Consensus Coal Production Forecast for West Virginia: 2019

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Christine Risch
Director of Resource and Energy Economics, Center for Business and Economic Research

Bo Feng, PhD
Director, Center for Business and Economic Research
Assistant Professor of Economics, Lewis College of Business

Mohammad Karim, PhD
Associate Professor of Finance, Lewis College of Business

Avishek Mallick, PhD
Associate Professor of Statistics, Department of Mathematics

Marshall University
One John Marshall Dr.
Huntington, West Virginia 25701
Phone: (304) 696-5747

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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 the crowd in producing an expectation for output from the coal industry. 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 for coal produced in West Virginia. Each of the component forecasts used to form the Consensus Forecast is 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 2019 through 2045.

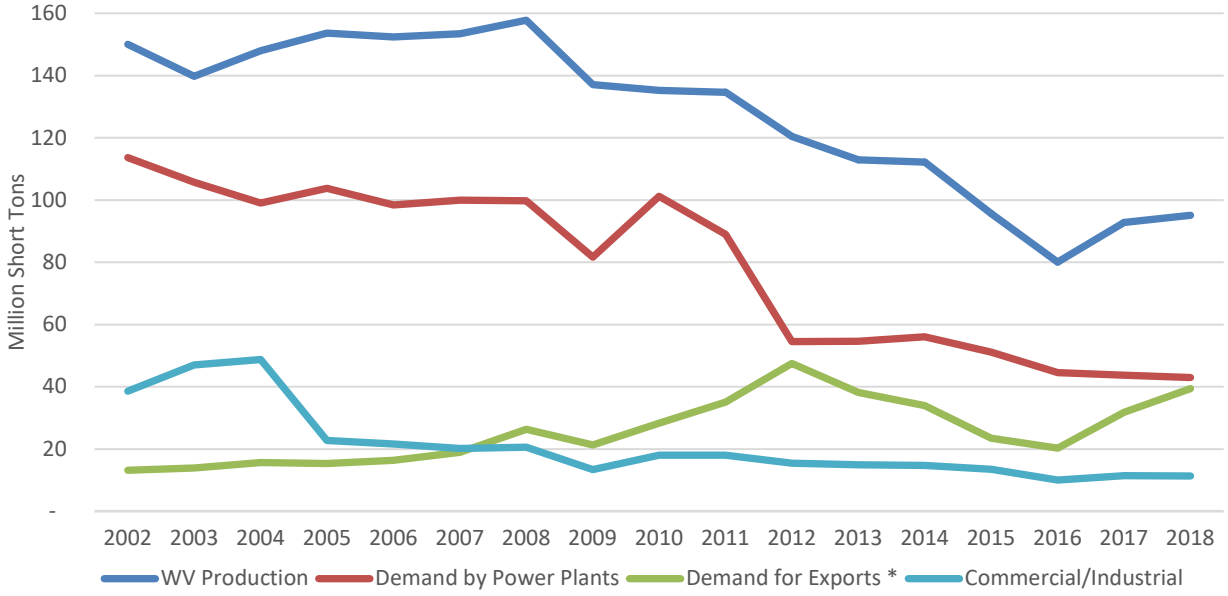
Overview

West Virginia coal production for 2018 was 95.1 million tons (EIA 2019),[1] an increase of 2.5 percent from the 92.8 million tons produced in 2017. This increase reflects various trends and events within the coal industry's primary markets: power generation, exports and industrial demand as well as expectations regarding environmental policy. Demand for West Virginia coal increased by about eight percent from 2017 levels, led by an increase in demand for exports.

Future demand for West Virginia coal depends on several variables. These include the capacity of gas-fired electrical generators in the region and the price paid for gas by those generators, 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. Recent demand trends with preliminary and estimated sector-level data for 2018 are shown in Figure 1.

[1] 92.8 million tons is the Energy Information Administration's revised 2017 production value based on the final 2017 value published by MSHA (clean coal production reported on MSHA Form 7000-2). The West Virginia Office of Miner's Health, Safety and Training (WVOMHST) reports 2017 production of 105,034,815 tons, but this is not exclusively clean coal, which is the final production volume. WVOMHST reports 104,969,188 tons for 2018.

Figure 1. Historical West Virginia Coal Production and Components of Demand



Source: EIA. Asterisked (*) 2018 volumes estimated by MU CBER. Other 2018 figures are preliminary by EIA.

The Electricity Sector

Preliminary coal distribution data for 2018, published by the U.S. Energy Information Administration (EIA), indicate that demand for West Virginia-produced coal by the electricity sector fell slightly in 2018, to about 43.0 million tons, compared to 43.8 million tons in 2017 (EIA 2019). This was a decline of 1.8 percent, between 2017 and 2018, while total coal distribution to the electric power industry fell by about 6.7 percent during the same time (EIA 2019).

Natural Gas Prices

In previous years, a large contributor to reduced coal demand was the price of natural gas. For 2017 and 2018, the average U.S. price of gas delivered to the electric power sector was fairly constant, averaging $3.52/mcf in 2017 (nominal dollars) and $3.67/mcf in 2018 (EIA 2017). Coal has been somewhat more competitive than in 2016, when delivered gas prices averaged $2.99/mcf.

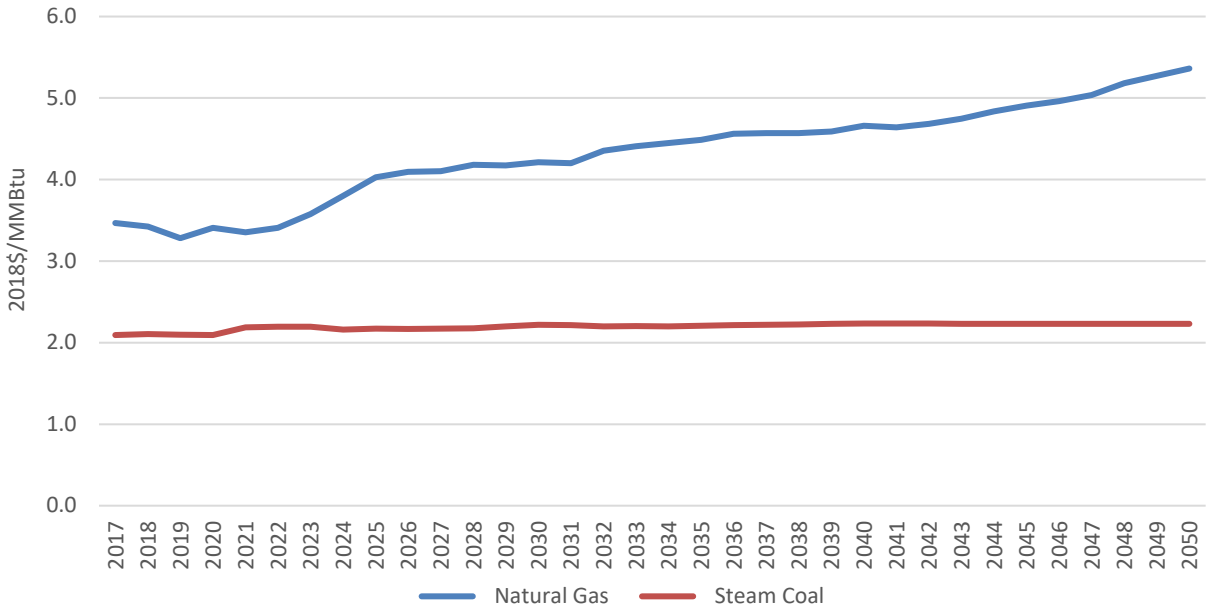
For several years, abundant gas production from the Marcellus play, combined with relatively low takeaway capacity, has resulted in especially low gas prices in a primary region in which West Virginia coal competes. However, that differential is diminishing, as shown in the following chart of weekly prices at the two primary Marcellus area price hubs vs. the Henry Hub (Figure 2).

Figure 2. Select Marcellus Area Vs. Henry Hub Gas Prices ($/MMBTU)

Source: EIA, Natural Gas Weekly.

In its Annual Energy Outlook (AEO) 2019 Reference Case analysis, the EIA continues to project real natural gas prices delivered to the power generation sector to increase at a faster rate than coal prices (Figure 3), which should moderate declining coal demand (EIA 2019).

Figure 3. EIA Forecasted Natural Gas & Coal Prices to Electricity Sector



Source: EIA, AEO 2019.

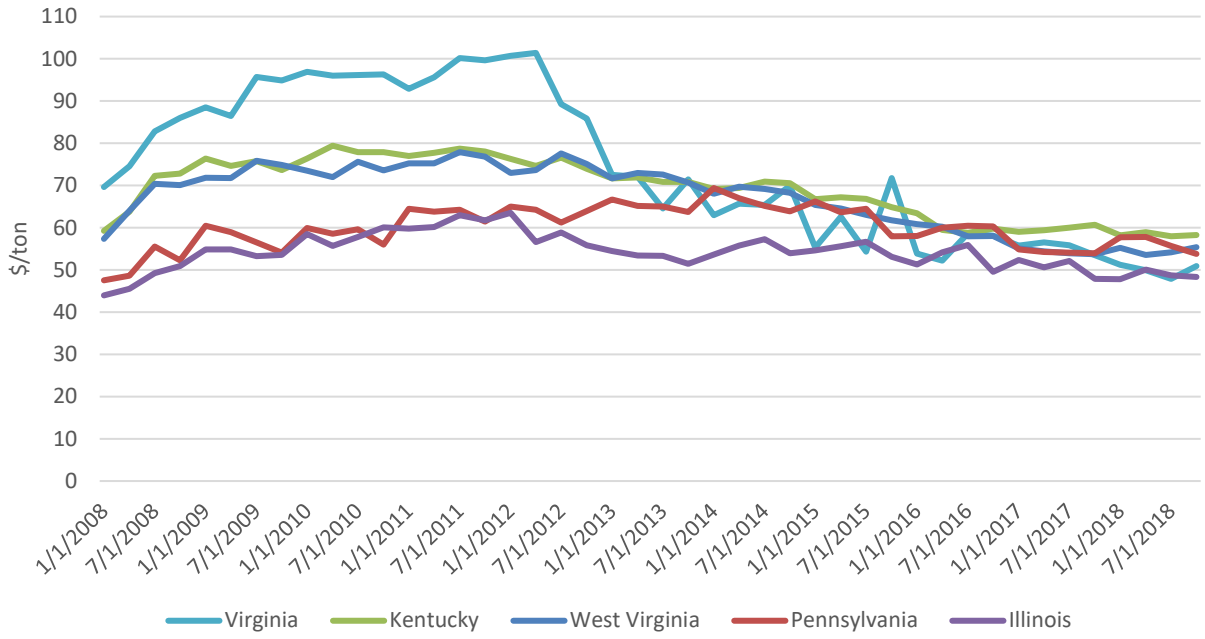
Coal-Fired Power Plant Retirements

Since 2015 no additional units at coal-fired power plants in West Virginia have closed. However, several other plants that have utilized West Virginia coal retired in 2018. These include the CP Crane plant in Maryland and two plants owned by Dayton Power & Light, J M Stuart and Killen, in Ohio (EIA 2019).

Prices of Coal Delivered to the Electricity Industry

The price of West Virginia-produced coal delivered to power plants has been falling since around 2012. Average prices for regional coal producing states are much closer than in previous decades. Prior to 2013 West Virginia, Virginia and Kentucky producers commanded a premium over coal produced from Pennsylvania and Illinois. That premium has largely disappeared, even for Virginia coal, which previously maintained prices 50 to 70 percent higher than IL and PA, and 20 to 30 percent above West Virginia coal (Figure 4).

Figure 4. Coal Prices to the Electricity Industry by Mine State



Source: EIA, Quarterly Coal Report.

Environmental Regulation

Recent regulatory changes have generally been in favor of coal production. In June 2019, the U.S. Environmental Protection Agency finalized the Affordable Clean Energy rule, and officially repealed the Clean Power Plan (EPA 2019). The new rule establishes emissions guidelines for states to use when developing plans to limit CO_2 from existing coal-fired power plants under the authority of Clean Air Act (CAA) section 111(d). A primary feature of the new rule is that it establishes heat rate improvement as the best system of emissions reduction for CO_2 from coal-fired generators (EPA 2019).

The Stream Protection Rule, issued by the U.S. Interior Department in 2016, was nullified in February 2017 (Office of Surface Mining Reclamation and Enforcement 2017). This rule would have increased the cost of mining coal by limiting the distance from a water body that coal mining can occur, inclusive of broad categories of water. A new version of the rule was published in the Federal Register on February 14, 2019. The new proposed rule revises the definition of "waters of the United States" by limiting protection to six categories of water: traditional navigable waters, their tributaries, certain ditches, some lake and ponds, some impoundment of covered waters, and wetlands next to covered waters. The proposal would exclude ephemeral streams (EPA 2019).

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) was essentially the same for 2017 and 2018, with demand up about 14 percent from 2016. This increase was almost entirely at coke plants, which represent annual demand of 10 million tons. This corresponds with a six percent increase in total U.S. steel production, to 86.8 million metric tons, up from 81.6 million metric tons in 2017 (International Trade Administration 2019).

In 2018, the U.S. imported 30.8 million metric tons of steel, an 11% decrease from 34.5 million metric tons in 2017. In 2018, the U.S. steel trade deficit amounted to 23.0 million metric tons, a 6% decrease from 24.4 million metric tons (ITA 2019). Imports from Turkey (-47%) showed the largest volume decline in 2018, followed by South Korea (-26%), Japan (-20%), Russia (-18%) and Taiwan (-15%) (ITA 2019).

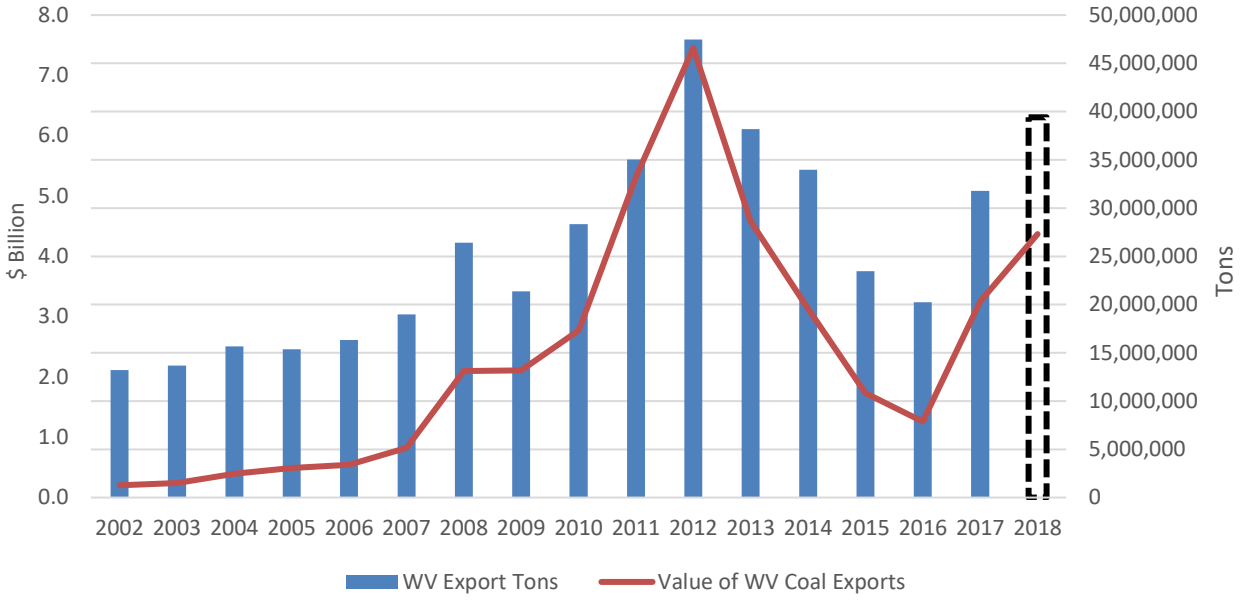
Exports

The nation's coal exports rose in 2017 and 2018, to 97 million short tons in 2017 and 116 million tons in 2018, up from about 60 million short tons in 2016.[2]

The value of coal exports from West Virginia rose to $4.4 billion in 2018, up from $3.3 billion in 2017. The State maintained exports to many countries in North America, Europe, South America, Africa and Asia. The top five importing countries by value were India, Ukraine, the Netherlands, Brazil and Canada (ITA 2019). The following figure (Figure 5) shows the value of West Virginia-based coal exports and associated tonnage from 2002 to 2018.

[2] 2018 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 5. Value and Tonnage of West Virginia Coal Exports, 2002-2018



Source: EIA, ITA; 2018 export tonnage estimated by CBER.

Component Forecasts

Energy Information Administration (EIA)

Publication: Annual Energy Outlook 2019

Date: January 2019

Forecast Horizon: 2019-2050

Region(s): Northern Appalachia, Central Appalachia

The EIA provides a forecast of coal production by region in its 2019 Annual Energy Outlook, projecting through 2050. 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. NEMS is a modular system, with modules that represent each of the fuel supply markets, conversion sectors, and end-use consumption sectors of the energy system (EIA 2019).

Only the EIA Reference Case figures are used for the Consensus forecast, which represents EIA's 'best assessment of how U.S. and world energy markets will operate through 2050." This projection assumes improvement in known energy production, delivery, and consumption technology trends (EIA 2019).

The EIA's forecasts for Appalachia are used to forecast West Virginia coal production. The method used to produce a West Virginia coal production forecast is described in Appendix A.

Key Assumptions:

Macroeconomic Issues: Real GDP growth averages 1.9% per year from 2016 to 2050.

Coal Prices: EIA projects minemouth prices for Appalachian coal to be about $62/ton in 2019 (2018$) and to remain between $58 and $64 through 2050.

Natural Gas Prices: Henry Hub[3] spot prices for natural gas averaged $3.08 per million Btu in 2017 and $2.99 per million Btu in 2018 in real $2018. Prices are expected to be about $3.00 in 2019 and rise thereafter at an annual rate of 1.5 percent, resulting in an average expected price of $4.90 per million Btu in 2050.

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

Electricity: U.S. use of coal for production of electricity is expected to decline by 0.8% annually through 2050. Coal-fired generating capacity is expected to decrease at a rate of 1.5 percent per year through 2050. By comparison, combined-cycle (natural gas) capacity and renewable capacity are both projected to increase by 2.3 percent per year. Combined cycle capacity is projected to surpass coal-fired capacity in 2019.

Industrial/Commercial: Industrial self-generators (CHP plants, power plants with a non-regulatory status, and small on-site generating systems) are expected to see a very slight decline in coal consumption of 0.1 percent per year through 2050. Metallurgical coal use in coke plants is projected to decrease by 0.4 percent per year. The commercial sector is expected to maintain flat coal consumption of one million tons per year.

Exports: The NEMS Coal Market Module projects steam and metallurgical coal trade flows from 17 coal-exporting regions of the world to 20 import regions for both steam and metallurgical coal, including five U.S. export regions and four U.S. import regions. U.S. coal exports are projected have peaked in 2018 and to fall throughout the forecast period to 63 million tons in 2050.

Environmental: The AEO2019 includes the effects of current legislation, environmental regulations, and international protocols including recent government actions for which implementing regulations were available as of the end of September 2018. This includes the Mercury and Air Toxics Standards (MATS) and the Cross-State Air Pollution Rule (CSAPR). A number of state-level policies are modeled, including the Illinois Future Energy Jobs Act, the New York Clean Energy Standard, and the Maryland Clean Energy Jobs Act, as well as regional initiatives such as the Regional Greenhouse Gas Initiative. The Clean Power Plan is not included (EIA 2019).

Energy Ventures Analysis (EVA)

Publication: EVA Long-Term Forecast

Date: June 2019

Forecast Horizon: 2019-2045

Region(s): West Virginia

The forecast of West Virginia coal production is tied to power sector demand for coal. To determine power sector demand, EVA utilizes the AURORAxmp 24/7 dispatch model (which EVA licenses) to calculate electricity generation by plant. EVA converts the generation into demand by fuel type based upon each plant's location, plant configuration, and environmental controls. The forecast reflects the least cost dispatch solution consistent with the operating parameters of individual units. Existing generation and announced retirements are reflected. In addition, the model adds and retires capacity in an economic manner and as required by law (Energy Ventures Analysis 2019).

Commodity prices, which are inputs into the AURORAxmp, reflect analysis of supply and demand in each non-power sector, i.e. industrial/commercial demand, domestic metallurgical demand, and export steam and metallurgical demand. Prices are calibrated based upon AURORAxmp results to reflect market balances based upon demand.

Key Assumptions:

Macroeconomic Issues: GDP growth is expected to average just over 2% per year.

Coal Prices: Coal prices for both Northern and Central Appalachia were relatively strong in 2018 as a result of the strong global market. In 2019, prices are expected to fall about 10% due to some softening in demand. By 2045, prices from both regions are expected to return to the 2019 levels in the $45-70 per ton range in real 2019 dollars and $74-115 per ton range in nominal dollars. The relatively wide range reflects the range in qualities from lower Btu, high sulfur steam coal to high quality metallurgical coals. Pricing can also be volatile due to unexpected changes in the market caused by weather, political events, and supply-side disruptions.

Natural Gas Prices: Gas prices are expected to increase through 2045 resulting in a price of $4.00 per MMBtu (2019$) in 2045.

Electricity: Growth in electricity demand is expected to average 0.5% per year which is a continuation of the relatively low growth that has been occurring as a result of lower

industrial activity, demand-side management, and behind the meter generation. While this rate could be lower or higher, the primary factor that could cause an increase in this rate is electric vehicle penetration. The modeled growth in electricity demand is expected to reduce demand for Northern and Central Appalachian coal by the power sector by 31% between 2019 and 2045 largely due to coal plant retirements. Further, with the retrofit of technologies on power plants, 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.

Industrial/Commercial: Non-coke industrial demand for Northern and Central Appalachian coal is projected to fall by about 35% between 2019 and 2045. This reflects the gradual switch-out of industrial boilers to gas. Demand for metallurgical coal from Northern and Central Appalachia during this same period is projected to fall by 27% as older coke ovens are expected to be closed and not replaced.

Exports: The level of exports is affected by global demand for coal and global supply. U.S. export levels are a function of the competitiveness of U.S. coals in the global market which in turn is affected by the relative strength of the U.S. dollar particularly with respect to the Australian dollar as global coal trade is U.S. dollar denominated and Australia is the largest exporter of bituminous coals. Both steam and metallurgical coals are exported from the U.S. In recent years, metallurgical exports accounted for most of the exports. Steam coal exports have caught up and are expected to account for most exports going forward. U.S. metallurgical coal exports exclusively originate in Appalachia. U.S. steam coals originate throughout the U.S. with the origin a function of coal quality, transportation logistics, and cost. Steam and met coal export forecasts are exogenously determined through an analysis of global supply and demand. The resulting price forecast, however, affects domestic pricing and therefore utility coal demand.

Steam coal exports from Northern and Central Appalachia were fairly strong in 2018 at almost 50 million tons. The strength reflected a strong global market, strong pricing, and supply issues from some of the traditional global suppliers. Going forward, exports are expected to decline over time. Exports from Northern Appalachia are expected to be stronger than exports from Central Appalachia due to Central Appalachia's higher cost structure. 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. In 2018, met coal exports from Northern Appalachia and Central and Southern Appalachia also benefited from the strong global market and strong pricing. Metallurgical coal exports from Northern and Central Appalachia are expected to remain strong through the forecast period in part because of the addition of a second mine at Arch's Leer mine complex in West Virginia. With China one of the two

largest global importers of coal, global coal markets can be affected significantly by changes in coal-related policies within China which cannot always be predicted.

Environmental: Phase I of the Cross-State Air Pollution Rule (CSAPR) went into effect January 1, 2015; Phase II went into effect January 1, 2017. The Mercury and Air Toxics Standards (MATS) went into effect in April 2015 with a liberal one-year extension. Section 316(b) of the Clean Water Act goes into effect with 2020 compliance for minor intake modifications and 2022 compliance for these requiring cooling towers. Coal Combustion Residuals (CCR) goes into effect by 2020. Conversion to dry ash handling is assumed by 2020 and use of lined landfills is assumed for subsequent ash disposal. Effluent Limitation Guidelines (ELGs) assumes FGD wastewater treatment compliance by 2023. National Ambient Air Quality Standards (NAAQS) revisions will include fine particulate and ozone standards. 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 the ability to add new coal-fired generation absent partial carbon capture and sequestration or co-firing with gas. The modeling also assumes the Affordable Clean Energy Rule with the proposed NSR process changes. Regional CO2 programs (i.e., RGGI and AB32) are assumed to continue.

Marshall University Center for Business and Economic Research (CBER)

Publication: CBER West Virginia Coal Production Forecast 2019

Date: June 2019

Forecast Horizon: 2019-2045

Region(s): West Virginia

CBER forecasted West Virginia total coal production from 2019 to 2045 by using a Vector Autoregression (VAR) model with seasonality adjustment using quarterly data from 2008-2018.

Key Assumptions:

This VAR model is a demand-based model. It forecasts coal production using several prices and demand related variables (Table 1). All variables (both impulse and response) were considered endogenous and modeled as first order Autoregressive Process (AR1).

The CBER forecast does not impose any macro- or micro-economic assumptions that may be subject to exogenous shocks in the future.

Table 1. Variable Description and Data Source

Variable	Source
WV Total Coal Production	EIA
Total WV Coal Delivered to the Electricity Industry	EIA
Delivered Coal Prices for Power Generation	EIA
U.S. Coal Export Price	EIA
Producer Price Index (Coal Selling Price)	BLS
Euro/Dollar Exchange Rate	Macrotrends

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

Publication: WVU BBER Coal Production Forecast 2018

Date: July 2018 (modified in June 2019)

Forecast Horizon: 2019-2045

Region: Northern West Virginia and Southern West Virginia

The WVU Bureau of Business and Economic Research 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 and 2017. 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 May 2018 Long-Term Forecast and the 2018 Annual Energy Outlook from the Energy Information Administration (West Virginia University 2018).

Consensus Forecast

The four long-term forecasts produced by EIA, EVA, CBER and BBER are combined to create the Consensus Forecast for West Virginia Coal Production. Three different approaches were used to derive the best consensus forecast.

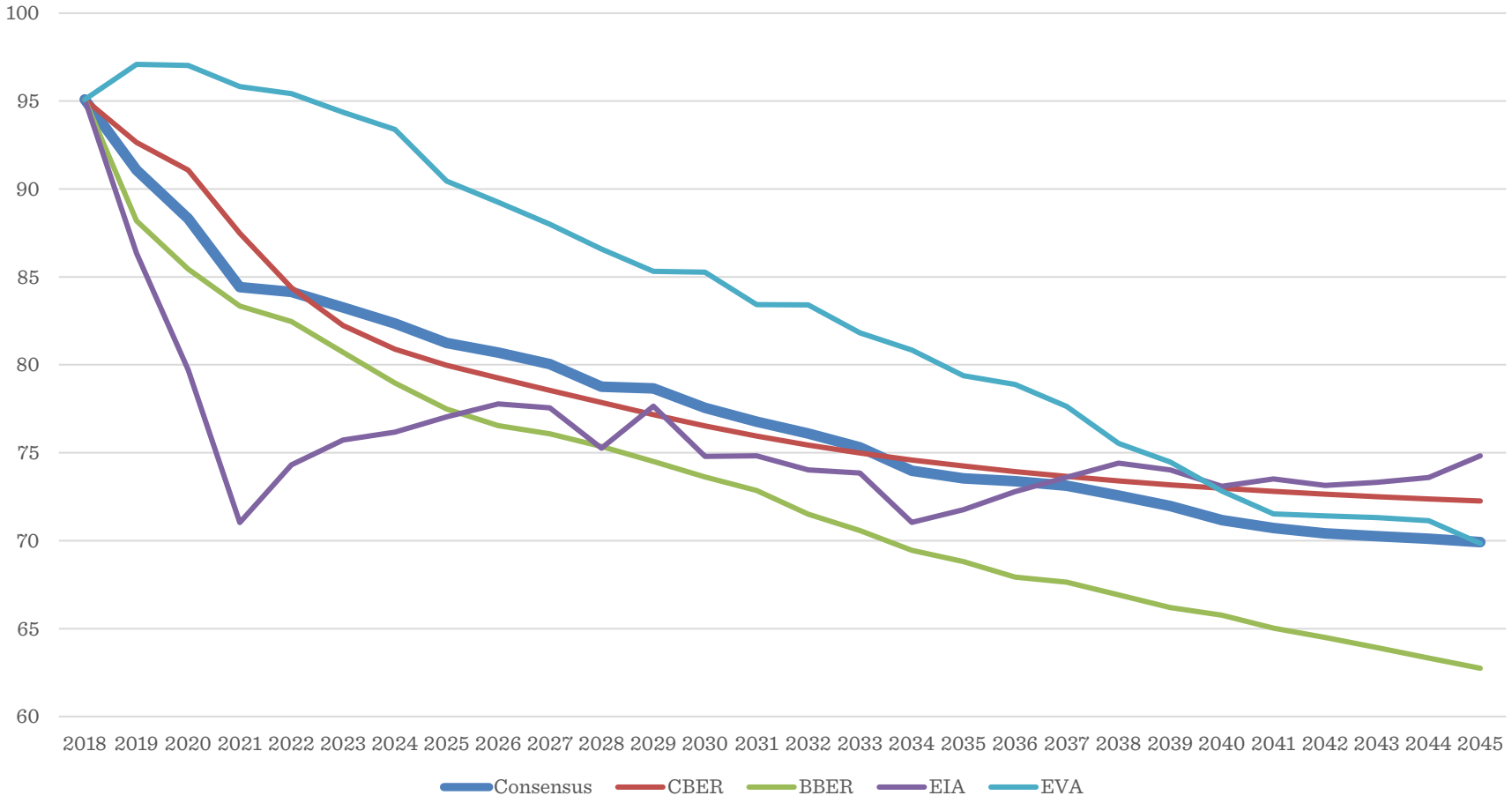
1. Weighted Average and Simple Average. Historical accuracy rates[4] of four forecasts were used as weights for this year's consensus forecast. However, results using weighted average were not significantly different from that using simple average (difference <3%). A simple average was then used to calculate consensus forecast for simplicity.[5]
2. "Midrange Value". This alternative approach first finds each year's maximum and minimum numbers from four forecasts, and then calculate the midrange value using midrange = (max+min)/2. The forecasted coal production, however, is not significantly different from that using simple average (difference <3%).
3. "Minimum Distance". The midrange value calculated in the 2nd approach of each year was compared with four forecasted numbers in that year, and the number with shortest "distance" (or smallest difference) to the midrange value is the consensus forecast. Again, forecasted coal production is not significantly different from that using simple average (difference <3%).

Thus, the consensus forecast was calculated using the simple average of EIA, EVA, CBER and BBER (Figure 6 and Table 2). The coal production in West Virginia is likely to decline from 91 million tons in 2019 to slightly below 70 million tons in 2045. There might be temporary increments in coal production due to exogenous shocks unforeseen by all four forecasts (see Appendix B for coal production forecast in case of a looming recession). The declining trend is unlikely to be reversed in the long run.

[4] Approaches to calculate historical accuracy rate can be very different as some may value short term accuracy more, while others may favor long term accuracy. A simple average of 1-year rates to 5-year rates was used in our approach, as accuracy rates longer than 5 years were not available.

[5] Due to the subjective nature of weight selection, a simple average approach (with same weight for all four forecasts) would generate a very similar forecast as the weighted average but does not require additional (often unrealistic) assumptions to estimate accuracy rate of historical forecasts.

Figure 6: Consensus and Component Forecasts 2019 (million tons)



Source: EIA, EVA, WVU BBER and authors' calculation.

Table 2: Consensus Forecast for West Virginia Coal Production 2019 (million tons)

Year	Historical	2019 Forecasting Group				2019 Consensus	2017 Consensus	2016 Consensus	2015 Consensus	2014 Consensus
		EIA	EVA	CBER	BBER*					
2014	111.9									112.4
2015	95.5								107.2	106.9
2016	80.1							79.5	103.4	101.4
2017	92.8						86.8	76.9	101.7	103.0
2018	95.1						83.6	74.7	102.7	103.3
2019		86.4	97.1	92.7	88.2	91.1	84.1	76.7	104.8	102.4
2020		79.7	97.0	91.1	85.4	88.3	87.1	80.1	104.9	101.5
2021		71.0	95.8	81.1	83.4	84.4	86.1	78.6	104.4	100.9
2022		74.3	95.4	82.6	82.5	84.1	85.9	75.7	103.4	100.7
2023		75.7	94.4	82.2	80.7	83.3	84.7	73.1	102.8	100.0
2024		76.2	93.4	80.9	79.0	82.3	82.8	70.3	102.8	99.9
2025		77.0	90.4	80.0	77.5	81.2	81.5	69.1	102.4	99.2
2026		77.8	89.2	79.2	76.5	80.7	80.2	67.9	102.2	98.2
2027		77.5	88.0	78.6	76.1	80.0	79.3	66.2	101.7	98.1
2028		75.3	86.6	77.9	75.4	78.8	77.7	64.5	101.2	97.1
2029		77.6	85.3	77.2	74.5	78.7	76.8	63.0	100.9	97.1
2030		74.8	85.3	76.5	73.6	77.6	76.3	61.7	100.9	96.5
2031		74.8	83.4	75.9	72.9	76.8	76.1	62.1	100.5	96.3
2032		74.0	83.4	75.4	71.5	76.1	76.0	62.9	100.9	95.1
2033		73.8	81.8	75.0	70.6	75.3	76.6	63.3	99.8	94.2
2034		71.0	80.8	74.6	69.5	74.0	76.7	63.1	98.3	93.7
2035		71.8	79.4	74.2	68.8	73.5	76.6	62.5	97.3	91.6
2036		72.8	78.9	73.9	67.9	73.4	76.5	62.3		
2037		73.6	77.6	73.7	67.6	73.1	76.1	60.4		
2038		74.4	75.5	73.4	66.9	72.6	75.6	59.7		
2039		74.0	74.5	73.2	66.2	72.0	75.8	58.6		
2040		73.1	72.8	73.0	65.8	71.2	75.3	57.1		
2041		73.5	71.5	72.8	65.0	70.7				
2042		73.1	71.4	72.6	64.5	70.4				
2043		73.3	71.3	72.5	63.9	70.3				
2044		73.6	71.1	72.4	63.3	70.1				
2045		74.8	69.8	72.3	62.7	69.9				

Source: EIA, EVA, WVU BBER and authors' calculation. Asterisked (*) BBER Forecast is a 2018 forecast. The other forecasts were produced in 2019.

Summary

The four component models incorporate a range of possible levels of West Virginia coal production over the next 26 years, with varying forecasts that illustrate the impact of primary supply and demand variables and uncertainty over the continuation of recent trends. The consensus reduces uncertainty by combining the forecasts into one aggregate projection. Despite a possible short-term increase in coal production, the consensus forecast suggests West Virginia is more likely to experience a reduction in coal production in the next two decades.

Through 2032, with the exception of current year production, the 2019 West Virginia Consensus Coal Forecast figures are very similar to the most recent Consensus Forecast produced in 2017. After 2032, the forecast is for slightly lower production than previously projected. However, aggregate production for 2019 through 2040 is only one percent lower than forecast in 2017.

References

EIA. 2019. "Annual Energy Outlook 2019." January. http://www.eia.gov/forecasts/aeo/.

EIA. 2019. *Archive weekly and monthly coal production.* U.S. Department of Energy. http://www.eia.gov/coal/production/weekly/archive/.

—. 2019. "Assumptions to AEO2019." *Analysis & Projections.* January.

EIA. 2019. *Electric Power Monthly.* U.S. Department of Energy. http://www.eia.gov/naturalgas/weekly/.

—. 2019. *Quarterly Coal Distribution Report.* https://www.eia.gov/coal/distribution/annual/.

—. 2019. "Summary of Legislation and Regulations Included in the AEO 2019." March.

Energy Ventures Analysis. 2019. *West Virginia Coal Production Forecast.*

EPA. 2019. "FACT SHEET - The Affordable Clean Energy Rule (ACE)." June 18.

—. 2019. "Revised Definition of “Waters of the United States”." *Proposed Rule.* February 14.

—. 2019. "Stationary Sources of Air Pollution." *Affordable Clean Energy Rule.* June 19.

International Trade Administration. 2019. "Steel Industry Executive Summary: April 2019."

ITA. 2019. "State Export Data, Global Patterns of a State's Exports."

—. 2019. "Steel Imports Report: United States ." *Global Steel Trade Monitor.* March.

Office of Surface Mining Reclamation and Enforcement. 2017. "Stream Protection Rule." https://www.osmre.gov/programs/rcm/streamprotectionrule.shtm.

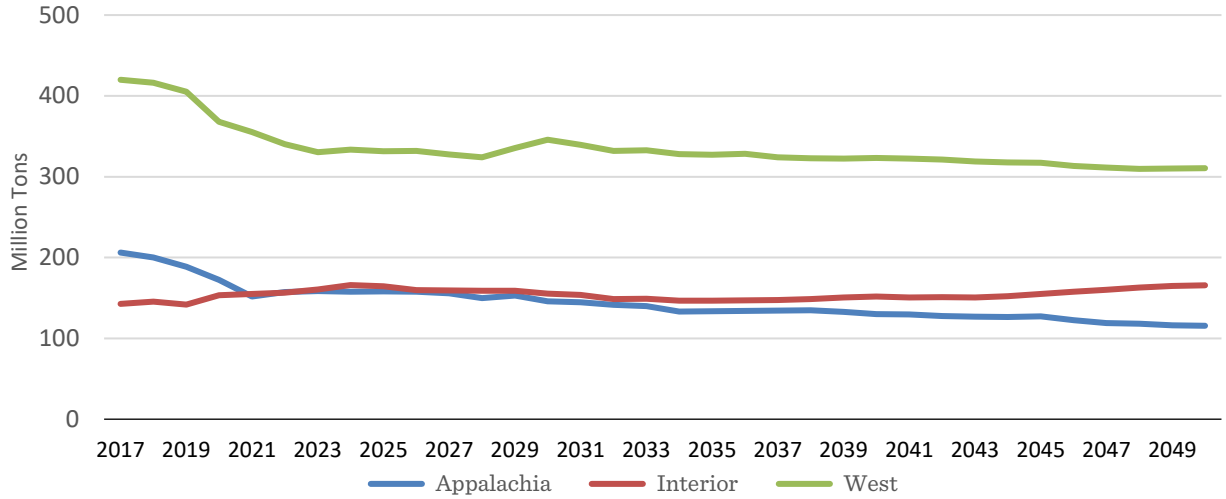
West Virginia University. 2018. *Coal Production in West Virginia: 2017-2045.* WVU College of Business & Economics. https://www.documentcloud.org/documents/2089129-wvu-bber-coal-forecast-2015.html.

Appendix A: EIA Forecast for West Virginia

The EIA's 2019 AEO forecasts Appalachian coal production to decline steadily through 2050, with some stability from 2022 to 2027. As shown below (Figure A1), Interior[6] production is projected to surpass Appalachian production in 2024.

Northern Appalachia includes Pennsylvania, Maryland, Ohio, and Northern West Virginia. Central Appalachia includes Virginia, Eastern Kentucky, Northern Tennessee, and Southern West Virginia (Figure A2).

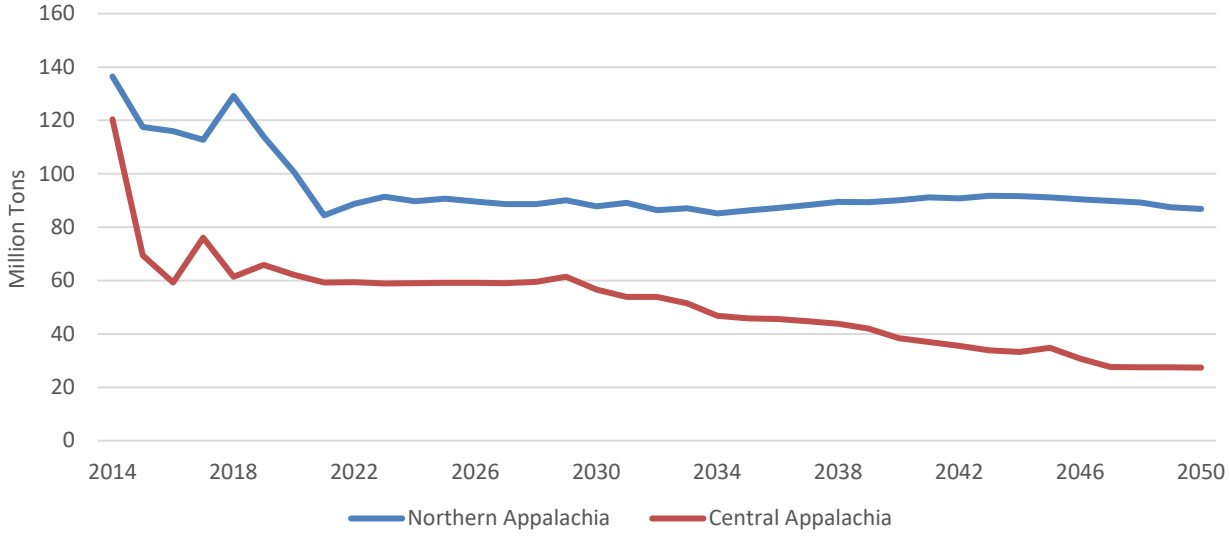
Figure A1. EIA Forecasted Coal Production, by Region



Source: EIA

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

Figure A2. EIA Forecasted Coal Production for Northern and Central Appalachia

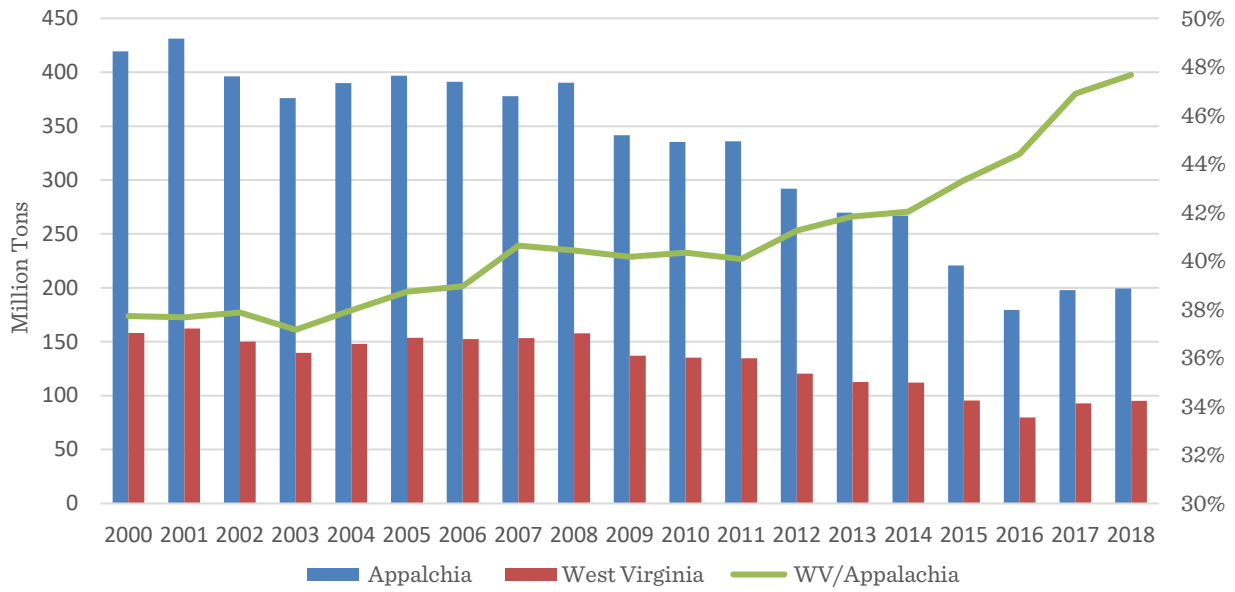


Source: EIA

The EIA forecast for WV coal production is derived from EIA's forecast for the Appalachia region, as the agency does not publish forecasts for individual states. The WV forecast was calculated using year-adjusted WV/Appalachia coal production ratios times each year's Appalachia forecast. As shown in Figure A3, there is a clear trend in the WV/Appalachia ratio (green line) over time. Thus, year-adjusted ratios for 2019-2045 were estimated using econometric techniques[7] assuming the upward trend will remain in the future.

[7] Alternative variables (e.g., Northern and Central Appalachia production) and measures (e.g., Annual Coal Production) were also used, and results are very close to the ones in Figure 5 or Table 2 which were chosen due to smaller measurement error.

Figure A3. EIA Appalachian Forecasts Applied to West Virginia Coal Production



Source: EIA and CBER calculations for West Virginia production.

Appendix B. Coal Production Under Economic Recession

The U.S. economy has been in the longest economic expansion in history since 2008. There are growing concerns over whether the current expansion will end in the next two years. In addition to regular forecasts (Figure 6 and Table 2) which mostly assume "business as usual", CBER forecasts also explore the impact of a possible economic recession in 2020 on WV coal production.

Table B1 shows U.S. coal production growth rates after each economic recession in post-WWII era. Total coal production tends to react spontaneously to economic downfall in history, but the trend ended after 1980 when declines in coal production often lagged the start of recession by one year but no longer than two years.[8] This shift may have been caused by structural changes in the U.S. macroeconomy that no longer largely rely on coal as a source of energy. Thus, if the economy experienced another recession similar to The Great Recession in 2008, it is reasonable to assume WV coal production would suffer an additional -17% reduction in year 2021, and the original decline rate in 2022 (Figure B1) would be corrected upward by 12%.[9] The direct impact of recession is assumed to disappear after 2022.[10]

Table B1. U.S. Coal Production Growth/Decline During Recent Recessions.

	1945	1948	1953	1957	1960	1969	1973	1980	1990	2001	2008
T	-7.9%	-3%	-7%	0%	2%	-4%	-6%	8%	13%	3%	4%
T+1	-5.2%	-27%	-14%	-23%	-7%	3%	-12%	-7%	-3%	-6%	-13%
T+2	20.6%	18%	21%	2%	5%	-17%	7%	14%	-2%	-11%	-1%
Diff (T, T+1)	3%	-24%	-7%	-23%	-9%	7%	-6%	-15%	-15%	-10%	-17%
Diff (T+1, T+2)	26%	46%	36%	25%	12%	-20%	19%	21%	1%	-5%	12%

Source: EIA and authors' calculation. T represents the year when recession started, while T+1 and T+2 represent one year and two years after the recession.

Comparing with the original forecast (Figure B1), the new one with a possible recession in 2020 (Figure B2) shows that WV coal production would further decline by another 15.5 million tons in 2021 and 6.3 million tons in 2022. Afterwards, the speed of decline would return to the level of the original forecast, but the output would remain lower in long-term.

[8] The U.S. coal production reacted to most recent recession a little different, as it kept declining after 2010.
[9] The average of growth rate change between year T and year T-1 for most recent three recessions (1990, 2001 and 2008).
[10] After 2022, the declining rate will return to the level of the original forecast.

Figure B1. WV Coal Production Forecast without Economic Recession in 2020

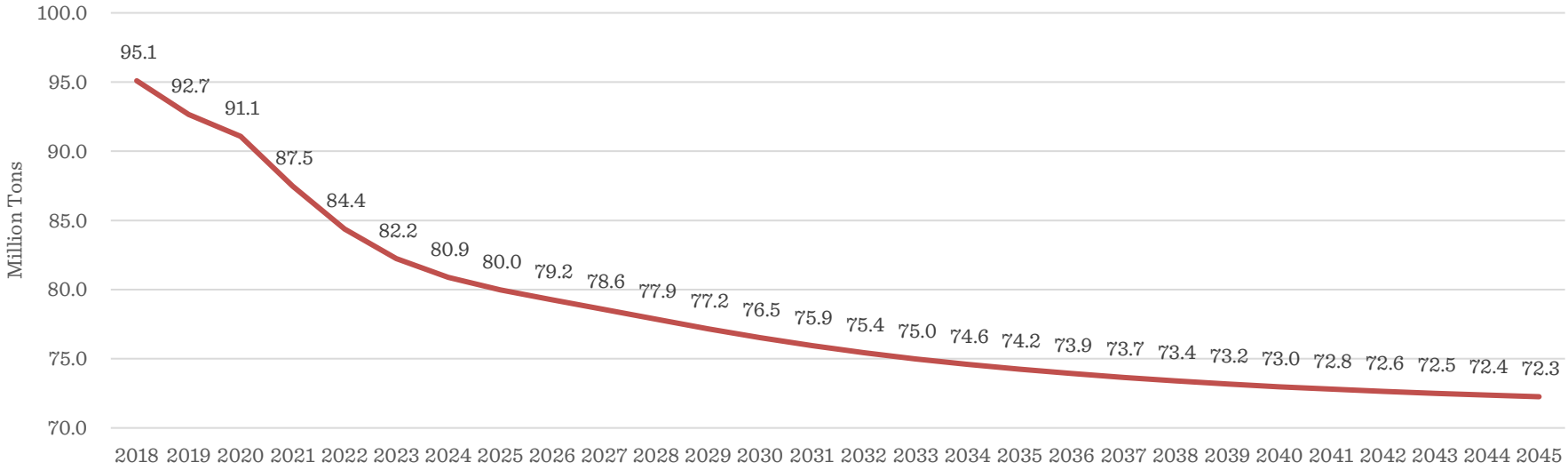


Figure B2. WV Coal Production Forecast with Potential Economic Recession in 2020