COAL PRODUCTION IN WEST VIRGINIA: 2018-2040

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P.O. Box 6527, Morgantown, WV 26506-6527
(304) 293-7831 bebureau@mail.wvu.edu
business.wvu.edu/bber

WRITTEN BY

Brian Lego
Research Assistant Professor

John Deskins, Ph.D.
Director

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Executive Summary

Recent Market Trends: After seeing statewide production fall by nearly in half between 2008 and 2016, West Virginia's coal industry has rebounded over the past several quarters as output increased nearly 27 percent between mid-2016 and mid-2018. Export demand has accounted for nearly all of the improvement in production over the past two years or so due to significant increases in coal shipments to India, Brazil, Ukraine and a few other countries. This has enabled Southern West Virginia to account for a majority of growth in statewide coal output in recent quarters. By contrast, domestic demand has remained negative, but more so for mines in Northern West Virginia, as the US electric power sector transitions away from coal-fired generation over to natural gas.

Short-Term Forecast: The baseline forecast calls for coal production to total approximately 91 million short tons in 2018, which represents a slight drop versus 2017 levels. Overall state output is expected to decline 3 percent annually over the next two years, leaving mined coal tonnage at just over 85 million by the end of the decade. Weakening export activity will likely drive most of the anticipated drop in production through 2020, but the retirement and/or conversion of several gigawatts worth of coal-fired generating capacity that sources coal from West Virginia mines will also account for some of this decline.

Long-Term Forecast: Coal production will continue to decline over the remainder of the outlook period, though most of the declines are expected to end by the early 2030s. Output is expected to fall by more than 12 million short tons between 2020 and 2030, with an additional loss of 7 million tons by 2040. Domestic shipments of thermal coal are expected to wane over the next decade as aging coal-fired generation capacity deals with rising maintenance costs and lack of competitiveness against natural gas, and in some markets, renewables. Both of the state's producing regions will be affected by this trend, but Northern West Virginia will be affected to a greater extent. Southern West Virginia's production should be buoyed by what is expected to be fairly stable levels of export demand, but output is likely to trend lower during the outlook as a growing portion of the region's reserves become unprofitable to recover.

Alternative Forecast Scenarios – Natural Gas Use: We examine different trajectories for natural gas utilization on coal production. In a scenario characterized by stronger natural gas use in both domestic and international markets, coal output would slip below 80 million short tons within a couple of years and sink below 70 million short tons by the mid-2020s. By contrast, should natural gas utilization be much weaker-than-expected going forward, coal production in this scenario would decline overall but exceed the baseline forecast by more than 6 percent in 2040. Northern West Virginia's coal production exhibits the largest sensitivity to future changes in natural gas utilization.

Alternative Forecast Scenarios – CO_2 Tax: We analyze the potential effects on West Virginia coal production created by a tax on CO_2 emissions. An initial tax of $15 per ton of CO_2 emissions in 2023, with built-in annual increases of two percent above the rate of inflation, leads to an estimated 20 million short ton drop in statewide coal production between its hypothetical effective date through 2030. Output is expected to decline an additional 10 million short tons or so over the remaining outlook period, leaving West Virginia coal production in 2040 at 43 million short tons, or just over half of 2016 levels.

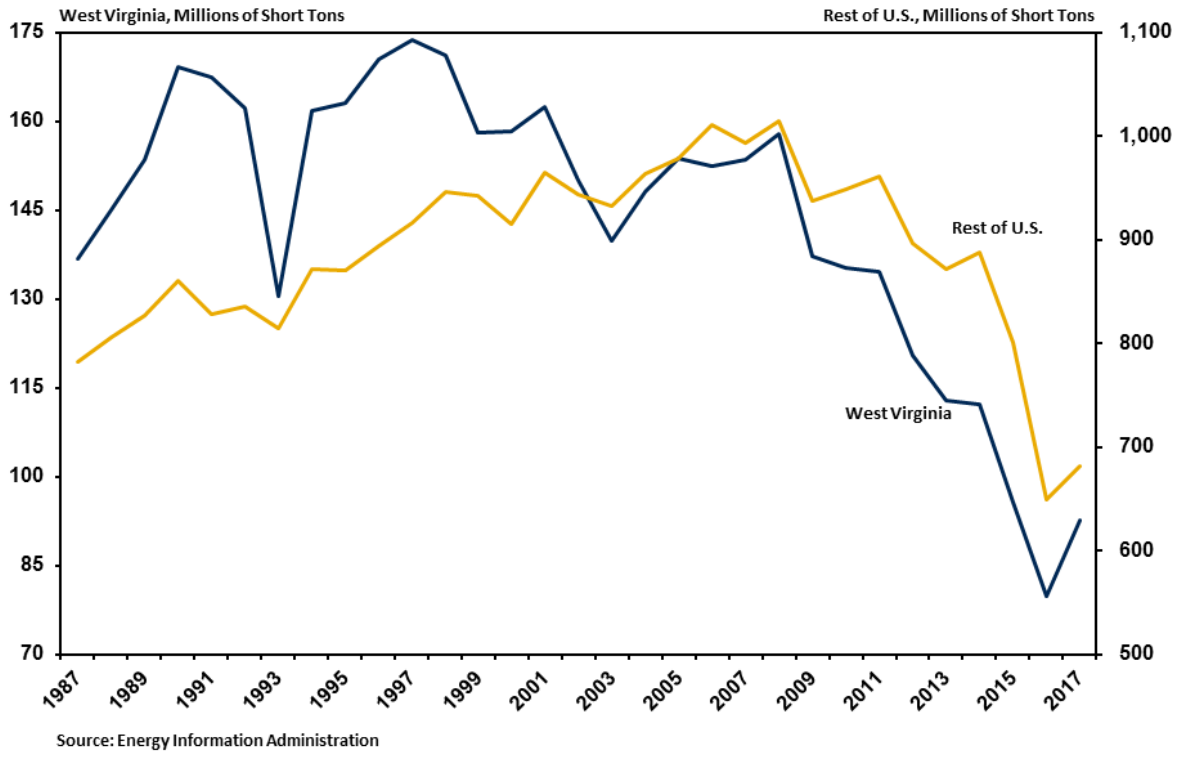
Alternative Forecast Scenarios – Export Demand: The impacts of stronger and weaker export demand on statewide coal production were also assessed. For example, higher-than-expected global demand for coal would cause mined tonnage to remain around 90 million short tons through 2030 before falling to 79 million tons by the end of the next decade. In an environment of appreciably weaker export demand, whether due to more aggressive reductions in coal use or some other underlying cause, production would plunge to 65 million short tons by the mid-2020s and roughly 53 million short tons by 2040.

1 Recent Trends in Coal Production

WEST VIRGINIA OVERVIEW: Surging export demand enabled West Virginia's coal industry to register an output increase of nearly 15 million short tons during 2017, falling just short of 93 million short tons.[1] This marked the largest percentage gain in statewide production for the industry since 1994, but output still lags behind levels posted as recently as 2015. Indeed, West Virginia coal production in 2017 was 40 percent below the previous cyclical peak in 2008 and still trailed the annual total from 2014 by more than 17 percent. Output briefly surpassed 100 million short tons on a seasonally adjusted annual basis in late-2017/early-2018, but this was due to a sustained cold snap boosting heating demand and surging coal exports. Although export demand remained strong during the first half of 2018, coal-fired generation has weakened, causing statewide output to slip back to an average of just over 90 million tons.

NATIONAL OVERVIEW: Coal output increased in most major coal-producing regions during 2017. Overall, US coal production (excluding West Virginia) increased 5 percent over the 2016 level, totaling 681 million tons for the year as a whole. Production activity across other coal basins has been more mixed in recent quarters, with growth occurring largely in areas that possess healthier reserves of metallurgical coal. Indeed, non-West Virginia coal mine production has trended lower in the past year, falling nearly 3 percent during the first half of 2018 compared to the same period in 2017.

Figure 1: Historical Coal Production Levels

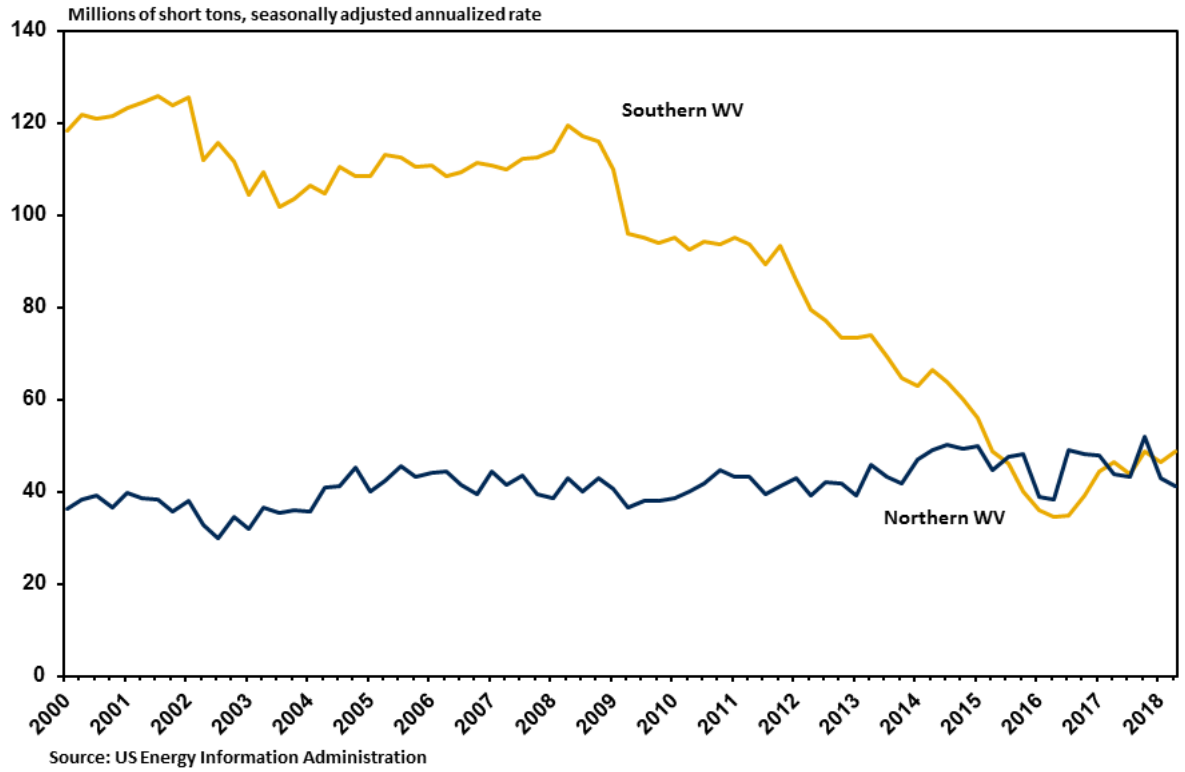


[1] The production figure for 2017 is an estimate and will not be considered final until the *Annual Coal Report 2017* is released by the US Energy Information Administration in November 2018.

WEST VIRGINIA'S SHARE OF NATIONAL COAL OUTPUT: Despite the significant declines in coal production that have been recorded in West Virginia over the past decade, the state continues to rank as the nation's second-leading producer of coal by a wide margin. In fact, West Virginia's northern and southern coal-producing regions each produced more coal tonnage on their own than all but three states (Wyoming, Illinois and Pennsylvania). West Virginia did see its share of national coal output increase to 12 percent in 2017, marking its highest proportion of nationwide production since 2011. This share has risen further during the first half of 2018 as states lying in the Powder River (portions of Wyoming and Montana) and Illinois (Indiana, Illinois and portion of Western Kentucky) coal basins are dealing with the ongoing shift away from thermal coal use by US electric utilities. Ultimately, however, these two basins still account for more than 56 percent of overall US coal production, and the Illinois Basin in particular remains a key competitor in the domestic electric power market because of its abundant high-sulfur coal reserves.

WEST VIRGINIA REGIONAL COAL OUTPUT: While coal production has shifted westward geographically in the US in relative terms over the past decade, production within West Virginia is now more evenly distributed across the state's two producing regions. As recently as 2011, Southern West Virginia mines accounted for well over two thirds of coal produced within the state. By mid-2015, both regions were producing roughly equivalent levels of coal tonnage, but over the course of the next seven quarters Northern West Virginia accounted for more than half of the state's overall production.

Figure 2: Historical Coal Production by Region in West Virginia

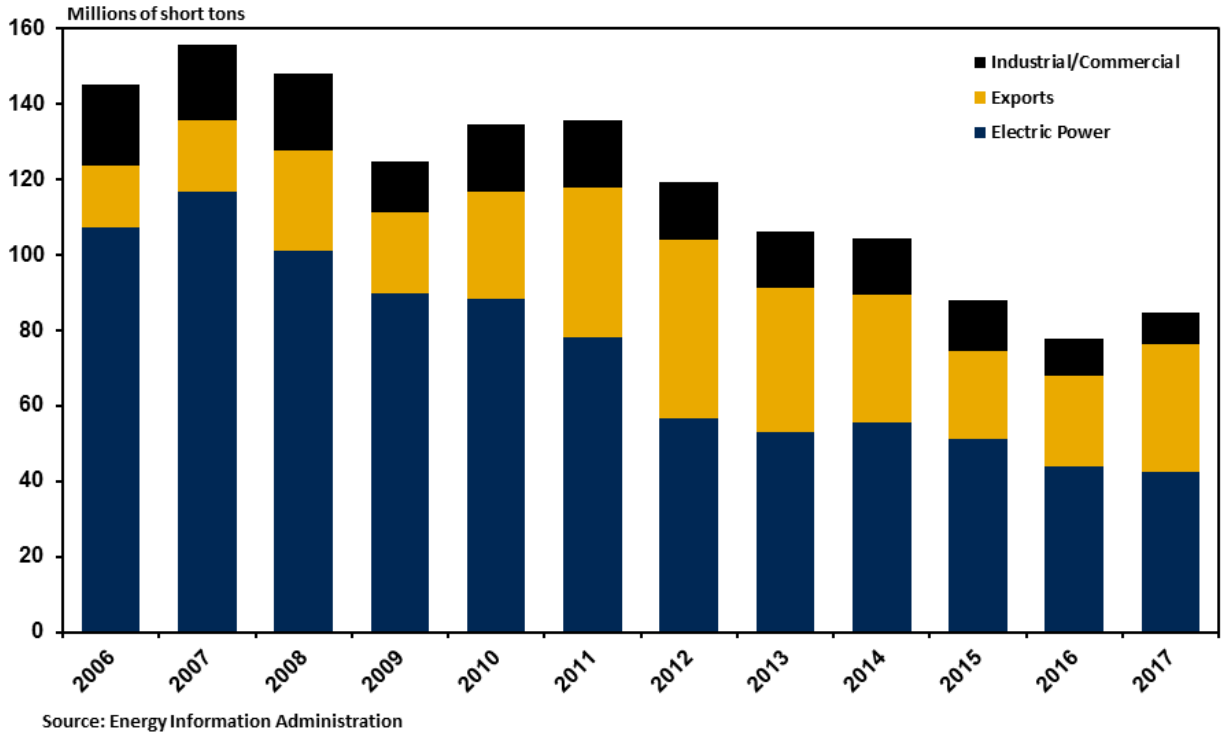


Outside of the surge in output linked to stronger-than-normal winter demand, coal production from the West Virginia's northern coal mines has trended lower since the second half of 2016. In fact, preliminary data indicate mined tonnage during the first half of 2018 is nearly 8 percent lower than its year ago level for the state's northern producing region. By comparison, Southern West Virginia coal output has increased in seven of the last eight quarters, with the seasonally adjusted annual rate of production improving by more than 40 percent since mid-2016. Overall, the region's mines have witnessed a 7 percent increase in production year-to-date in 2018 versus 2017. The difference in performance between the state's two producing regions over the past year or so derives in large part from the fact that most of Northern West Virginia's coal output is shipped to domestic coal-fired power plants while Southern West Virginia has benefited from strong export demand for its premium met and thermal coal reserves.

2 Electric Power Sector Coal Demand

Coal demand is affected by a blend of domestic and international market and regulatory forces, and each of these has played a significant role in shaping not only the trend in statewide coal production, but also the different paths for the state's northern and southern coal-producing regions. Even as coal accounts for a dwindling share of electricity generation in the US, domestic power plants still represent the top destination market for West Virginia coal by a wide margin. Of the nearly 51 million short tons distributed to domestic coal buyers in 2017, roughly 80 percent (42 million tons) was shipped to coal-fired power plants in 14 states. Shipments of coal from West Virginia mines to domestic utilities have fallen in 9 of the last 10 years and are down 46 percent from the tonnage delivered to US power plants in 2011.

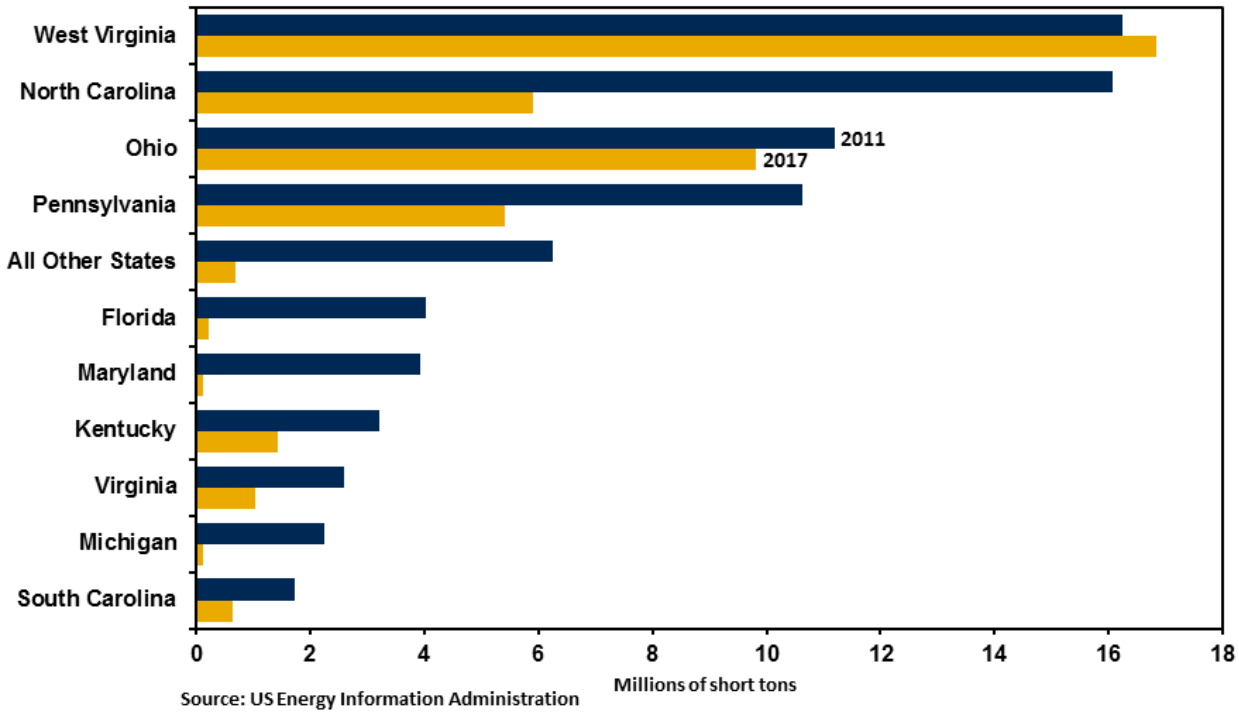
Figure 3: Distribution of West Virginia Coal Shipments by End-Use Market



Source: Energy Information Administration

As coal use by the electric power sector has plunged nationwide over the past several years, and the fact that so much of the state's coal is used by domestic power plants, the trend has clearly had a significant effect on West Virginia's coal mining industry. One noteworthy trend, however, is that coal shipments to West Virginia power plants has actually increased slightly between 2011 and 2017 despite the retirement of the Philip Sporn, Kanawha River and Kammer power plants. Since every other state that received thermal coal shipments from West Virginia mines in 2011 has cut back the number of tons purchased, by large margins in several instances, in-state power plants are accounting for a much larger share of domestic shipments over this time period. Indeed, West Virginia power plants now account for 40 percent of domestic thermal coal shipments from the state's mines, nearly double the share from just six years earlier.

Figure 4: Destination States for WV Coal Shipments to Electric Utilities, 2011 vs 2017



A combination of reduced coal consumption and shifts in coal sourcing by power plants in several states that were traditional leading destination markets in the past has accounted for the bulk of losses in domestic shipments of thermal coal from West Virginia mines. For example, North Carolina, Pennsylvania, Ohio and Florida have each seen the amount of coal tonnage burned by electric power plants (via retirement or reduced utilization rates) cut by nearly half over the last six years. Additional retirements this year will cause Ohio to see an additional reduction in thermal coal use following the recent decommission to the JM Stuart power plant and Killen Generating Station. All told, these two plants had a combined nameplate capacity of roughly 3 GW and purchased nearly 1.1 million tons of coal from the Tunnel Ridge Mine in Ohio County during 2017.

Even among states that sourced smaller tonnages from West Virginia mines in years past have throttled back these purchases even further or cut them out entirely as their coal-fired capacity has diminished in size. For example, New York, New Jersey, Mississippi, Massachusetts and a handful of other states

received more than 6 million tons of thermal coal shipments in 2011, but that quantity dropped to a cumulative 690,000 tons among these states in 2017 as coal-fired generators in these states were closed or had much lower capacity factors.

In some cases, however, utilities operating in these key states have lowered the coal they source from West Virginia mines in an even more disproportionate manner due to relative prices for coal from other basins and/or satisfying compliance standards for certain environmental regulations. For instance, electric utilities in North Carolina reduced coal consumption by 14 million short tons (50 percent overall) between 2011 and 2017, but coal shipments sourced from West Virginia mining operations dropped by nearly two thirds (10 million short tons) over that same time frame.

The shift in sourcing patterns was even more dramatic for Florida. Coal shipments to electric utilities in the Sunshine State have fallen by just over seven million short tons (~33 percent) since 2011. Of the nearly 23 million short tons of coal used by coal-fired generators in 2011, roughly 4 million tons were sourced from West Virginia mines. By 2017, of the nearly 15 million short tons of thermal coal consumed in Florida, just over 200,000 tons originated in West Virginia as the coal-fired fleet had shifted domestic coal purchases mostly to the Illinois Basin and imported nearly 3 million short tons of coal from Colombia.

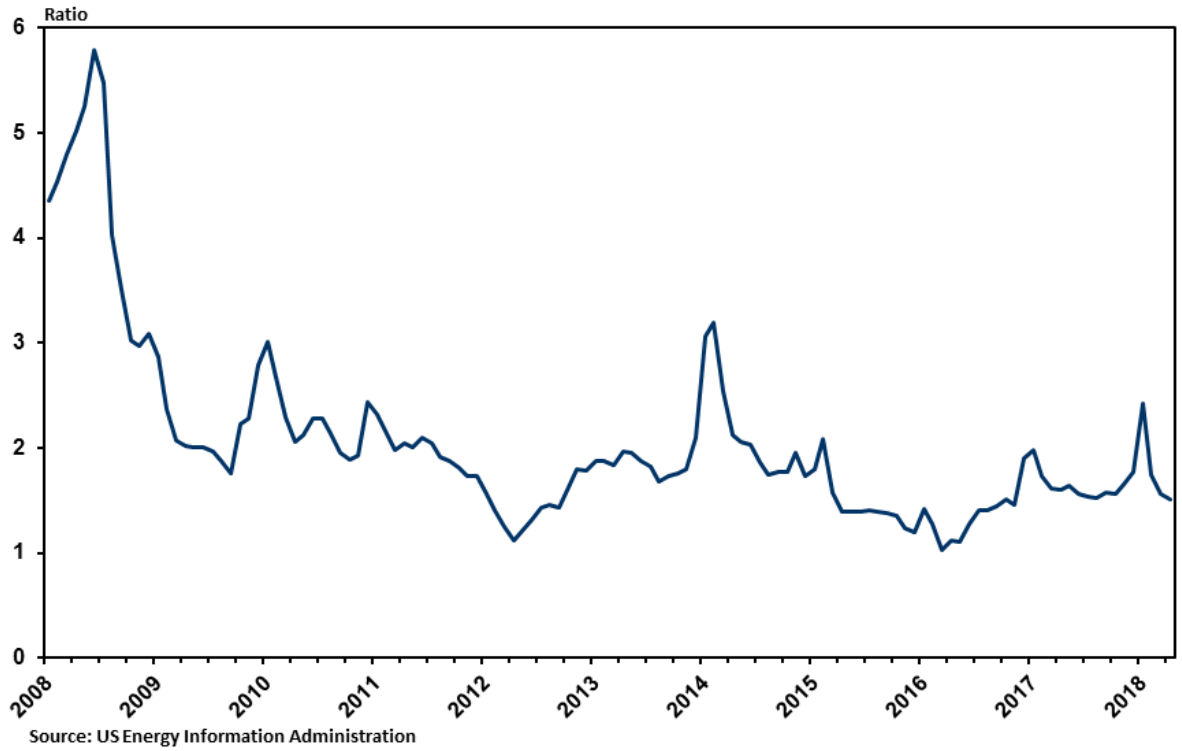
Shifts in coal sourcing by power plants have also helped to push the diverging production trends observed for Northern and Southern West Virginia in recent years. During the 2000s, West Virginia's southern coalfields produced on average nearly two-thirds of the state's coal shipments destined for domestic power plants. By 2017, that share fell to 30 percent as much of the state's thermal coal production had shifted already toward higher-sulfur deposits found in more productive and lower-cost mines in Northern West Virginia.

TECHNOLOGICAL CHANGE: This pronounced shift away from Southern West Virginia coal for electricity generation emanates from the interplay of geological, technological, economic and regulatory factors. Costs of flue gas desulfurization (FGD) "scrubbers" or dry sorbent injection (DSI) systems, which help to remove sulfur dioxide, nitrogen oxides, hydrogen chloride gas, mercury and other particulates from smokestack emissions, fell appreciably in the past decade or so. This has enabled electric utilities to burn lower-cost coal from Northern Appalachia (which includes Northern West Virginia) and Illinois Basin mines with higher concentrations of these emissions, while still satisfying the overall portfolio of federal and state emissions requirements.

REGULATORY POLICY: The deployment of FGD and DSI systems were an even more crucial technological change since they also allowed utilities to meet compliance standards for the Mercury and Air Toxics Standard (MATS) rule. This rule requires fossil-fuel steam electric generators to meet emissions limits for a range of toxic elements and compounds. The rule is now under review by the Trump Administration and has been subject to significant amounts of litigation, but most generators are in compliance as the rule's original implementation window (including extensions) ended in 2016. In addition, utilities have recently indicated they would prefer the rule be enforced as is going forward since they have already undertaken the massive capital investments to achieve compliance.[2]

[2] "In about-face, utilities urge EPA to keep mercury rule," *Energy & Environment News, https://www.eenews.net/stories/1060088801. Accessed July 11, 2018.*

Figure 5: Ratio of Natural Gas Prices to Coal Prices per Btu Paid by Electric Utilities



Overall, more than 50 GW of coal-fired capacity was retired between 2012 and 2017. Disentangling whether these capacity reductions can be attributed solely to the MATS rule or in conjunction with a broader portfolio of other previous regulatory changes (such as CSAPR, etc), a generator's age or falling prices for other fuel sources requires a micro-level analysis at the power plant level. Nevertheless, whether it was the most important contributor or not, the time frame for many of these power plant retirements does indicate the MATS rule played a factor in altering the US electric power sector.

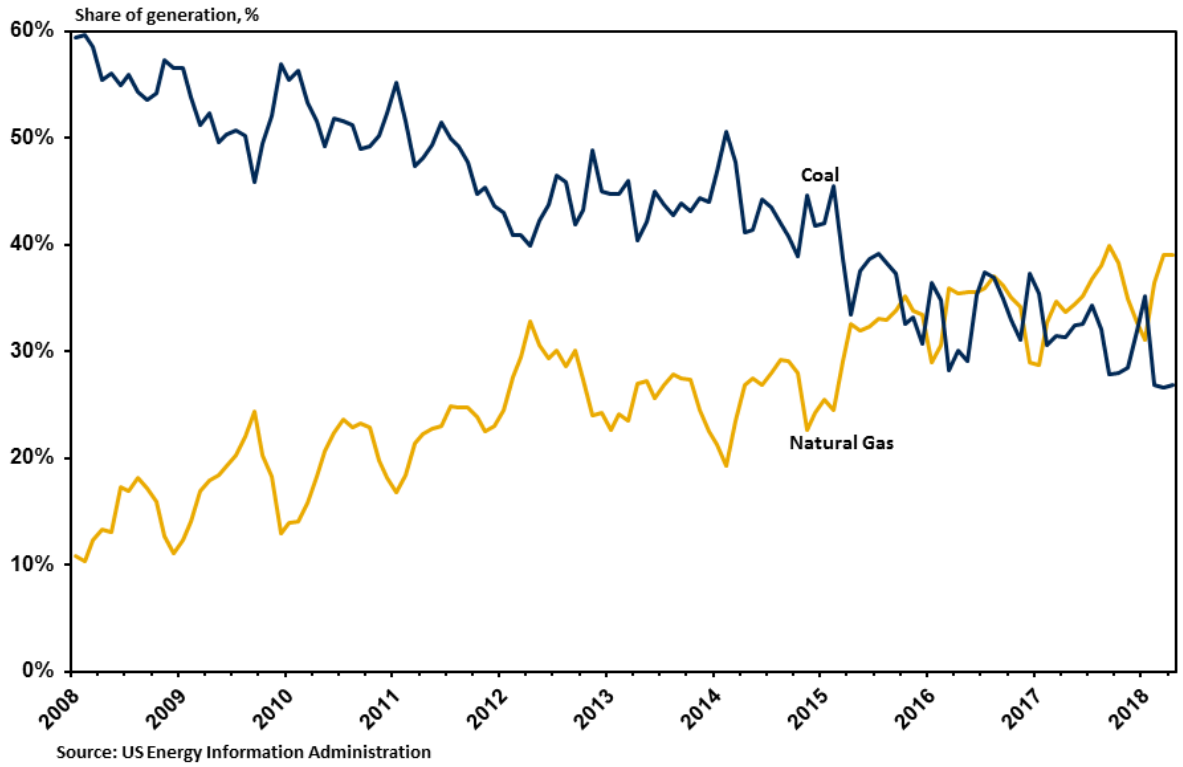
Other major environmental regulatory policy changes of the past several years that affect coal demand directly or indirectly, including the Clean Power Plan (CPP), performance standards for new, modified and reconstructed generators and the Stream Protection Rule, have either been repealed or are under some combination of judicial or legislative review. Some states have decided to forge ahead with their own mass-based reductions in power plant emissions that correspond with the goals set forth in the CPP. In addition some major utilities, such as American Electric Power, Duke and Southern Company, have chosen to shift their portfolio of generation assets away from coal and toward natural gas and renewables independent of federal regulatory changes.

CHANGING FUEL SOURCES: While regulatory policy changes and geographic shifts in utilities' coal sourcing have affected the state's coal industry over the past several years, burgeoning domestic natural gas-fired electric generation capacity has also presented significant difficulties for thermal coal demand produced in West Virginia. Indeed, the dramatic growth in natural gas production since 2010 in Pennsylvania, West Virginia and Ohio due to the large-scale development and exploration of the Marcellus and Utica shale plays - along with falling costs in the construction and operation of natural gas-fired power plants - has allowed natural gas to emerge as an alternative to coal for baseload generation.

As recently as the late-2000s/early-2010s, natural gas had a price disadvantage compared to other fuel sources due to supply constraints and insufficient infrastructure. Thus, in most parts of the country natural gas served as a fuel for industrial users or a back-up source of generation to be dispatched during peak-load demand periods. Prior to the collapse in energy prices created by the Great Recession, electric utilities paid nearly 6 times more for natural gas relative to coal on a per Btu basis. Moreover, hurricanes that threatened the Gulf of Mexico had the ability to cause natural gas prices to spike and remain high for extended periods of time given that other dependable supply sources were not available. Since the beginning of 2012, however, the massive supplies of natural gas flowing from the Appalachian Basin have yielded structurally lower prices for natural gas relative to coal. Even during instances of extreme weather that have occurred over this time period, such as the 2014 Polar Vortex and an extended cold snap in early-2018 (the Bomb Cyclone), price spikes have been smaller and shorter lived.

A key measure of how natural gas has evolved as a primary fuel for electricity generation is the utilization rate of gas-fired plants. Per the US Energy Information Administration (EIA), capacity factors, which measure the ratio of a plant's actual output to its potential output if the facility were operating at peak levels, for natural gas plants averaged 35 percent in 2005 while the corresponding figure for coal plants was 67 percent. By 2017, natural gas combined-cycle (CC) plants had an average operating rate of 55 percent (56 percent during 2015 and 2016) while coal plants operated at less than 54 percent on average. Preliminary data indicate this multi-year trend has continued in 2018 as CC natural gas plants are operating at nearly 8 percentage points higher on average during most of the first and second quarter.

Figure 6: Electricity Generation by Fuel Source – Primary WV Coal Destination States



This shift in fuels to fulfill baseload demand has also helped to exacerbate the divergent patterns of coal output for the northern- and southern coal-producing regions in West Virginia, since Southern West Virginia is more expensive on a per Btu basis. In the late 2000s, coal accounted for more than half of the electricity generation, on average, among states that sourced coal from West Virginia mines. These shares were roughly identical for both fuel sources in much of 2015 and 2016, but in all but two months since then natural gas has maintained a higher share of electricity generation versus coal in these 14 or so states that purchase thermal coal from West Virginia.

The change in electricity generation is having an even more apparent impact if one weights coal-fired generation by the tonnage of shipments delivered to power plants in destination states. For example, the shipments-weighted share of coal-fired generation fell from 55 percent down to 46 percent between 2014 and 2017 for Southern West Virginia. For states receiving shipments from Northern West Virginia mines, the weighted share of generation coming from coal fell by seven percentage points during that time period, but remains at 64 percent due to the fact that such a large percentage of coal from the northern coalfields ends up being burned by West Virginia-based power plants.

3 Industrial/Commercial Coal Demand

Aside from electricity generation, industrial and commercial uses constitute the other major domestic source of demand for West Virginia coal. Specific grades of coal mined primarily in the state's southern coalfields are used in the coking process to manufacture steel. However, the secular decline in the US steel industry has reduced domestic demand for premium grade coal. Domestic coking coal use has fallen from a national total of 30.2 million short tons to 17.5 million short tons between 1997 and 2017. For West Virginia, domestic metallurgical coal shipments have declined by 27 percent since 2011, totaling just below 10 million tons in 2017.

In addition to its direct uses in steel production, coal is also a prominent fuel source for CHP generation at various types of manufacturing facilities and some commercial buildings. At the same time, however, consumption of non-coke coal sourced from West Virginia mines for industrial, commercial and institutional uses has also been on a downward trend for many years. In concert with a reduced footprint for the manufacturing sector, increases in heat-rate efficiencies for coal-fired CHP boilers as well as production facilities switching over to natural gas as the primary fuel source for CHP have driven the domestic use of non-coke industrial coal lower over time. Higher efficiency standards for lighting, electric motors and other electrical machinery and equipment have reduced the energy intensity of the industrial and commercial sectors. Overall, non-coke industrial and commercial coal shipped from West Virginia coal mines has dropped from 4.5 million short tons in 2011 down to 1.4 million short tons in 2017.

4 Coal Export Demand

Given the downward trend in coal use across all domestic end-markets, export markets have represented the one opportunity for growth for West Virginia's coal producers. While not completely offsetting the losses in domestic shipments that have occurred over the course of the last decade or so, coal exports have at least provided some offset and now account around one third of the state's overall production. Exports are an even more crucial base for Southern West Virginia's coal mines. During 2017, of the 46 million short tons of coal produced by the state's southern counties, preliminary data indicate that approximately half of that production was exported. Even though most of the exported coal tonnage from these mines is used to manufacture steel, thermal coal exports have picked up in parts of the world as some developing countries have ramped up construction of coal-fired generation capacity.

Coal exports from West Virginia, peaked in 2012 and proceeded to fall sharply until late-2016. Several years of significant overcapacity in Chinese steel production, slowing economic growth in Asia and collapsing wholesale power prices throughout much of Europe left global markets for both thermal and metallurgical coal oversupplied. Indeed, coal exports from West Virginia averaged fewer than 24 million tons per year during 2015 and 2016, marking a 41 percent drop from the tonnage exported between 2011 and 2013. With both thermal and metallurgical coal export prices cratering, many of the state's mines that were heavily exposed to the global coal trade became unprofitable. Ultimately, this helped to precipitate a wave of financial struggles and bankruptcies throughout the industry and forced many of the major operators in West Virginia to idle, close or sell mines.

Market conditions have improved visibly for coal exports over the past several quarters. Nearly 97 million short tons of coal was exported from US ports during 2017, with preliminary estimates indicating West Virginia mines accounted for 34 million short tons of these shipments. Although coal from the state's southern and northern mines was exported to least 37 countries, shipments to a handful of countries accounted for most of the exported tonnage. India was the state's largest customer, accounting for nearly 20 percent of West Virginia exports and thermal coal comprised a significant share of these shipments.

EXPORT MARKETS: While India's recent build-up in coal-fired generation capacity boosted its thermal coal demand, other coal-consuming industries connected to the developing country's rapid economic growth, particularly cement, have had to ratchet up purchases of coal following the banned usage of petroleum coke by several northern Indian states in an effort to reduce air pollution. India has remained West Virginia's top overseas market thus far in 2018 by a sizable margin, importing nearly double the tonnage of thermal and metallurgical coal through the first five months of 2018 that it received over the same time period in 2017.

Ukraine represents another increasingly important coal export market for West Virginia in recent years. Most of the shipments from the state destined for Ukraine have been metallurgical grade coal, as the Eastern European nation has sought to bolster its met coal imports since losing Crimea—and the anthracite coal mines located there—to Russian-backed separatists in 2014. Metallurgical coal exports from West Virginia to Ukraine more than doubled between 2016 and 2017, and through the first half of 2018 have increased nearly 70 percent on a year-over-year basis.

Table 1: Top Destination Countries for West Virginia Coal Exports, Ranked by 2013 Value

Country	2013	2014	2015	2016	2017	% change (2016-17)
Netherlands	570	422	255	114	233	104%
Italy	467	413	159	96	224	134%
United Kingdom	424	287	147	49	124	153%
Brazil	397	353	212	157	275	75%
Turkey	343	194	60	68	147	117%
France	336	151	43	56	191	241%
Ukraine	311	286	227	121	459	278%
India	283	141	179	165	636	285%
Morocco	249	197	9	44	103	133%
Canada	186	190	151	148	177	20%
China	183	35	0	0	0	-2%
Mexico	173	52	39	42	70	66%
Germany	152	112	34	22	60	174%
South Korea	122	19	31	57	150	161%
Spain	117	65	34	42	106	151%
World	4,859	3,258	1,784	1,281	3,254	154%

Source: International Trade Administration
Note: Data are in millions 2017 dollars.

Apart from India and Ukraine, which account for roughly 30 percent of coal exports from West Virginia by tonnage (and one-third in overall value), Brazil ranked third among importing countries in terms of the coal tonnage shipments received from West Virginia. Although Brazil has fairly sizable reserves of sub-bituminous coal that is utilized by its power plants, it possesses no appreciable production of premium grade metallurgical coal that is needed to drive its large domestic steel industry. In fact, Brazil ranked first among all nations in terms of the tonnage of met coal it imported from the US during 2017 at 7.3 million short tons--and more than 2.2 million short tons coming from West Virginia. With continued strong growth in Brazil's steel industry, demand for met coal out of West Virginia remained strong during the first six months of 2018, rising more than 50 percent over 2017 levels for the same span of months.

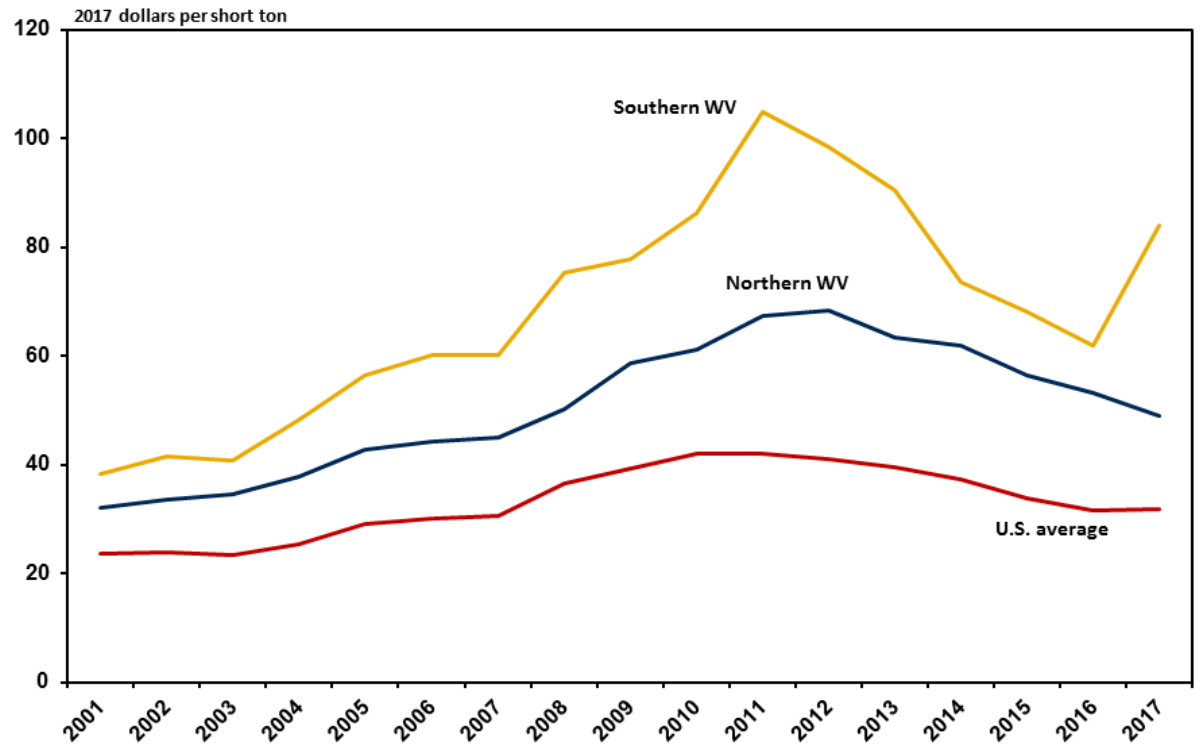
Coal shipments from West Virginia to the European Union as a whole declined by nearly 75 percent between 2013 and 2016. Aside from the hit to met coal demand caused by the correction in global steel markets, the electric utility sector across much of the continent witnessed the initial stages of a large-scale transition in generation away from coal and over to utility-scale renewables. The Netherlands, Germany and Poland still rank as the heaviest coal users among EU nations, but by 2017, wind, solar and biomass accounted for nearly 21 percent of generation for the entire set of member states. This slightly edged out the share of generation attributed to coal and lignite. Due to the massive build-up in renewable generation and the continent's lack of growth in power demand, wholesale power market prices have remained extremely low, which has caused many coal-fired power plants to face significant financial problems and caused many individual countries to phase coal out even faster due to the potential for large bailouts.

5 Prices and Mine Productivity

Coal prices increased rapidly over the course of the 2000s. Between 2001 and 2011, the inflation-adjusted sales price of coal rose at an average annual rate of 8.5 percent per year for the state. Real sales prices increased nationally during this timeframe as well, but at a slower pace of 5.8 percent annually.

As has been the case with trends in production, there were notable differences in both the level and rate of growth in prices between the state's northern and southern coalfields. Real average sales prices increased 10.7 percent per year, reaching $105 per short ton (in 2017 dollars) by 2011 in Southern West Virginia due to high-cost productive capacity entering service just to meet increased market demand and higher production of metallurgical coal bound for overseas export markets. By comparison, inflation-adjusted sales prices for Northern West Virginia's (primarily high-sulfur thermal) coal increased just over 7 percent annually to a peak of $68 per short ton in 2012.

Figure 7: Average Coal Sales Price by Region



Source: Energy Information Administration
Note: Estimates for 2017 are preliminary.

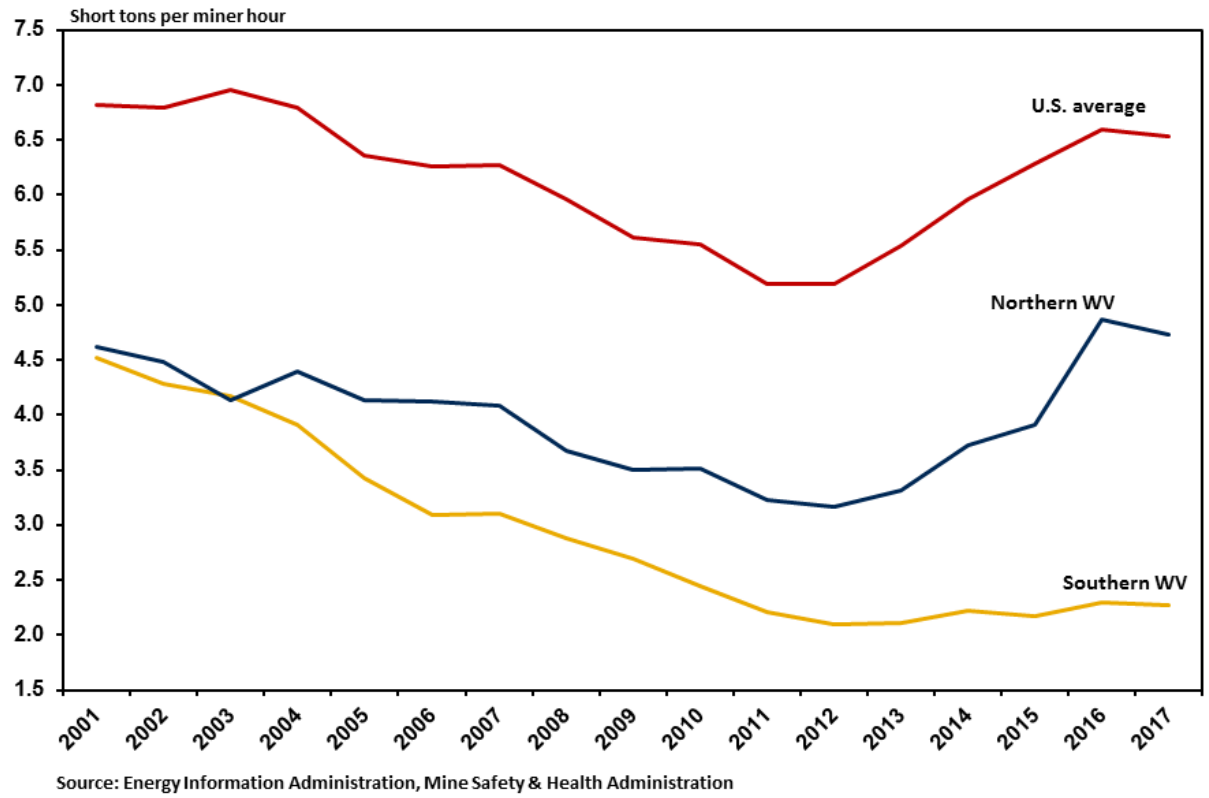
Coal prices generally bottomed out in early- to mid-2016 and have increased substantially over the last several quarters. Metallurgical coal export prices averaged more than $144 per short ton during the first quarter of 2018, more than double what was observed two years earlier. Export prices were actually higher during the first two quarters of 2017, though that was due in large part to the global supply shortfall created by Cyclone Debbie's destruction in Queensland, Australia. Thermal coal prices have followed different tracks since the broader cyclical upswing began for coal markets nearly two years ago. Domestic

thermal coal prices have generally trended lower since 2012, as shrinking coal-fired generating capacity is weighing on demand and most output is being supplied by highly-productive mining operations. Strong demand growth in India is providing a boost to thermal coal export prices to some extent, but as has been the case in the US, the transition to renewable fuels is keeping a lid on prices.

COAL MINE PRODUCTIVITY: In addition to being affected by broader shifts in global coal demand, prices are also directly affected by supply-side issues that are determined by a combination of regulatory burden, capital/labor utilization, fuel prices and geological constraints. In the short run, labor use tends to have the greatest direct influence on the relative cost of extracting coal from a given seam and thus changes in productivity, as is usually measured in short tons per labor hour, explains a sizable portion of the movement in coal prices over time.

Though mine productivity has declined in most US coal basins since the beginning of the 2000s, Southern West Virginia endured a major drop-off in productivity, but has stabilized around 2.2 tons per miner hour. The region's underground (UG) and surface mines have experienced substantial declines in productivity, since thin or fragmented seams require more manpower to extract a given ton of coal. Average productivity levels for both mining methods have fallen by half in the region since 2001, from 3.8 to 1.9 short tons per miner hour and 5.7 down to 3.2 short tons per miner at UG and surface mines, respectively. Productivity in Northern West Virginia tracked Southern West Virginia's during the 2000s, but the two regions have seen an appreciable divergence in this trend over the past five years or so. Indeed, several major mines expanded or opened in the past decade in Marshall, Ohio, Marion and Taylor counties. Overall, the region has seen average productivity levels increase by 47 percent since 2012.

Figure 8: Average Mine Productivity by Region



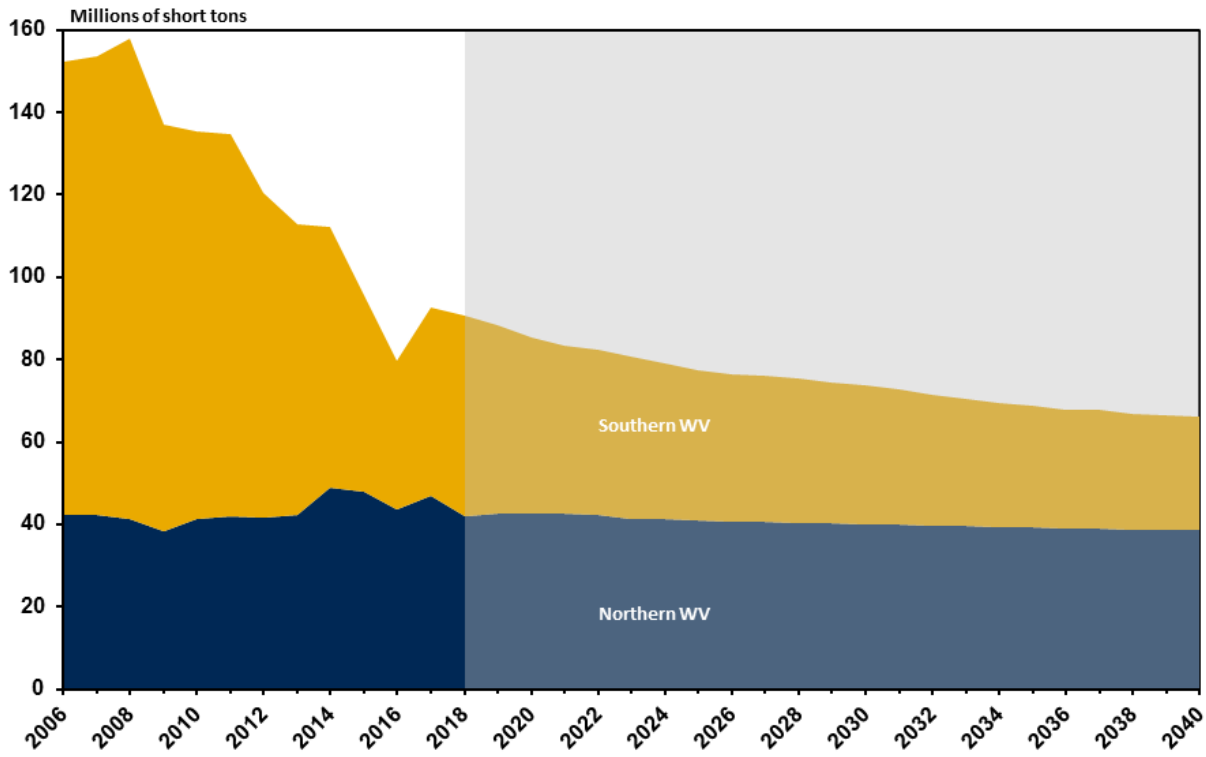
Source: Energy Information Administration, Mine Safety & Health Administration

6 West Virginia Coal Production and Price Outlook

6.1 Short-Term Outlook

We utilize an econometric model to forecast coal production for the state's northern and southern coalfields through 2040 based upon a series of variables that influence the demand and supply for each region's coal reserves.[3] Overall, the baseline forecast calls for state coal production to fall to an annual total of 91 million short tons during calendar year 2018, which would represent a decline of just over 2 percent from 2017. Coal output is expected to weaken further over the next two years, falling at an average annual rate of 3 percent during 2019 and 2020, leaving production at roughly 85 million tons by the end of this decade.

Figure 9: Coal Production Forecast by Region



Sources: Energy Information Administration, WVU BBER Coal Production Forecast
Note: Forecast period designated by shaded area.

Total statewide production is expected to slow during the second half of the year, but this will stem in large part from weaker output for some mines in Northern West Virginia. Regional output is expected to total just over 42 million short tons in 2018, or nearly a 10 percent decline from 2017. One immediate factor for the region's production drop is the loss of roughly 3 GW in coal-fired capacity, as the mid-2018 retirement of two power plants in Ohio will likely lead to a one-million-ton loss of shipments from Ohio County, WV's Tunnel Ridge Mine. In addition, natural gas is expected to supplant coal-fired generation further within several states that purchase coal from mines in Northern West Virginia this year, as some

[3] For a more detailed description of the model and major underlying forecast assumptions, see the Appendix.

coal plants remain uncompetitive, particularly in deregulated markets. On a positive note, a handful of northern mines will continue to benefit from strong export demand for metallurgical coal in markets such as Brazil, South Korea and Italy.

By comparison, Southern West Virginia coal production is expected to total more than 48 million tons in 2018, a 6 percent increase from 2017. While the region's output is still far below what it produced as recently as 2014, coal production has jumped by nearly 13 million tons since 2016 and will finish the year with two consecutive calendar year gains for the first time in a decade. While exports are expected to decline slightly in the second half of the year, Southern West Virginia coal mines should continue to benefit from their exposure to high-growth markets such as India and the recent expansion in energy-related trade ties with Ukraine.

Losses in domestic thermal coal demand will hurt both of West Virginia's coal-producing regions over the next two years, though Southern West Virginia will likely be affected to a greater extent. Duke Energy is on track to shift its portfolio even further toward natural gas over the next several years as several of its coal-fired power plants in North Carolina are being (or will soon be) retrofitted to run partially or totally on natural gas, which will result in the likely loss of at least part of the 6 million short tons of thermal coal shipped from Southern West Virginia mines to North Carolina. In addition, coal export demand will likely cool from the 100 million short tons or so that is anticipated for 2018, though a repeat of the 2014-2016 global crash in coal demand is not expected. Export tonnage is expected to average roughly 95 million short tons in 2019 and 2020.

While the global economic backdrop for coal demand will likely remain healthy over the next couple of years, deteriorating trade relations between the US and many of its trading partners over the past several months pose an appreciable risk to the state's coal producers going forward. Indeed, the Trump Administration has already instituted a broad import duty of 25 percent on steel and 10 percent on aluminum. Several countries have responded with retaliatory tariffs on US-produced steel along with a host of other goods, including coal, which has the effect of making coal from West Virginia mines more expensive to overseas buyers.

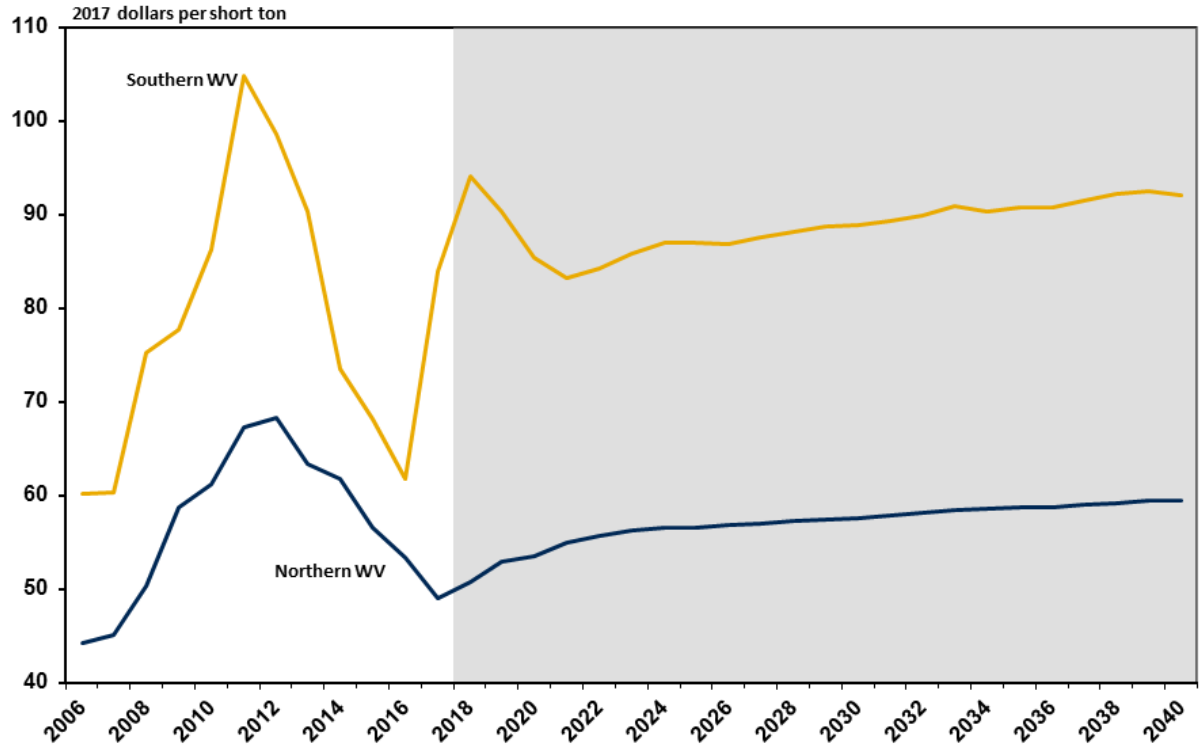
Exemptions were granted to South Korea, Brazil and a handful of other countries that buy relatively large quantities of coal from West Virginia, which will reduce the tariff's overall impact on coal. However, the steel and aluminum tariffs were only part of a larger shift in US trade policy by the Trump Administration, which includes much greater scrutiny of NAFTA and other multi-lateral trade deals as well as targeting China for tariffs on a wide range of goods that are imported into the US.

While each of these actions individually are not expected to cause lasting harm to global economic growth (or coal demand, in particular), a burgeoning trade war could emerge if more countries decide to assess retaliatory tariffs of their own on broad baskets of goods produced in the US. For example, the administration has proposed tariffs on imported cars and parts, which along with the other enacted and proposed tariffs would affect more than $870 billion in imports. In addition to a direct import price increase on cars and parts, these tariffs would build in an additional layer of inflation as steel and aluminum make up a significant portion of an assembled car and for individual components. In addition, met coal exports from the US would likely be hurt as well since the hit to imported autos would dampen steel demand. From a global economic perspective, aside from weighing on car purchases in the US, the direct impact would affect overall consumer spending and eventually precipitate broader economic impacts in the US and abroad over time as many nations would respond in kind with their own retaliatory tariffs on US exports—which could ultimately trigger an economic slowdown or an outright recession.

The federal regulatory environment presents another source of downside risk to West Virginia's coal industry over the next few years. Although the Trump Administration's decision to repeal and/or replace several major EPA rules established during the Obama Administration's years in office, including the Clean Power Plan, New Source Performance Standards and others, any changes will likely be subjected to legal challenges that could last for several years. Uncertainty over the ultimate legal fate of these challenges along with the potential of a future presidential administration altering policy goals one way or another combine to create significant regulatory risk, especially for electric utilities and other related industries that require the policy stability needed to formulate and implement their long-term resource plans.

PRICE OUTLOOK: Healthy global demand for premium grade metallurgical coal will keep average market prices for mines in Southern West Virginia at an elevated level over the next couple of years. Prices for the state's southern mines are expected to average $94 per short in 2017 dollars for calendar year 2018, marking a 12 percent increase from 2017 and the highest level since 2012. Some retrenchment in export demand during 2019 and 2020 will weigh on pricing, but the region's average market sales price is expected to fall between $85 to $90 per ton (in 2017 dollars). Weak domestic thermal coal demand will keep a lid on average sales prices for the state's northern coal-producing mines increases over the next few years. Overall, market prices for Northern West Virginia coal will increase three percent annually through 2020, but will remain below 2016 levels after adjusting for inflation.

Figure 10: Average Coal Price Forecast by Region



Sources: Energy Information Administration, WVU BBER Coal Production Forecast
Note: Forecast period designated by shaded area.

6.2 Long-Term Outlook

While the regulatory backdrop poses a risk to future coal production, on both the upside and downside, the lingering uncertainty over what specific changes the Trump Administration decides to make to the overall portfolio of environmental rules that affect the coal industry make their combined impacts on output difficult to assess. Consequently, the baseline forecast follows a "business-as-usual" approach where rules that are in place are incorporated into the model assumptions based upon how they affect the demand or supply for coal from each of the state's producing regions.

Even though conditions have improved measurably in Southern West Virginia's coal industry over the past two years or so, the long-term outlook for coal production from both producing regions in the state has deteriorated since the previous report. The forecast calls for coal output to fall steadily after 2020, dropping back below the 80 million short ton mark by the mid-2020s and then dipping below 70 million short tons around a decade later. Ultimately, statewide coal production is expected to total 66 million short tons in 2040, representing a 17 percent decline from 2016 levels.

ELECTRIC POWER SECTOR: For the domestic thermal coal market, both producing regions will face pressure from the planned retirements of coal-fired power plants or their full or partial conversions to natural gas. Utilities operating in Ohio, North Carolina, West Virginia, Pennsylvania and a few other states have identified significant amounts of coal generating capacity for retirement or conversion (partial or total) to natural gas. Further reductions in the coal-fired fleet are also expected to occur in the Eastern US as falling production and generation costs put utility-scale wind and solar generation in a more competitive position. Indeed, the intermittent nature of wind and solar remains more of a limiting factor in growth for renewables in some eastern states at this time, compared to areas such as Texas and California, but these obstacles are expected to dissipate over time due to anticipated improvements (and lower costs) associated with scaling battery technology to utility-scale applications.

These generation portfolio changes are largely scheduled to occur through the early 2020s, but more of West Virginia's thermal coal production remains at an increased risk of even larger declines over the long term. Even if the most efficient coal plants make up the coal fleet over the latter half of the outlook, older plants are typically more costly since they require more equipment and facility maintenance on average and also have to undertake capital investments to maintain compliance with a range of regulations. Given that the capacity-weighted average age of the US coal-fired fleet currently stands at roughly 40 years old, the bulk of coal-fired power plants still in operation during 2030 will likely have been in service for more than 50 years.

Overall, the weighted share of electricity generation for Northern West Virginia is expected to fall to 55 percent or so by the mid-2020s and trend lower over the remainder of the outlook period, slipping several more percentage points over the next decade. Shipments to coal-fired power plants in West Virginia will buoy the coal share of generation for the state's northern coal mines, but the likely construction of at least one of the three proposed natural gas power plants will lower coal's dominance in generating electricity. By comparison, the weighted share of generation for states receiving shipments from Southern West Virginia is forecast to dip below 40 percent within the next five years and continue falling in subsequent years, falling into the lower 30-percent range by the mid-2030s.

INDUSTRIAL DEMAND: Domestic demand for West Virginia coal will also be challenged by declines in use via industrial and commercial applications. Fuel switching by industrial customers will account for the majority of this drop, as an abundance of low-cost shale gas enables manufacturers to transition to natural gas for CHP needs. Efficiency gains in industrial machinery and HVAC equipment, as well as the design and construction of energy-efficient buildings and declining costs created by high-efficiency lighting equipment also stand to reduce coal (and overall energy) use in commercial settings.[4]

EXPORTS: Given the diminishing use of coal in the US, global markets are expected to be a more consistent source of demand for coal from West Virginia's mines. The forecast calls for US coal exports to fall in a relatively stable range of 80 to 87 million tons between 2020 and 2040, which would suggest (based upon historical standards) West Virginia coal exports will likely average 25 to 30 million short tons.

However, this range of export tonnage for the state is only expected to last through the first half of the outlook period before trending into the lower 20 million ton range during the second half of the forecast horizon. First, a significant portion of the productive capacity that came on-line in the 2017-2018 rebound can be characterized as swing production, smaller operations that ramp up output as global prices increase due to growing demand and/or a major supply shortfall. With export prices expected to cool over the next several years, production from these mines will decline in kind until the next boom in demand or supply crunch. Secondly, some of the largest met coal operations in the state have been in operation for many years, but have seen two large upswings in global coal demand in the space of less than a decade. Given what is known about their recoverable reserves, several of these operations will likely begin to approach the point of seam depletion (from an economic perspective) within the next decade.

Southern West Virginia will continue to account for most of the state's export shipments due to its abundant met coal reserves as well as increasing demand for the region's thermal coal from Asia and parts of Europe. Northern West Virginia has traditionally had a lower exposure to exports, but the forecast assumes exports will become a larger role in the region's end-market coal demand going forward as mining companies in the area seek to offset declining coal-fired generation in the US by increasing sales to developing countries that are expected to add significant coal capacity.

India will likely remain at or near the top in terms of the state's top overseas buyer of coal from West Virginia. The nation's sheer energy needs that are created not only by a rapidly-growing economy, but also the goal of providing electricity to all of its citizens, many of them who are located in rural and impoverished regions, will require a lot of new electric generation capacity that cannot be met by renewable generation alone. Indeed, India has an estimated 43 GW or so of coal-fired capacity under construction and another 101 GW in the announced, permitted or in the pre-permit phases.

PRODUCTION BY REGION: Both producing regions in West Virginia are expected to endure declines in coal production between 2020 and 2040, but Southern West Virginia will likely endure the largest overall losses in output over this time frame. While the decline that occurred between 2012 and 2016 will not be repeated, Southern West Virginia will see shipments of coal to domestic power plants shrink further as Duke Energy accelerates the transition of its generation portfolio away from coal over to natural gas. Export demand will buoy the region's production going forward, but given that coal use is declining in many parts of the world, opportunities for growth will be difficult. Southern West Virginia's coal industry

[4] Assumptions regarding domestic industrial demand for coal are derived in part from the EIA's *Annual Energy Outlook 2018*.

will also be limited to a significant degree by its high cost structure compared to other coal basins, as many decades of aggressive mining have left the region with a depleted base of recoverable reserves and high operating costs. Overall, Southern West Virginia production is expected to fall from the lower 40-million ton range down to just over 27 million tons by the late 2030s.

Given its large exposure to the ongoing shifts in the US electric power sector, coal production from Northern West Virginia is expected to decline over the long term. Low production costs will enable the region's most highly-productive mines to navigate a shrinking domestic market for thermal coal, though even these operations will also see shipments taper over time as additional coal-fired generation is retired, converted or dispatched less frequently in Ohio, Pennsylvania and Kentucky. Export markets will account for an increasing share of the region's coal production over the long term and should help to offset the loss in domestic demand. Developing economies such as India, Turkey and Vietnam are potential destination markets as these countries are set to expand their coal-fired generation capacity in the coming years and have indicated a desire to diversify the countries from whence they source coal. Furthermore, even though the region contains a large quantity of recoverable reserves, some mines will likely begin to approach the point of exhausting their economically-feasible reserves during the outlook period as production has been strong and steadier (compared to Southern West Virginia) for much of the last five years or so. Overall, coal output from the state's northern mines is expected to decline roughly 10 percent between 2020 and 2040, falling to 38 million tons by the late 2030s.

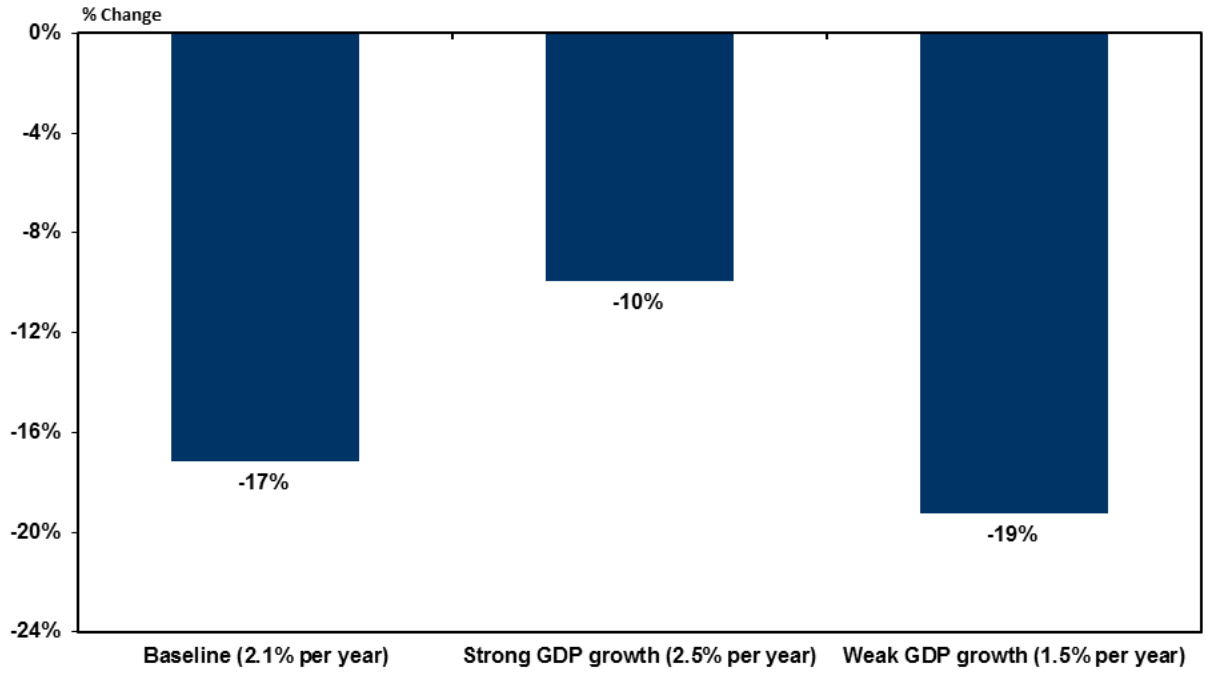
7 Alternative Scenarios for Coal Production

The baseline forecast is built upon a series of assumptions that can have significant impacts on the state's coal production outlook. These assumptions include expectations for domestic and global economic growth, the competitive and regulatory environments and how each interact with costs to the mining industry itself as well as those borne by the electric power and industrial sectors. The impact of these assumptions can be substantial and, by consequence, illustrate the extent to which the baseline forecast can deviate in a significant manner due to future changes in policy or markets. Each of the following scenarios assume changes in policy or underlying economic conditions in isolation of one another, with all other exogenous variables held constant.

7.1 Sensitivity Analysis: Differences in Economic Growth

Economic growth influences electricity demand and steel production, which are easily the pre-dominant uses of coal. The baseline forecast utilizes some macroeconomic inputs from IHS Markit, which assumes real GDP will grow at an average annual rate of 2.1 percent between 2016 and 2040—a rate that is well short of growth observed during the post-WWII era. Using this assumption, statewide coal production is expected to decline 17 percent from 2016 levels. By raising expectations for national economic growth to a rate of nearly 2.5 percent per year would shrink the overall loss in the state's coal production decline to just over 10 percent, as stronger growth would require a higher level of met coal output from Southern West Virginia and additional thermal coal from Northern West Virginia. By comparison, reducing the assumption for real GDP growth down to a rate of 1.5 percent annually would cause production to fall by 19 percent compared to 2016.

Figure 11: Change in West Virginia Coal Production by GDP Growth Scenario (2016-2040)



Source: Bureau of Economic Analysis; IHS Markit; WVU BBER Coal Production Forecast

7.2 Sensitivity Analysis: Natural Gas Use

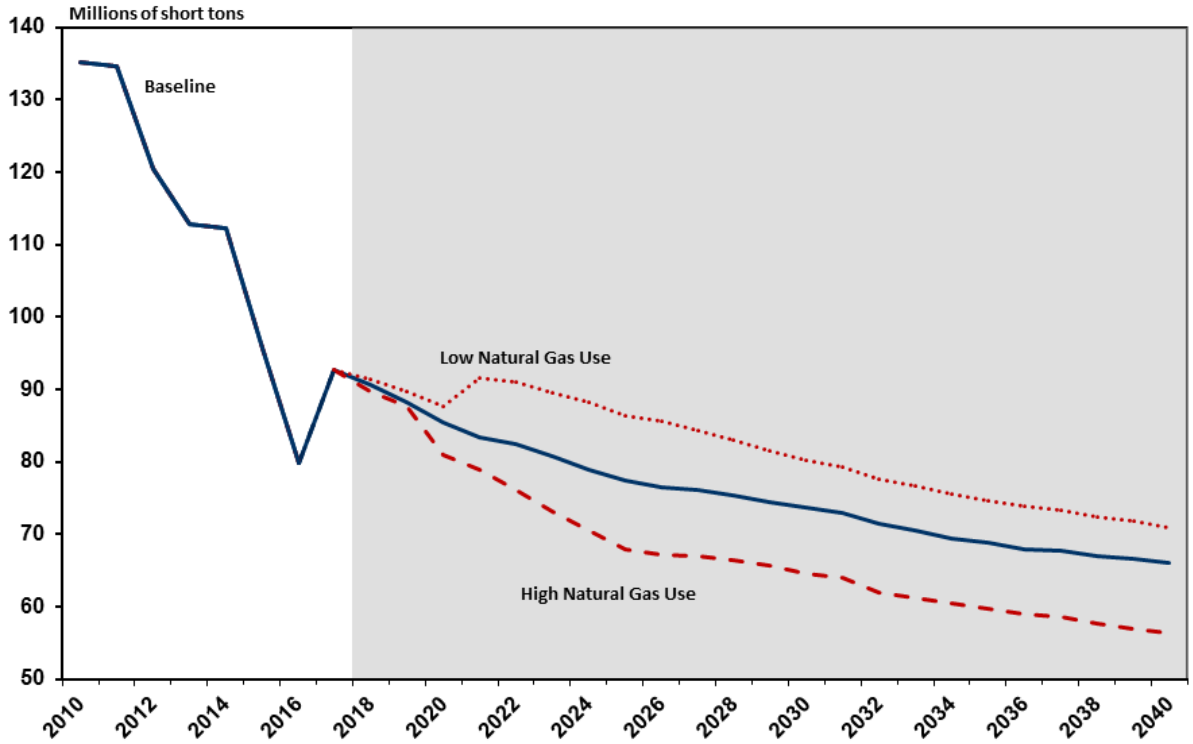
The first scenarios under consideration in this report examine differing trajectories for the channels of end-market demand for natural gas. The baseline forecast assumes that natural gas production will rise throughout much of the outlook period, with supply growth from the Marcellus, Utica, and other shale plays responding to increased use of natural gas in electricity generation, new downstream processing facilities in the Mid-Atlantic and Gulf Coast regions as well as rising international consumption of US shale gas via LNG exports. The baseline forecast calls for natural gas use by industrial consumers to increase by nearly 30 percent between 2016 and 2040 thanks to overall growth in manufacturing activity as well as the increased conversion of CHP boilers from coal to gas. Inflation-adjusted prices paid by utilities for natural gas are expected to increase during the outlook period, but will not surpass $4.00 per MMBtu on an inflation-adjusted basis until the late-2030s.

LOW NATURAL GAS USE SCENARIO: An alternative scenario was developed, under which natural gas use will be weaker than expected compared to the baseline forecast. The mechanisms by which natural gas consumption could fail to match expectations would likely come from issues that affect the availability of natural gas. These might include fracking bans, tighter rules on methane emissions from wells or equipment, pipeline cancellations or weaker-than-expected productivity levels from US shale formations. In one form or another, these changes would tend to raise the price of natural gas for both domestic and overseas consumers and would make it more costly relative to coal and renewables as a fuel for electric utilities and industrial consumers. Indeed, inflation-adjusted prices paid by utilities would surpass $4 per MMBtu as soon as 2020 and continue rising at a rate of more than 2 percent per year. Real prices for industrial electricity are also expected to be an average of more than 15 percent each year through 2040.

As Figure 12 suggests, this scenario would result in a higher level of coal output from West Virginia relative to the baseline—roughly 4 million short tons higher overall in 2040. Most of this difference would stem from electricity generation (both utilities and CHP) as higher-priced natural gas would encourage more coal generation to stay on-line longer during the outlook period, assuming no changes in emissions rules or the introduction of a tax on CO_2 emissions from power plants and other users. However, the difference in statewide coal production between the baseline and this alternative is expected to shrink as time progresses. More coal-fired power plants would remain in operation for longer, but the fact that few plants have been built in the past decade (and more than 50 GW has been retired in recent years) would point to a large portion of the remaining coal fleet reaching the end of normal service lifetimes by the mid- to late-2020s. The most efficient plants or the ones most critical to grid operability would likely be kept open for extended periods, but rising maintenance costs for aging generators and facilities would cause less efficient plants to be retired from service.

Natural gas generation would still be added under this scenario as it would likely retain competitiveness against coal plants in areas closer to shale gas production, but new wind and solar capacity, which has fewer regulatory and permitting issues to overcome (and thus takes less time to build) would eventually account for a significant portion of new generation coming on line during the outlook period.

Figure 12: Coal Production Forecast – Baseline vs Natural Gas Use Scenarios



Sources: Energy Information Administration, WVU BBER Coal Production Forecast
Note: Forecast period designated by shaded area.

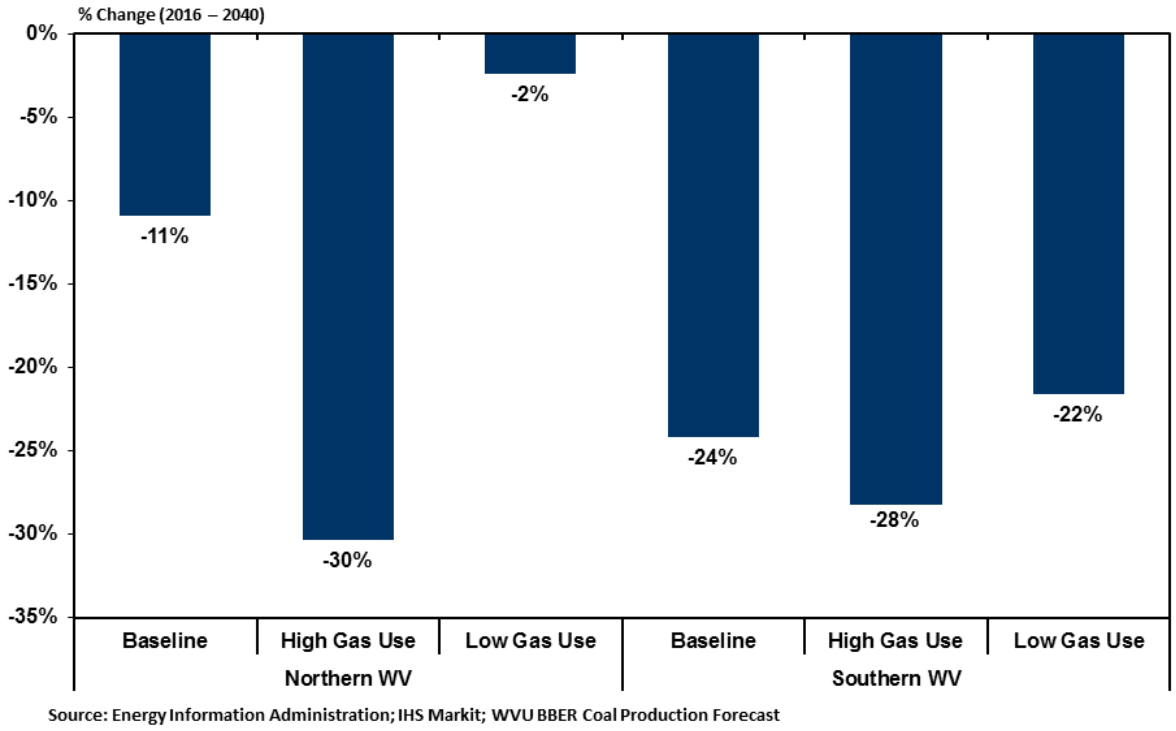
HIGH NATURAL GAS USE SCENARIO: As an additional alternative scenario concerning natural gas, this report also examined the potential impacts higher-than-expected utilization of natural gas would on coal production in West Virginia. Just as in the low gas scenario, the underlying factors that could cause gas use to surpass what is anticipated in the baseline could include additional discoveries of shale formations, upward revisions in proven reserves within current shale plays or stronger-than-expected gains in productivity. As has been the experience with the Marcellus and Utica shale plays in recent years, these factors would have appreciable impacts on the relative prices of coal and natural gas. This scenario assumes that natural gas prices for electric utilities would continue its decade-long downward trend and fall below the 2016 annual average of less than $3 per MMBtu (in 2017 dollars) by 2022 and remain at or below that level throughout the remainder of the forecast horizon. Industrial users would also see a discount of six to seven percent under this alternative scenario when compared to the baseline.

West Virginia mines would see appreciably larger declines in coal production during the outlook period in an environment with more favorable prices and higher-than-expected availability of natural gas. In essence, this scenario would point to the continuation of market conditions that characterized coal and natural gas markets between much of 2012 and 2016, where the shale gas revolution caused natural gas prices to fall significantly and helped to foster a growing share of electricity generation as utilities had to grapple with new emissions rules (MATS, etc) and the decision to retrofit an aging fleet. Even greater amounts of coal-fired capacity would be retired during the outlook period under this scenario as a larger percentage of fleets in deregulated wholesale power markets would no longer be competitive to combined-cycle plants and low natural gas prices would even incentivize utilities in other areas to partially

or fully convert coal assets or simply retire and replace coal generators with natural gas. Indeed, when weighted by shipments, coal would account for approximately 10 percentage points less of electricity generation. Industrial coal shipments would decline 0.5 to 1.0 percent per year between 2020 and 2040, with most of this loss coming from commercial users and CHP fuel conversions.

REGIONAL DIFFERENCES BY GAS SCENARIO: Statewide coal production is projected to fall to less than 80 million short tons by 2021 and decline at a fairly rapid pace for the next several years until slipping to fewer than 68 million short tons in 2026. Declines will become more gradual during the second half of the outlook period as total state coal output falls to just 56 million tons by 2040. On a regional basis, however, the state's northern and southern mines will see wildly different outcomes under this scenario. Since so little of its output is consumed by domestic power plants, Southern West Virginia is only expected to see production come in just over one million short tons or so below the baseline.

Figure 13: Regional Coal Production Forecast – Baseline vs Natural Gas Use Scenarios



Source: Energy Information Administration; IHS Markit; WVU BBER Coal Production Forecast

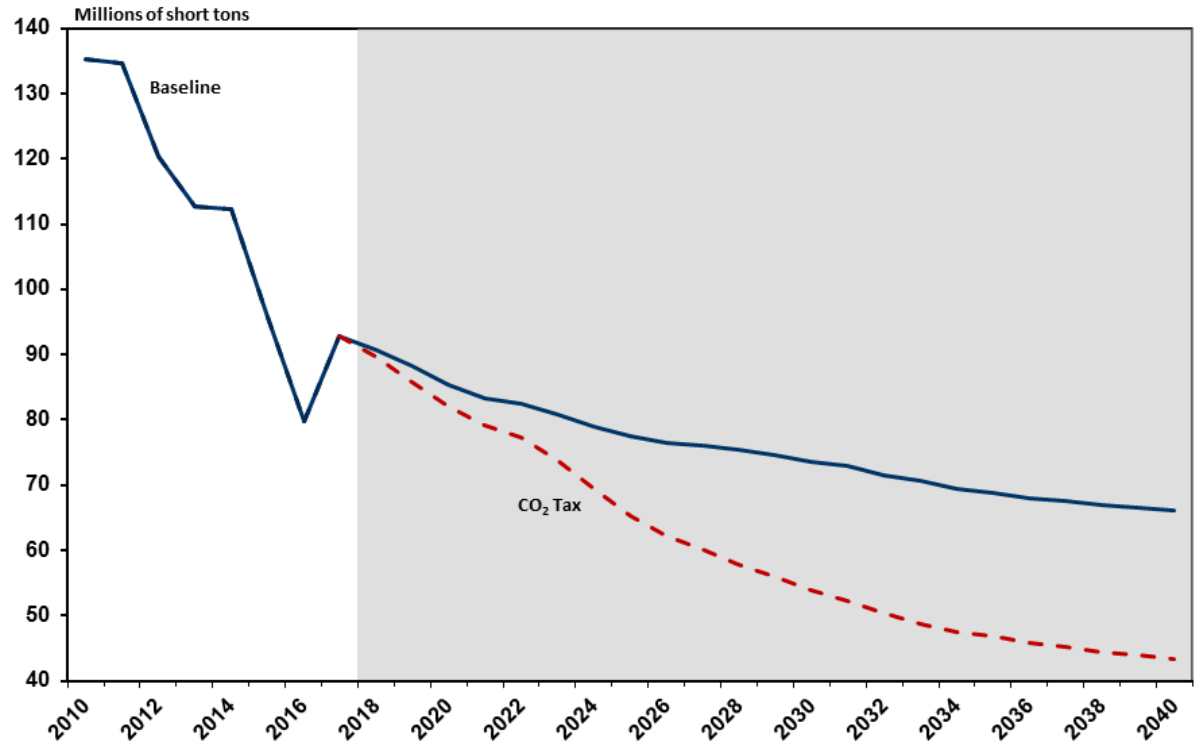
For Northern West Virginia, since two-thirds of the region's coal output was consumed by domestic power plants in 2017, persistently low natural gas prices would accelerate coal plant retirements or capacity conversions in many of the states that consume its high-sulfur coal. Indeed, coal production for the state's northern mines is expected to be down slightly relative to 2016 levels by the end of the baseline forecast. With a higher penetration of natural gas into electricity generation, the region's mines would likely see fewer utilities buying coal in general and those that continue to buy will purchase less overall as some power plants will opt to co-fire with gas turbines alongside of coal plants. Overall, Northern West Virginia coal production is expected to fall to decline more than 30 percent from 2016 levels by 2040, slipping to just 30 million short tons by the end of the outlook period.

7.3 Sensitivity Analysis: Carbon Dioxide Tax

An idea long favored by many economists, taxes on carbon dioxide are a mechanism by which a price can be charged for the emissions created during the burning of fossil fuels. The purpose for charging a tax on emissions is that the tax forces the business who produces or burns the fuel to realize the cost that carbon emissions place on society. In the absence of such a tax, the cost to society from producing energy may exceed the direct cost faced by individuals and businesses as they consume and produce energy and may therefore lead to inefficiently high levels of production.[5]

The explicit impacts on coal production by taxing CO_2 emissions from domestic power plants and the industrial sector are the focus of this scenario.[6] This scenario begins with the passage of a nationwide tax of $15 per ton of CO_2 in 2021 and goes into effect by 2023, followed by annual increases of two percentage points above the rate of inflation. Each ton of coal would cost power plants $34 per ton, or $1.40 per MMBtu, due to the fact that burning a ton of coal yields ~2.3 tons of CO_2. By 2040, the tax would rise to a nominal value of $2.75 per MMBtu. Other analyses estimating the impacts of a CO_2 tax often utilize a higher initial tax, apply it to a broader set of industries, and/or increase the tax by a faster rate. This report could serve as a lower bound estimate of the tax's impact on coal production.

Figure 14: Coal Production Forecast – Baseline vs CO_2 Tax Scenario



Sources: Energy Information Administration, WVU BBER Coal Production Forecast
Note: Forecast period designated by shaded area.

[5] For a more complete discussion of carbon dioxide taxes, see https://www.brookings.edu/blog/brookings-now/2016/05/04/9-things-you-should-know-about-the-carbon-tax-2/.

[6] Exports and the transportation sector are not included, but exports will likely be included in future reports.

Coal production is expected to decline somewhat relative to the baseline in the years prior to passage of the tax, reflecting broader acceptance of a tax on CO2 emissions by US policymakers and voters. The tax will put coal-fired generation in an increasingly difficult spot going forward. Although natural gas-fired generation will be subject to the CO_2 tax, it produces carbon dioxide on a per MMBtu basis than coal, meaning it will garner a growing relative price advantage so long as supply growth matches expectations. In addition to natural gas, the CO_2 tax will put coal at a cost disadvantage versus utility-scale renewables in many areas as well, particularly if battery technology makes large-scale energy storage a commercially-viable option as is anticipated. Carbon capture and sequestration (CCS) would enable more coal generation to remain on-line as it would reduce the facility's net emissions. However, CCS is not included in this scenario as the technology has little evidence of commercial viability at this time.

Domestic thermal coal demand will likely shrink rapidly between the mid-2020s and early-2030s. Indeed, coal-fired power plants will account for less than 20 percent of electricity generation in nearly every state that consumes coal from West Virginia mines – even approaching zero in a few. West Virginia will likely remain an exception as it should retain a portion of its coal generation, but the cost of burning thermal coal will almost certainly cause many of the state's power plants to face financial difficulties without sizable increases in retail rates for residential, commercial and industrial customers. Domestic industrial demand for coal, in coke and CHP applications, is expected to remain largely in line with the baseline forecast, with any anticipated declines likely to arise from factories switching CHP boilers over to natural gas (or even renewables in certain markets) at an accelerated pace.

With a decidedly smaller domestic market to sell into, some coal producers in West Virginia would need to turn toward supplying export markets. Unfortunately, a CO_2 tax is assumed to reduce the overall level of exports, which would weigh further on coal production. High production mines that already have an export focus would face fewer effects on average from the CO_2 tax than those solely supplying domestic power plants, but the tax's direct effects on energy costs will affect all mines since high levels of electricity are needed to run a wide array of machinery, conveyors, drills, and other equipment on site. All else constant, higher energy costs would likely push more mines into a less competitive position in the global coal trade and cause operations that were previously less efficient out of business entirely.

Given the overall backdrop for this scenario, statewide coal production is expected to be significantly weaker compared to the baseline. Output is expected to decline by 25 million short tons (32 percent) between 2021 and 2030 alone, as large amounts of coal generation is retired or converted to other fuels and high-cost thermal and met coal exporters are forced to close. Production is expected to fall an additional 10 million tons or so over the remainder of the outlook period, sliding all the way down to 43 million short tons by 2040. Continued increases in the CO_2 tax will push more domestic coal-fired generation into retirement or fuel conversion; furthermore, some mines that managed to remain in operation will see their recovery rates fall off in a significant manner as additional tax increases push production costs up to the point that a growing share of reserves become unprofitable.

Output from both regions will be affected by implementing a CO_2 tax, but as with the high natural gas use scenario, Northern West Virginia will see larger production losses since so much of its coal is consumed at domestic power plants. Production for the state's northern mines is expected to plunge by nearly half compared to 2016, with 18 million tons or so of output being lost between 2021 and 2040. Southern West Virginia coal production is expected to be approximately 7 million short tons weaker compared to the baseline level in 2040, as coal output from the region declines to 20 million short tons by the end of the outlook period.

7.4 Sensitivity Analysis: Changes in Export Demand

Since exports account for anywhere between 30 to 40 percent of West Virginia's coal production in a given year, potential shifts in the global coal trade could affect the overall trajectory of statewide coal production. This is especially true in light of the anticipated weakness in domestic coal demand over the next 20 years or so. Thus, stronger- or weaker-than-expected export coal export demand will have a material impact on the state's coal industry over the long term.

STRONG EXPORT DEMAND: The baseline forecast assumes coal exports from the state will fall in a range 25 and 30 million short tons annually between 2020 and 2040, with the potential for weaker and stronger years mixed in due to the possibility of economic downturns or a surge in global coal demand (or supply disruptions) occurring along the way. Under an alternative scenario of stronger-than-expected coal demand, US coal exports will follow the same general pattern as the baseline forecast during the first few years of the outlook period, but fall no lower than the mid-80 million ton range. Thereafter, US coal exports are expected to increase 1.6 percent annually between 2022 and 2040. Despite these increases, 2012 and 2013 will remain the two peak years for US coal exports.

Metallurgical coal is expected to account for most of overall demand growth for US coal exports, as several major steel-producing countries in Europe and Asia have indicated a desire to diversify their bases of met coal imports beyond Australia, Indonesia or South Africa. Mines in Southern West Virginia, Pennsylvania, Virginia and Alabama would likely account for these trade flow shifts as these states contain enough spare productive capacity to supply global markets. At the same time, however, thermal coal would also account for a portion of rising coal demand as it would likely stem from stronger-than-anticipated economic growth in emerging economies such as China, India, Turkey and Vietnam. All coal basins in the US would realize some benefit from thermal coal demand exceeding levels expected for the baseline forecast, but insufficient export terminal and rail infrastructure and widespread opposition against coal in US states along the West Coast (and the Canadian province of Vancouver) point to coal exports flowing from Appalachian and Eastern Interior mines through ports along the East and Gulf Coast.

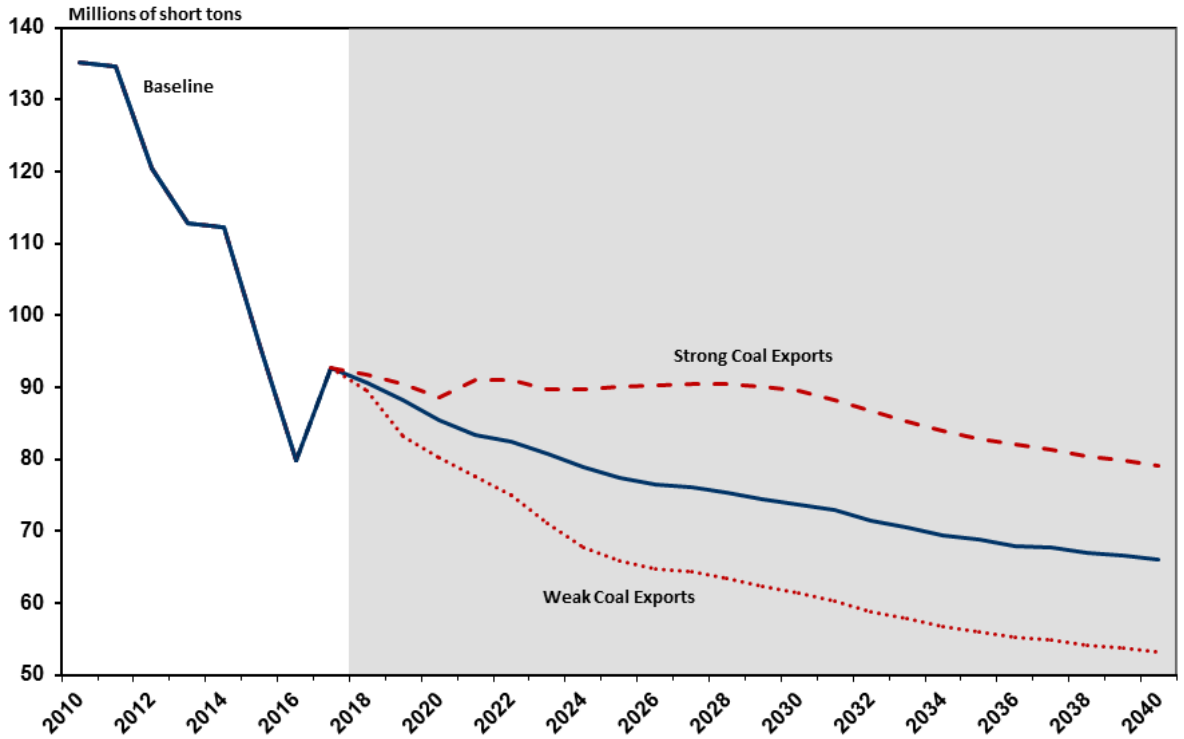
Based upon these assumptions, statewide coal production would average around 90 million short tons through 2030. Most of the added production activity would come from Southern West Virginia, though the state's northern mines would also contribute as high thermal coal export prices would incentivize producers to raise output for overseas sales. By the early 2030s, statewide coal output is expected to decline steadily as mines deplete reserves. Northern West Virginia should garner an increased share of the state's coal export base, but without considerable growth in productive capacity, several of the region's mines will likely be faced with their own shortfalls in recoverable reserves if output proceeds at levels as called for in the scenario. Overall, production is expected to fall to 79 million short tons by the end of the outlook period, roughly 19 percent above the baseline and on par with 2016 production levels.

WEAK EXPORT DEMAND: In a scenario with weak export demand for coal, after holding mostly in line with the export activity anticipated in the baseline during 2018 and 2019, US coal exports will decline 1.5 percent on an average annual basis between 2020 and 2040, with an accelerated pace of declines occurring in the mid- to late-2030s. Total coal exports would fall to their lowest levels since the Great Recession. The key driving forces behind a weaker outlook for global coal demand would likely come from a faster and larger-scale transition to natural gas and renewable forms of electricity generation. This could be driven by multi-nation policy accords (such as the Paris Agreement) to reduce power plant CO_2 emissions or individual countries increasing investment in renewable energy resources independent of

the Paris Agreement. In addition, continued declines in the cost structure of utility-scale renewable generation and rapid improvements in the commercial scalability of battery storage technology could foster an increased desire to expand renewables instead of coal-fired generation.

Although developing countries would still likely need to expand coal-fired capacity to meet their energy needs, India recently indicated it will move forward more aggressively in adding renewable energy production. For example, India has seen dozens of its coal plants under construction experience major financial turmoil due to shifting investor preferences for renewable energy projects and increased resistance to coal investment throughout global capital markets. These financial pitfalls could lead to coal-fired power plants in the pipeline getting canceled and replaced with other fuel sources, while unprofitable existing plants are shuttered and replaced with solar and wind generation along with natural gas. Policy announcements by the current Modi government suggest this is a possibility going forward, as India's Power Minister recently announced the target of adding 200 GW of renewable capacity by 2022.

Figure 15: Coal Production Forecast – Baseline vs Export Demand Scenarios



Sources: Energy Information Administration, WVU BBER Coal Production Forecast
Note: Forecast period designated by shaded area.

Metallurgical coal exports are assumed to be less affected by these policy or technological changes, though any weakening of global coal demand over the long term would have to account for lower-than-expected export activity since they represent around half of all coal exported from US trade ports. For example, the wider adoption of recycling steel scrap in China could curb coking coal demand over the long term while improvements in the commercial viability of alternative steel-making methods also have the potential to erode coal use.

Since domestic demand for coal will likely decline, shrinking coal demand in many of West Virginia's key export markets will lead to a significant decline in statewide coal production in this scenario. Coal output will fall to around 65 million short tons by the mid-2020s, reflecting the combined impacts of the expected elimination (or reduced utilization) of coal-fired generation throughout Europe and the possibility of much less coal-fired generation coming on line in India and other developing nations. The scenario assumes global coal use will continue to decline, pushing additional mines out of production during the remainder of the outlook period. Statewide coal production is expected to drop to around 53 million short tons by the late-2030s, which would represent a level 13 million short tons below the baseline.

Appendix: Coal Forecast Model Description and General Forecast Assumptions

Publication: West Virginia University BBER Coal Production Forecast 2018

Date: Summer 2018

Forecast Horizon: 2018-2040

Regions: Northern 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 the Energy Information Administration (EIA). US-specific explanatory variables were taken from the IHS Markit 2018 Q2 Long-Term Forecast and the 2018 Annual Energy Outlook from the. Key assumptions for the model include:

Macroeconomic Growth: Real Gross Domestic Product is expected to increase at an average annual rate of 2.1 percent through 2040.

Coal Prices: Inflation-adjusted coal prices are expected to increase in both regions, reaching $59 per short ton (in 2017 dollars) in Northern West Virginia and $92 per short ton in Southern West Virginia—averaged for metallurgical and thermal coal. The US average price is expected to rise to $40 by 2040.

Natural Gas Prices: The national average price for real natural gas (2017 dollars) paid by utilities is expected to increase at an average annual rate of 1 percent per year between 2018 and 2040, but won't surpass $4.00 / MMBtu in inflation-adjusted terms until the late-2030s.

Electricity: Total U.S. electricity generation is expected to increase 0.6 percent per year between 2017 and 2040. Coal will account for a declining share of generating capacity during the outlook period as no new coal plants are constructed and additional capacity is retired. By the late-2030s, coal is expected to account for less than 23 percent (unweighted) of generation in states that source West Virginia coal.

Industrial/commercial use: Total commercial/industrial demand for West Virginia coal is expected to decline 0.1 percent per year over the forecast horizon. Most of this decline will be driven by non-coke coal C&I use due to energy efficiency programs and natural gas conversion.

Export Demand: The baseline forecast assumes 2012 was the 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. Exports will fall from 100 million tons in 2018 to the mid-80 million ton range by the late-2030s. Southern West Virginia will account for the majority of state coal exports.

Environmental: The baseline forecast incorporates only laws that are in place and not currently subject to substantial adjudication or under regulatory review by the Trump Administration. Coal-fired generation that was retired between the 2012-2016 MATS rule implementation and compliance period is expected to remain off line. The Clean Power Plan, Stream Protection Rule, New Source Performance Standards rules and any other finalized rules are not incorporated into the baseline. The Trump Administration's proposed use of the Federal Power Act and Defense Production Act, which will reportedly require regional transmission operators (RTOs) to purchase power from certain plants so as "to ensure grid reliability, promote the national defense and maximize domestic energy supplies" is excluded.

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