

APPALACHIAN COAL INDUSTRY, POWER GENERATION AND SUPPLY CHAIN

Prepared for the Appalachian Regional Commission
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Introduction

Recognizing the significant economic challenges facing the Appalachian Region due to the changing economics of America's energy production, the Obama Administration has initiated the Partnerships for Opportunity and Workforce and Economic Revitalization (POWER) Initiative.¹ POWER will provide resources for communities and regions seeking to diversify local economies, create jobs in existing or new industries, and leverage new sources of investment. The Appalachian Regional Commission (ARC) is participating in the initiative along with the U.S. Economic Development Administration (EDA) and eight other federal agencies.

To work most effectively with its local and regional partners, and communicate key priorities to federal government agencies, it is essential that ARC strengthen its data-driven knowledge about the coal industry in Appalachia in terms of:

- The economic contributions and trends of coal-related industries in the United States and Appalachia, namely: a) coal mining and production; b) coal-powered energy plants; and c) supply chain linkages, including transportation and logistics, focused on Appalachia;
- The geographic locations and concentrations of coal-related economic activity in Appalachia to understand the areas most impacted; and
- Likely future scenarios for the coal industry in the United States and Appalachia, and the magnitude of economic loss that may await parts of the Appalachian Region.

The last major study by ARC on the coal industry was conducted in 2001, and focused on the economic impacts of coal production.² While this study provided useful economic data on coal production and the future impacts of reduced coal production, additional and updated data research is needed for at least two reasons: first, that study is now almost 15 years old and a fresh look is necessary to provide ARC with current information on coal, and second, that previous study was almost entirely focused on coal production, and thus excludes critical information on the broader coal industry ecosystem such as coal-fired power plants and transportation/supply chain implications.

Thus, the objectives of this paper on the U.S. and Appalachian coal industries are to:

- Complete a scan of data and research relevant to the coal industry ecosystem (e.g., production, power generation, supply chain linkages) in Appalachia.
- Present the most current, readily-available data and trends on coal-related industries, and synthesize information across numerous sources.

¹ For more information on the POWER Initiative, see <http://www.arc.gov/POWER> and for reference on the Appalachian Region, see

http://www.arc.gov/appalachian_region/TheAppalachianRegion.asp

² http://www.arc.gov/research/researchreportdetails.asp?REPORT_ID=54

- Suggest future in-depth research for ARC to consider to gain a more complete, detailed understanding of the coal industry ecosystem and economic implications in Appalachia.

The remainder of this paper is organized around the following topics:

1. The coal mining industry and production in terms of short tons, employees, productivity, and exports;
2. Coal-fired power plants and electricity generation;
3. The transportation of coal shipments by mode;
4. Outlook for coal in the United States and Appalachia; and
5. A summary of findings and potential new research directions to further amplify our knowledge of this critical industry to Appalachia.

Coal Mining Industry – Trends in the United States and Appalachia

Central to the POWER Initiative is the reality that the coal industry is in decline nationally. This decline is most typically associated with two factors: 1) decreased natural gas prices that are leading to an increase in electricity generated by natural gas and a decrease in coal; and 2) a variety of environmental regulations and climate policy initiatives that increase the current (and future) costs of coal relative to other industries. In addition to these overarching trends, a number of other factors also influence the U.S. coal industry: the declining global demand for coal (in particular from China) which impacts U.S. exports of coal; geographic shifts in U.S. coal production and productivity; and year-to-year changes in weather and the economy which impacts demand.³

Beyond some of these macro trends, it is critical to better understand the coal mining industry in terms of production (measured in short tons), employees, productivity, and exports. Data on these four factors are presented below to show how the coal industry has varied over time, including fairly severe declines over the past three-to-five years in Appalachia. This section also details coal production by geography, starting with broader national and Appalachian perspectives, and then narrowing to state-level and county-level data trends.

Coal Industry Production

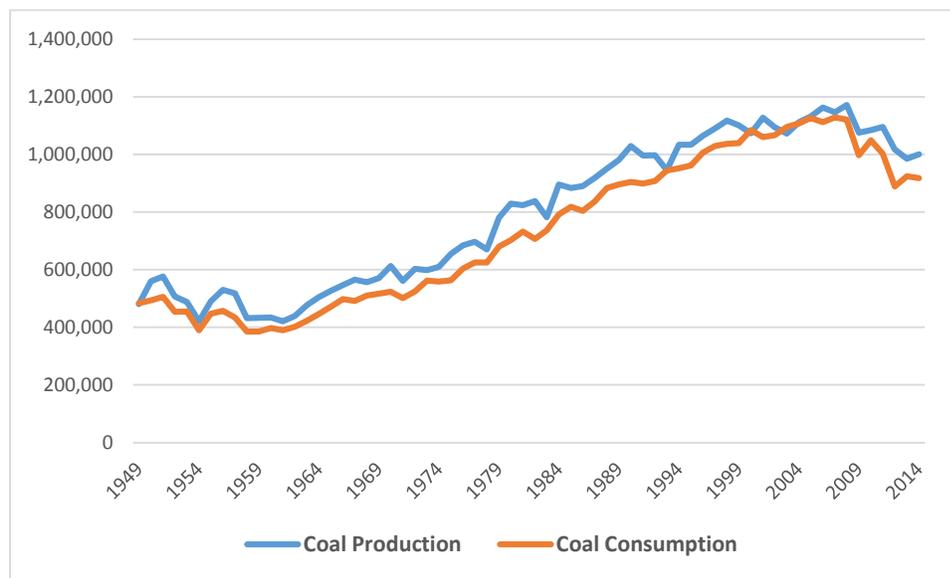
This section focuses on coal mining production for the United States, the Appalachian Region, and the states and counties within Appalachia. By far the most commonly reported metric on coal production is “short tons” of coal. This analysis generally examines coal as a single commodity although the reality is that coal differs between regions, with the Appalachian Region generally producing bituminous coal (relatively

³ For example, the “great recession” that took place between 2007 and 2009 lowered overall demand for energy, and more recently, 2015 (in particular November and December) was milder than the year before.

high heating value with carbon content of 45-85 percent) and much of the West producing sub-bituminous coal which has a lower heating value, and lower carbon content (35-45 percent).

In terms of long-term trends of U.S. coal production, coal has seen a fairly steady increase since the 1950s with coal production (and consumption) rising from about 500 million short tons to over 1.1 billion short tons in the mid-2000s before declining a bit over the last five years (Figure 1). Perhaps not surprisingly, U.S. consumption of coal has closely tracked production over time, with consumption currently trailing production by about 80 million short tons per year.

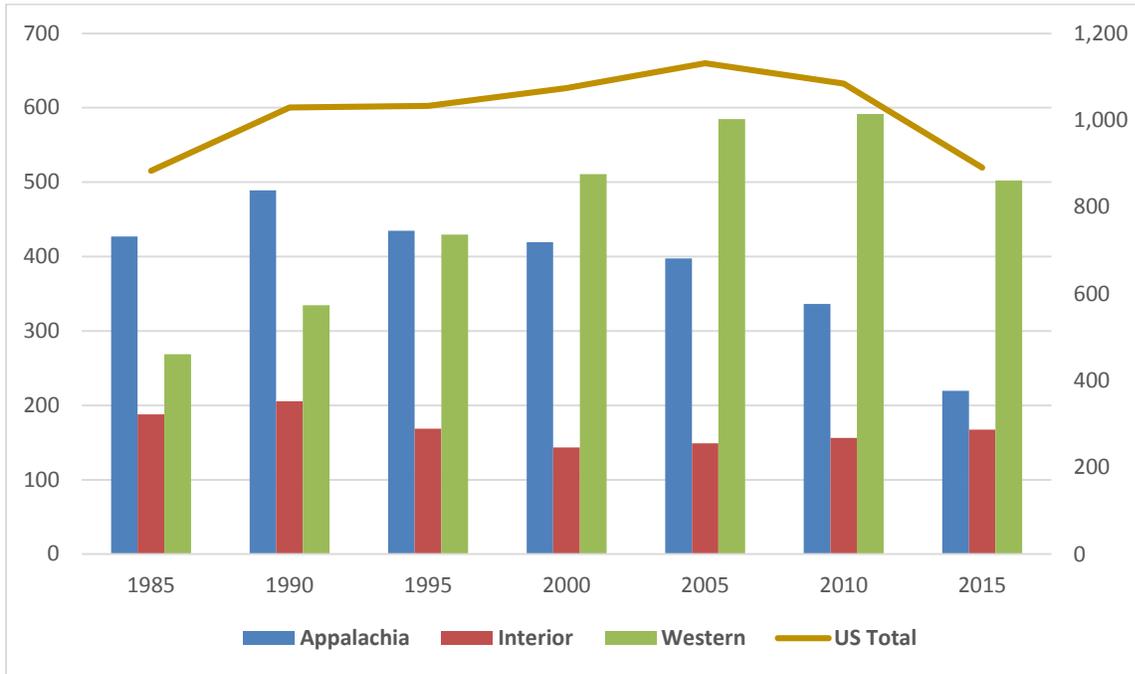
Figure 1. U.S. Coal Mining Production and Consumption, 1949 to 2014 (millions of short tons)



Source: Energy Information Administration (EIA), Monthly Energy Review

Focusing on coal production over the last 30 years, we can see fairly divergent trends in major regions of the United States. As shown in Figure 2, production in Appalachia peaked around 1990 and has been declining since, with the decline accelerating over the past five years. Meanwhile, coal production in the western United States largely grew over this time period until hitting a peak around 2010. The result is that over the past 10 years, coal production in Appalachia has decreased by 45 percent, which is more than double the national decrease of 21 percent.

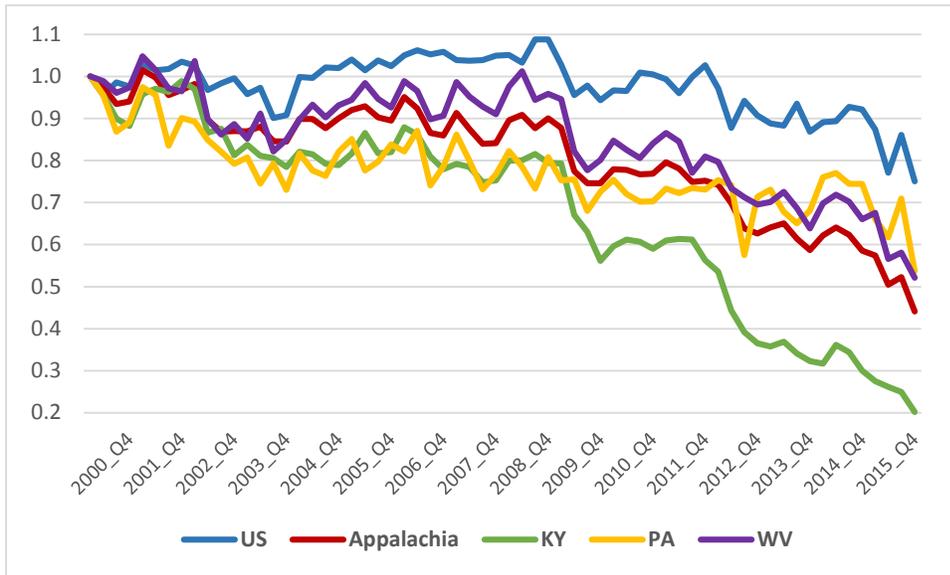
Figure 2. Coal Mining Production, 1985 to 2015 (millions of short tons)



Source: Energy Information Administration (EIA), Monthly Production

Figure 3 illustrates coal production growth trends in Appalachia by quarter, from 2000 to 2015; the gap in growth between the United States and the Region steadily increased during this time. National production levels in 2015 were 75 percent as high as in 2000; while Appalachian production levels in 2015 had fallen to 44 percent of their 2000 level, indicating a much larger drop in production in the Region than the rest of the nation. The three largest coal producing states in Appalachia, West Virginia, Pennsylvania and Kentucky, demonstrate how production growth trends vary across states. In particular, Appalachian Kentucky's coal production (eastern Kentucky) decreased by a staggering 80 percent between 2000 and 2015. This loss of production accelerated around 2009 as eastern Kentucky's coal production dropped from over 90 million short tons in 2008 to 28 million in 2015. West Virginia and Pennsylvania have fared slightly better but still experienced a decrease of about 50 percent over this time period.

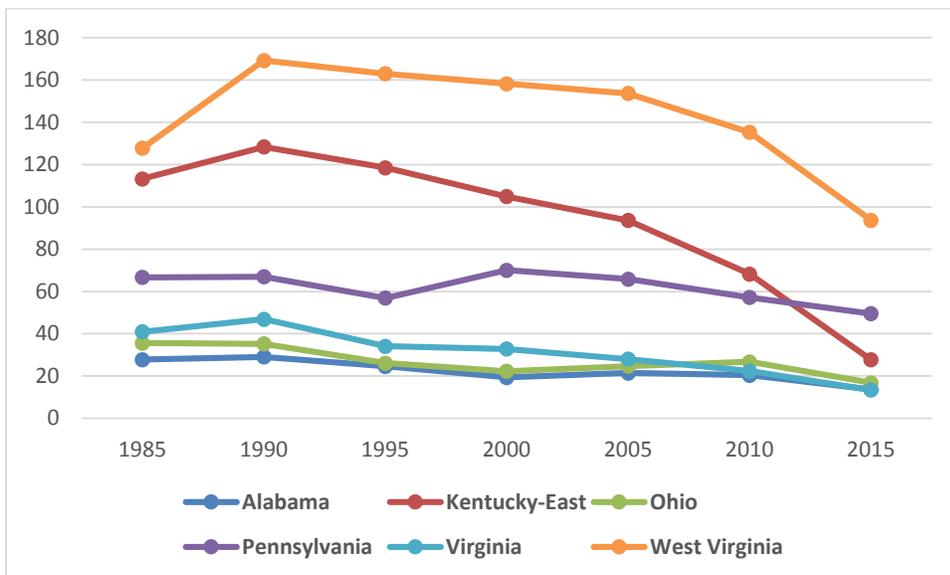
Figure 3. Growth Index of Coal Mining Production (short tons) in U.S., Appalachia, and Key States, 2000 to 2015



Source: U.S. Department of Labor, Mine Safety and Health Administration (MSHA)

These trends are further explored by state in Figure 4, adding in data for Ohio, Alabama and Virginia as the next tier of coal producers in Appalachia. Again, the decline in production is most notable in eastern Kentucky, with West Virginia remaining fairly stable until the decline over the past 10 years. The other states also display a downward trend, though less severe.

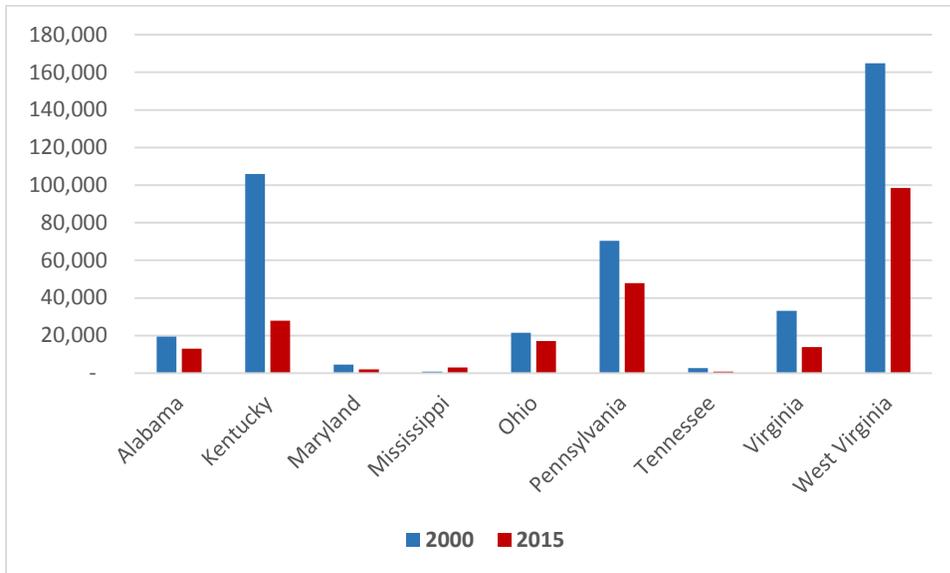
Figure 4. Coal Mining Production in Key Appalachian States 1985 to 2015 (millions of short tons)



Source: Energy Information Administration (EIA), Monthly Production

Figure 5 below shows the relative scale of coal production by Appalachian states (only including production in Appalachian counties); West Virginia is the dominant producer with 44 percent of the Region’s total production. With Kentucky’s rapid decline, Pennsylvania is now the number two producer with 21 percent of the Region’s coal production. Decreases in coal have occurred throughout the Region – for example, Virginia has seen its coal production fall from over 33 million short tons in 2000 to just shy of 14 million in 2015.

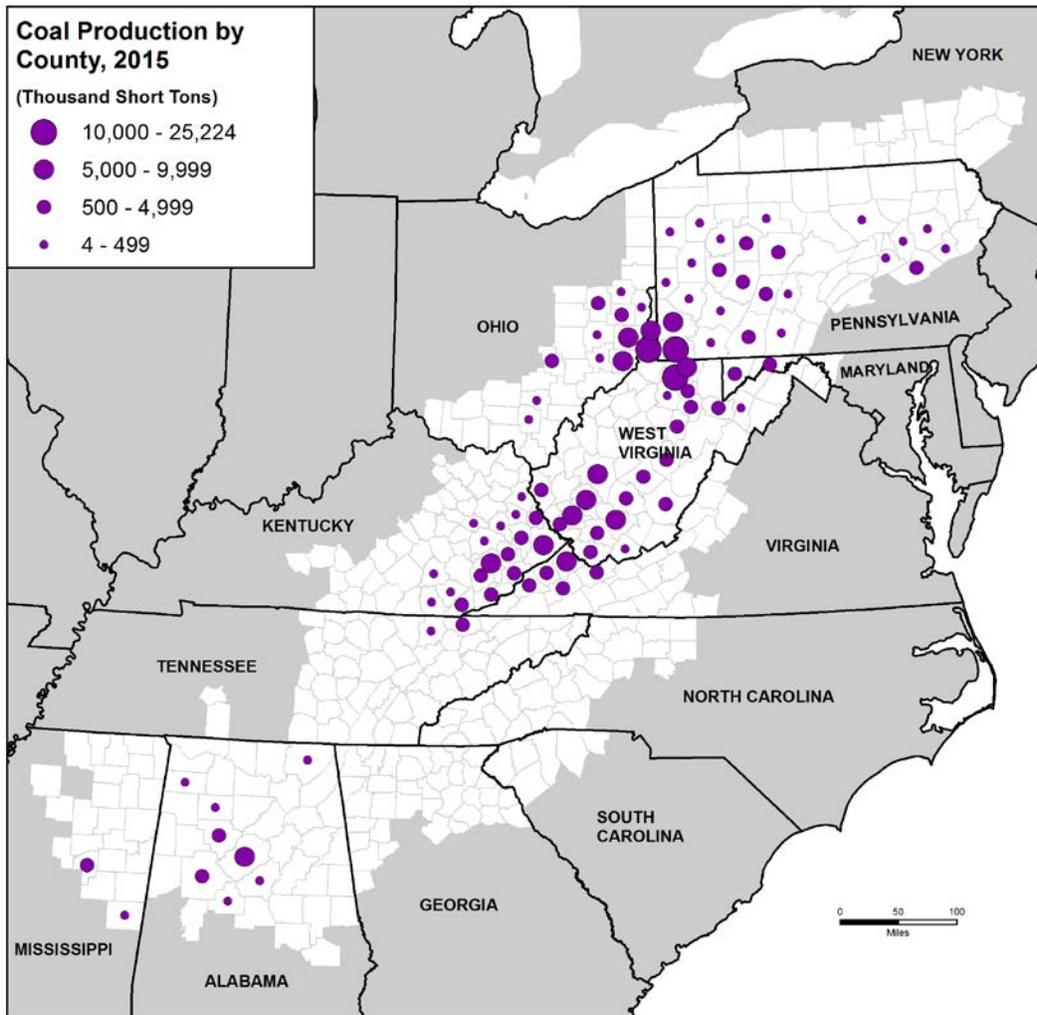
Figure 5. Coal Mining Production in Appalachia by State, 2000 and 2015 (thousands of short tons)



Source: U.S. Department of Labor, Mine Safety and Health Administration (MSHA)

The map in Figure 6 below displays 2015 coal production by county in Appalachia. Currently, the largest producing counties are in the tristate Ohio, West Virginia, Pennsylvania area with the next biggest cluster running northeast along the Appalachian Mountains in Kentucky, Virginia and West Virginia. Other areas with coal production include a number of counties throughout Pennsylvania, and pockets of Alabama, Mississippi, and Tennessee.

Figure 6. Coal Mining Production by County in Appalachia, 2015 (thousands of short tons)

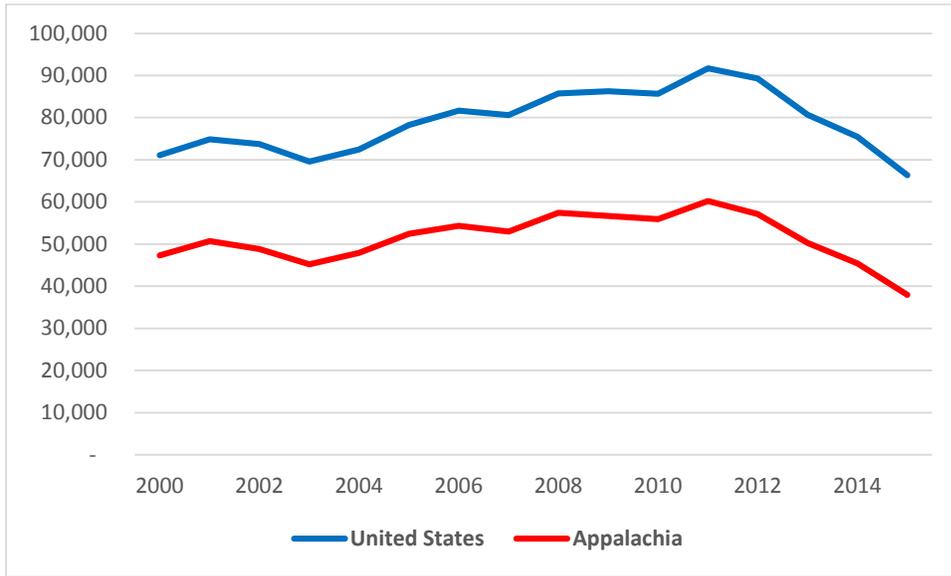


Appalachian Regional Commission, 2016
Data source: U.S. Mine Safety and Health Administration

Coal Industry Employment

When connecting coal mining production to the Region's economy, it is also critical to examine historic and recent employment trends in coal for the United States and Appalachia. Over the past 15 years, the total number of coal mining jobs (miners, processing, office management, administrative support, etc.) in the Appalachian Region closely mirrored the national trend (Figure 7). In fact, Appalachia contributed about two-thirds of all U.S. jobs in coal mining production from 2000 to 2011 as coal production is more labor intensive in Appalachia than the western part of the country. However, with the rapid decline over the past five years, the Appalachian share of all U.S. coal jobs dropped to 57 percent in 2015, its lowest point in at least 15 years. While the U.S. lost 28 percent of coal jobs from 2011 to 2015, Appalachia saw a decrease of 37 percent.

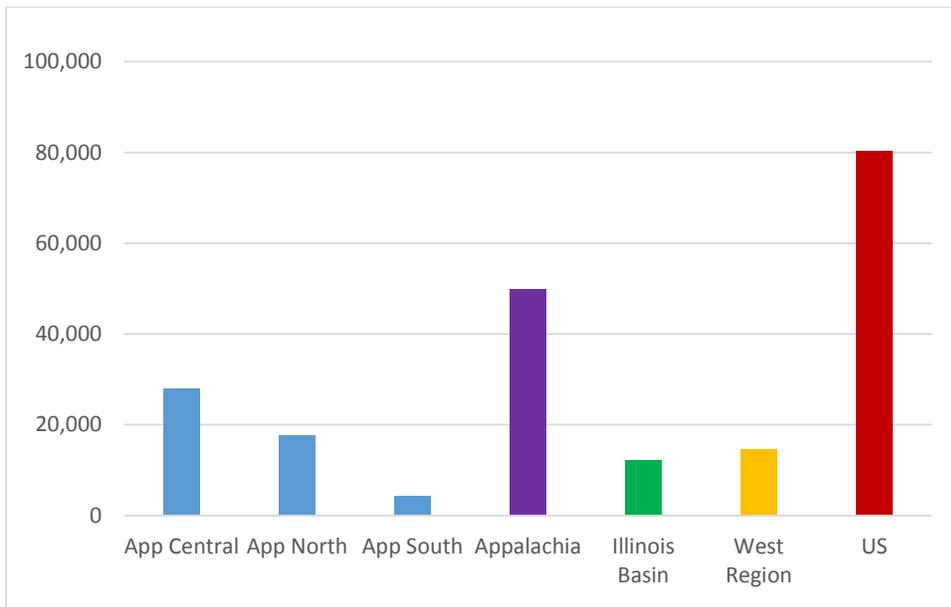
Figure 7. Coal Mining Employment in the U.S. and Appalachia, 2000 to 2015



Source: U.S. Department of Labor, Mine Safety and Health Administration (MSHA)

Appalachian coal industries generate the majority of coal mining jobs nationwide, with the Illinois Basin and the West Region each accounting for fewer than 20,000 jobs (see Figure 8). The majority of coal mining jobs in Appalachia are in the Central and Northern regions, consistent with the production concentrations above.

Figure 8. Coal Mining Employment in Major U.S. Regions, 2013

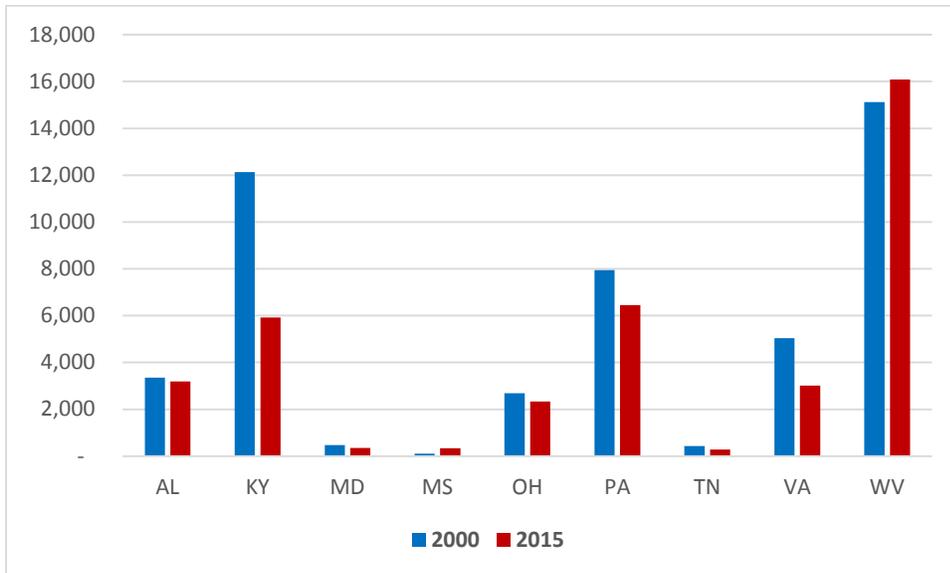


Source: Energy Information Administration (EIA)

Turning to coal mining jobs by state in Appalachia (and again, only including the Appalachian part of each state), Figure 9 displays coal mining jobs in 2000 and 2015.

Over this time period, the Appalachian Region experienced a loss of over 9,300 jobs with the decrease most severe in Kentucky (loss of 6,200 jobs). Virginia saw the next biggest job loss with over 2,000 fewer employees, followed by Pennsylvania with a decrease of 1,500 jobs. Interestingly, West Virginia saw a slight *increase* in coal mining jobs from 2000 to 2015 but this masks some interesting dynamics (growth and then steep decline), partially driven by a temporary surge in exports and an apparent reduction in productivity.

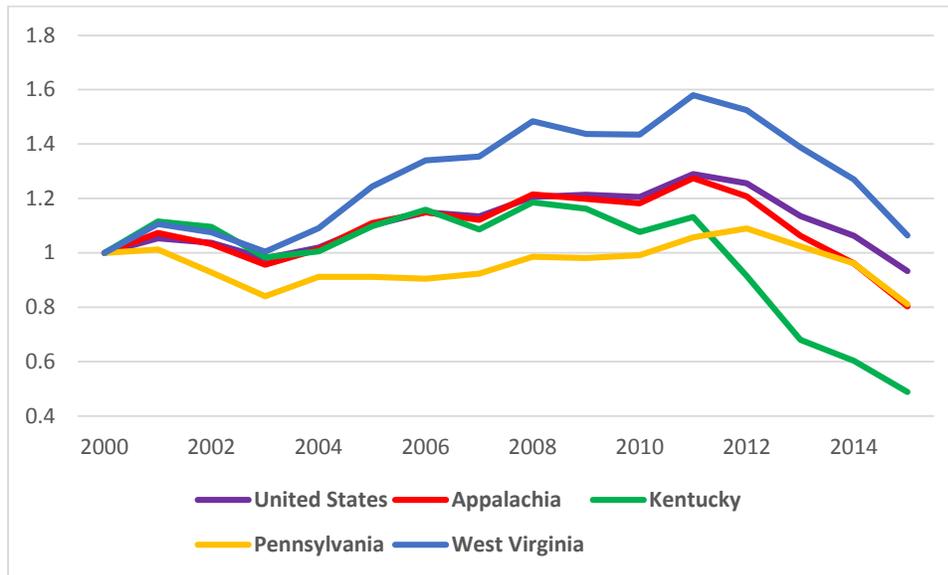
Figure 9. Coal Mining Jobs by State in Appalachia, 2000 and 2015



Source: U.S. Department of Labor, Mine Safety and Health Administration (MSHA)

The overall trend from 2000 to 2015 includes some interesting year-to-year dynamics that vary among the largest coal-producing Appalachian states, as shown in Figure 10. For example, West Virginia saw a marked increase in jobs between 2003 and 2011 with decline more pronounced over the last few years (7,800 job reduction in just four years). Other states saw relatively flat coal mining job growth during the 2000s with consistent declines over the past four to five years. Put another way, of the 26,432 coal mining jobs lost in the United States from 2011 to 2015, 87.2 percent of them were in Appalachia, a regional loss of 23,058 direct jobs in mining (not including other likely indirect or supplier reductions).

Figure 10. Growth Index of Coal Mining Jobs by State in Appalachia, 2000 and 2015



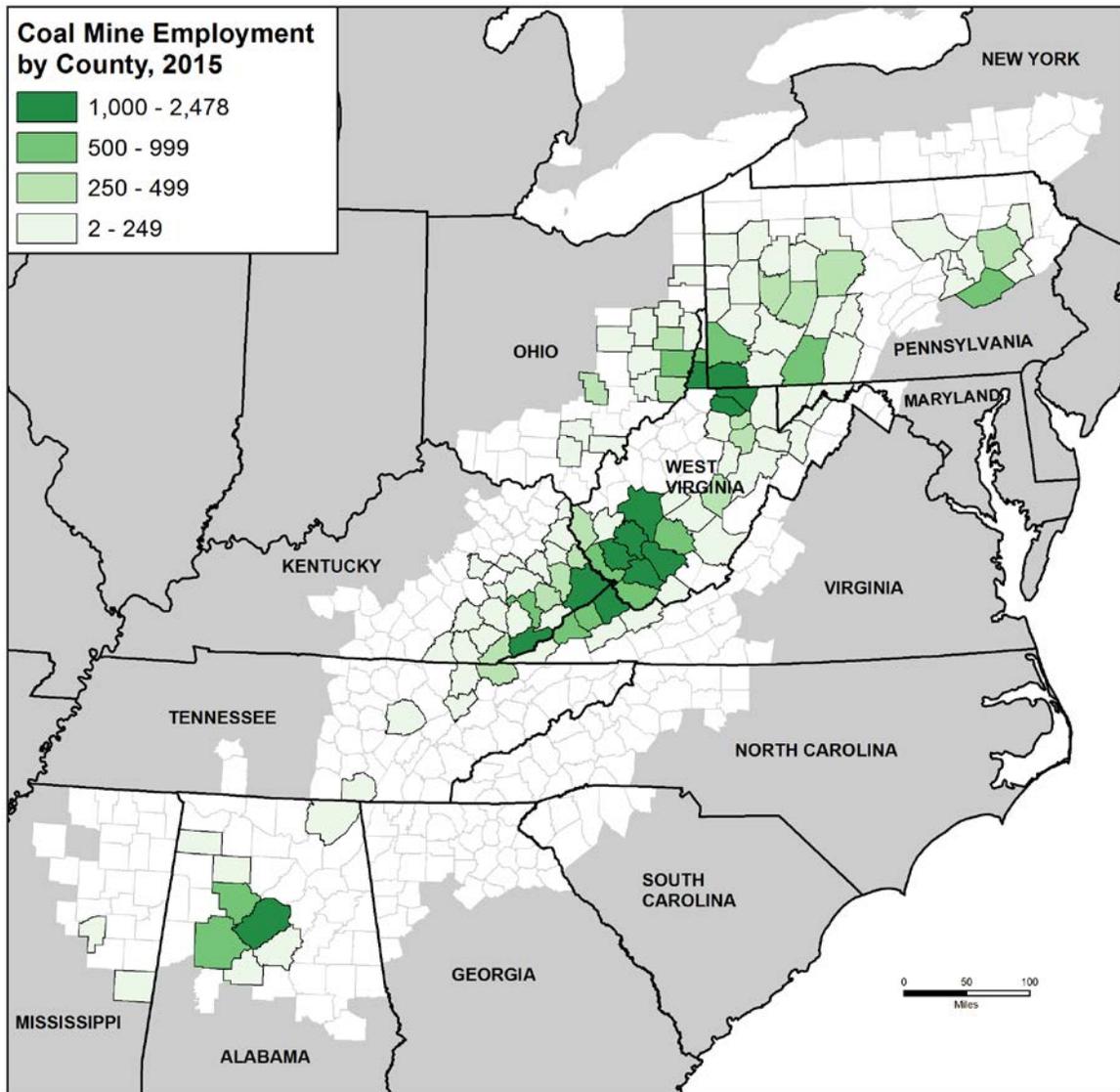
Source: U.S. Department of Labor, Mine Safety and Health Administration (MSHA)

The following maps (Figures 11, 12, and 13) provide county-level coal mining employment data in terms of:

- Total coal mining employment as of 2015;
- The change in coal mining employment from 2011 to 2015; and
- The location quotient (industry concentration) of coal mining in 2014.

The color coding demonstrates a similar geographic pattern as the coal mining production map provided earlier, except that the loss of coal mining jobs appears much more pronounced in eastern Kentucky, southern West Virginia, and the far western part of Virginia. Job losses are still prevalent through Pennsylvania and other parts of the Region, but the heaviest jobs losses are very much concentrated in the core of the Region (which also tends to correspond with the highest levels of overall economic distress: http://www.arc.gov/research/MapsofAppalachia.asp?MAP_ID=105).

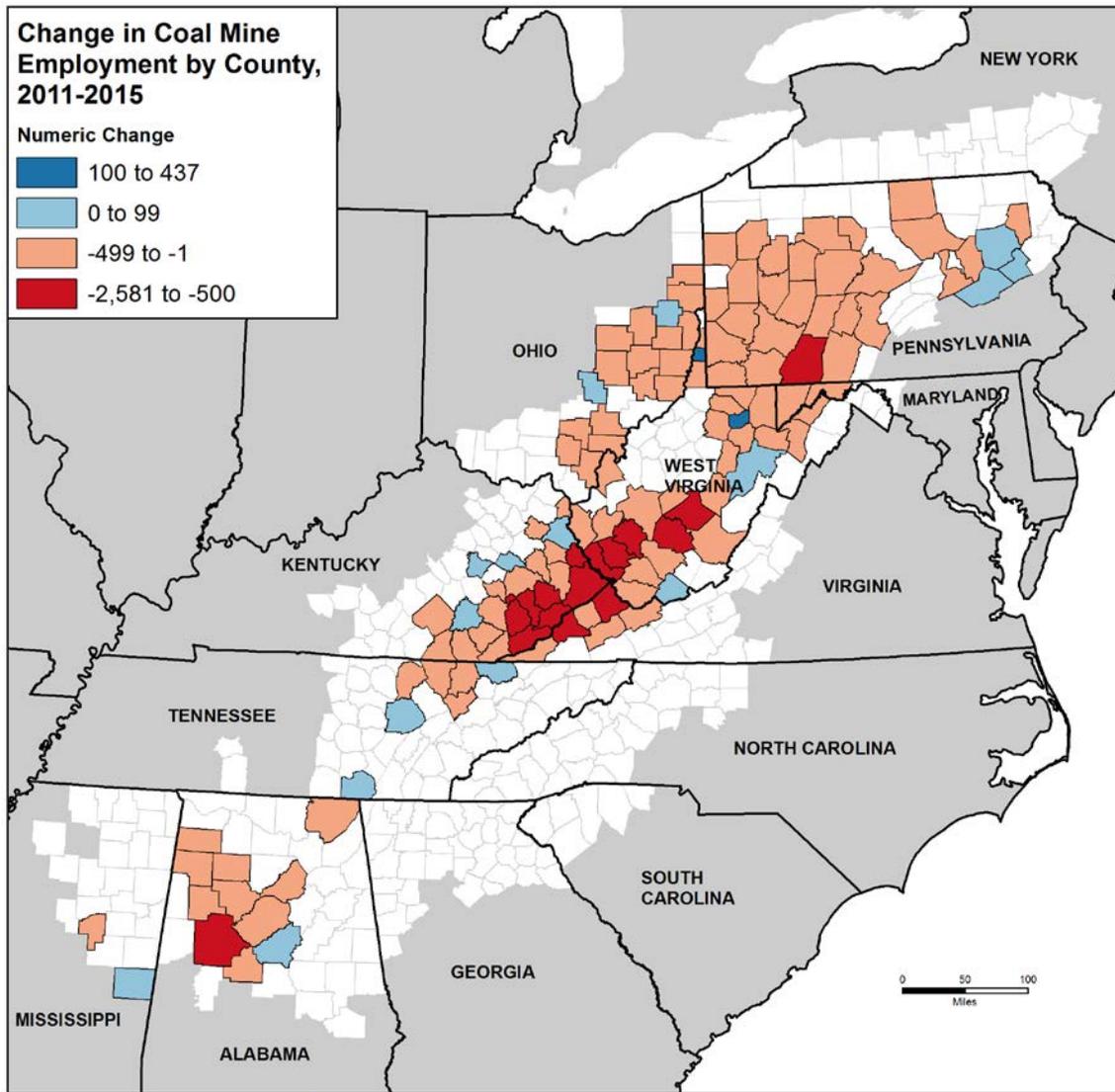
Figure 11. Coal Mining Jobs by County in Appalachia, 2015



Appalachian Regional Commission, 2016
Data source: U.S. Mine Safety and Health Administration

As shown in Figure 12 below, a number of counties in the Appalachian Region experienced job losses in coal mining from 2011 to 2015. The most severe coal job losses were in Central Appalachia (counties in Kentucky, West Virginia, and Virginia) with widespread losses also experienced in Pennsylvania, Ohio, and Alabama. At the state level, Appalachian Kentucky experienced a coal mining job decline of 55.5 percent over this short time period, while both Tennessee and Virginia experienced coal mining job losses of 40 percent. Appalachian counties in Kentucky and West Virginia combined to lose over 16,000 jobs over the last five years, representing 70 percent of the region-wide 23,058 job loss from 2011 to 2015.

Figure 12. Change in Coal Mining Jobs by County in Appalachia, 2011 to 2015

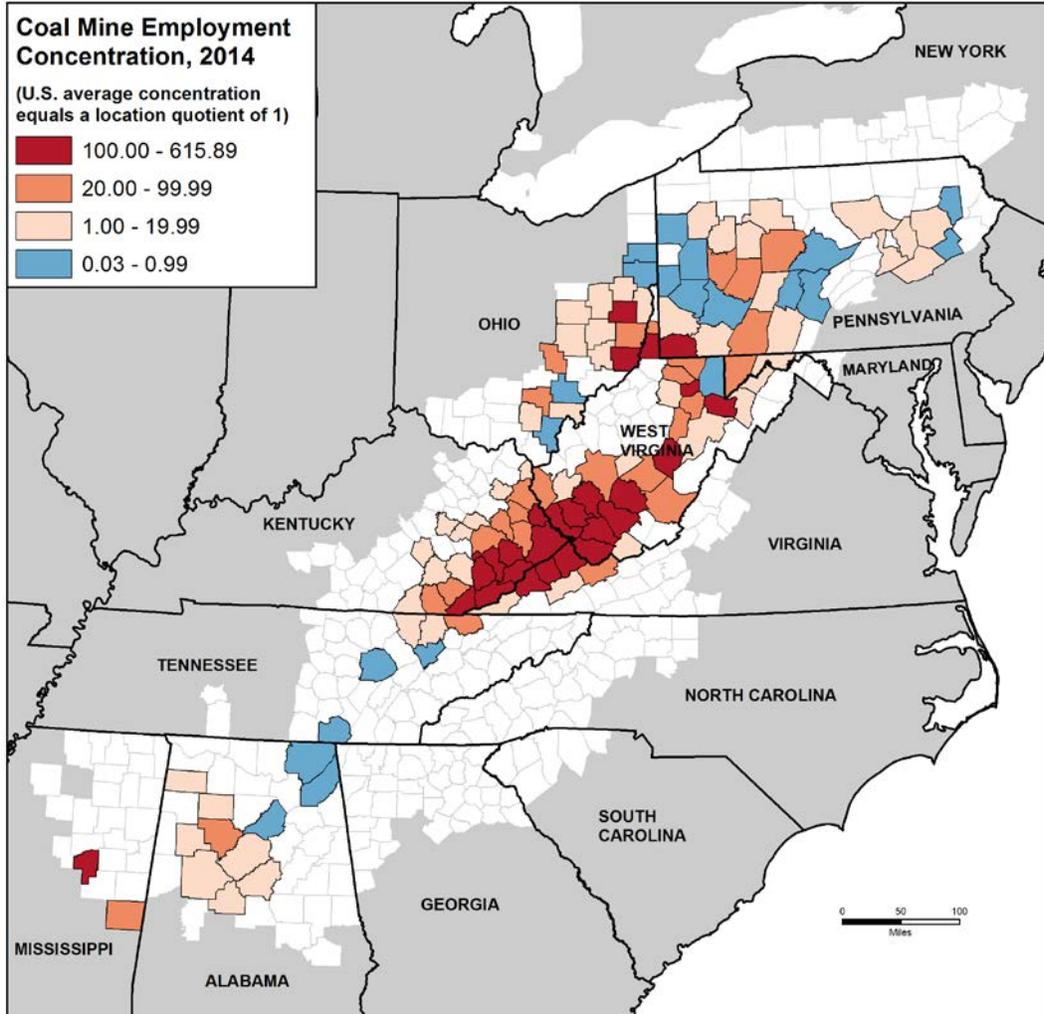


Appalachian Regional Commission, 2016
 Data source: U.S. Mine Safety and Health Administration

The data on coal mining industry concentrations by county appear to show a similar pattern to job losses and existing concentrations at first glance, but on closer examination the economic dependence on coal mining is revealed. The location quotients discussed below measure how concentrated jobs in coal mining are in a county, compared to the national concentration. Any county with a concentration over 1.0 means that it has disproportionately more jobs in coal than the United States (which is not hard to do given that most counties nationwide don't have coal mining employment). But in Appalachia, there are 52 counties with a location quotient of 20 or more, meaning that coal mining is 20 times more important to local jobs than in the nation. Put another way, of the 17 counties with a concentration of 150 or more, coal mining represents 10 percent or more

of total jobs in the county. These are staggering levels of industry concentration that are also generally associated with job losses (especially over the last 5 years as shown in the preceding map) – a recipe for severe economic hardship.

Figure 13. Coal Mining Industry Concentration (Location Quotient) by County, 2014



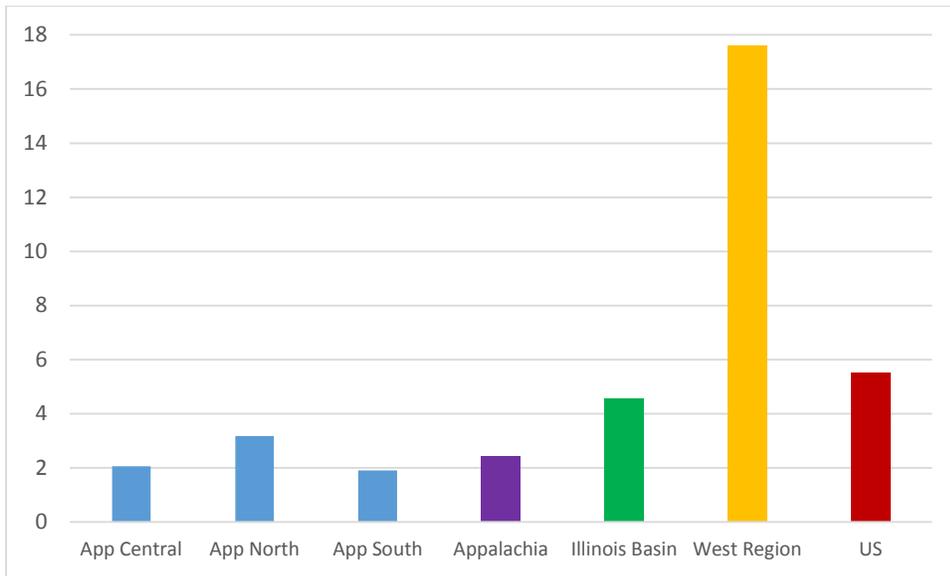
Appalachian Regional Commission, 2016
 Data sources: U.S. Mine Safety and Health Administration; U.S. Bureau of Labor Statistics

Coal Industry Productivity

Another way of understanding coal mining production in the United States and Appalachia is through productivity, most commonly measured in terms of short tons of production per employee (or employee hour). As shown below, productivity varies greatly between regions of the U.S. and has also changed significantly over time. Looking first at how productivity varies between regions, Figure 14 below demonstrates the higher productivity of the Western Region of the U.S. and the Illinois Basin compared to regions in Appalachia. In other words, coal mining production is far more labor intensive in

Appalachia, requiring more employees to produce and process coal, than the western part of the United States. Within Appalachia, the northern part of the region (primarily parts of Pennsylvania and Ohio) have slightly higher productivity than the central and southern parts of the region.

Figure 14. Coal Mining Productivity (tons per employee hour), 2013



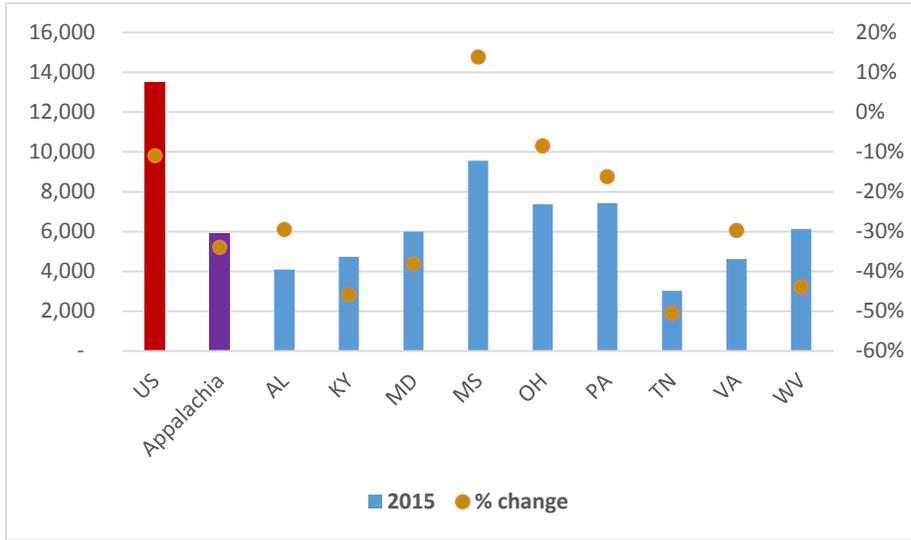
Source: Energy Information Administration (EIA)

Coal mining productivity in 2015 ranged from 3,031 short tons per employee in Tennessee to 9,554 short tons per employee in Mississippi. As demonstrated in Figure 15, productivity has fallen over time for most Appalachian states from 2000 to 2015 (with the lone exception of Mississippi). The overall productivity decrease for Appalachia was 34 percent in this time period compared to an 11 percent loss for the nation, reflecting the shift in production towards the western region. The largest decreases in productivity have occurred in Tennessee (50 percent decrease), Kentucky (46 percent), West Virginia (44 percent), and Maryland (38 percent).

In short, coal mining in Appalachia (particularly the central region) is now more difficult and expensive to mine than in other parts of the country. It was the first part of the United States to see extensive coal mining and the easier and less expensive coal was depleted years ago. Enhancements in technology, particularly for underground mining, kept coal production strong into the 1990s but productivity has clearly fallen since then. One strength of the central region is production of coking coal which is part of the metallurgical market, and can command higher prices from global markets (though as we'll see below, coal exports have fallen rapidly in the last few years).⁴

⁴ "Coal Mining Industry Profile," developed for the U.S. Army Corps of Engineers by Leonardo Technologies, Inc., January 16, 2015.

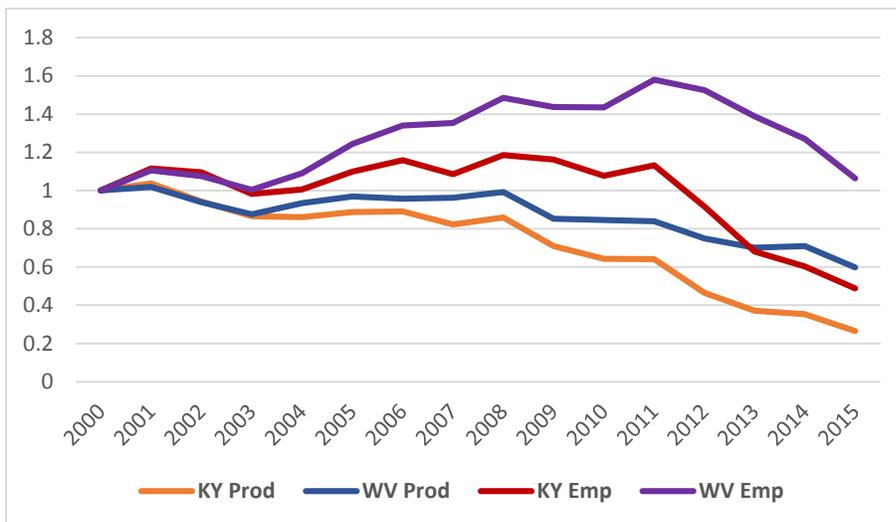
Figure 15. Coal Mining Productivity (short tons per employee) and Percent Change for U.S. and Appalachian States, 2000 to 2015



Source: U.S. Department of Labor, Mine Safety and Health Administration (MSHA)

One result of the decrease in productivity from 2000 to 2015 is that the growth trends for production (short tons) and employment are not as strongly correlated as one might think. As shown in Figure 16, the growth trend for Kentucky employment (the red line) is consistently above the growth trend for production (orange) with the decline in production starting earlier (around 2008) than the drop in employment which has fallen most rapidly in the last four to five years. In West Virginia, employment (purple) grew from about 2003 to 2011 before starting its decline through 2015. West Virginia coal production was much flatter over this time period with steady declines experienced since 2008.

Figure 16. Growth Index of Coal Production and Employment in WV and KY, 2000 to 2015

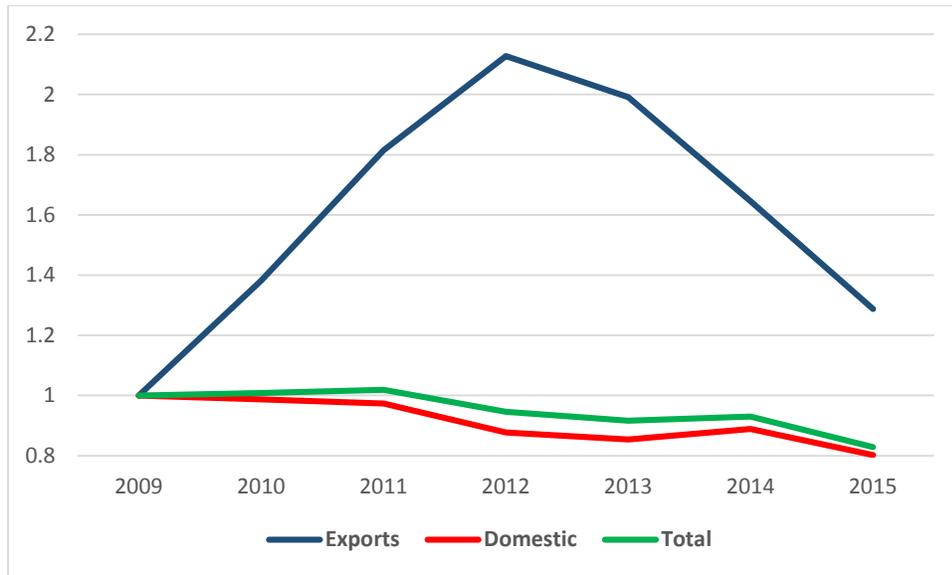


Source: U.S. Department of Labor, Mine Safety and Health Administration (MSHA)

Coal Industry Exports

While the majority of coal in the United States is produced for domestic consumption, coal exports to global markets are a critical component of the industry and can fluctuate greatly. Figure 17 shows the growth trend from 2009 to 2015 for total U.S. coal production, exports, and domestic production, demonstrating a fairly gradual downward trend for total and domestic production but large growth swings for exports. Over this period, exports more than doubled from just under 60 million short tons in 2009 to over 125 million short tons exported in 2012, before falling since then to about 76 million tons in 2015.

Figure 17. Growth Index of U.S. Coal Production, Exports and Domestic Output

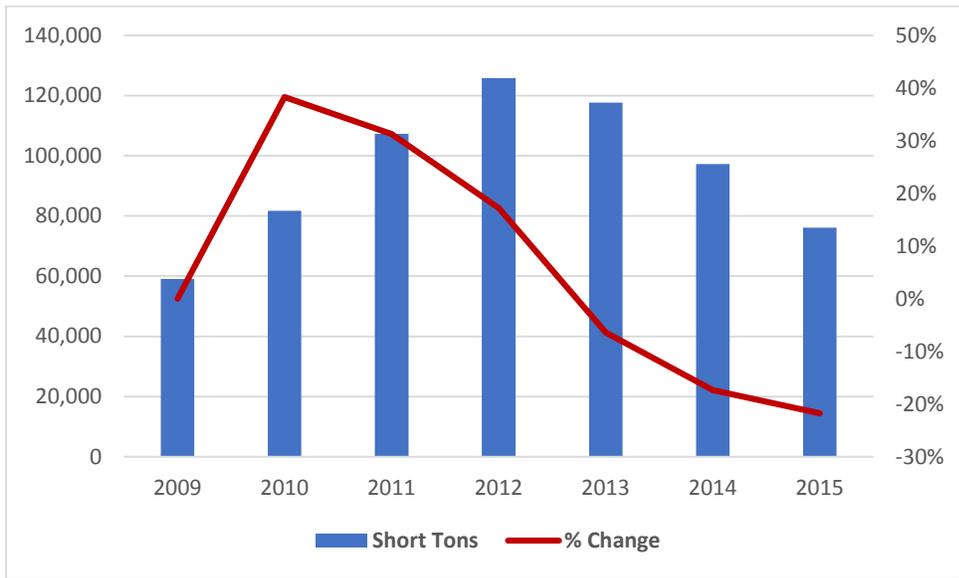


Source: Energy Information Administration (EIA)

These trends are illustrated in more detail in Figure 18; one can see the dramatic rise and fall of coal exports over a relatively short time. According to the EIA, slower growth in world demand, lower coal prices, and higher exports from other coal producing states led to this most recent decline. Of the countries to which the United States exports coal, the ones seeing the biggest drop in coal shipments from the U.S. were the United Kingdom, Italy, South Korea, Brazil, and Mexico.⁵ Meanwhile, U.S. coal exports to China, which had reached 8.3 million short tons in 2013 have declined sharply to less than 1 million by 2015, a decrease of nearly 88 percent.

⁵ U.S. Energy Information Administration, Today in Energy (March 7, 2016) – “U.S. coal exports declined 23 percent in 2015, as coal imports remained steady.”

Figure 18. U.S. Coal Exports, 2009 to 2015 (thousands of short tons)



Source: Energy Information Administration (EIA)

These export trends are particularly relevant to Appalachia as the Region tends to export a far greater share of its coal output than the western United States. For example, it's estimated that Wyoming, the largest coal producing state in the U.S., exported about one percent of its coal to global markets. In stark contrast, West Virginia, the second largest coal producing state, exported 27 percent of its production (35 million short tons), making West Virginia much more dependent on global markets for its growth opportunities. In terms of value, bituminous coal comprised 53 percent of all West Virginia exports in 2013 (\$4.5 billion) according to data from the U.S. Census Bureau. In broad terms, this variation is due to: 1) differences in coal quality (heating) as Appalachian coal is often used for metallurgical purposes such as steel production; and 2) proximity and access to international shipping ports.⁶

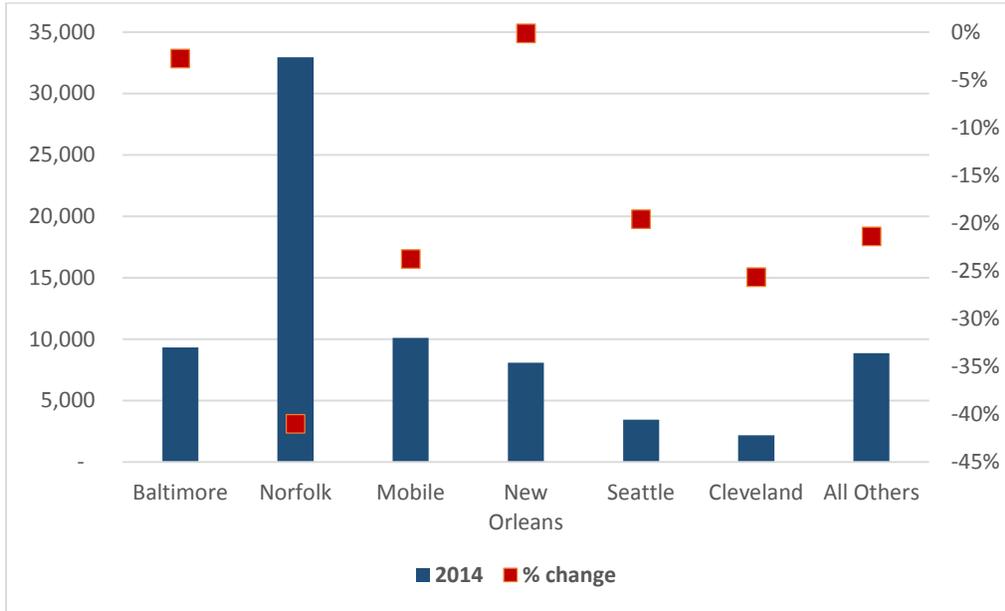
Other large coal-exporting states in Appalachia include Kentucky, with seven percent of its coal production destined for global markets, Pennsylvania which exports 25 percent of its coal production, and Virginia which exports an impressive 43 percent of its coal production. A 2013 Ernst & Young report estimated that exported coal produces even larger overall economic impacts than coal produced for domestic purposes based on higher coal prices, and greater supply chain impacts (e.g., transportation to ports).

The connection between coal exporting states and shipping ports becomes abundantly clear when we examine coal exports by Customs District. As shown below in Figure 19, the port of Norfolk in Virginia is by far the largest U.S. port for coal exports. In 2014, Norfolk handled 44 percent of all coal exports in the nation, and the ports of Mobile and Baltimore ranked second and third nationally. Clearly, these ports are critical to

⁶ Data on coal exports by state is largely derived from "U.S. Coal Exports: National and State Economic Contributions," prepared for the National Mining Association by Ernst & Young, 2013.

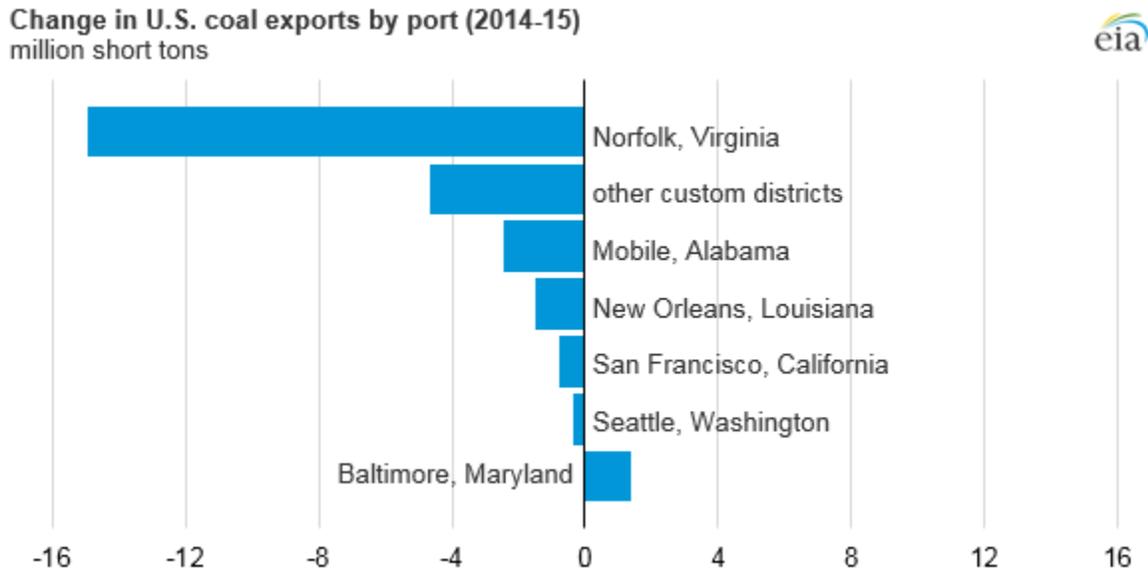
Appalachia’s overall global connectivity and demonstrate a close linkage of the Region to these ports and the importance of good rail and highway connectivity. Similar to recent export trends, most ports have seen a significant decrease in export activity in 2015 (Figure 20).

Figure 19. U.S. Coal Exports by Customs District 2014 (thousands of short tons) and Percent Change to 2015



Source: Energy Information Administration (EIA)

Figure 20. Change in U.S. Coal Exports by Port, 2014 to 2015 (millions of short tons)

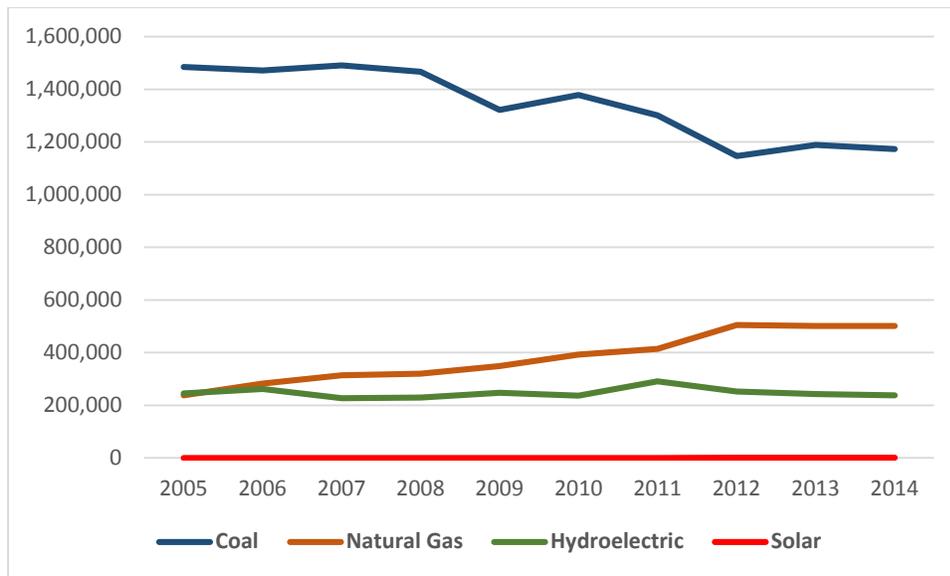


Source: Energy Information Administration (EIA)

Energy Generation and Coal-Fired Power Plants – Trends

Another key aspect of understanding the coal industry is to analyze trends in energy generation and coal-fired power plants. By a wide margin, domestic coal consumption is used to power electricity-generating power plants (steam coal), with more modest amounts of coal used for industrial production. As is widely known, the reductions in natural gas prices in recent years have generally led to an increase in the energy generation from natural gas, and conversely, a reduction in the energy generation from coal. At the same time, renewable energy generation is on the upswing, especially via solar and wind, but those production levels remain relatively modest compared to other sources.⁷ Figure 21 shows these trends for the United States over the last 10 years in terms of energy generation by source. Energy generation from coal displays a clear downward trend starting in 2008 as megawatt (MW) hours fell from just under 1.5 billion MW hours to under 1.2 billion MW hours in 2015. Of note, coal still represented the largest single source of energy for the U.S. overall.

Figure 21. U.S. Energy Generation by Source (thousand megawatt hours)



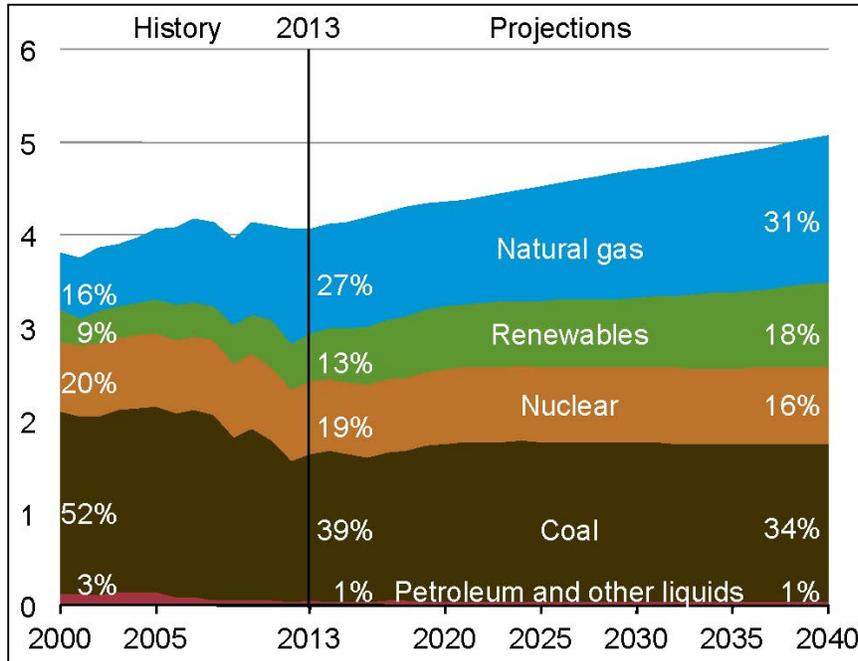
Source: Energy Information Administration (EIA)

Along these lines, Figure 22 presents the amount and share of electricity generation by source in the U.S. from 2000 to 2013, along with projections to 2040. Coal generation fell from 52 percent of electricity generation in 2000 to 39 percent in 2013 and is expected to see a further decrease in share over time. Natural gas, on the other hand, increased its share from 16 percent to 27 percent from 2000 to 2013 and is likely to see even greater market share in the future, with renewables (hydroelectric, wind, solar, etc.) on a steady growth path. These future projections from the EIA are based on more or less status quo conditions (known as the “Reference case”), and as discussed below, various factors

⁷ Solar electricity generation expanded from just 16,000 MW hours in 2005 to 1.2 million MW hours in 2014, an increase of over 7,500 percent.

could easily precipitate a more rapid decline in coal for electricity generation in the future.

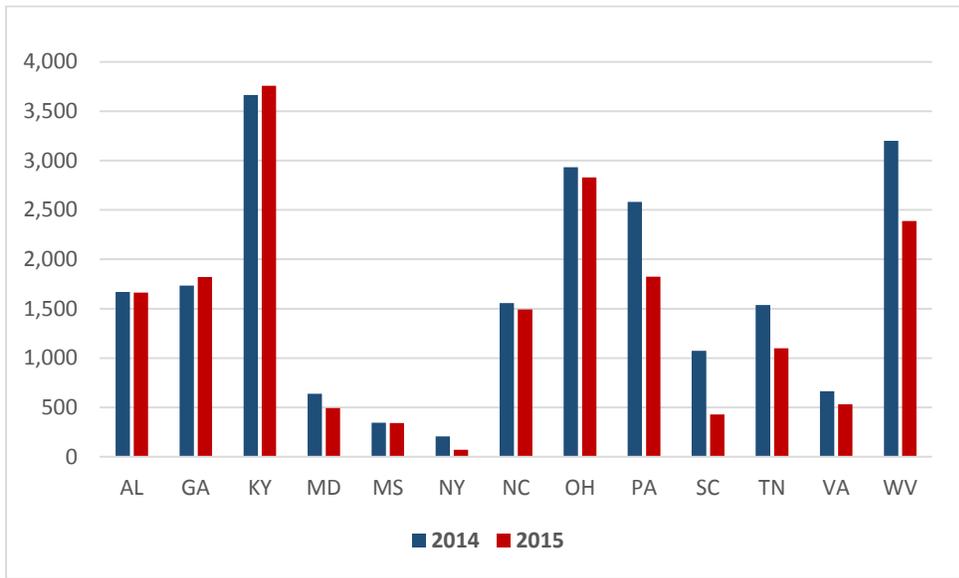
Figure 22. U.S. Energy Generation by Source, History and Projections, 2000 to 2040



Source: Energy Information Administration (EIA)

The use of coal for electricity generation varies greatly among Appalachian states (see Figure 23). Of the Appalachian states, the biggest coal users are Kentucky, Ohio, West Virginia, Pennsylvania, Georgia and Alabama. It is important to keep in mind that this data captures activity for the *entire* state, not just the Appalachian portion of states, and thus it is likely that significant coal consumption for electricity is occurring outside the Region. However, Appalachian states are still heavily reliant on coal for power generation.

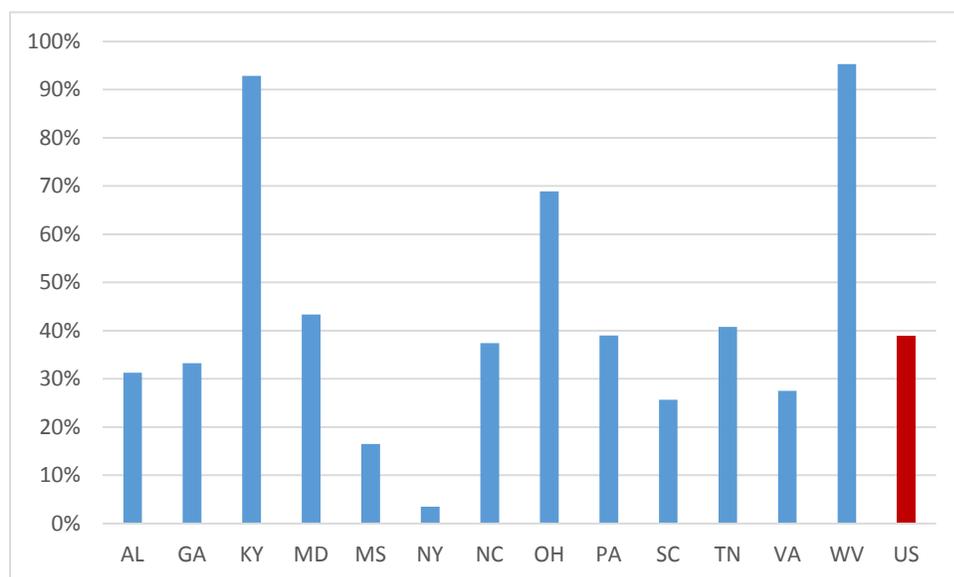
Figure 23. Coal Receipts for Electricity Generation by State, October 2014 and October 2015



Source: Energy Information Administration (EIA); note that this data is for the entire state, not just the portion in Appalachia, and thus represents broad, illustrative info that may not be fully representative of conditions for the Appalachian portion of each state (with the exception of West Virginia which is entirely within Appalachia).

Figure 24 displays the share of electricity generation from coal in each Appalachian state and the nation. As noted above, coal had a 39 percent U.S. market share in 2013 (and continues to fall) but a much higher share in certain Appalachian states. In particular, West Virginia uses coal for 95 percent of its electricity generation and Kentucky is nearly as dependent on coal at 93 percent. It’s interesting to see three large, geographically proximate states (Ohio, New York, and Pennsylvania) have such different electricity generation patterns. For example, Ohio still gets 69 percent of its electricity from coal, while New York has only a 3 percent market share for coal, with Pennsylvania in between at 39 percent. The remaining Appalachian states range from 16 percent in Mississippi to 43 percent in Maryland (again, using state-level data).

Figure 24. Percentage of Electricity Generation from Coal for Appalachian States and U.S., 2013

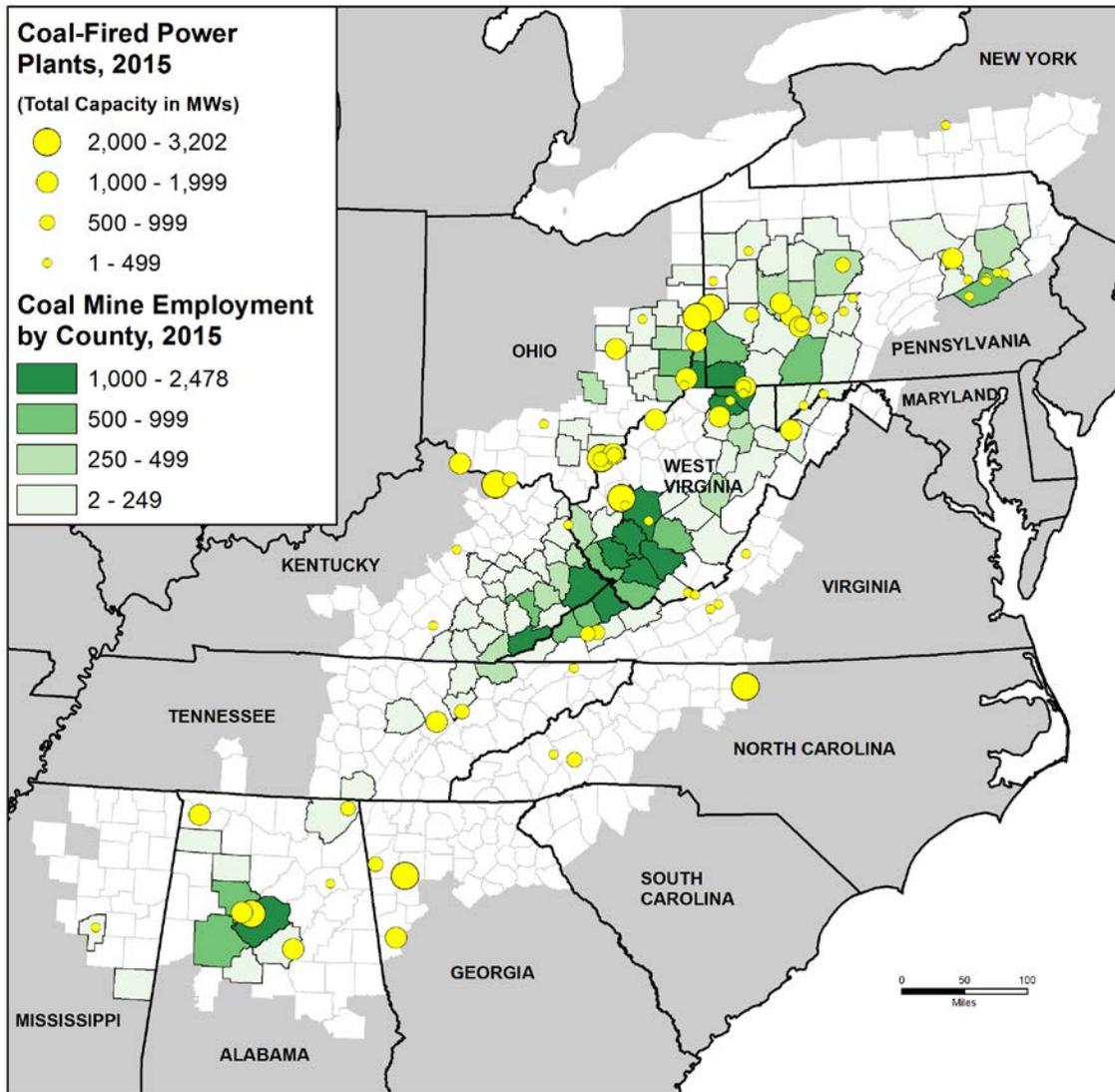


Source: Energy Information Administration (EIA)

The map in Figure 25 displays the presence and size of coal-fired power plants in Appalachia (yellow dots) along with coal mining employment by county. There are two prominent overlays of coal power plants and coal mining production: 1) the northern part of the Region centered on the intersection of Ohio, Pennsylvania, and West Virginia; and 2) central Alabama, near Birmingham, where there are at least three major coal power plants, and a cluster of coal mining production. This is one way to consider how various areas of Appalachia could be impacted in multiple ways as the coal industry continues to decline. Meanwhile, the largest cluster of coal mining employment in eastern Kentucky, the southwest part of West Virginia, and the far western part of Virginia has relatively few power plants but supplies coal to a wide-range of power plants in Appalachia and beyond. For example, eastern Kentucky coal is predominately shipped to other southeastern states with 22,600 short tons shipped to other U.S. states and only 2,183 short tons shipped within state. Conversely, more than half of western Kentucky coal is shipped within state.⁸ This means that the coal produced in central Appalachia leads to significant transportation supply chain impacts in the rest of the Region and globally (based on the high export share mentioned earlier for West Virginia and Virginia). The transportation implications of coal shipments are discussed in more detail below.

⁸ Kentucky Coal Facts, 15th Edition, 2015. Produced by the Kentucky Energy and Environment Cabinet in partnership with the Kentucky Coal Association.

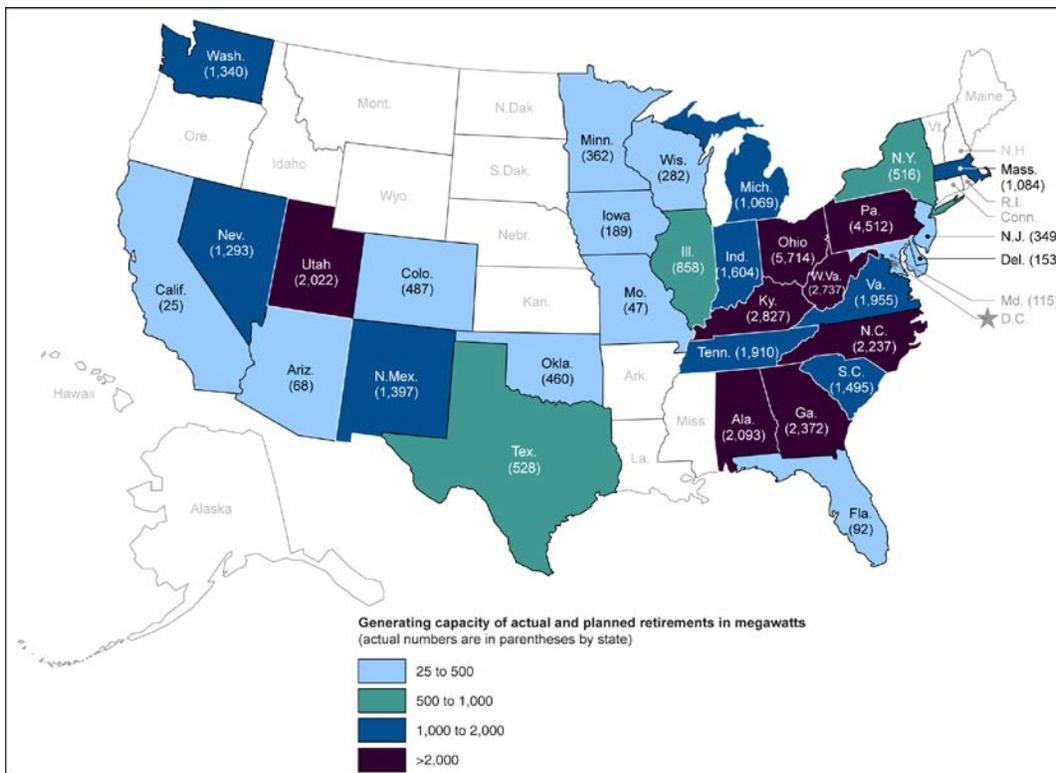
Figure 25. Coal-Fired Power Plants and Coal Mine Employment in Appalachia, 2015



As discussed throughout this paper, the conditions for energy in recent years has largely been working against coal in a few different ways from lower natural gas prices to stricter environmental regulations from the U.S. Environmental Protection Agency to increased costs to mine coal in Appalachia. Accordingly, the U.S. General Accounting Office (GAO) has specifically studied the coal-fired power plant industry to monitor its status in terms of recent and planned retirements of coal-fired power plants. They found that in the United States, "Thirteen percent of coal-fueled generating capacity – 42,192 megawatt hours – has either been retired since 2012 or is planned for retirement by 2025." The retirements are primarily at plants that are older, small, more polluting, and not as extensively used.

Looking more closely at the data, it's clear from Figure 26 that many of these coal power plant retirements are located in or near the Appalachian Region. Specifically, about 38 percent of the net summer generating capacity that power companies retired or plan to retire from 2012 through 2025 is located in four states—Ohio (14 percent), Pennsylvania (11 percent), Kentucky (7 percent), and West Virginia (6 percent).⁹ More recent data from the EIA confirms these trends as they report a reduction of 18 gigawatts of power were retired in 2015 for electricity generation, and 80 percent of that reduction was from conventional coal steam power plants. The 2015 retirements were concentrated in Appalachian states – Georgia, Ohio, and Kentucky, with other major retirements in West Virginia and Virginia.¹⁰

Figure 26. Net Summer Generating Capacity of Actual and Planned Retirements of Coal-Fueled Electricity Generating Units by State, 2012 to 2025



Source: GAO Analysis of SNL Financial Data; Map Resources (Map); GAO 14-672

Note: Data on generating unit capacity refers to units with over 25 megawatts of net summer generating capacity—a generating unit's capacity to produce electricity during the summer when electricity demand for many electricity systems and losses in efficiency are generally the highest.

⁹ "Update on Agencies' Monitoring Efforts and Coal-Fueled Generating Unit Retirements," United States Government Accountability Office, Report to the Ranking Member, Committee on Energy and Natural Resources, U.S. Senate, August 2014.

¹⁰ See <http://www.eia.gov/todayinenergy/detail.cfm?id=25272>

Coal Transportation in the United States and Appalachia

As discussed above, coal production and consumption (for electricity) are often not located in the same place, and a significant share of Appalachian coal is bound for ports and international trade. Therefore, it's critical to understand the transportation services and goods movement represented by coal. When analyzing coal transportation flows in Appalachia and the rest of the United States it's worth starting with a big picture understanding of coal's role in goods movement. As shown in Table 1, coal represents a very small share of freight transportation in terms of value (just 0.3 percent across all modes) in the U.S. but a much more significant share in terms of tonnage (about 10 percent of all goods movement), and ton-miles (over 22 percent).¹¹

Table 1. U.S. Commodity Flows for 2007 and 2012 for Coal and All Commodities

	Commodity description	Value			Tons			Ton-miles		
		2012 (million dollars)	2007 (million dollars)	Percent change	2012 (thousands)	2007 (thousands)	Percent change	2012 (millions)	2007 (millions)	Percent change
All Modes	All commodities	13,852,143	11,684,872	18.5	11,299,409	12,543,425	-9.9	2,969,506	3,344,658	-11.2
	Coal	41,178	38,228	7.7	1,047,934	1,416,187	-26.0	663,676	835,796	-20.6
	Coal as % of All Commodities	0.3%	0.3%		9.3%	11.3%		22.3%	25.0%	
Rail	All commodities	473,070	436,420	8.4	1,628,537	1,861,307	-12.5	1,211,481	1,344,040	-9.9
	Coal	23,636	25,907	-8.8	709,486	1,015,209	-30.1	609,335	773,290	-21.2
	Coal as % of All Commodities	5.0%	5.9%		43.6%	54.5%		50.3%	57.5%	

Source: U.S. Commodity Flow Survey, Bureau of Transportation Statistics

The coal share increases significantly when looking only at rail goods movement. Coal as a share of all commodity shipments is over 5 percent in terms of value, over 43 percent in terms of tonnage, and over 50 percent in terms of ton-miles (reflecting the long-distance shipments of this commodity). [Note: data in this section of the paper is largely from the U.S. Commodity Flow Survey and the closely associated Freight Analysis Framework. These data are available publicly for 2007 and 2012 but not more recent years, and are state level rather than customized for Appalachian counties.]

Over this time period (2007 to 2012), coal shipments decreased by 26 percent by tonnage and even more sharply for rail shipments of coal (30 percent decrease). This trend, which appears to be continuing to decline through 2015 based on other coal production data, has resulted in lower shares of overall commodity flows. For example, coal represented 54.5 percent of all rail goods movement in 2007 but 43.6 percent in 2012.

West Virginia Commodity Flows

To look more closely at the same kind of data for Appalachia, we can examine the role of coal for West Virginia – the largest coal producing state in the Region (second largest nationally). Table 2 presents commodity flows originating in West Virginia for 2012, and it

¹¹ This analysis focuses solely on the "coal" commodity and does not include data for the "other coal and petroleum products, not elsewhere classified". Based on initial research, that "other" category may include a small amount of coal products but is difficult to disentangle from other products.

shows the remarkably important role that coal plays in the state. Across all modes, coal represents almost 17 percent of value, over 75 percent of tonnage and 84 percent of ton-miles.

Table 2. West Virginia Commodity Flows for Coal and All Commodities, 2012

		Value (Thous \$)	Tonnage	Ton-Miles
All Modes	All Commodities	54,759	174,741	56,674
	Coal	9,225	132,520	47,642
	Coal as %	16.8%	75.8%	84.1%
Rail	All Commodities	9,532	99,808	42,532
	Coal	5,906	94,408	39,947
	Coal as %	62.0%	94.6%	93.9%

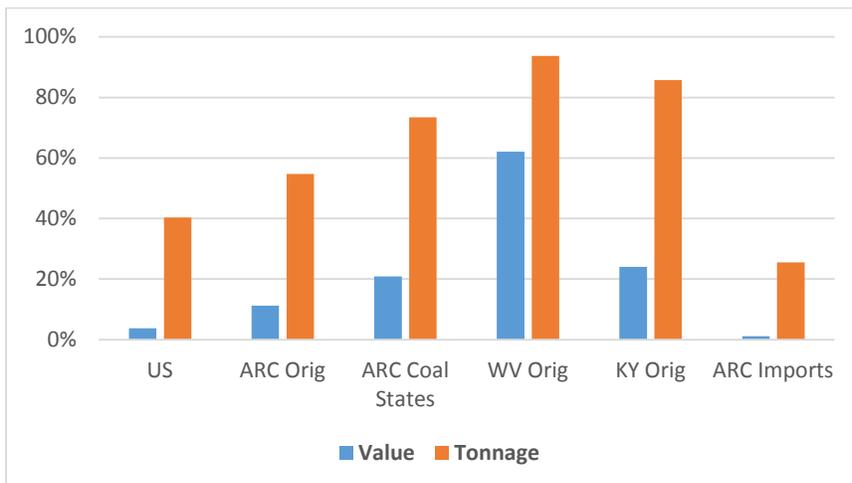
Source: U.S. Commodity Flow Survey, Bureau of Transportation Statistics

Focusing on rail flows originating in West Virginia, coal represents 62 percent of value, and almost 95 percent of tonnage. The values would be even higher if we included trips that are classified as traveling by both “rail and water”. The next largest rail commodities (coal and oil products not elsewhere classified, basic chemicals and plastics) are just fractions of those rail volumes.

Coal Share of Rail Movements by Region

To compare the share of coal of all rail movements, Figure 27 demonstrates how these values differ for different regions, states and the nation. Using the FAF data set from FHWA (which is built from the Commodity Flow Survey), we can examine rail flows that originate in different markets (U.S., Appalachia, West Virginia, and Kentucky) and are destined for Appalachian states. In this graph, Appalachian Coal States are the four largest producing coal states in the Region – West Virginia, Kentucky, Pennsylvania, and Ohio.

Figure 27. Coal Share of All Rail Movements by Value and Tons, 2012

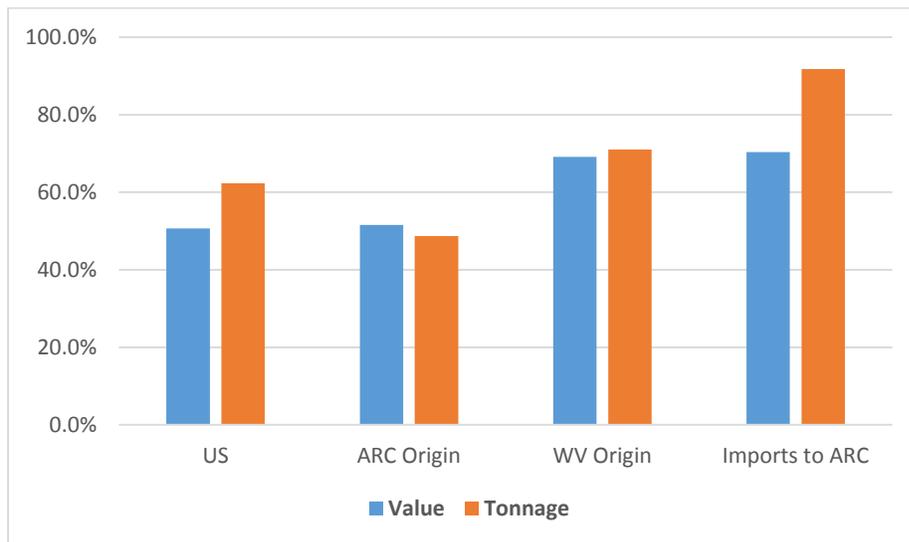


Source: Federal Highway Administration (FHWA), Freight Analysis Framework (FAF)

Coal thus plays an over-sized role in rail movements in Appalachia, especially for the coal states that produce and originate goods movement. Imports of coal to the Appalachian states¹² (smaller by volume) also represent over 20 percent of tonnage by rail.

A different way of examining coal is to analyze the mode share of coal goods movement (e.g., percent by truck, rail, water, etc.) for different regions and states. Figure 28 displays the rail mode share of coal freight shipments in 2012 for the U.S., coal shipments originating in Appalachian states, coal shipments originating in West Virginia, and imports to Appalachian states. Compared to the overall share of all goods that are shipped by rail in the nation (14.4 percent in terms of tonnage), rail has a much larger role in shipping coal with over 60 percent of tonnage at the national level, over 70 percent in West Virginia, and 92 percent of imported coal to Appalachian states is shipped via rail. These findings correspond to recently released data from the EIA that estimate that rail has about a 70 percent mode share of coal shipments sent to the power sector. This finding also corresponds to broader coal trends, as coal shipments experienced a decrease of 18 percent in volume from 2014 to 2015.

Figure 28. Rail Mode Share of Coal Shipments by Value and Tons, 2012



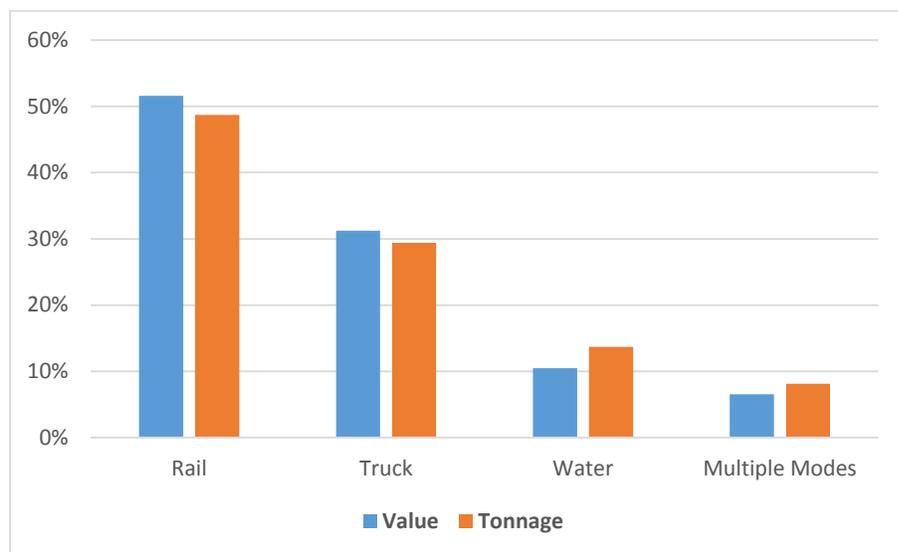
Source: Federal Highway Administration (FHWA), Freight Analysis Framework (FAF)

Examining coal shipments originating in Appalachian states, the mode share is a bit more diverse (see Figure 29 below) but rail is still clearly the most prevalent mode. The truck mode share is about 30 percent for value and tonnage for Appalachian coal shipments,

¹² Because the FAF data is organized by states and major metro areas, it would be very time-consuming (requiring lots of estimation work) to try to compile data for the Appalachian Region. Fortunately, in terms of data purposes, the majority of coal produced by Appalachian states is within the Region (e.g., all of WV, most of PA, about half of KY, etc.).

and this somewhat high value likely reflects the fairly large intra-state trade of coal in Appalachia. For example, 36 percent of coal originating in Appalachian states is destined for in-state markets such as coal-fired power plants. Another 10.5 percent of coal value and 13.7 percent of coal tonnage is shipped by water (barges) reflecting the Region’s strong inland waterway system. Coal shipments by “multiple modes” typically includes some combination of rail, water, and truck.

Figure 29. Mode Share of Coal Shipments from Appalachian States, 2012



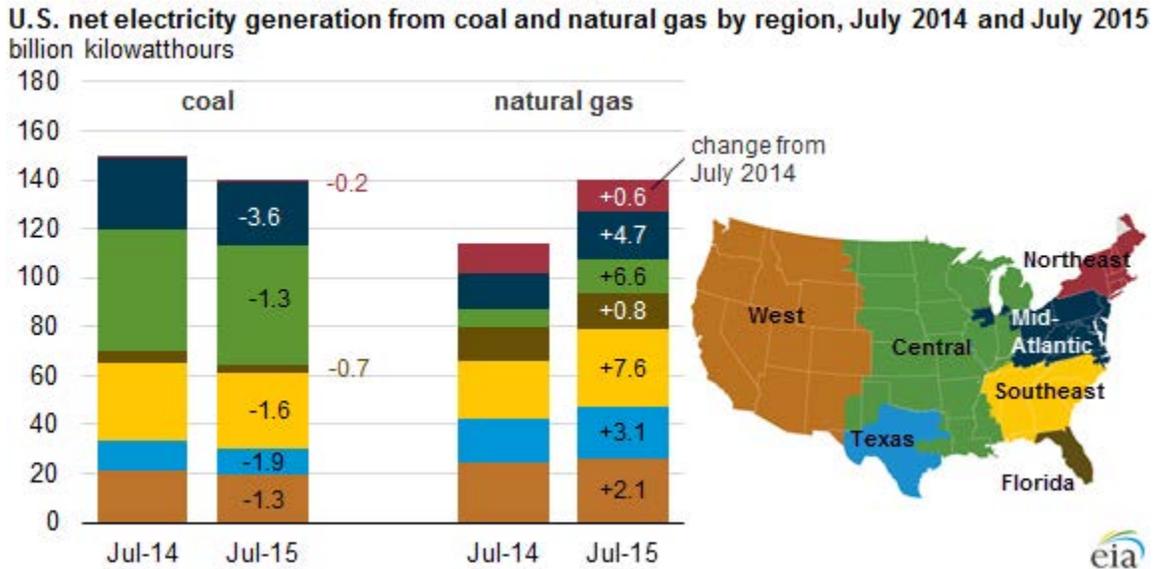
Source: Federal Highway Administration (FHWA), Freight Analysis Framework (FAF)

Coal Industry Outlook – United States and Appalachia

For the first time ever (on a monthly basis), natural gas surpassed coal as the largest source of net electricity generation in the nation in the summer of 2015. This was a significant turning point in 2015¹³ as coal has exceeded all other sources as long as accurate records have been tracked by the EIA. As shown in the map from EIA in Figure 30, all regions of the country saw a positive gain in natural gas generation, led by the Southeast, Central and Mid-Atlantic regions. This corresponded with a decrease in coal that was felt in every region of the nation. These conflicting trends produced this somewhat significant milestone that is symptomatic about the overall trends and outlook for coal.

¹³ As shown earlier, coal is still a larger component of electricity generation on an annual basis, but with monthly variations largely driven by weather, natural gas did exceed coal on a monthly basis in April and July 2015. <http://www.eia.gov/todayinenergy/detail.cfm?id=23252>

Figure 30. U.S. Net Electricity Generation from Coal and Natural Gas by Region, July 2014 and July 2015



Source: Energy Information Administration (EIA), Electric Monthly Update

Looking ahead, most analysts agree that the use of coal will continue to suffer compared to other sources, with a gradual decline in energy market share in the U.S. The most recent estimates of coal production for 2015 (890 million short tons) result in a decrease of almost 110 million short tons. This was the lowest level of coal mining production since 1986, and as documented throughout this paper, the declines are being felt most acutely in Appalachia and more specifically, the central part of the region (Kentucky, West Virginia, Virginia). Short-term forecasts from the EIA project a continued decline in 2016, with a fairly conservative estimate of a 29 million short ton reduction compared to 2015 volumes.

As noted earlier, the EIA Reference case projections show a decrease in the U.S. electricity market share from 39 percent in 2013 to 34 percent by 2040. However, there is significant variation in future projections with a number of key factors likely to influence the size and share of the coal industry over the next 10 to 25 years. Based on the EIA's Annual Energy Outlook 2015 report,¹⁴ a few key findings are worth highlighting:

- Energy efficiency and conservation via new policies and technologies are likely to keep growth in energy consumption fairly moderate in the future, averaging just 0.3 percent per year to 2040.
- Growth in renewable energy generation is expected to meet much of the new demand for electricity generation as the EIA projects an increase of 72 percent from 2013 to 2040 in renewable energy generation, with solar photovoltaic technology the fastest renewable growth sector.

¹⁴ See <http://www.eia.gov/forecasts/aeo/>

- In the Reference case, despite the recent reductions in US coal production, the EIA projects gradual growth in coal from 2013 to 2030, partly as natural gas prices rise slightly and coal production continues to mimic broader economic trends.
- Compliance with the Mercury and Air Toxic Standards (MATS) and other energy competition is expected to result in the retirement of 31 gigawatts of electricity at coal-fired power plants by the end of 2016, though generation may be boosted by the remaining plants.
- Some of the alternative scenarios assessed by the EIA tend to point to lower overall coal production over the next 10 to 25 years, depending on different policy, environmental regulations, oil and gas prices, and other key factors.
- Even in the Reference case, coal produced from the Appalachian region is expected to decline as the US continues to shift from the more extensively mined and more expensive coal reserves in Central Appalachia to lower cost coal in other regions, with growth in the western region.
- The EIA projects virtually no increase in coal generating capacity over the next 25 years as new capacity will primarily be driven by natural gas, wind and solar power (depending on scenario).

Summary of Findings and Future Research Directions

The research and data compiled for this paper reveal a number of key findings. In many ways, the anecdotal stories and broadly cited trends of regional and national leaders are now supported by data-driven trends to more precisely describe the coal industry and how it varies between the United States and Appalachia, and how it varies within Appalachia and where it is most concentrated. A brief listing of key findings includes:

- National coal production only started to decline in recent years but has been declining in Appalachia since 1990, with declines most pronounced over the past four-to-five years and sharpest in Central Appalachia (namely eastern Kentucky).
- Coal production was lower in 2015 than 2000 in every Appalachian state. West Virginia generates 44 percent of the Region's total production and is second nationally to Wyoming. With Kentucky's rapid decline, Pennsylvania is now the number two producer in Appalachia with 21 percent of the Region's coal production. Decreases in coal have occurred throughout the Region – for example, Virginia has seen its coal production fall from over 33 million short tons in 2000 to just shy of 14 million in 2015.
- Appalachia contributed about two-thirds of all U.S. jobs in coal mining production from 2000 to 2011 as coal production is more labor intensive in Appalachia than the western part of the U.S. However, with the rapid decline over the past five years, the Appalachian share of all U.S. coal jobs dropped to 57 percent in 2015, its lowest point in years. For example, while the nation lost 28 percent of coal jobs from 2011 to 2015, Appalachia saw a decrease of 37 percent.

- From 2000 to 2015, the Appalachian Region experienced a loss of over 9,300 jobs with the decrease most severe in Kentucky (loss of 6,200 jobs). Virginia saw the next biggest job loss with over 2,000 fewer employees, followed by Pennsylvania with a decrease of 1,500 jobs. Interestingly, West Virginia saw a slight *increase* in coal mining jobs from 2000 to 2015 but this masks some interesting dynamics, partially driven by a temporary surge in exports and a reduction in productivity.
- This longer-term employment trend masks the more severe job losses that have occurred over the past five years in the Appalachian Region. Since 2011, the Region suffered coal mining job losses of over 23,000 jobs, a decrease of 37 percent. This represented 87 percent of the coal mining job losses nationwide. The largest job losses have centered in Kentucky (about 8,250 jobs, a 55 percent decrease) and West Virginia (8,000 jobs lost), with significant reductions also seen in Virginia, Pennsylvania, and most Appalachian states.
- In Appalachia, there are 52 counties with a location quotient of 20 or more, meaning that coal mining is 20 times more important to local jobs than in the U.S. overall. Put another way, of the 17 counties with a concentration of 150 or more, coal mining represents 10 percent or more of total jobs in the county. These are staggering levels of industry concentration that are also generally associated with job losses and high levels of economic hardship in Central Appalachia.
- The western region of the United States has much higher productivity than regions in Appalachia, with the Illinois Basin slightly more productive than Appalachia. In other words, coal mining production is far more labor intensive in Appalachia, requiring more employees to produce and process coal, than the western part of the country. Within Appalachia, the northern part of the Region (primarily parts of Pennsylvania and Ohio) have slightly higher productivity than the central and southern parts of the region.
- The recent rise and subsequent fall of U.S. coal exports are particularly relevant to Appalachia as the Region tends to export a far greater share of its coal output than the western part of the U.S. For example, it's estimated that Wyoming, the largest coal producing state in the US, exported about 1.0 percent of its coal to global markets. In stark contrast, West Virginia, the second largest coal producing state, exported 27 percent of its production (35 million short tons).
- The port of Norfolk in Virginia is by far the largest port in the nation for coal exports. In 2014, Norfolk handled 44 percent of all coal exports in the U.S., and the ports of Mobile and Baltimore ranked second and third nationally. These ports are critical to Appalachia's overall global connectivity and demonstrate a close linkage of the Region to its ports and the importance of good rail and highway connectivity.
- Energy generation from coal displays a clear downward trend starting in 2008 as megawatt hours fell from just under 1.5 billion MW hours to under 1.2 billion MW hours in 2015. Of note, coal still represented the largest single source of energy for the US overall.

- Coal generation fell from 52 percent of electricity generation in 2000 to 39 percent in 2013 and is expected to see a further decrease in share over time. Natural gas, on the other hand, increased its share from 16 percent to 27 percent from 2000 to 2013 and is likely to see even more market share in the future, with renewables (hydroelectric, wind, solar, etc.) on a steady growth path.
- Coal had a 39 percent U.S. market share of electricity generation in 2013 but a much higher share in certain Appalachian states. In particular, West Virginia uses coal for 95 percent of its electricity generation and Kentucky is nearly as dependent on coal at 93 percent. It's interesting to see three large, geographically proximate states (Ohio, New York, and Pennsylvania) have such different electricity generation patterns. For example, the state of Ohio still gets 69 percent of its electricity from coal, while New York has only a 3 percent market share for coal, with Pennsylvania in between at 39 percent.
- According to the GAO, many of the coal power plant retirements are located in or near the Appalachian Region. Specifically, about 38 percent of the net summer generating capacity that power companies retired or plan to retire from 2012 through 2025 is located in four states—Ohio (14 percent), Pennsylvania (11 percent), Kentucky (7 percent), and West Virginia (6 percent).
- Coal as a share of all rail commodity shipments is over 5 percent in terms of value, over 43 percent in terms of tonnage, and over 50 percent in terms of ton-miles (reflecting the long-distance shipments of this commodity). In other words, coal is a hugely important commodity for freight transportation across the U.S.
- Coal plays an over-sized role in rail movements in Appalachia, especially for the coal states that produce and originate goods movement, representing over 60 percent of rail movements in originating the largest coal producing states (West Virginia, Pennsylvania, Kentucky, and Ohio).
- For the first time ever, natural gas surpassed coal as the largest source of net electricity generation in the U.S. This was a significant turning point in 2015 as coal has exceeded all other sources as long as accurate records have been tracked by the EIA. All regions of the country saw a positive gain in natural gas generation, led by the Southeast, Central and Mid-Atlantic regions. This corresponded with a decrease in coal that was felt in every region of the nation. This conflicting trends produced this somewhat significant milestone that is symptomatic about the overall trends and outlook for coal.

Potential Future Research Directions

Based on the research, data collection efforts, and inherent linkages between the coal industry and the broader economy discovered in this white paper, a few areas for future research appear to be:

- **Obtain and/or estimate data on jobs and related economic variables (e.g., value added, wages) at coal-fired power plants.** Readily available data from free, public sources such as BLS, BEA and County Business Patterns generally does not include employment or similar economic data for coal-fired power plants. This industry is grouped within the broader Utilities sector but data at the county-level is often suppressed when trying to view more detailed economic data. New research could leverage existing data sources on known power plants and other sources to try to derive reasonably accurate estimates of the importance of this sector, which is particularly relevant in light of coal-fired power plant retirements. A related piece of research could also examine jobs and other economic data at gas-fired power plants or other renewables sources. A recent study in Pennsylvania attempted to measure some of these trade-offs but more data and research are needed.
- **Obtain and analyze customized Appalachian Region transportation trade flow data for coal and related industries.** As noted, the publicly available data from the U.S. Commodity Flow Survey and Freight Analysis Framework (FAF) are primarily at the state level which is difficult to use to more accurately reflect conditions and trends in Appalachia given the geography of counties where only West Virginia is fully represented in the Region.¹⁵ The TRANSEARCH database of commodity flows could be purchased for this purpose, and ideally would provide more current information on trade flow volumes by mode since FAF data was last estimated for 2012. Other statistical estimation methods are possible as well, if a TRANSEARCH data purchase is too costly.
- **Develop a more detailed assessment and estimation of supply chain impacts of the coal industry.** Previous economic studies of the coal industry have typically used standard input-output methods to estimate the supply chain (indirect) impacts of coal mining production. This white paper begins to detail the very close linkages between coal and freight transportation (in particular freight rail transport). But, more work is needed to understand and devise customized estimates of the types of support and supplier industries most impacted by the coal sector and its various components (mining, electricity generation, rail transportation, etc.).
- **Develop future coal industry forecasts for Appalachia.** While the EIA energy outlook is helpful, it provides limited information specific to Appalachia. And it is quickly outdated as even the 2015 Outlook report uses 2013 as its base year (while we know coal declined significantly from 2013 to 2015). Working from multiple sources, researchers could generate new future scenarios specific to Appalachia and its states to better reflect recent trends and longer-term challenges to the coal industry. Those updated coal production and energy generation forecasts

¹⁵ FAF data can be analyzed for major metro areas but Appalachia contains so many rural areas that this option is not particularly useful.

could then be used to estimate broader economic and transportation implications.

- **Construct and map a more comprehensive coal industry eco-system for Appalachia.** The data and information presented in this white paper begins to develop a more complete assessment and mapping of the coal industry eco-system. But, additional research that blends more detailed transportation and supply chain impacts, with existing coal production and electricity generation data, could offer opportunities to “connect the dots” of all the various impacts and implications of the coal industry in Appalachia and beyond.