Consensus Coal Production Forecast for West Virginia: 2016

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CENTER FOR BUSINESS AND ECONOMIC RESEARCH

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Executive Summary

The 2016 West Virginia Consensus Coal Production Forecast is an annual projection developed to anticipate the volume of tax revenues likely to be received for mandatory reclamation activities undertaken by the Special Reclamation Fund and the Special Reclamation Water Trust Fund. The Consensus calculates projected West Virginia coal production for the years 2016 through 2040.

The consensus forecast projects West Virginia coal production to decline to about 80 million tons in 2016, remain flat for a few years, and then decline to 57 million tons by 2040. Examination of recent trends in demand for West Virginia coal show declines since 2012 led by reduced exports. Since 2012, demand by the power generation industry has been flat, while demand by the commercial and industrial sectors has slowly declined.

The 2016 forecast figures are lower than the 2015 Consensus, in part due to inclusion of possible effects of the EPA's Clean Power Plan rule for regulating carbon dioxide emissions from power plants. The potential effects of the rule are included in two of the component forecasts, while two forecasts do not explicitly include the rule.

The four component forecasts that comprise the consensus are from the U.S. Energy Information Administration (EIA), Energy Ventures Analysis (EVA), Marshall University's Center for Business & Economic Research (CBER) and West Virginia University's Bureau for Business & Economic Research (BBER). The EIA and EVA models explicitly include potential effects of the Clean Power Plan, whereas the CBER and BBER models do not. The EIA maintains the highest share of the consensus due to the relatively high historical accuracy of its forecasts.

Expectations are for most of the projected near-term decline in demand for West Virginia coal to come from the power generation industry. This is due both to persistent low prices for natural gas used for competing generation and to pending retirements of coal-fired generating capacity in the region at plants that are customers of West Virginia coal. Natural gas prices are expected to rise throughout the forecast time period and mitigate some of the potential decline. However, when combined with plant closure and the potential impacts of the Clean Power Plan, the net effect is for demand to continue to fall.

Consensus Coal Production Forecast for West Virginia: 2016

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 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.

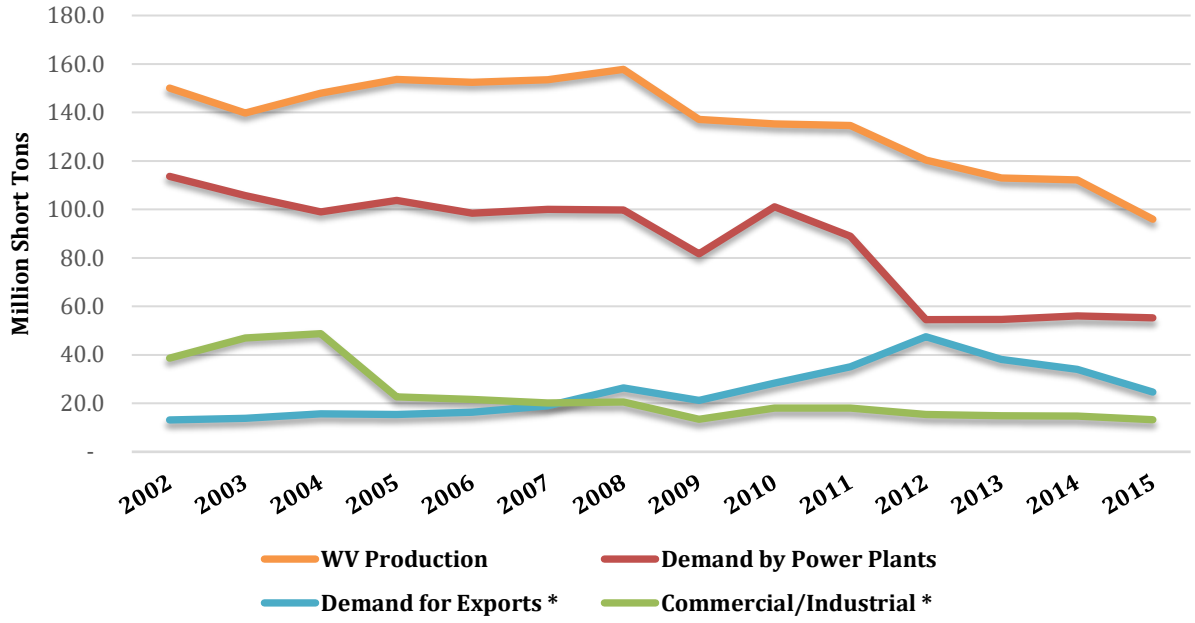
This report describes recent historical coal production trends for the State of West Virginia including the individual industries that comprise the major segments of demand. Each of the component forecasts used to form the Consensus Forecast is then described, with information about assumptions and resulting 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 2016 through 2040.

Overview

West Virginia coal production for 2015 was around 95.5 million tons (EIA 2016),[1] a decline of about 14 percent from the 111.9 million tons produced in 2014. This decline reflects various trends and events within the coal industry's primary markets: power generation, exports and industrial demand as well as expectations regarding environmentalc policy. Figure 1 shows recent demand trends with preliminary and estimated sector-level data for 2015.

[1] 95.5 million tons is the Energy Information Administration's revised 2015 production value based on the final 2015 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 2015 production of 102.9 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



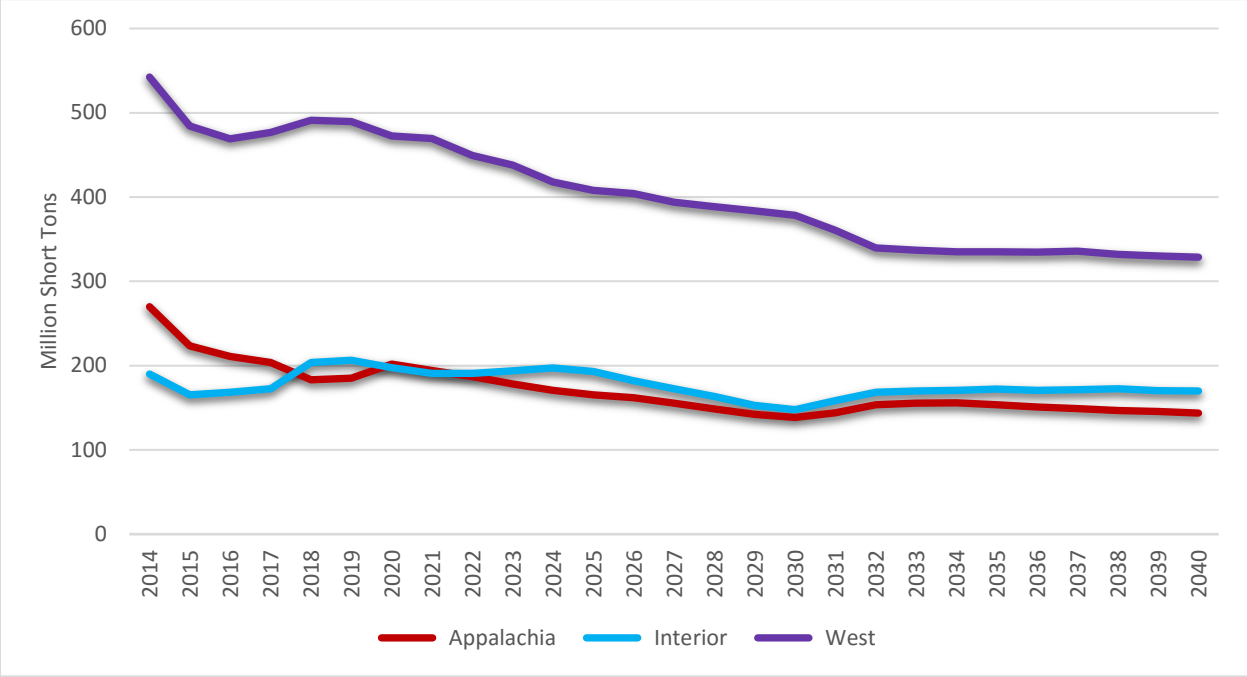
Source: (EIA 2016). Asterisked (*) 2015 volumes estimated by MU CBER. Other 2015 figures are preliminary by EIA.

Future demand for West Virginia coal depends on several variables. These include the price(s) paid by gas-fired electrical generators for natural gas in the region, the lifespan and generation levels of the coal-fired power plants that will continue to burn coal from the State, exchange rates and the rate of economic growth of countries that import West Virginia coal, and the nature of compliance with environmental regulations.

The Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2016 base case model forecasts Appalachian coal production to decline steadily through 2040, with some stability in the 2017 to 2021 and 2028 to 2032 time periods. As shown in Figure 2, stable Interior[2] coal production is projected to surpass declining Appalachian production after 2017.

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

Figure 2: EIA Forecasted Coal Production, by Region



Source: (EIA 2016)

The Electricity Sector

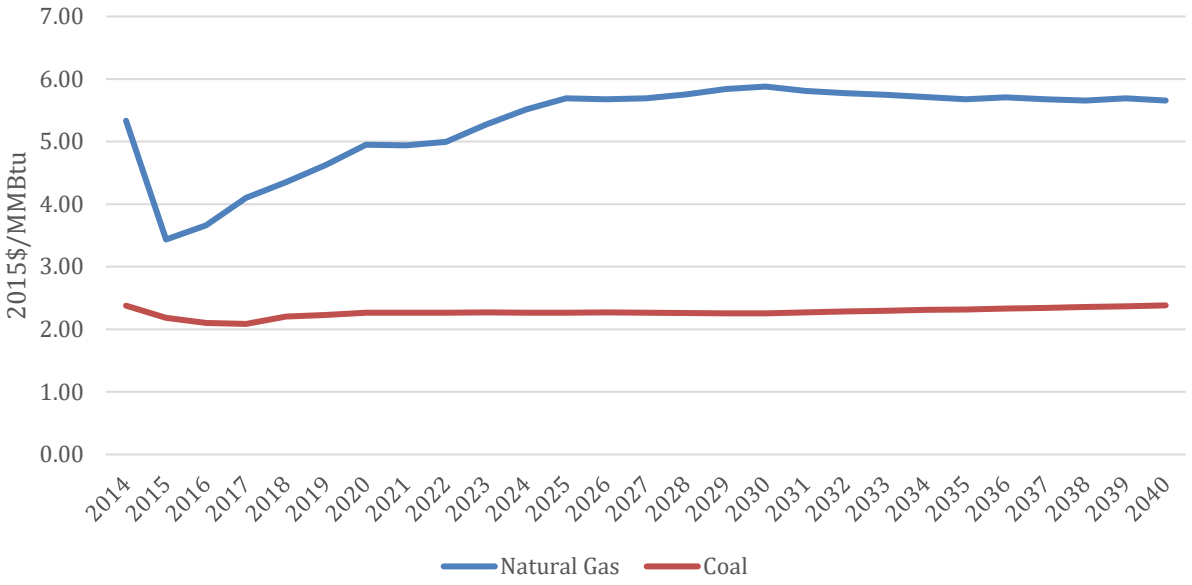
Preliminary power plant fuel receipts data for 2015 published by the EIA indicate that demand for West Virginia-produced coal by the electricity sector fell slightly in 2015, to about 55.3 million tons, compared to about 56.1 million tons in 2014 (EIA 2016). Demand for West Virginia coal by the power generation industry declined by only 1.4 percent between 2014 and 2015 while total electric power industry coal consumption fell by nearly 13 percent (EIA 2016). A large contributor to coal demand is the price of natural gas, which fell in 2015, with the average U.S. price for the electric power sector declining to $3.35/mcf from $5.20/mcf in 2014 (EIA 2016).

Natural Gas Prices

Similar to many forecasts, in its AEO 2016 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 (see Figure 3). Rising natural gas prices are expected to moderate declining coal demand. However, abundant gas production from the Marcellus play continues to result in particularly low gas prices in that area one in which West Virginia coal competes. In 2015, Marcellus-area prices continued to trade at a discount to the Henry Hub price, the national benchmark for natural gas. Recent prices for Zone 4 Marcellus gas, a hub in northeast Pennsylvania, and Dominion South, a hub in southwest Pennsylvania illustrate this

differential. Through June of 2016, prices at these hubs have been in the range of 50 to 75% of the Henry Hub price.[3]

Figure 3: Forecasted Natural Gas & Coal Prices to Electricity Sector[4]



Source: (EIA 2016)

Coal-Fired Power Plant Retirements

Since 2015, no additional units at coal-fired power plants in West Virginia have closed. However, other coal-fired plants in the region that consume West Virginia coal have announced plans to retire. These include new plans, such as those to close units at Sammis in Ohio (The Plain Dealer 2016), as well as other previously announced closures such as the Asheville plant in North Carolina (The Charlotte Observer 2016) and the Yorktown plant Virginia (The Daily Press 2016).

Environmental Regulation

The potential impact of the EPA's Clean Power Plan (CPP) rule is included in two of the component forecasts that comprise the West Virginia Consensus Forecast, those from EIA and Energy Ventures Analysis (EVA). The EPA finalized the CPP in 2015, but the Supreme Court stayed the rule in 2016 due to pending litigation (EIA 2016). Because of the stay, some forecasters exclude the CPP from baseline forecasts.

[3] EIA, *Natural Gas Weekly Update*, January through June of 2016.
[4]Natural gas prices were converted from 2015$/Mcf to 2015$/MMBtu using a factor of 0.9756.

EIA's base case forecast does include the impact of the Clean Power Plan. Due in part to this rule, EIA projects declines in consumption of coal for power generation at a rate of 1.6 percent per year through 2040.

The Industrial Sector

As shown previously in Figure 1 demand for West Virginia 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 driven by a decline in demand for metallurgical coal. EIA's national-level projections forecast a decline in industrial demand for coking coal through 2040, at an annualized rate of 1.2 percent, and an increase in other industrial demand at a rate of 0.6 percent per year (EIA 2016).

U.S. imports of steel products have declined since mid-2015. According to data published by the U.S. Department of Commerce International Trade Administration (ITA) imports of steel mill products in the first half of 2016 were about 31% lower than for the first half of 2015 (ITA 2016). The effect of this decline on demand for steel produced in the U.S. is uncertain.

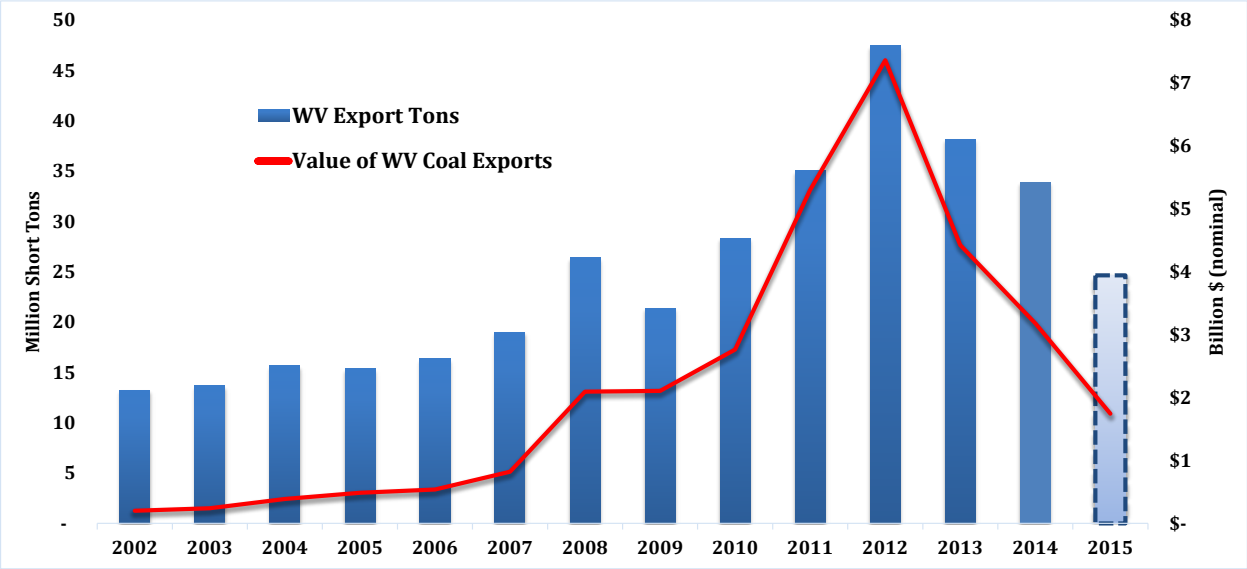
Exports

The nation's coal exports fell again in 2015, to 74 million short tons, down from about 97 million short tons in 2014.[5] The EIA AEO 2016 Reference Case projects total U.S. coal exports to remain below 2015 levels until 2031 (EIA 2016).

The value of coal exports from West Virginia fell to $1.7 billion in 2015, from $3.2 billion in 2014. In spite of another year of declining coal exports, both in value and tonnage, the state maintained exports to many countries in Europe, South America, Africa and Asia. The top five importing countries by value were the Netherlands, Ukraine, Brazil, France and Canada (ITA 2016). Figure 4 shows the value of West Virginia-based coal exports and associated tonnage from 2002 to 2015.

[5] 2015 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 and the value of coal exports from the state.

Figure 4: Value and Tonnage of West Virginia Coal Exports, 2002 to 2015



Source: (EIA 2016) (ITA 2016); 2015 Export tonnage estimated by CBER.

Component Forecasts

Energy Information Administration (EIA)

Publication: Annual Energy Outlook 2016

Date: July 2016

Forecast Horizon: 2016-2040

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 2016). 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 2040, the annual growth rate for Northern Appalachia is applied to 2015 production figures for Northern West Virginia and the annual growth rate for Central Appalachia is applied to Southern West Virginia figures.[6] Only the EIA Reference Case figures are used.[7]

Key Assumptions:

Macroeconomic Issues: Real GDP growth averages 2.2% per year from 2015 to 2040.

Coal Prices: U.S. real minemouth prices are expected to decline slightly in the near-term and return to current levels by 2022. EIA expects Northern Appalachian coal prices to be relatively flat through 2025 and to increase thereafter, from $58.70 in 2015 to $68.80 by 2040. Central Appalachian prices are projected to decline and return to current levels by 2025 and then to increase slightly through 2040, from $67.90 in 2015 to $70.90 in 2040.

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

[7] The EIA presents several situations in the Annual Energy Outlook 2016: a Reference Case, Alternative Clean Power Plan (CPP) cases, High and Low Economic Growth Cases, High and Low World Oil Price Cases, High and Low Oil and Gas Resource Cases, High and Low Technology Efficiency Innovation Cases and others. 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[8] spot prices for natural gas averaged $3.33 per million Btu in 2014 and $2.62 per million Btu in 2015.[9] Prices are expected to be about $2.58 in 2016 and rise thereafter at an annual rate of 2.5 percent, resulting in an average expected price of $4.86 per million Btu in 2040.

Electricity: U.S. use of coal for production of electricity is expected to decline by 1.6% annually from 2015 to 2040. Coal-fired generating capacity is expected to decrease at a rate of two percent per year through the 2040. By comparison, combined-cycle (natural gas) capacity is projected to increase by 1.8 percent per year and renewable capacity by 3.3 percent per year.

Industrial/Commercial: The industrial sector is expected to have a slight increase in coal consumption by 2025 compared to 2015 levels. A decline in consumption is projected in metallurgical coal use (27 percent lower in 2040 than 2015). Other industrial use is projected to increase by about 17 percent from 2015 levels. The commercial sector is expected to maintain flat coal consumption throughout the forecast period.

Exports: National coal exports are expected to decline in the near-term and return to 2015 levels around 2030.

Environmental: The AEO2016 Reference case assumes that the CPP will proceed as currently promulgated, and that all states will implement it by using a mass-based standard that caps emissions from both existing and new power plants, with allowance revenues rebated to ratepayers (EIA 2016).

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

[9] Henry Hub spot prices are listed in real dollars in 2015. Nominal prices from previous years are inflation-adjusted to the equivalent dollar value in the year 2015.

Results:

Table 1: EIA Annual Energy Outlook 2016 Adapted to West Virginia Production[10]

West Virginia Coal Production (million tons)				
Historical		**Preliminary**	**Forecast**	
2013	**2014**	**2015**	**2016**	**2017**
112.8	111.9	95.5	96.1	92.6
		Forecast		
2018	**2019**	**2020**	**2021**	**2022**
86.2	88.0	94.6	91.1	87.2
		Forecast		
2023	**2024**	**2025**	**2026**	**2027**
82.0	78.0	74.9	72.5	69.0
		Forecast		
2028	**2029**	**2030**	**2031**	**2032**
65.3	61.7	59.4	61.0	64.2
		Forecast		
2033	**2034**	**2035**	**2036**	**2037**
64.9	64.7	63.3	63.4	63.8
		Forecast		
2038	**2039**	**2040**		
63.5	63.3	63.1		

[10] The preliminary total coal production number for 2015 (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: July 2016

Forecast Horizon: 2015-2040

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

EVA utilizes the AURORAxmp dispatch model that calculates electricity generation by fuel type by developing the least cost dispatch solution to meet power demand. All existing and planned generation capacity is included, and the model can add or retire capacity as needed.

Key Assumptions:[11]

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 be in the $52-54 per ton range in real 2015 dollars and $82-85 per ton range in nominal dollars.

Natural Gas Prices: Gas prices are expected to steadily increase through 2040 resulting in a price of $6.30 per MMBtu (2015$) in 2040.

Electricity: Growth in electricity demand is expected to average 0.6% per year through 2040. Demand for Appalachian coal by the electricity sector is projected to fall 30% 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 22% between 2014 and 2040. Demand for metallurgical coal from Northern and Central (primarily) Appalachia during this same period is projected to fall by about 27%.

Exports: Steam coal exports from Northern and Central (primarily) Appalachia peaked in 2012 and are projected to decline by about 70% between 2014 and 2040. The decline

[11] Key assumptions for the EVA Long-Term Forecast were provided via email.

reflects the relative lack of competitiveness of Central Appalachia coals in the global market. Steam coal exports overall could 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; Phase II goes into effect January 1, 2017. 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 2019 compliance for minor intake modifications and 2022 compliance for these requiring cooling towers. A final rule related to power plant wastewater discharges was announced in September 2015. Upgrades to waste water treatment plants are assumed by 2022. Coal Combustion Residuals (CCR) goes into effect by 2020. Conversion to dry ash handling is assumed by 2022 and use of lined landfills for subsequent ash disposal. 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 partial carbon capture and sequestration or co-firing with gas. Due to the Supreme Court stay of the Clean Power Plan, EVA's base case analysis assumes no Federal program is in place to reduce CO2 emissions on existing plants. However, this forecast is based on projected coal demand under a mass compliance approach to the rule with and without national trading. Regional CO2 programs (i.e., RGGI and AB32) are assumed to continue.

Results:

Table 2: EVA Long-Term West Virginia Coal Production Forecast 2016

West Virginia Coal Production (million tons)				
Historical		Preliminary	Forecast	
2013	**2014**	**2015**	**2016**	**2017**
112.8	111.9	95.5	56.2	51.2
		Forecast		
2018	**2019**	**2020**	**2021**	**2022**
48.1	56.1	65.8	67.5	63.5
		Forecast		
2023	**2024**	**2025**	**2026**	**2027**
62.1	58.8	61.1	60.3	58.5
		Forecast		
2028	**2029**	**2030**	**2031**	**2032**
57.4	56.7	55.5	56.4	56.7
		Forecast		
2033	**2034**	**2035**	**2036**	**2037**
58.4	58.7	58.6	58.4	57.5
		Forecast		
2038	**2039**	**2040**		
56.2	53.6	49.7		

Marshall University Center for Business and Economic Research (CBER)

Publication: CBER West Virginia Coal Production Forecast 2016

Date: July 2016

Forecast Horizon: 2016-2040

Region(s): West Virginia

The CBER forecast of West Virginia total coal production is an econometric model based on quarterly coal production from 1984 through the third quarter of 2015[12]. The forecast model treats 2009 through 2015 as a structural change in the coal market.[13] Data for the model are from EIA's monthly coal fuel receipts contained in Schedule 2 of Form EIA-923.[14] 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 forecasted demand for West Virginia-sourced coal in regional power generation.[15] For years beyond 2025, 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. The CBER forecast uses a consensus approach to forecasting coal production in both the short-run and long-run scenarios, combining a base model (status quo) and a structural break model including a dummy variable for the years 2009 through 2015. (See Appendix B for additional details in this consensus approach.)

Natural Gas Prices: Annual natural gas price increases of 2.5% are projected between 2015 and 2025 in the case with the 2009-2015 dummy variable.

Electricity: Demand for West Virginia coal by the electricity sector in the Eastern region is expected to decline by 3.0% annually between 2015 and 2025.[16]

[12] Final data for all model variables was not available past the third quarter of 2015 at the time of publication.
[13] Dummy variables were included in the model to identify 2009-2015, which moderated the decline in forecasted values, that otherwise result when weighting 2009-2015 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
[14] Form EIA-923 is available at http://www.eia.gov/electricity/data/eia923/.
[15] For more detail on the power generation demand model, see Appendix B.
[16] 3.0% is an average annual rate.

Exports: Exports are not explicitly modeled in the long-term forecast. However, in the mid to long-term moderate recovery in export markets for West Virginia coal is expected to mitigate some of the decline in demand from the regional power generation sector.

Environmental: Expectations regarding the Clean Power Plan and other environmental legislation affect the demand for West Virginia coal. While environmental policy is not an explicit factor in the CBER forecast, changes in behavior due to the expected impacts of legislation on the economy are present in the historical production data utilized in the model.

Results:

Table 3: CBER Long-term West Virginia Coal Production Forecast 2016

West Virginia Coal Production (million tons)				
Historical		**Preliminary**	**Forecast**	
2013	**2014**	**2015**	**2016**	**2017**
112.8	111.9	95.5	94.1	90.8
		Forecast		
2018	**2019**	**2020**	**2021**	**2022**
87.7	84.6	81.5	78.3	75.2
		Forecast		
2023	**2024**	**2025**	**2026**	**2027**
72.1	68.9	66.1	65.4	64.9
		Forecast		
2028	**2029**	**2030**	**2031**	**2032**
64.3	63.8	63.3	62.7	62.1
		Forecast		
2033	**2034**	**2035**	**2036**	**2037**
61.5	60.9	60.3	59.7	59.1
		Forecast		
2038	**2039**	**2040**		
58.4	57.8	57.1		

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

Publication: WVU BBER Coal Production Forecast 2016

Date: July 2016

Forecast Horizon: 2016-2036

Region: Northern West Virginia and Southern West Virginia

The WVU BBER Coal Production Forecast is an econometric model based upon changes in factors that affect the demand and price for coal sourced from mines in Northern and Southern West Virginia between 1985 through 2014. Historical data on coal prices, production and other energy-related data are obtained from a variety of Energy Information Administration reports. Forecasts for the model's US-specific explanatory variables were taken from the IHS Economics May 2016 forecast and the 2016 Annual Energy Outlook preliminary report from the EIA. Region-specific explanatory variables e.g. exports, were projected by the BBER based upon historical relationships with their corresponding national data series.

Key Assumptions:[17]

Macroeconomic Issues: Expected annual real GDP growth is 2.3% through the forecast horizon.

Coal Prices: Inflation-adjusted coal prices are expected to increase, reaching $64 per short ton (in 2009 dollars) in Northern West Virginia and $62 per short ton in Southern West Virginia— averaged for metallurgical and thermal coal. The U.S. average price is expected to rise to $38 by 2036.

Natural Gas Prices: Real natural gas prices (2009 dollars) paid by utilities are expected to increase at an average annual rate of 2.3% per year between 2016 and 2036, reaching an inflation-adjusted amount of just over $4 by 2036.

Electricity: Total U.S. electricity generation is expected to increase 0.7% per year between 2016 and 2036. Coal and natural gas are expected to account for nearly identical shares (approximately 30%) of overall electricity generation. No new coal-fired power plants are expected to be constructed during the outlook period.

Industrial/Commercial: Total commercial/industrial demand for West Virginia coal is expected to decline 1% per year over the forecast horizon. Most of this decline will be

[17] Key assumptions for the WVU BBER Coal Production Forecast 2016 were provided via email.

driven by non-coke coal industrial/commercial use due to energy efficiency gains and natural gas conversion.

Exports: The baseline forecast assumes 2012 was an all-time peak for West Virginia coal export activity and both metallurgical and steam coal exports from the state will remain below these levels throughout the outlook period. Total exports are expected to increase 42% cumulatively between 2016 and 2036. Southern West Virginia will continue to account for the majority of state coal exports.

Environmental: Only laws that are in place and not currently subject to legal challenges are considered. Retirements of coal-fired generation not compliant with the MATS rule will continue through 2017. The Clean Power Plan and New Source Performance Standards rules are not considered, but given their relevance to future West Virginia coal production, they are addressed in an alternative scenario.

Results:

Table 4: WVU BBER West Virginia Coal Production Forecast 2016

West Virginia Coal Production (million tons)				
Historical		Preliminary	Forecast	
2013	**2014**	**2015**	**2016**	**2017**
112.8	111.9	95.5	68.0	69.2
		Forecast		
2018	**2019**	**2020**	**2021**	**2022**
73.5	75.0	75.4	75.0	74.3
		Forecast		
2023	**2024**	**2025**	**2026**	**2027**
73.8	73.2	72.4	71.7	70.9
		Forecast		
2028	**2029**	**2030**	**2031**	**2032**
69.8	69.1	68.3	67.8	67.7
		Forecast		
2033	**2034**	**2035**	**2036**	
67.5	67.3	67.1	66.8	

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.[18] 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 2013 through present were evaluated for accuracy. For example, EIA's 2015 Annual Energy Outlook was assessed by considering the accuracy of its 2013, 2014, and 2015 projections.

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.

Table 5: Average Absolute Errors

	Average Error
EIA	7.42%
EVA	9.32%
CBER	8.81%
WVU	8.13%

[18] 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):

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

The Consensus Forecast needed to predict West Virginia coal production through 2040. Since one of the component forecasts (WVU BBER) terminated in 2036, two separate weighting rubrics were used in the consensus calculation. Using the following weights, the Consensus Forecast is calculated.

Table 6: Consensus Weights for 2016-2036

	Weight
EIA	0.28
EVA	0.22
CBER	0.24
WVU	0.26

Table 7: Consensus Weights for 2037-2040

	Weight
EIA	0.38
EVA	0.30
CBER	0.32

The results are shown below in table and figure format. The Consensus Forecast for West Virginia Coal Production shows production levels decreasing through 2018 and then temporarily rebounding through 2020. After 2020, production levels show a steady decreasing trend through 2030. West Virginia coal production levels remain stable from 2030 to 2036 before falling to 57 million tons in 2040.

Table 8: Consensus Forecast for West Virginia Coal Production 2016

West Virginia Coal Production (million tons)				
Historical		**Preliminary**	**Forecast**	
2013	**2014**	**2015**	**2016**	**2017**
112.8	111.9	95.5	79.5	76.9
		Forecast		
2018	**2019**	**2020**	**2021**	**2022**
74.7	76.7	80.1	78.6	75.7
		Forecast		
2023	**2024**	**2025**	**2026**	**2027**
73.1	70.3	69.1	67.9	66.2
		Forecast		
2028	**2029**	**2030**	**2031**	**2032**
64.5	63	61.7	62.1	62.9
		Forecast		
2033	**2034**	**2035**	**2036**	**2037**
63.3	63.1	62.5	62.3	60.4
		Forecast		
2038	**2039**	**2040**		
59.7	58.6	57.1		

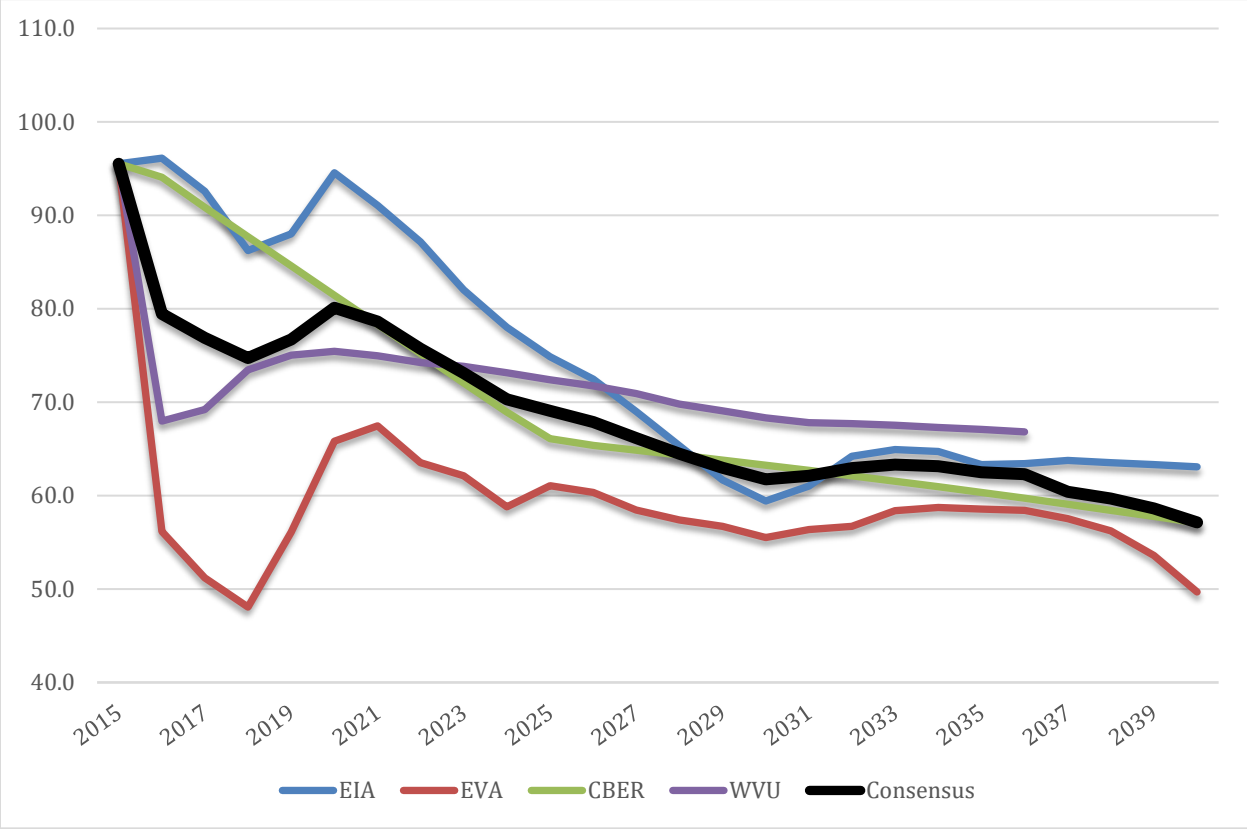
Table 9: Comparison of Component Forecasts and 2013-2016 Consensus Forecasts

West Virginia Coal Production (million tons)

Year	2016 Forecasting Group				2016 Consensus	2015 Consensus	2014 Consensus	2013 Consensus	Actual Tonnage
	EIA	EVA	CBER	WVU					
2013								117.4	112.8
2014							112.4	117.8	111.9
2015						107.2	106.9	113.9	95.5[19]
2016	96.1	56.2	94.1	68.0	79.5	103.4	101.4	112.2	
2017	92.6	51.2	90.8	69.2	76.9	101.7	103.0	113.5	
2018	86.2	48.1	87.7	73.5	74.7	102.7	103.3	108.7	
2019	88.0	56.1	84.6	75.0	76.7	104.8	102.4	105.6	
2020	94.6	65.8	81.5	75.4	80.1	104.9	101.5	105.4	
2021	91.1	67.5	78.3	75.0	78.6	104.4	100.9	104.8	
2022	87.2	63.5	75.2	74.3	75.7	103.4	100.7	106.6	
2023	82.0	62.1	72.1	73.8	73.1	102.8	100.0	107.6	
2024	78.0	58.8	68.9	73.2	70.3	102.8	99.9	107.2	
2025	74.9	61.1	66.1	72.4	69.1	102.4	99.2	106.3	
2026	72.5	60.3	65.4	71.7	67.9	102.2	98.2	106.3	
2027	69.0	58.5	64.9	70.9	66.2	101.7	98.1	106.1	
2028	65.3	57.4	64.3	69.8	64.5	101.2	97.1	105.4	
2029	61.7	56.7	63.8	69.1	63.0	100.9	97.1	105.0	
2030	59.4	55.5	63.3	68.3	61.7	100.9	96.5	104.4	
2031	61.0	56.4	62.7	67.8	62.1	100.5	96.3	103.5	
2032	64.2	56.7	62.1	67.7	62.9	100.9	95.1	101.9	
2033	64.9	58.4	61.5	67.5	63.3	99.8	94.2	99.6	
2034	64.7	58.7	60.9	67.3	63.1	98.3	93.7	99.0	
2035	63.3	58.6	60.3	67.1	62.5	97.3	91.6	97.3	
2036	63.4	58.4	59.7	66.8	62.3				
2037	63.8	57.5	59.1		60.4				
2038	63.5	56.2	58.4		59.7				
2039	63.3	53.6	57.8		58.6				
2040	63.1	49.7	57.1		57.1				

[19] Preliminary production estimate for 2015 from EIA based on data from the U.S. Mine Safety and Health Administration and railroad car loadings from the Association of American Railroads.

Figure 5: Component and Consensus Forecasts 2016 (million tons)



Summary

The 2016 West Virginia Consensus Coal Forecast figures are lower than the 2015 Consensus. A primary reason for this is inclusion of possible effects of the EPA's Clean Power Plan rule for regulating carbon dioxide emissions from power plants.

The component models within the consensus forecast incorporate a wide range of possible levels of West Virginia coal production over the next 25 years. These varying levels of forecasted coal production illustrate the impact of various supply and demand variables and uncertainty over the continuation of recent trends. The consensus reduces uncertainty by combining the forecasts into one aggregate projection where West Virginia coal production declines sharply in 2016, flattens for a few years, and then declines moderately through 2040.

The EIA maintains the highest share of the consensus due to historical accuracy of its forecasts. The EIA model projects total coal consumption in the U.S. electric power sector to be lower than in its AEO2015 analysis due in part to assumed implementation of the Clean

Power Plan, and to projected natural gas prices that are lower than prior assumptions.[20] Central Appalachian coal production is projected to decline faster than in Northern and Southern Appalachia. Northern production is projected to decline by 1.5 percent per year through 2040 while Central Appalachian production is projected to decline by 1.8 percent per year.

The CBER model is influenced by inclusion of preliminary 2015 coal production and demand data. This added another year of decline to already declining historical trends.

The WVU base case model does not include the potential effects of the Clean Power Plan. This provides one explanation for its higher projected levels of production toward the end of the forecast period.

[20] 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 10: Growth Rates for Coal Production in Northern and Central Appalachia (EIA)

	2015	**2016**	**2017**	**2018**	**2019**
Northern Appalachia	-8.7%	6.8%	-3.2%	-21.6%	-2.4%
Central Appalachia	-39.3%	-5.4%	-4.2%	9.9%	5.7%
	2020	**2021**	**2022**	**2023**	**2024**
Northern Appalachia	15.5%	-5.4%	-4.3%	-2.4%	-4.5%
Central Appalachia	1.4%	-2.3%	-4.2%	-8.8%	-5.1%
	2025	**2026**	**2027**	**2028**	**2029**
Northern Appalachia	-2.7%	-1.2%	-4.2%	-4.6%	-4.3%
Central Appalachia	-5.3%	-5.1%	-5.3%	-6.0%	-6.8%
	2030	**2031**	**2032**	**2033**	**2034**
Northern Appalachia	-2.9%	7.2%	11.3%	-0.2%	0.1%
Central Appalachia	-4.4%	-2.0%	-1.5%	2.9%	-0.8%
	2035	**2036**	**2037**	**2038**	**2039**
Northern Appalachia	-0.4%	-1.5%	-0.7%	-1.0%	-1.5%
Central Appalachia	-4.4%	2.4%	2.1%	0.3%	1.2%
	2040				
Northern Appalachia	-2.6%				
Central Appalachia	2.3%				

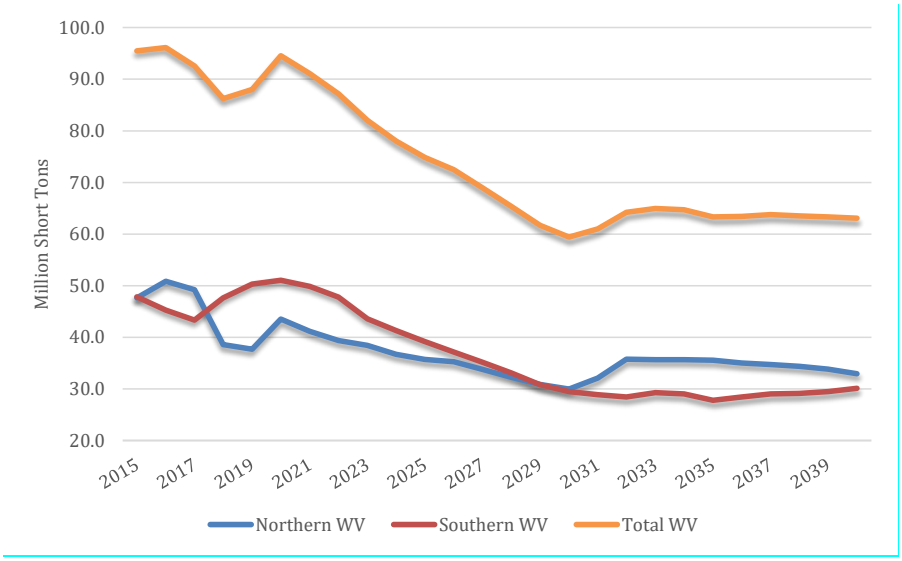
These regional growth rates are applied to preliminary 2015 production data for Northern and Southern West Virginia coal to achieve the 2016 State forecast shown in Table 11.[21] Growth rates for Northern Appalachia are used to project Northern West Virginia coal production, and rates for Central Appalachia are applied to Southern West Virginia. Total forecasted West Virginia coal production is the sum of calculated forecasts for Northern and Southern West Virginia.

[21] 2015 production data is the preliminary data published by EIA.

Table 11: West Virginia Coal Production by Region (EIA)

	2015	2016	2017	2018	2019
Northern WV	47.6	50.9	49.2	38.6	37.7
Southern WV	47.8	45.3	43.3	47.6	50.3
Total WV	**95.5**	**96.1**	**92.6**	**86.2**	**88.0**
	2020	**2021**	**2022**	**2023**	**2024**
Northern WV	43.5	41.2	39.4	38.4	36.7
Southern WV	51.0	49.9	47.8	43.6	41.3
Total WV	**94.6**	**91.1**	**87.2**	**82.0**	**78.0**
	2025	**2026**	**2027**	**2028**	**2029**
Northern WV	35.7	35.3	33.8	32.2	30.8
Southern WV	39.2	37.2	35.2	33.1	30.8
Total WV	**74.9**	**72.5**	**69.0**	**65.3**	**61.7**
	2030	**2031**	**2032**	**2033**	**2034**
Northern WV	30.0	32.1	35.7	35.7	35.7
Southern WV	29.5	28.9	28.5	29.3	29.0
Total WV	**59.4**	**61.0**	**64.2**	**64.9**	**64.7**
	2035	**2036**	**2037**	**2038**	**2039**
Northern WV	35.5	35.0	34.7	34.4	33.9
Southern WV	27.8	28.4	29.0	29.1	29.5
Total WV	**63.3**	**63.4**	**63.8**	**63.5**	**63.3**
	2040				
Northern WV	33.0				
Southern WV	30.1				
Total WV	**63.1**				

Figure 6: West Virginia Coal Production by Region (EIA)



Appendix B: Power Generation Demand Forecast

As in previous forecasts, 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 2016), which have been aggregated into total quarterly fuel receipts of coal sourced from West Virginia for the period 2002-2015 (3rd quarter). 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.

The 2016 CBER West Virginia Coal Production Forecast is a consensus of a base model and a structural break model. In the base model, the above described variables are considered with all years weighted the same. The second model treats the substantial decline in production observed in 2009-2015 as a structural break in the coal market.[22] The CBER forecast gives both the base model and structural break model an even weight in the final forecast calculation. This consensus approach is also applied to the long-run CBER forecast.

[22] Dummy variables were included in the model to identify the years 2009-2015, which moderated the decline in forecasted values that otherwise result when weighting 2009-2015 equally to the preceding years.