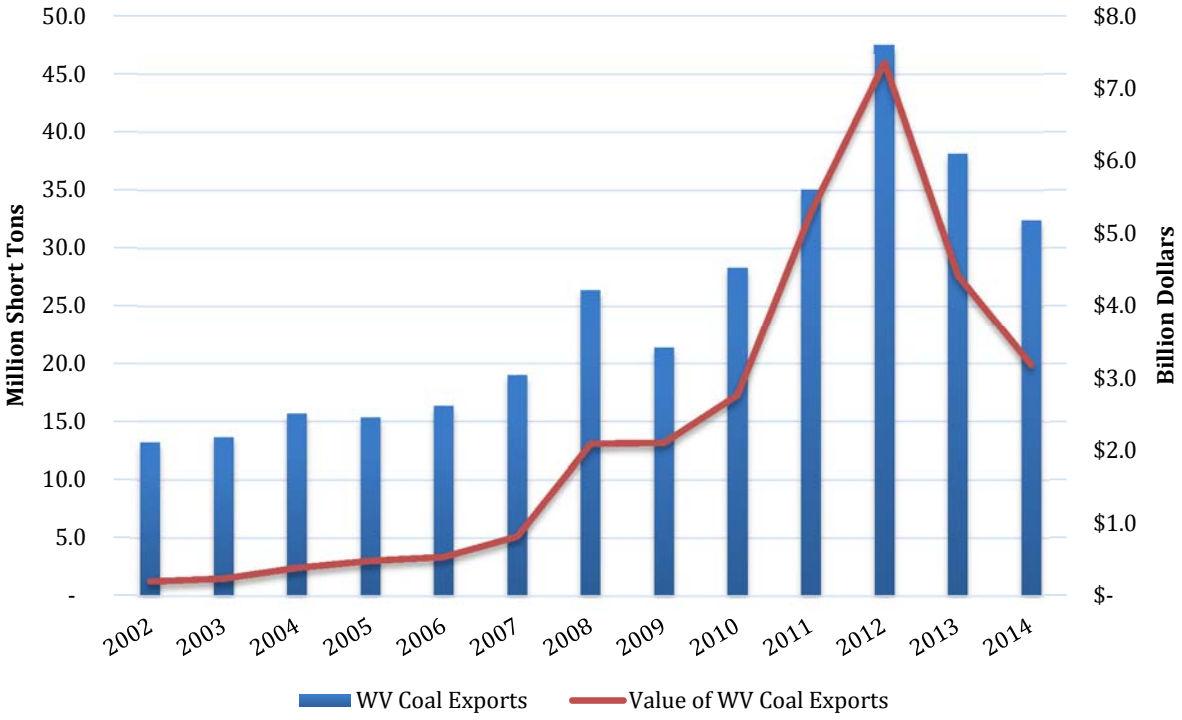
The nation's coal exports fell again in 2014, to 97 million short tons, down from approximately 118 million short tons in 2013.[3] The EIA AEO 2015 Reference Case projects total US coal exports to grow by 35% between 2014 and 2035, with 2015 being the lowest year of the forecast. Much of the growth is from increased exports of steam coal from mines

[3] 2014 data for coal export tonnage by U.S. state of origin has not yet been released. CBER estimates West Virginia's exports based on historical shares of total exports, value of coal exports and average export prices.

in the Interior and Western[4] regions, although coking coal exports are also projected to increase (EIA 2015).

West Virginia has consistent exports to many countries in Europe, South America, Africa and Asia. The value of coal exports from the state fell to $3.2 billion in 2014, from $4.4 billion in 2013. The top five importing countries by value were the Netherlands, Italy, Brazil, the United Kingdom and Ukraine (ITA 2015). The following graphic shows the value of West Virginia-based coal exports and associated tonnage from 2002 to 2014.

**Figure 5: Value and Tonnage of West Virginia Coal Exports, 2002 to 2014**




Source: (EIA 2015) (ITA 2015); 2014 Export tonnage estimated by CBER.

[4] Alaska, Arizona, California, Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming.

## Component Forecasts

### Energy Information Administration (EIA)

Publication: Annual Energy Outlook 2015

Date: April 2015

Forecast Horizon: 2014-2040

Region(s): Northern Appalachia, Central Appalachia

The EIA provides a forecast of coal production by region in its Annual Energy Outlook, projecting through 2040 (EIA 2015). This projection is generated using the National Energy Modeling System (NEMS). NEMS uses a market-based approach that balances energy supply and demand while considering regulations and industry standards.

The EIA's regional forecasts are adjusted to adapt these figures to forecast West Virginia coal production. The Northern Appalachia region includes Pennsylvania, Maryland, Ohio, and Northern West Virginia while Central Appalachia includes Virginia, Eastern Kentucky, Northern Tennessee, and Southern West Virginia. To forecast West Virginia coal production through 2035, the annual growth rate for Northern Appalachia is applied to historical production figures for Northern West Virginia and the annual growth rate for Central Appalachia is applied to Southern West Virginia figures.[5] Only the EIA Reference Case figures are used.[6]

*Key Assumptions:*

Macroeconomic Issues: The long-term macroeconomic projection from IHS Global Insight, Inc. is used in the EIA forecast. Real GDP growth averages 2.4% per year from 2013 to 2040.

Coal Prices: U.S. real minemouth prices are expected to increase from $37.20 per ton to $49.20 per ton in $2013 by 2040, reflecting the assumption that coal mining productivity will continue to decline. EIA expects Appalachian coal prices to also increase from $72.60 in 2013 to $102.9 by 2040.

[5] For more information on the adaptation of the EIA's forecasts, see Appendix A.

[6] The EIA presents six primary situations in the Annual Energy Outlook 2015: a Reference Case, a High Economic Growth Case, a Low Economic Growth Case, a High Oil Price Case, a Low Oil Price Case, and a High Oil and Gas Resource Case. The Reference Case was selected for the Consensus Forecast as a continuation of current trends, assuming known technology and technological/demographic trends.

Natural Gas Prices: Henry Hub[7] spot prices for natural gas averaged $3.73 per million Btu in 2013.[8] Prices are expected be lower in 2015 but rebound by 2020 with an average expected price of $7.85 per million Btu in 2040.

Electricity: U.S. electricity use is expected to increase by 0.8% annually from 2013 to 2040. One gigawatt (GW) of coal-fired capacity is expected to be added through the 2040 in comparison to 144 GW of natural gas capacity, 77 GW of renewable capacity, and 9 GW of nuclear capacity.

Industrial/Commercial: The industrial sector is expected to have a slight increase in coal consumption through 2028 compared to 2014 levels, after which usage is projected to decline. All of the decline is projected in metallurgical coal use (14 percent lower in 2040 than 2014). Other industrial use is projected to increase by about 12 percent from 2014 levels. The commercial sector is expected to maintain flat coal consumption throughout the forecast period.

Exports: National coal exports are expected to decrease through 2015 to a level of 82 million short tons, then increase over the remainder of the forecast horizon to 141 million short tons in 2040. This growth is primarily attributed to exports of steam coal from the Interior and Western regions.

Environmental: Current legislation and environmental regulations, for which implementing regulations were available at the end of October 2014, are considered in the forecast. (Some exceptions are made for laws that will take effect soon after the AEO 2015 is released.) Pending and proposed legislation, including the Clean Power Plan, are not included in projections. The EIA does model three different greenhouse gas cases with varying economy-wide $CO_2$ emissions prices under which coal production is significantly lower than its Base Case.

[7] The Henry Hub in Louisiana is the delivery point for the natural gas futures contract on the New York Mercantile Exchange.

[8] Henry Hub spot prices are listed in real dollars in 2013. Nominal prices from previous years are inflation-adjusted to the equivalent dollar value in the year 2013.

*Results:*

**Table 1: EIA Annual Energy Outlook 2014 Adapted to West Virginia Production[9]**

| West Virginia Coal Production (million tons) | | | | |
|---|---|---|---|---|
| Historical | | Preliminary | Forecast | |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| 120.4 | 112.8 | 111.9 | 108.4 | 105.9 |
| Forecast | | | | |
| **2017** | **2018** | **2019** | **2020** | **2021** |
| 102.9 | 103.1 | 107.5 | 107.1 | 105.8 |
| Forecast | | | | |
| **2022** | **2023** | **2024** | **2025** | **2026** |
| 103.9 | 102.1 | 101.7 | 101.9 | 100.8 |
| Forecast | | | | |
| **2027** | **2028** | **2029** | **2030** | **2031** |
| 99.6 | 98.5 | 98.3 | 99.0 | 98.8 |
| Forecast | | | | |
| **2032** | **2033** | **2034** | **2035** | |
| 99.9 | 98.9 | 95.4 | 94.7 | |

[9] The preliminary total coal production number for 2014 (used here and in the following charts/figures) is reported as weekly and monthly data by the EIA and is based on mine-level data reported to the Mine Safety and Health Administration (MSHA).

## Energy Ventures Analysis (EVA)

Publication: EVA Long-Term Forecast

Date: June 2015

Forecast Horizon: 2015-2040

Region(s): Northern Appalachia, Central Appalachia, West Virginia

EVA utilizes the Aurora XP Dispatch Model that calculates electricity generation by fuel type by developing the least cost generation situation that will meet power demand. All existing and planned generation capacity is included and the model can add or retire capacity as needed (Energy Ventures Analysis 2013).

*Key Assumptions:*

Macroeconomic Issues: GDP growth is expected to average 2.0 % per year through 2040.

Coal Prices: Coal prices for both Northern and Central Appalachia are expected to recover from the very low prices in 2015 although the recovery will take a number of years. By 2040, prices from both regions are expected to approach $60 per ton in real 2015 dollars and $90 per ton in nominal dollars.

Natural Gas Prices: Gas prices are expected to steadily increase through 2040 resulting in a price of close to $7 per MMBtu (2015$) in 2040.

Electricity: Growth in electricity demand is expected to average 0.7% per year through 2040. Demand for Appalachian coal by the electricity sector is projected to fall 27% between 2014 and 2040. With the retrofit of technologies, coal supply has become fungible meaning demand can switch between coal supply regions (e.g., Northern Appalachia and Illinois Basin) based upon the relative competitiveness of each. Future demand which is based upon an equilibrium analysis may shift between supply regions.

Industrial/Commercial: Non-coke industrial demand for Appalachian coal is projected to fall by about 40% between 2014 and 2040. Demand for metallurgical coal from Northern and Central (primarily) Appalachia during this same period is projected to fall by about 20%.

Exports: Steam coal exports from Northern and Central (primarily) Appalachia peaked in 2012 and are projected to decline by over 70% between 2014 and 2040. The decline reflects the relative lack of competitiveness of Central Appalachia coals in the global market. Steam coal exports overall are expected to increase if one or more announced

export terminals are built in the Pacific Northwest allowing competitive delivery of Powder River Basin coals into the Pacific market. Met coal exports from Northern and Central (primarily) Appalachia peaked in 2011 and are projected to decline by about 20% between 2014 and 2040. Compared to 2014, total Appalachian coal exports are projected to decline by 30% by 2040.

Environmental: The Cross-State Air Pollution Rule (CSAPR) went into effect January 1, 2015. The Mercury and Air Toxics Standards (MATS) went into effect April 2015 with a liberal one year extension. Section 316(b) of the Clean Water Act goes into effect with 2018 compliance for minor intake modifications and 2020 compliance for these requiring cooling towers. Coal Combustion Residuals (CCR) goes into effect by 2020. Conversion to dry ash handling is required by some. New landfills require lining. National Ambient Air Quality Standards (NAAQS) revisions will include fine particulate and ozone standards. SCR's will be required on all units for NOx. Regional haze compliance using Best Available Retrofit Technology will go into effect in 2020 excepting any announced settlements. Greenhouse Gas New Source Performance Standard is assumed to limit ability to add new coal-fired generation absent carbon capture and sequestration. No Federal program to reduce CO2 emissions on existing plants is assumed. Regional CO2 programs (i.e., RGGI and AB32) are assumed to continue.

*Results:*

**Table 2: EVA Long-Term West Virginia Coal Production Forecast 2014**

| West Virginia Coal Production (million tons) | | | | |
|---|---|---|---|---|
| Historical | | Preliminary | Forecast | |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| 120.4 | 112.8 | 111.9 | 109.9 | 104.7 |
| | | Forecast | | |
| **2017** | **2018** | **2019** | **2020** | **2021** |
| 101.9 | 105.5 | 108.3 | 109.2 | 110.4 |
| | | Forecast | | |
| **2022** | **2023** | **2024** | **2025** | **2026** |
| 110.4 | 111.7 | 113.2 | 111.9 | 113.2 |
| | | Forecast | | |
| **2027** | **2028** | **2029** | **2030** | **2031** |
| 113.8 | 114.4 | 114.8 | 114.9 | 115.0 |
| | | Forecast | | |
| **2032** | **2033** | **2034** | **2035** | |
| 116.2 | 114.8 | 114.9 | 114.0 | |

## Marshall University Center for Business and Economic Research (CBER)

Publication: CBER West Virginia Coal Production Forecast 2015

Date: June 2015

Forecast Horizon: 2014-2035

Region(s): West Virginia

The CBER forecast of West Virginia total coal production is an econometric model based on quarterly changes in total production from 1984 through 2013. The forecast model treats 2012 as a structural change in the coal market.[10] Data for the model are from EIA's monthly coal fuel receipts contained in Schedule 2 of Form EIA-923.[11] To create the initial short-term forecast, quarterly changes in total coal production were modeled with a vector autoregression (VAR) approach that explicitly accounted for the national price of exported coal and forecasted demand for West Virginia-sourced coal in regional power generation.[12] For years beyond 2023, the CBER forecast utilizes an autoregressive approach, which estimates future changes in total coal production based on historical patterns.

*Key Assumptions:*

Macroeconomic Issues: Moderate average annual GDP growth rates of about 2 to 2.5% per year, consistent with other macroeconomic forecasts.

Coal Prices: In the short-term, coal prices are expected to follow trends of the last decade, with increases exceeding that of general inflation. In the long-term prices increases are expected to be more modest.

Natural Gas Prices: Stable gas prices are expected in the short term. The planned addition of new natural gas capacity will also impact regional competitiveness in the near-term.

Electricity: Growth in electricity demand in the Eastern region of about 1.5% over the short term forecast horizon. Demand for West Virginia coal by the electricity sector in the Eastern region is expected to decline by 7.0% annually between 2014 and 2023.[13]

Industrial/Commercial: The conversion of former coal-fired self-generators to natural gas is expected to reduce industrial demand for West Virginia coal.

[10] Dummy variables were included in the model to identify 2012 which moderated the decline in forecasted values that otherwise result when weighting 2012 equally to the preceding years. See Hansen (2001) for a discussion of structural change as relating to U.S. Labor market trends. http://www.ssc.wisc.edu/~bhansen/papers/jep_01.pdf

[11] Form EIA-923 is available at http://www.eia.gov/electricity/data/eia923/.

[12] For more detail on the power generation demand model, see Appendix B.

[13] 7.0% is a compound annual rate.

Exports: Moderate growth in export markets for West Virginia coal is expected to mitigate some of the decline in demand from the regional power generation sector.

Environmental: Power plant closures due to non-compliance with MATS are expected to continue at a steady pace through 2016. West Virginia has already lost market share at plants that are soon to retire, causing some of these effects to occur prior to closure.

*Results:*

**Table 3: CBER Long-term West Virginia Coal Production Forecast 2014**

| West Virginia Coal Production (million tons) | | | | |
|---|---|---|---|---|
| Historical | | Preliminary | Forecast | |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| 120.4 | 112.8 | 111.9 | 105.7 | 103.6 |
| | | Forecast | | |
| **2017** | **2018** | **2019** | **2020** | **2021** |
| 101.5 | 99.5 | 97.5 | 95.4 | 93.4 |
| | | Forecast | | |
| **2022** | **2023** | **2024** | **2025** | **2026** |
| 91.4 | 89.4 | 88.2 | 87.6 | 87.0 |
| | | Forecast | | |
| **2027** | **2028** | **2029** | **2030** | **2031** |
| 86.3 | 85.7 | 85.1 | 84.5 | 83.9 |
| | | Forecast | | |
| **2032** | **2033** | **2034** | **2035** | |
| 83.3 | 82.7 | 82.00 | 81.4 | |

## West Virginia University Bureau for Business and Economic Research (BBER)

Publication: Coal Production in West Virginia: 2015-2035

Date: May 2015

Forecast Horizon: 2015-2035

Region: Northern West Virginia and Southern West Virginia

The WVUfbb BBER Coal Production Forecast is an econometric model analyzing demand and price data for West Virginia mines from 1985 through 2014. Historical data as well as U.S.-level forecasts published in EIA's Annual Energy Outlook 2015 and IHS Global Insight's April 2015 Forecast are used in the model. Region-specific variables are calculated by WVU BBER (West Virginia University BBER 2015).

*Key Assumptions:*

Macroeconomic Issues: Expected annual real GDP is 2.4% through the forecast horizon.

Coal Prices: The U.S. average price of coal is expected to reach $42 per short ton by 2035. Inflation-adjusted coal prices are also forecasted to increase in both Northern and Southern West Virginia.

Natural Gas Prices: Real natural gas prices to utilities are projected to increase 2% annually.

Electricity: The annual increase of electricity generation during the forecast horizon is expected at 1%. Coal and natural gas are forecasted to hold similar shares of electricity generation by 2035.

Industrial/Commercial: Industrial and commercial use of West Virginia coal is expected to decrease 23% by 2035.

Exports: 2012 is listed as an all-time peak for coal exports from West Virginia. Export levels are not expected to reach this level again through 2035.

Environmental: Only current legislation and environmental regulations not under legal dispute are considered in the forecast including MATS and the Clean-Air Interstate Rule (CAIR). Continuing retirement of coal plants is expected through 2016 to comply with MATS. The Clean Power Plan is not considered.

*Results:*

**Table 4: WVU BBER West Virginia Coal Production Forecast 2014**

| West Virginia Coal Production (million tons) | | | | |
|---|---|---|---|---|
| Historical | | Preliminary | Forecast | |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| 120.4 | 112.8 | 111.9 | 103.9 | 98.2 |
| | | Forecast | | |
| **2017** | **2018** | **2019** | **2020** | **2021** |
| 99.9 | 101.5 | 103.3 | 104.7 | 104.8 |
| | | Forecast | | |
| **2022** | **2023** | **2024** | **2025** | **2026** |
| 104.7 | 105.1 | 104.9 | 104.7 | 104.5 |
| | | Forecast | | |
| **2027** | **2028** | **2029** | **2030** | **2031** |
| 104.0 | 103.0 | 102.2 | 101.6 | 100.5 |
| | | Forecast | | |
| **2032** | **2033** | **2034** | **2035** | |
| 99.8 | 98.6 | 97.3 | 95.6 | |

## Consensus Forecast

The four long-term forecasts produced by EIA, EVA, CBER, and WVU are combined to create the Consensus Forecast for West Virginia Coal Production.[14] A weighted average is used to combine the four projections as follows (Armstrong 2001):

$$WV\ Coal\ Production_t = w_{EIA} * EIA\ Production_t + w_{EVA} * EVA\ Production_t + w_{CBER} * CBER\ Production_t + w_{WVU} * WVU\ Production_t$$

The weight ($w_i$) assigned to each forecast is based on the accuracy of past forecasts by that organization. All available forecasts for 2011 through present were evaluated for accuracy. For example, EIA's 2015 Annual Energy Outlook was assessed by considering the accuracy of its 2011, 2012, 2013, and 2014 projections.

Only recent years were evaluated due to the tumultuous macroeconomic conditions that appeared in late 2007 and 2008. Predictions for the first years of the time horizon were considered because accuracy is typically highest at the beginning of the forecast. Long-term accuracy was not considered in this weighting method due to the large potential for unpredictable macroeconomic conditions to affect annual error.

The error ($e_i$) of a forecast was determined using the following formula.

$$e_{i,t} = \frac{Forecast\ Production_{i,t} - Actual\ Production_t}{Actual\ Production_t}$$

The absolute value of the errors was averaged for each forecasting organization to remove the effects of under-estimation and over-estimation canceling each other. Since a new methodology was used by CBER in 2014, average error was calculated by evaluating the accuracy of the 2014 forecast and creating an in-sample forecast in 2015 and comparing these results to the actual values for 2011 through 2014.

**Table 5: Average Absolute Errors**

| | Average Error |
|---|---|
| EIA | 5.81% |
| EVA | 7.26% |
| CBER | 9.75% |
| WVU | 8.19% |

[14] For more information on the creation of consensus forecasts, see http://www.forecastingprinciples.com/paperpdf/Combining.pdf.

The weight given to each organization in the consensus was calculated as follows (Armstrong 2001):

$$w_i = \frac{\frac{1}{e_i}}{\sum_i \frac{1}{e_i}}$$

Using the following weights, the Consensus Forecast is calculated.

**Table 6: Consensus Weights**

| | Weight |
|---|---|
| EIA | 0.32 |
| EVA | 0.26 |
| CBER | 0.19 |
| WVU | 0.23 |

The results are shown below in table and figure format. The Consensus Forecast for West Virginia Coal Production shows production levels decreasing through 2017 and then remaining fairly steady though 2021. After 2021, production levels show a gradual and steady decreasing trend falling to 97 million tons of coal produced in 2035.

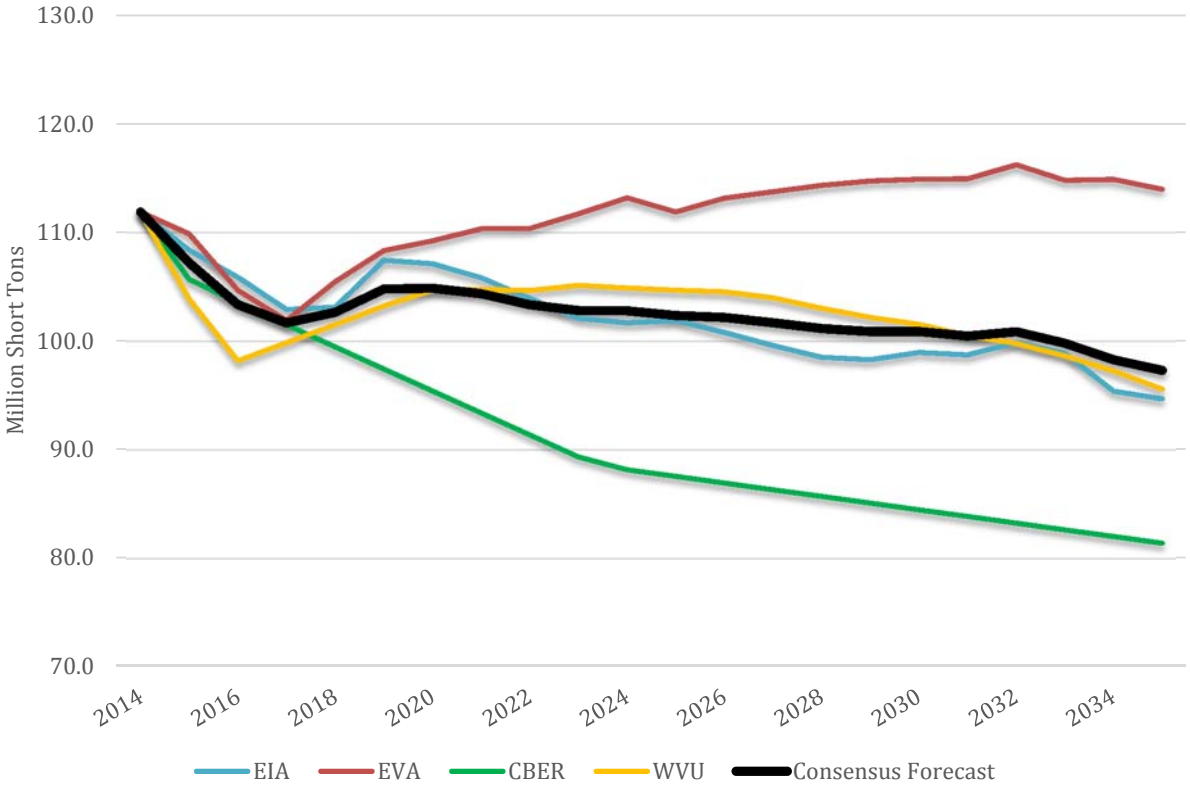
**Table 7: Consensus Forecast for West Virginia Coal Production 2014**

| **West Virginia Coal Production (million tons)** | | | | |
|---|---|---|---|---|
| **Historical** | | **Preliminary** | **Forecast** | |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| 120.4 | 112.8 | 111.9 | 107.2 | 103.4 |
| | | **Forecast** | | |
| **2017** | **2018** | **2019** | **2020** | **2021** |
| 101.7 | 102.7 | 104.8 | 104.9 | 104.4 |
| | | **Forecast** | | |
| **2022** | **2023** | **2024** | **2025** | **2026** |
| 103.4 | 102.8 | 102.8 | 102.4 | 102.2 |
| | | **Forecast** | | |
| **2027** | **2028** | **2029** | **2030** | **2031** |
| 101.7 | 101.2 | 100.9 | 100.9 | 100.5 |
| | | **Forecast** | | |
| **2032** | **2033** | **2034** | **2035** | |
| 100.9 | 99.8 | 98.3 | 97.3 | |

## Table 8: Comparison of Component Forecasts and 2013-2015 Consensus Forecasts

| West Virginia Coal Production (million tons) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 2015 Forecasting Group | | | | 2015 Consensus | 2014 Consensus | 2013 Consensus |
| | EIA | EVA | CBER | WVU | | | |
| **2015** | 108.4 | 109.9 | 105.7 | 103.9 | 107.2 | 106.9 | 113.9 |
| **2016** | 105.9 | 104.7 | 103.6 | 98.2 | 103.4 | 101.4 | 112.2 |
| **2017** | 102.9 | 101.9 | 101.5 | 99.9 | 101.7 | 103.0 | 113.5 |
| **2018** | 103.1 | 105.5 | 99.5 | 101.5 | 102.7 | 103.3 | 108.7 |
| **2019** | 107.5 | 108.3 | 97.5 | 103.3 | 104.8 | 102.4 | 105.6 |
| **2020** | 107.1 | 109.2 | 95.4 | 104.7 | 104.9 | 101.5 | 105.4 |
| **2021** | 105.8 | 110.4 | 93.4 | 104.8 | 104.4 | 100.9 | 104.8 |
| **2022** | 103.9 | 110.4 | 91.4 | 104.7 | 103.4 | 100.7 | 106.6 |
| **2023** | 102.1 | 111.7 | 89.4 | 105.1 | 102.8 | 100.0 | 107.6 |
| **2024** | 101.7 | 113.2 | 88.2 | 104.9 | 102.8 | 99.9 | 107.2 |
| **2025** | 101.9 | 111.9 | 87.6 | 104.7 | 102.4 | 99.2 | 106.3 |
| **2026** | 100.8 | 113.2 | 87.0 | 104.5 | 102.2 | 98.2 | 106.3 |
| **2027** | 99.6 | 113.8 | 86.3 | 104.0 | 101.7 | 98.1 | 106.1 |
| **2028** | 98.5 | 114.4 | 85.7 | 103.0 | 101.2 | 97.1 | 105.4 |
| **2029** | 98.3 | 114.8 | 85.1 | 102.2 | 100.9 | 97.1 | 105.0 |
| **2030** | 99.0 | 114.9 | 84.5 | 101.6 | 100.9 | 96.5 | 104.4 |
| **2031** | 98.8 | 115.0 | 83.9 | 100.5 | 100.5 | 96.3 | 103.5 |
| **2032** | 99.9 | 116.2 | 83.3 | 99.8 | 100.9 | 95.1 | 101.9 |
| **2033** | 98.9 | 114.8 | 82.7 | 98.6 | 99.8 | 94.2 | 99.6 |
| **2034** | 95.4 | 114.9 | 82.0 | 97.3 | 98.3 | 93.7 | 99.0 |
| **2035** | 94.7 | 114.0 | 81.4 | 95.6 | 97.3 | 91.6 | 97.3 |

**Figure 6: Component and Consensus Forecasts 2014 (million tons)**




## Summary

The 2015 West Virginia Consensus Coal Forecast figures are higher than the 2014 Consensus. A primary reason for this is lower coal prices, which in some models are an indication of lower production costs and more competitive supply from Appalachian producers as higher cost mines have closed. The EIA and EVA models both project higher production for West Virginia than in the prior forecast, while the CBER model projects lower production.

A significant change to the 2015 Consensus Coal Forecast is the addition of the WVU long-term forecast. This increases the number of long-term forecasts to four from three, and lowers the weights of the component forecasts. The EIA maintains the highest share of the consensus due to historical accuracy of its forecasts, but its share of the consensus is lower than in the last two years.

The EIA model projects total coal consumption in the U.S. electric power sector to be higher than in its AEO2014 analysis due to an increase in output from the remaining coal-fired

power plants, with the projected capacity factor for the U.S. coal fleet increasing from 60% in 2013 to 67% in 2016.[15] The relatively low operating costs of existing coal-fired units limit the decline in coal use in the EIA reference case model. The AEO2015 also projects lower prices and lower production for Appalachian coal through 2040 compared to AEO2014. All of the increased decline comes from Northern and Southern Appalachia, as Central Appalachian production is projected to be higher. Northern production is projected to be on average about 10 percent lower than the AEO2014 analysis, while Central production is projected to be about seven percent higher, even though productivity is still expected to decline more rapidly in Central Appalachia.

The EVA model projects West Virginia's share of both the Northern and Central Appalachian coal supply to grow over time. A 2015 change to this model was to increase the maximum economic life of coal power plants from 65 to 70 years, which results in increased coal usage for power generation over time.

The CBER model is influenced by inclusion of final 2013 production and demand data, which added another year of decline to historical trends. The addition of coal export prices to the model allows explicit incorporation of the impact of an additional market that was previously not analyzed.

The component models within the consensus forecast incorporate a wide range of possible levels of West Virginia coal production over the next 20 years. These varying levels of forecasted coal production illustrate the impact of various supply variables and uncertainty over whether the continuation of recent trends will or will not continue. The consensus reduces uncertainty by combining the forecasts into one aggregate projection where West Virginia coal production continues to decline through 2018, recovers slightly for a couple years, and then declines slowly through 2035.

[15] EIA AEO2015, Coal Market Module.

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## Appendix A: EIA Forecasts for Northern and Southern West Virginia

The EIA forecasts coal production by region in its Annual Energy Outlook. Appalachia is split into three regions: Northern, Central, and Southern. For the purposes of this study, only the Northern and Central Appalachian regions are applicable. The Northern Appalachia region includes Pennsylvania, Maryland, Ohio, and Northern West Virginia while Central Appalachia includes Virginia, Eastern Kentucky, Northern Tennessee, and Southern West Virginia. Forecasts for these regions are adapted to Northern and Southern West Virginia production. EIA's forecasted annual growth rates for Northern and Central Appalachia are shown first.

**Table 9: Growth Rates for Coal Production in Northern and Central Appalachia (EIA)**

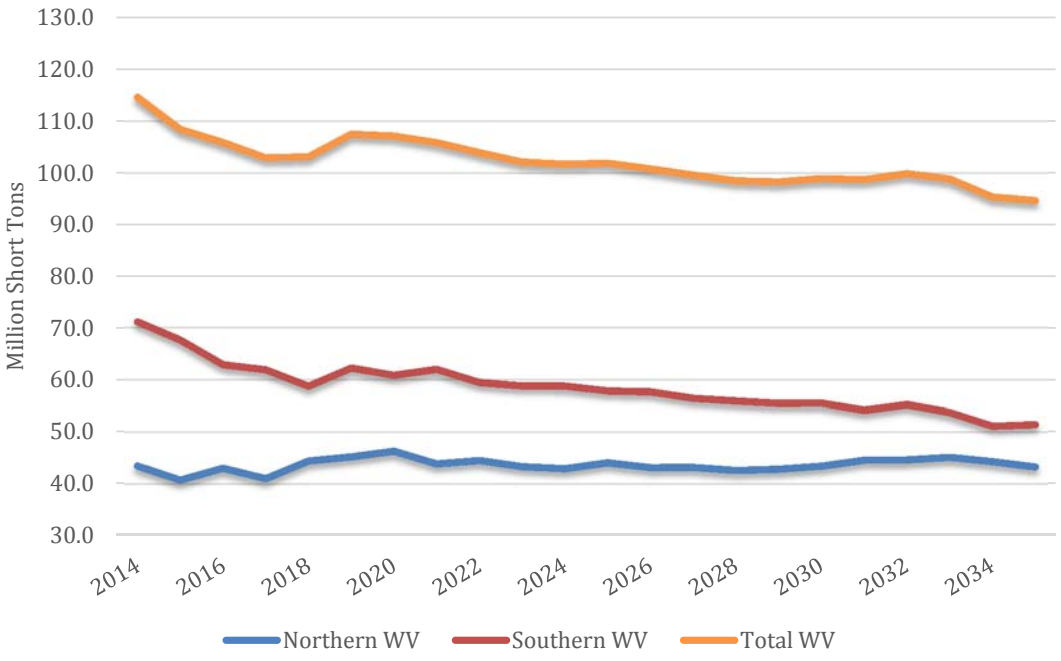
| | **2014** | **2015** | **2016** | **2017** | **2018** |
|---|---|---|---|---|---|
| Northern Appalachia | 2.5% | 6.2% | 5.6% | 4.6% | 8.2% |
| Central Appalachia | 1.0% | -4.9% | -7.1% | -1.6% | -5.1% |
| | **2019** | **2020** | **2021** | **2022** | **2023** |
| Northern Appalachia | 1.8% | 2.3% | -5.2% | 1.4% | -2.6% |
| Central Appalachia | 6.0% | -2.3% | 1.9% | -4.1% | -1.1% |
| | **2024** | **2025** | **2026** | **2027** | **2028** |
| Northern Appalachia | 0.9% | 2.7% | -2.1% | 0.0% | -1.3% |
| Central Appalachia | 0.0% | -1.6% | -0.3% | -2.1% | -0.9% |
| | **2029** | **2030** | **2031** | **2032** | **2033** |
| Northern Appalachia | 0.6% | 1.4% | 2.6% | 0.1% | 1.1% |
| Central Appalachia | -0.9% | 0.1% | -2.5% | 2.0% | -2.7% |
| | **2034** | **2035** | | | |
| Northern Appalachia | -1.8% | -2.3% | | | |
| Central Appalachia | -4.9% | 0.6% | | | |

These regional growth rates are applied to historical West Virginia coal production data to achieve the State forecast. Growth rates for Northern Appalachia are used to project Northern West Virginia coal production, and rates for Central Appalachia are applied to Southern West Virginia. The calculated forecasts for Northern and Southern West Virginia are summed to produce the total West Virginia coal production.

## Table 10: West Virginia Coal Production by Region (EIA)

| | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|
| Northern WV | 43,466 | 40,753 | 43,040 | 41,046 | 44,427 |
| Southern WV | 71,113 | 67,643 | 62,861 | 61,880 | 58,710 |
| **Total WV** | **114,579** | **108,395** | **105,900** | **102,926** | **103,137** |
| | **2019** | **2020** | **2021** | **2022** | **2023** |
| Northern WV | 45,247 | 46,310 | 43,890 | 44,514 | 43,341 |
| Southern WV | 62,219 | 60,819 | 61,959 | 59,429 | 58,781 |
| **Total WV** | **107,467** | **107,129** | **105,849** | **103,944** | **102,122** |
| | **2024** | **2025** | **2026** | **2027** | **2028** |
| Northern WV | 42,945 | 44,093 | 43,182 | 43,189 | 42,623 |
| Southern WV | 58,760 | 57,821 | 57,637 | 56,419 | 55,913 |
| **Total WV** | **101,705** | **101,914** | **100,819** | **99,608** | **98,535** |
| | **2029** | **2030** | **2031** | **2032** | **2033** |
| Northern WV | 42,866 | 43,457 | 44,604 | 44,661 | 45,141 |
| Southern WV | 55,436 | 55,518 | 54,150 | 55,220 | 53,737 |
| **Total WV** | **98,302** | **98,975** | **98,754** | **99,882** | **98,878** |
| | **2034** | **2035** | | | |
| Northern WV | 44,312 | 43,297 | | | |
| Southern WV | 51,107 | 51,417 | | | |
| **Total WV** | **95,419** | **94,714** | | | |

## Figure 7: West Virginia Coal Production by Region (EIA)



## Appendix B: Power Generation Demand Forecast

To better understand the dynamics influencing total coal production for West Virginia, CBER analyzed data on West Virginia Coal consumed by power plants in the eastern region of the United States. The data for the analysis are from EIA's monthly fuel receipts data (EIA 2015), which have been aggregated into total quarterly fuel receipts of coal sourced from West Virginia for the period 2002-2013. Additional factors considered for the analysis include real natural gas prices and electricity demand (as indicated by average heating and cooling degree days in the region).

To construct the power generation demand forecast, CBER first projected electricity demand in the region, using coal-fired power plant capacity as a proxy. A key assumption is that capacity required to serve estimated electricity demand is irrespective of fuel type, and thus indicative of electricity demand generally. Using a vector autoregression model (VAR), CBER jointly forecasted the quarterly change in total fuel receipts for West Virginia-sourced coal and real natural gas prices, conditional on modest growth in electricity demand and treating the substantial decline observed in 2012 as a structural break in the coal market.[16]

[16] Dummy variables were included in the model to identify 2012 which moderated the decline in forecasted values that otherwise result when weighting 2012 equally to the preceding years.