

ANALYZING AND ESTIMATING THE ECONOMIC AND JOB BENEFITS OF U.S. COAL

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ABSTRACT

This report analyzes the current state of the U.S. coal industry and jobs, and forecasts future trends under different possible scenarios. It finds that current data greatly underestimate the size and importance of the coal industry: i) failure to include contractor employment undercounts mining jobs by 30%-40%;¹ ii) including indirect jobs effects increases the jobs generated by a factor of 3 to 4; iii) coal is vital to U.S. manufacturing and railroads; iv) coal-related jobs are essential to many regional and local economies.

The industry is currently distressed, and this is having especially serious effects in Appalachia. In states such as Kentucky and West Virginia, the loss of coal-related jobs has meant the difference between prosperity and severe recession. These jobs are also important in states like Ohio, Pennsylvania, and Virginia. The reason for this is that coal-related jobs in these states are three to four times as numerous as is generally recognized, and are of critical importance in many local areas and regions.

MISI forecast and compared the jobs impacts of seven scenarios (Table A-1) involving assumptions about economic growth, technologies, tax credits, and Research and Development (R&D). All of the scenarios generate substantially more jobs than the Reference Case -- between 5 and 10 million additional jobs, and more than 15 – 20 million cumulative jobs in total – Figure A-1. The Administration's goal of achieving 3% GDP growth will create an additional 3.2 million coal-generated jobs, for a total of nearly 25 million jobs. Utilizing both carbon capture and sequestration (CCS) tax credits and DOE R&D greatly increases the number of jobs created, and to maximize job creation tax credits are not sufficient; rather, DOE R&D is also required. The full maximization of job creation is thus achieved using both CCS tax credits and DOE R&D. For some regions in Appalachia this could mean the difference between increased employment and prosperity or a future of worsening unemployment and recession. Major findings include:

- Exclusion of contractor employment estimates from state job data represents a serious undercount of coal mining jobs.
- For every coal mining job in Appalachia, 2.5 jobs are created in the Appalachian region and 3.5 jobs are created in the U.S. as a whole.
- The loss of nearly 100,000 coal-related jobs in Appalachia over 2011-2015 had devastating consequences, and the economic situation in Appalachia is dire.
- The futures represented in the scenarios analyzed have dramatic effects on U.S. coal production, and these impacts increase as the forecast period lengthens.
- Higher economic growth and increases in electricity demand will increase the demand for coal and coal-related jobs.
- Achieving the Administration goal of 3% growth rate instead of 2.6% would likely generate about 15% more jobs over the forecast period in each of the scenarios.

¹The U.S. Mine Safety and Health Administration cannot present contractor employment below the national level. Therefore, the widely used coal jobs estimates attributed to either a county or state reflect operator employment only, and exclude contractors. See U.S. Department of Labor, Mine Safety and Health Administration, "Coal Mine Employment by State (CY 2009 - 2015)," June 2017.

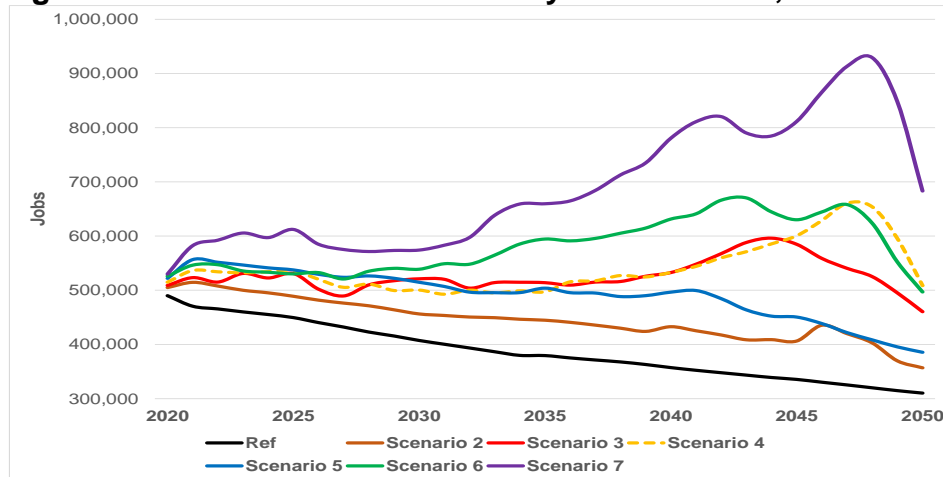
- The sharp decline in jobs in the later years in Figure A-1 results from the model's timeline for building new plants and the associated construction jobs.
- The marginal impacts of achieving the DOE R&D program goals in conjunction with CCS tax credits are large and could generate an additional 9.4 million jobs – 315,000 jobs per year.
- Manufacturing is of critical importance to the U.S. economy and jobs, and coal is critical to the manufacturing industry.
- Coal power plants are the economic mainstays in many local areas and provide reliable, affordable electricity that supports local economies

Table A-1: Forecast Scenarios

Scenarios	O&G Prices	Economic Growth	Electricity Demand	CCS Tax Credits ²	CO ₂ Capture Technology	EOR O&M
1. No CPP Reference Case	Reference	Reference	Reference	No	Reference	Reference
2. High Economic Growth Case	Reference	High	High	No	Low Learning	Low Costs
3. High Growth, CCS TC Case	Reference	High	High	Yes	Low Learning	Low Costs
4. High Growth, CCS TC, PG Case	Reference	High	High	Yes	R&D Program Goals	Low Costs
5. High O&G Prices Case	High	High	High	No	Low Learning	Low Costs
6. High O&G Prices/ CCS TC Case	High	High	High	Yes	Low Learning	Low Costs
7. High O&G Prices/ CCS TC/PG Case	High	High	High	Yes	R&D Program Goals	Low Costs

Source: MISI and NETL.

Figure A-1: Total Jobs Generated by All Scenarios, 2020 - 2050



Source: MISI.

Thus, the marginal impacts of the DOE program are substantial, and could generate 4 million additional jobs. However, the major finding is that to maximize job creation both CCS tax credits and the DOE R&D program need to be implemented. This will stimulate economic growth and will, in turn, create even more jobs.

²Modeled on proposed tax credits of \$35/ton CO₂ for EOR and \$50/ton CO₂ for geologic storage.

EXECUTIVE SUMMARY

The U.S. Coal Economy

The U.S. coal industry is distressed, and the fate of U.S. coal mining regions and jobs figured prominently in the 2016 Presidential election. EIA forecasts that coal will continue to decrease as a source of U.S. electricity production through 2050.

The economic and societal costs of coal mine closures are large, and the decline of the coal industry has taken a heavy toll. For example, the increased poverty associated with coal job losses is startling, and in some eastern Kentucky counties poverty rates exceed 30% and child poverty rates approach 50%.

The U.S. has the best freight railroad system in the world, and coal is essential to it. Railroads derive more revenue from coal than from any other commodity – nearly 20%, and coal accounts for up to 33% of railroad profits. However, in recent years coal rail traffic has declined nearly 30%.

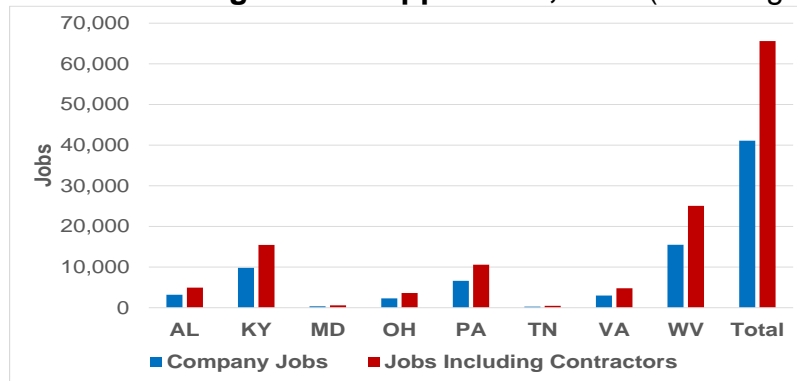
Job Impacts of the Coal Industry

U.S. employment in coal mining peaked in 1923 at 863,000. Since then, mechanization has greatly improved productivity in coal mining, and employment has declined at the same time coal production increased. Between 2011 and 2015, Appalachia lost more than 36% of its coal mining employment, and over 70% of the Appalachian coal job losses were concentrated in Kentucky and in West Virginia.

Contractor jobs are not included in estimates of state coal mining jobs, but contractors comprise 30-40% of coal mining employment. This exclusion represents a serious undercount of jobs. To more accurately measure the impact of coal jobs and provide more robust estimates of coal mining jobs by state in Appalachia, MISI prorated the contractor jobs to each Appalachian state. Including contractor jobs, coal mining employment in Appalachia: i) totaled more than 95,000 in 2009; ii) increased to over 102,000 in 2011; decreased to about 65,600 in 2015. Thus, coal jobs in Appalachia increased more than 7% between 2009 and 2011, and then decreased steeply by 53% between 2011 and 2015. By 2015, employment was 31% lower than in 2009 and, as shown in Figure EX-1, there were about 66,000 coal mining jobs in Appalachia – not 41,000 as is generally reported.

Direct jobs (and job losses) can be translated into total jobs, which are the sum of the direct and indirect jobs: Direct jobs are those created directly in the specific activity; indirect jobs are those created throughout the required interindustry supply chain and in supporting activities. MISI estimates that every coal mining job in Appalachia creates 2.5 jobs in the Appalachian region and 3.5 jobs in the U.S. as a whole.

Figure EX-1: Coal Mining Jobs in Appalachia, 2015 (including contractors)

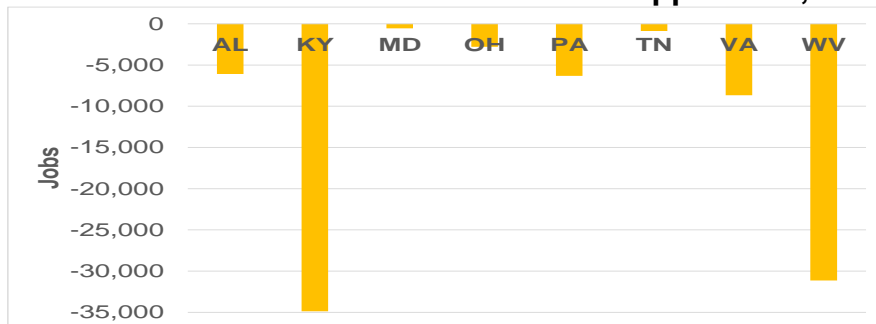


Source: MISI.

MISI estimates that Appalachian coal mining jobs created in the Appalachian region: i) 238,000 jobs in 2009; ii) 255,000 jobs in 2011; and iii) 164,000 jobs in 2015. Thus, the total job loss (direct and indirect) in Appalachia between 2011 and 2015 due to declining Appalachian coal employment was 91,000 jobs. MISI estimates that coal mining jobs in Appalachia created in the U.S. as a whole: i) 333,000 jobs in 2009; ii) 357,000 jobs in 2011; and iii) 230,000 jobs in 2015.

Figure EX-2 shows the actual total job impacts on Appalachia of lost coal jobs between 2011 and 2015: i) 91,300 jobs were lost in the eight states; ii) 34,900 jobs – nearly 40% of the total – were lost in Kentucky; iii) 31,100 – 34% of the total – were lost in West Virginia; iv) nearly three quarters of the jobs lost were in these two states.

Figure EX-2: Total Coal Related Job Losses in Appalachia, 2011-2015*



*Including contractors and indirect jobs. Source: MISI.

Thus, the coal-related job losses in Appalachia were actually four times as large as is generally reported, and the job losses in the U.S. were nearly six times as large. These job losses in Appalachia over a five year period had devastating consequences – especially for Kentucky and West Virginia. Absent these losses, both states would have experienced full employment instead of recession. Coal jobs are thus the difference between recession and full employment, especially at the county level. Further, coal jobs in Appalachia pay very well. For example, a coal mining job in eastern Kentucky pays more than twice as well as the average private sector job in the state.

Coal mining job losses in Appalachia were substantial between 2011 and 2015. The most severe job losses were in Central Appalachia (counties in Kentucky, West Virginia, and Virginia) with widespread losses also in Ohio and Pennsylvania. There is thus an alarming economic situation in Appalachia: Of 430 counties, 203 are either distressed or at-risk, 11 are competitive, only 1 is in attainment – Shelby County, Alabama.

Between 2011 and 2015, in the Interior region coal mining employment decreased by about 1%; in the Western region, coal mining employment decreased by 13%. The job changes within the states in the regions varied markedly.

Forecasts

MISI forecast the jobs impacts of the U.S. coal industry through 2050 under seven alternate economic and energy scenarios involving assumptions about economic growth, technologies, tax credits, and Research and Development (R&D). MISI used a version of EIA’s National Energy Modeling System (NEMS) to examine the potential impact on coal and coal-related jobs of the seven futures the scenarios describe (Table EX-1).³

Table EX-1: Forecast Scenarios

Scenarios	O&G Prices	Economic Growth	Electricity Demand	CCS Tax Credits ⁴	CO ₂ Capture Technology	EOR O&M
1. No CPP Reference Case	Reference	Reference	Reference	No	Reference	Reference
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7. High O&G Prices/CCS TC/PG Case	High	High	High	Yes	R&D Program Goals	Low Costs

Source: MISI and NETL.

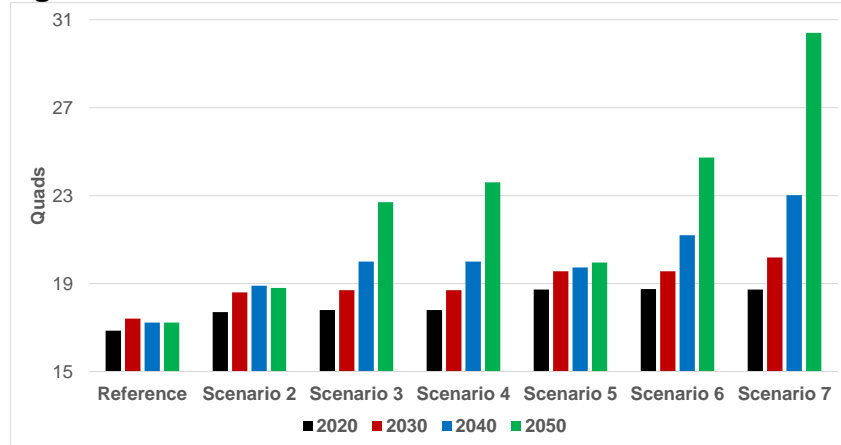
The Reference Case is the *AEO 17* “no CPP” case, which projects no increase in coal use through 2050. Here, due to increasing labor productivity and flat or declining coal demand, coal-related jobs decrease continuously. However, the U.S. may require more coal than is currently anticipated for a variety of factors. For example, EIA forecasts that through 2050 natural gas costs to utilities will increase much more rapidly than coal costs.

³MISI used the NEMS version “NETL CTUS-NEMS.”

⁴Modeled on proposed tax credits of \$35/ton CO₂ for EOR and \$50/ton CO₂ for geologic storage.

Figure EX-3 indicates that the scenario futures have dramatic effects on U.S. coal production and that the impacts increase as the forecast period lengthens.

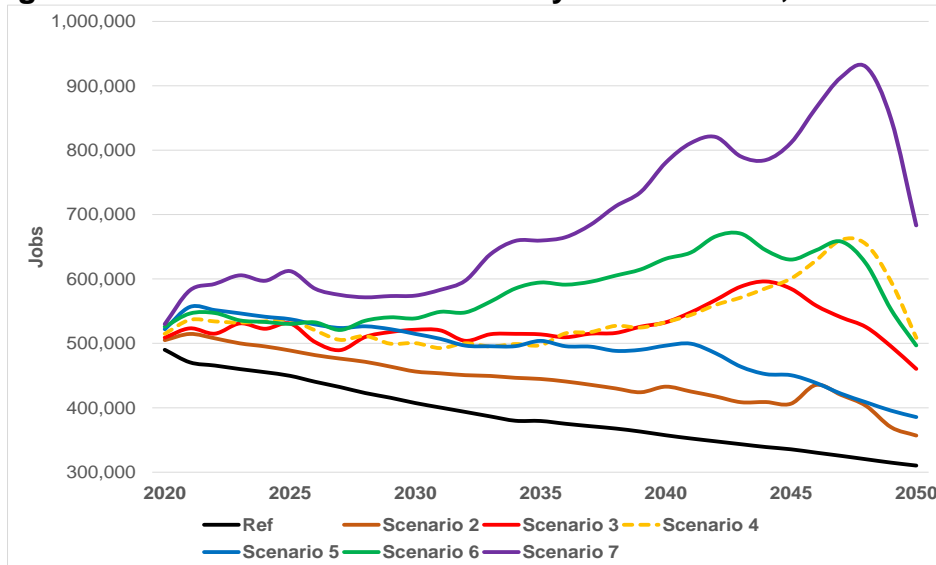
Figure EX-3: U.S. Coal Production Under Each Scenario



Source: MISI and NETL.

Figure EX-4 shows the total number of jobs created annually under each scenario (directly and indirectly) by coal mining, new coal plant construction, coal plant O&M, EOR, saline sequestration, and pipelines.

Figure EX-4: Total Jobs Generated by All Scenarios, 2020 - 2050



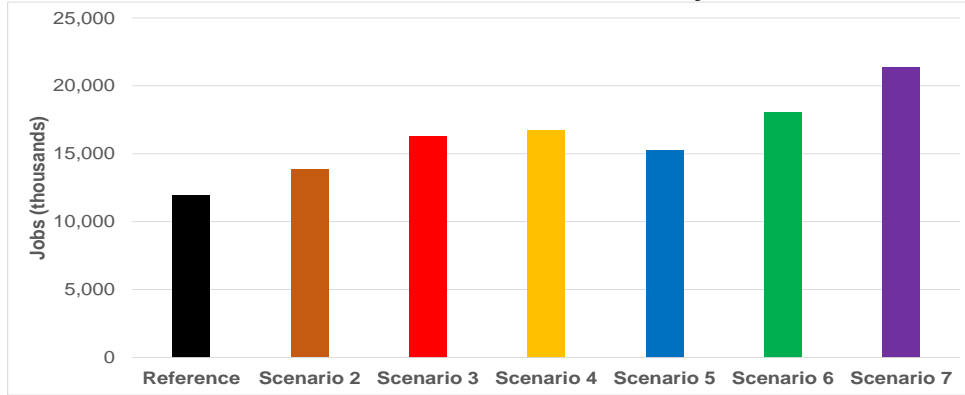
Source: MISI.

Figure EX-5 shows the total cumulative job-years generated by the scenarios through 2050, and illustrates that all of the alternate scenario futures generate significantly more job-years than the Reference Case. MISI finds that:

- Under all of the scenarios, except Scenario 7, the total number of jobs generated by the coal mining industry decreases continually through 2050, due primarily to continued increases in productivity in the coal mining industry.

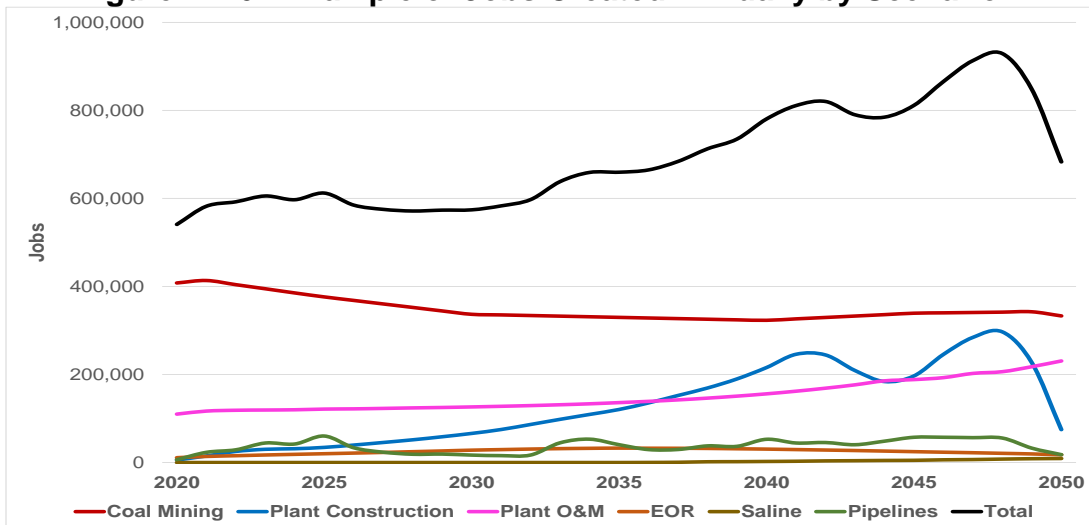
- In all of the scenarios, the coal mining industry generates more jobs over the forecast period than the other technologies and programs (Figure EX-6).
- In all of the scenarios, coal plant O&M generates the second largest number of jobs over the forecast period (Figure EX-6). The numbers of jobs created by pipelines and EOR are relatively small in all of the scenarios (Figure EX-6).
- The sharp decline in jobs in the later years in Figures EX-4 and EX-6 results from the model's timeline for building new plants and the associated construction jobs.

Figure EX-5: Total Cumulative Job Years Generated by All Scenarios, 2020 - 2050



Source: MISO.

Figure EX-6: Example of Jobs Created Annually by Scenario 7



Source: MISO.

The major policy implications of the scenario results include:

1. A higher rate of economic growth will substantially increase the demand for energy, including coal, and will substantially increase coal-related jobs.
2. The Administration's goal of 3% GDP growth (compared to 2.6%) will further increase the number of coal-related jobs by as much as 15%, and would create more than 3.2 million additional jobs for a total of nearly 25 million jobs.
3. The largest job increases occur within the high oil and natural gas prices environment utilizing both CCS tax credits and DOE R&D.

4. Even in an environment of moderate oil and natural gas prices, utilizing both CCS tax credits and DOE R&D greatly increases the number of jobs created.
5. Full maximization of job creation is achieved using both CCS tax credits and DOE R&D within a high oil and natural gas prices environment. This results in the creation of an additional 9.4 million cumulative jobs – 315,000 jobs per year.
6. The marginal impacts of the DOE program are substantial. With moderate oil and natural gas prices, the R&D program creates an additional 500,000 jobs; in a high oil and natural gas prices environment the program creates about 3.3 million additional jobs – and nearly 4 million jobs with 3% economic growth.

The salient finding is that to maximize job creation both CCS tax credits and the DOE R&D program must be implemented. This will stimulate economic growth which will, in turn, create even more jobs. West Virginia could gain enough jobs to comprise about 4% - 9% of state employment, and this this could mean the difference between increased employment and prosperity or a future of worsening unemployment and recession.

Importance of Coal in Manufacturing

Manufacturing is critical to the U.S. economy and jobs, and coal is critical to manufacturing. Manufacturing is essential to the economy: i) it has a higher job multiplier than other sectors; ii) there is a close linkage between innovation and manufacturing; iii) manufacturing firms provide 70% of U.S. innovations and 90% of patents; iv) manufacturing productivity has increased at twice the U.S. average; v) manufacturing accounts for 60% of U.S. exports' value; vi) it generates high-skilled, high-wage jobs.

Low U.S. industrial electricity prices are a strong competitive advantage, since electricity represents a significant portion of total industrial energy costs. This competitive advantage is also true among U.S. states. There is a close relationship between the reliable, affordable electricity provided by coal and a state's manufacturing output, and states with the most manufacturing generate most of their electricity with coal.

U.S. manufacturing is dependent on the reliable, affordable electricity provided by coal power plants, and the steel industry exemplifies the importance of U.S. manufacturing. Every job in the steel industry creates seven jobs in the U.S. economy, and it is impossible to make steel without coal. Further, electricity is critical for the third industrial revolution of the 21st century, which involves 3D printing, additive manufacturing, digitalized manufacturing, nanotechnology, genetic engineering, etc.

Importance of Coal Power in Regional Economies and Jobs

Coal power plants play a critical role in supporting local and regional economies and jobs: i) they are among largest industrial facilities and major employers in many local areas; ii) they pay a large share of property taxes; iii) they provide high quality, well-paying jobs often “not available elsewhere;” v) most important, coal plants provide reliable, affordable electricity that powers local industry, business, and commerce, and without this power local economies will wither.

I. THE ISSUES

The U.S. coal industry has been distressed for years: Coal mines have been closed, coal power plants have been shut, and many jobs in coal-related industries have been lost. EIA forecasts that coal will continue to decrease as a source of U.S. electricity production for the next several decades. In addition, the fate of U.S. coal mining regions and jobs figured prominently in the 2016 Presidential election. It is thus important to determine the current state of the industry and jobs and potential future trends under different possible scenarios. This is the major objective the report. Here we:

- Assess and quantify the economic and job benefits to the U.S. of the domestic coal industry and advanced coal technologies
- Estimate the actual and potential employment and jobs impacts of the U.S. coal industry, coal power generation, and related industries and technologies
- Estimate the potential future for the industry and industry jobs under scenarios representing alternate futures
- Assess the role of coal in U.S. manufacturing
- Analyze the importance of coal in regional economies and jobs

Specifically:

- Chapter II examines the current state of the U.S. coal economy.
- Chapter III analyzes the jobs impacts of the coal industry.
- Chapter IV develops forecasts of the future jobs impacts of the coal industry under different assumptions and scenarios.
- Chapter V discusses the importance of coal to U.S. manufacturing.
- Chapter VI assesses the importance of coal in regional economies and jobs.
- Chapter VII presents the findings and recommendations derived from the research.

II. THE CURRENT STATE OF THE U.S. COAL ECONOMY

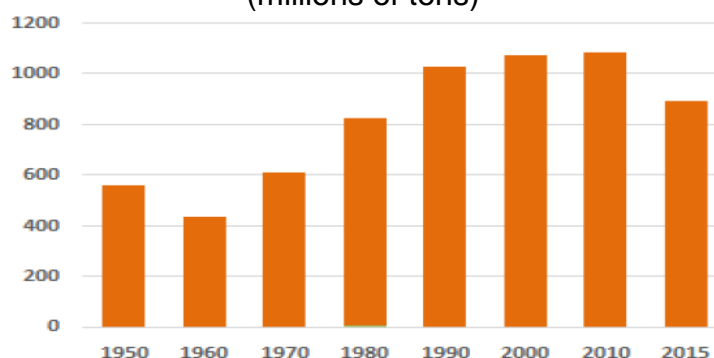
II.A. Coal in the U.S.: Past, Present, and Future

Coal was the cornerstone of American energy supply and economic progress for nearly two centuries. From the railroads reaching across the continent, to the steel mills of Pittsburgh, to the over 300 GW of coal-based power plants, coal was the foundation of the nation's energy supply.

Over the decades, oil replaced coal in transportation and natural gas replaced coal in space heating. However, the continuing rise of moderately priced coal as the basis of U.S. electricity enabled families to take advantage of an ever increasing array of home appliances and provided manufacturers with an affordable and reliable energy source to successfully compete with their counterparts around the world. The National Academy of Engineering identified electricity as the most important engineering invention of the 20th Century.⁵ It was coal that enabled the U.S. to bring electricity not only to its largest cities, but also to the most remote rural regions of the nation. In the 1920s, less than 10% of family farms had electricity. Thanks to the Rural Electrification Act of 1936, agricultural access to electricity steadily increased and, at present, nearly 100% of farms have the power to not only provide a cornucopia for the nation but to help feed the rest of the world as well.

The U.S. has 27% of the world's coal and that resource is distributed widely across the nation. Over 15 states produce at least five million short tons of coal per year. A vast supply system of mining, processing, transporting, and consuming coal has been a hallmark of the industry for over 100 years. Coal miners have been increasingly productive as demand for coal rose steadily throughout the 20th century, and especially since 1950 – Figure II-1.⁶

Figure II-1
U.S. Coal Production, 1950 – 2015
(millions of tons)



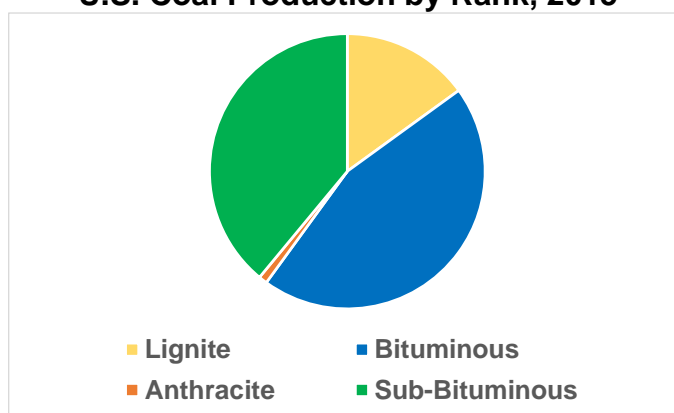
Source: U.S. Energy Information Administration.

⁵National Academy of Engineering, "Greatest Engineering Achievements of the 20th Century," <http://www.greatachievements.org/>.

⁶Coal production essentially doubled between 1950 and 2010; <https://www.eia.gov/totlenergy/data/annual/pdf/aer.pdf>.

In 1950, the U.S. produced 560 million short tons of coal, 92 million of which were utilized to produce 154,520 million kWh -- 46% of U.S. electricity. By 2010, the U.S. produced 1,084 million short tons of coal and 975 million of those short tons were utilized to produce 1,847,290 million kWh of power. As natural gas power plants replaced some aging coal plants and as anti-coal regulations increased, coal's role in electricity declined. By 2015, about one third of U.S. electricity was produced by coal.⁷ Wyoming, the nation's leading coal producer, provides nearly 40% of U.S. coal through the Powder River Basin. Most Wyoming coal is sub-bituminous, which makes it an attractive choice for power plants because it has less sulfur and burns at around 8,400 to 8,800 BTUs per pound.⁸ As shown in Figure II-2, most U.S. produced is either bituminous or sub-bituminous.

Figure II-2
U.S. Coal Production by Rank, 2015



Source: U.S. Energy Information Administration, *Annual Coal Report, 2015*.

Apart from the dramatic increase in coal production over the past few decades, the locus of that production has also changed significantly. Due to regulations relating to the Clean Air Act, coal in the western part of the nation became increasingly attractive to electric utilities. The coal resources in Wyoming, Montana, and Colorado provided a significant and inexpensive source of low sulfur coal leading to a major increase in coal production from those states. In 1975 about 17% of coal production came from western mines. By 2010, production in the West exceeded 630 million short tons and accounted for 59% of the nation's coal production.⁹

At the same time, productivity in the coal industry increased rapidly due to a combination of easier to mine surface coal in Wyoming and technological advances in the mining process. In 1950, productivity per miner was about 0.76 short tons of coal per hour. With the advent of PRB production and new technology, by 2010 productivity per miner had increased to 5.55 short tons per hour.

⁷U.S. Energy Information Administration, "What is U.S. Electricity Generation by Source?" <https://www.eia.gov/tools/faqs/faq.php?id=427&t=3>.

⁸Wyoming Mining Association, "Coal," <https://www.wyomingmining.org/minerals/coal/>.

⁹U.S. Energy Information Administration, "Total Energy," <https://www.eia.gov/totalenergy/>.

Over the second half of the 20th Century coal lost market share in space heating and transportation, but gained significantly in the production of electricity. The U.S. still uses a large amount of coal, and over 90% of the coal is utilized to make electric power. However, since 2010 the rise of natural gas generation as well as environmental regulations have reduced coal's role. Nevertheless, coal is still a crucial part of electricity. In 2016, about 30% of the nation's power came from coal.¹⁰ In the Spring of 2017, U.S. coal production increased about 15% year-over-year. However, it remains to be determined if this is a reversal of a longer term trend of declining production or a temporary perturbation.

The role of coal in the U.S. has undergone significant transformations over the past century, and the increasing importance of electricity and the concomitant demand for coal is probably the most significant change that has taken place. The U.S. is at another crossroads. Specifically, the question becomes how much coal will be produced and utilized in the future? As LNG and pipeline exports significantly increase, will natural gas be available and affordable enough to continue to replace coal? Will wind and solar power become more reliable and more affordable with new technologies? What regulations will be put in place that will impact the future of coal? The answers to these questions will have serious and long-term implications for the coal and power industries.

In recent years, regulations such as the EPA's Mercury and Air Toxic Standards (MATS) have impacted the coal industry by leading to the closing of both mines and power plants – Figure II-3.¹¹ EIA forecasts indicate that implementation of the Clean Power Plan (CPP) would have a significant impact on both the production and consumption of coal. EIA projects a significant decline in coal production under the Clean Power Plan over the next three decades.¹²

Coal plant retirements under the CPP are projected to increase to 90 GW, and almost all retirements will occur by 2020.¹³ This is more than double the retirements projected in the *AEO 2015* base case. A small number of oil and gas steam units are also expected to retire due to the proposed rule. Thus, in only about three years under the CPP the U.S. could lose at least 100 GW of generating capacity -- a substantial number of relatively inexpensive generation sources and about one-tenth of U.S. total generating capacity. By 2030, coal's share of generation under the CPP would be reduced to 25% or less, while natural gas would increase its share to 31% and wind to 12%.¹⁴ Further, under the CPP "Average annual U.S. retail electricity rate increases range from 11% per year to 14% per year (relative to baseline) over the same time period. For the overall economy, losses to U.S. consumers range from \$64 billion to \$79 billion on a present value basis over the same time period."¹⁵

¹⁰U.S. Energy Information Administration, "Total Energy," <https://www.eia.gov/totalenergy/>.

¹¹Energy Transition Advisors, "The U.S. Coal Crash," 2015.

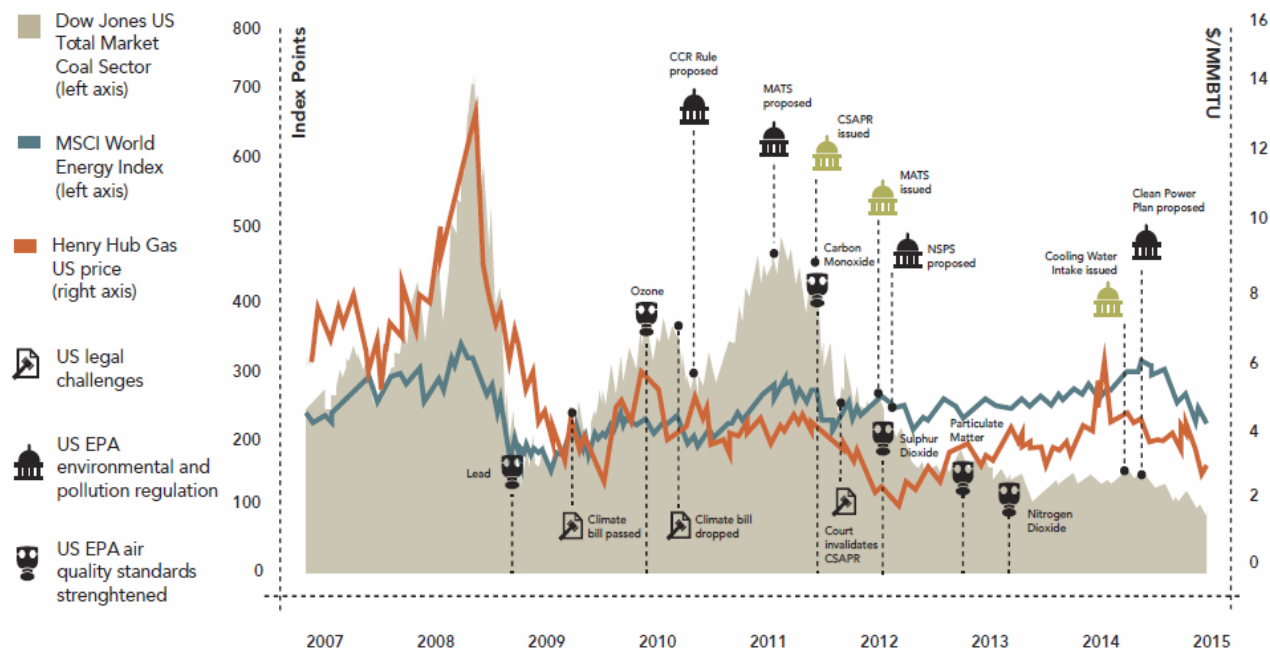
¹²U.S. Energy Information Administration, *Annual Energy Outlook, 2017*, January 2017.

¹³Ibid.

¹⁴Institute For Energy Research, "How to Kill the Coal Industry," May 2015, <http://instituteeforenergyresearch.org/analysis/how-to-kill-the-coal-industry-implement-epas-clean-power-plan/>.

¹⁵NERA Economic Consulting, <http://www.americaspower.org/wp-content/uploads/2015/11/NERA-CPP-Final-Nov-7.pdf>.

**Figure II-3
EPA Regulations and Other Factors Impacting the U.S. Coal industry**



Source: Energy Transition Advisors, "The U.S. Coal Crash," 2015.

II.B. The Human Impact of Coal Mine Closures

For over 150 years, coal has provided a significant stimulus to the U.S. economy by increasing output, income, and employment in all sectors through direct, indirect and induced effects.¹⁶ Hundreds of communities have depended for generations on coal for their economic stability. The economic activity and jobs created by coal mining has led to employment and income for retailers, teachers, mechanics, medical professionals, police, truck drivers, -- the list goes on and encompasses the full range of a community's social structure. Further, since the vast majority of coal facilities are located in rural and non-metropolitan areas, the coal industry is frequently the major employer in the local region. Many communities, in essence, are almost totally dependent on the coal industry to maintain social equilibrium and at least a modest order of prosperity. Thus, closure of a coal mine has far more reverberating adverse effects than if the closure had occurred in a metropolitan area where other opportunities for employment may be available. The rapid decline of the coal industry in recent years has taken a heavy human toll, including unemployment, outmigration, reduced community services, family disintegration, and the hopelessness associated with drug addiction. While other regions of the U.S. have prospered and grown, many communities in coal country have endured a bleak spiral of poverty and population attrition.

¹⁶Adam Rose and Dan Wei, "The Economic Impacts of Coal Utilization and Displacement in the Continental United States, 2015," <http://www.americaspower.org/wp-content/uploads/2015/08/penn-state-study.pdf>.

The economic and societal costs of coal mine closures in the U.S. are significant. These costs include:

- Declines in direct coal-related jobs, mines, and power plants
- Impacts on families and individuals -- economic, social, psychological
- Impacts on businesses -- direct and indirect
- Impacts on institutions, e.g. schools, human services
- Impacts on local, county, and state tax revenues
- Impacts on the local communities at large, e.g., outmigration
- Regional inequities, e.g. the particular vulnerability of rural areas, concentration and intensification of adverse impacts in particular states and parts of states

Independent interviews of residents of coal dependent communities reveal the despair that has accompanied the decline of coal. For example:

- "I feel in my heart that there is no hope for Harlan. There's no hope for our children in the future here, and I hate that." Madonna Sizemore, Harlan, Kentucky.¹⁷
- "What hurts me more than anything else, is seeing people I've known and grown up with to have a future and then all of a sudden to have that future jerked out from underneath them -- with no hope." C.V. Bennett III, Harlan County, Kentucky coal miner.¹⁸
- "So many people are laid off. So many places are closing. People are hanging on with hope, and the hope is going away." Harlan County, Kentucky, Clerk Donna Hoskins.¹⁹
- "Many of our people have simply given up looking for jobs. They have lost their homes, their cars, their dreams, and their hope." William Raney, president, West Virginia Coal Association.²⁰
- "I just really wish that the people who make these drastic decisions lived in our communities for a while." Valerie Nagel, Union Township, Ohio firefighter.²¹

Ms. Nagel's sentiment that policymakers in Washington are far removed from the problems facing people in coal communities was clearly articulated by U.S. Congressman Tim Murphy from Pennsylvania in opening a Congressional hearing on the impact of the decline of coal: "Our witnesses today can speak to what the coal industry means to coal-reliant regions like eastern Kentucky, West Virginia, Pennsylvania, and western Colorado.

¹⁷"Deep in Coal Country and Pondering the Future Without it," *USA Today*, <https://www.usatoday.com/story/money/business/2014/12/06/coal-mining-future/20003199/>.

¹⁸Ibid.

¹⁹"Coal Jobs and Production Fell Sharply in Eastern Kentucky and Western Kentucky in 2015," *Lexington Herald Ledger*, <http://www.kentucky.com/news/state/article57684253.html#storylink=cpy>.

²⁰"Coal Dependent States Lose Jobs and Gain Drug Addiction. What to do?" *Forbes*, <https://www.forbes.com/sites/kensilverstein/2016/01/03/coal-dependent-states-lose-jobs-and-gain-drug-addiction-what-to-do/2/#735b817345df>.

²¹"Closing of Power Plants Expected to Have Ripple Effect For Other Businesses in Union Township," *Pittsburgh Post-Gazette*, <http://www.post-gazette.com/business/businessnews/2013/07/21/Closing-of-power-plants-expected-to-have-ripple-effect-for-other-businesses-in-Union-Township/stories/201307210265/>.

For some of these communities, what happens here in Washington is the difference between a decent living and poverty.”²²

The continuing litany of coal company bankruptcies and mine closures is a somber background to the continuing and escalating social and economic difficulties that face coal communities, ranging from drastic declines of tax revenues, outmigration of working age population, declining birth rates, school closures, breakdown of community services, and increases in such social problems as drug abuse. William Raney, president of the West Virginia Coal Association has linked drug abuse in coal communities with the well-publicized opioid epidemic. Indeed, drug abuse is becoming a bane across the country, and coal country is no exception. According to an analysis by the Kentucky Injury Prevention and Research Center, in 2013 Kentucky had the second-highest number of drug overdoses per 100,000 people in the U.S. West Virginia had the highest. In fact, total statewide drug overdose deaths in Kentucky have increased a stunning 347%, from 241 in 2000 to 1,077 in 2014. Overdose rates in eastern Kentucky counties are some of the highest in the nation, with the majority of overdoses there caused by prescription drugs commonly used to treat pain, anxiety, and insomnia.²³

It is important that the loss of coal mining jobs be considered in the context of the quality of such jobs: Jobs in the coal industry are some of the highest paying positions in the coal regions. In regard to the central Appalachian states, Phil Smith, of the United Mine Workers Association, has pointed out coal jobs are "by orders of magnitude the best job out there." For example, as discussed, in Section III, in Belmont County, Ohio the average weekly wage of a service job is about \$575, whereas coal miners earn \$1,600 per week – three times as much.²⁴ Further, these relatively higher-paying jobs have multiplicative effects that ripple throughout the community. As New Mexico’s San Juan County CEO Kim Carpenter stated: "It's going to be a major blow to this area, as seven out of 10 taxpayers in San Juan County are related to the power industries."²⁵ Thus, the loss of these jobs in the coal industry, with their much higher than average remuneration, has significant effects throughout local economies. As David Hardwood, mayor of Galatia, Illinois stated, "It impacts everybody. It doesn't just impact coal miners. It impacts trucking businesses, the stores, all their vendors. It's not just one segment. Down here, we're all tied together."²⁶

The increase in poverty associated with coal job losses has been well documented and recognized broadly with no area more representative than eastern Kentucky. The

²²U.S. Government Publishing Office, <https://www.gpo.gov/fdsys/pkg/CHRG-113hhr87546/html/CHRG-113hhr87546.htm>.

²³"Drug Overdoses Climb to Record Level in Kentucky in 2015," *Lexington Herald Ledger*, <http://www.kentucky.com/news/state/article83770067.html>.

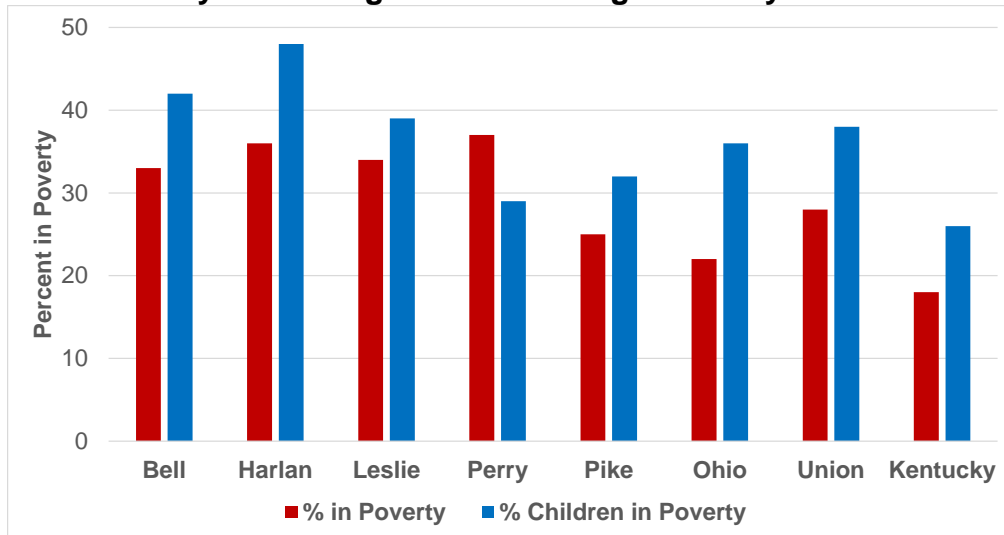
²⁴Ibid.

²⁵"PNM Looks at Possible Power Plant Closure in 2022," *Farmington Daily Times*, <http://www.daily-times.com/story/money/industries/coal/2017/03/16/pnm-looks-possible-power-plant-closure-2022/99276420/>.

²⁶"With New Era Mine Closing Galatia Residents Brace For Bust," *The Southern Illinoisan*, http://the-southern.com/news/local/communities/harrisburg/with-new-era-mine-closing-galatia-residents-brace-for-bust/article_a341f620-8c03-5845-b20e-c8f18dc44c17.html.

continuing waves of coal mine closures, coupled with the rise of poverty, is a somber background to the continuing and escalating social and economic difficulties that face coal communities. In this region, 26 of 31 counties are considered “distressed” by the Appalachian Regional Commission, a designation based on continued high unemployment rates, low per capita income, and high poverty rates.²⁷ In many counties in eastern Kentucky poverty rates exceed 30 percent, and child poverty rates approach 50 percent²⁸ – Figure II-4.

Figure II-4
Poverty in Leading Coal Producing Kentucky Counties



Source: U.S. Census Bureau.

There is little doubt that the vast wave of coal company bankruptcies and coal mine closures has had a devastating effect on the numerous communities throughout the U.S. that are dependent on coal. Generations of residents of these communities have been dependent on coal for their livelihood, and the security and benefits of their livelihood are disappearing before their eyes. These communities simply do not have the infrastructure to handle such major changes in so short an amount of time. The onslaught of stringent coal regulations coupled with competition from natural gas have converged to have debilitating impacts on established communities. Salient examples include:

- Although Pennsylvania and other nearby regions are also home to shale gas operations, coal miners may not be getting many of those jobs. For example, Phil Smith (UMWA) stated "If you drive around Kentucky, you are seeing a lot of license plates from Texas and Oklahoma. The locals aren't getting those jobs."²⁹

²⁷Federal Reserve Bank of Cleveland, “Eastern Kentucky: A Region in Flux,” <https://www.clevelandfed.org/newsroom-and-events/publications/forefront/ff-v7n01/ff-20160302-v7n0105-eastern-kentucky-a-region-in-flux.aspx>.

²⁸<https://kylmi.ky.gov/admin/gsipub/htmlarea/Uploads/Handout%20-%20Poverty%20-%202022%20pages%20-%20Poverty%20by%20Age%20by%20ADD%20by%20County%20-%202010-2014%20ACS.pdf>.

²⁹CNBC, “What Shuttering Coal Plants Means For Energy Jobs,” <http://www.cnbc.com/2015/04/13/what-shuttering-coal-plants-means-for-energy-jobs.html>.

- In 2014, Arch Coal, parent company of Cumberland River Coal Co., announced plans to idle its Appalachia, Virginia mine and lay off 213 workers, a devastating final blow to the town of 1,800. That followed a similar move by A&G Coal Co., once one of the region's biggest employers.³⁰
- "This is going to be a ghost town. All we're missing is the tumbleweeds." Melissa DiNunno, owner of Paesano Italian Cuisine in Washington County, Pennsylvania.³¹

The decline of the coal industry has significantly reduced the quality of life in West Virginia; for example:³²

- Boone County has lost 2,700 coal mining jobs since 2011, the most of any county in the U.S. The county received \$5.5 million in coal-severance tax money in 2010 but only \$1.5 million in 2016. Boone County is closing three of its 10 elementary schools. The bankruptcies of the major coal producers have left the County with \$8 million in uncollected property taxes overall.
- Mingo County has an unemployment rate of 12.5 percent. The Mingo County school district property tax base declined 40% by 2017, from \$22.6 million to \$13.6 million. This decline has led to the laying off 48 teachers and elimination of almost all extra-curricular activities. The County government has also eliminated or reduced support for fairs, libraries, fire departments, parks, and ambulance services.
- The Logan County unemployment rate is 10.7 percent. The county has lost over \$200 million in coal property valuations. Coal company bankruptcies have cost the district \$2.6 million in unpaid property taxes.
- Kanawha County suffered a 25 percent decrease in coal severance receipts. This necessitated cuts to outside agencies and a cut in pay for county elected officials. Services experiencing cuts included fire services, police services, and the health department.

II.C. Impacts of Reduced Severance Taxes

In addition to the steady decline associated with reduced economic activity and jobs, one of the major drivers of community problems in coal country is the continuing decline in severance tax revenues.³³ Coal producing states typically obtain a significant portion of their revenue from severance taxes and utilize those revenues to support governmental activities, improve infrastructure, and enable counties to provide

³⁰Fox News US, "Losing the War on Coal: One Virginia Town's Painful Decline," <http://www.foxnews.com/us/2014/10/19/losing-war-on-coal-one-virginia-town-painful-decline.html>.

³¹"Closing of Power Plants Expected to Have Ripple Effect For Other Businesses in Union Township," op. cit.

³²Dr. Emilia Istrate, "The Cruel Coal Facts: The Impact on West Virginia Counties From the Collapse of the Coal Economy," <http://docplayer.net/29161211-The-cruel-coal-facts-the-impact-on-west-virginia-counties-from-the-collapse-of-the-coal-economy.html>.

³³A severance tax is one imposed on a nonrenewable resource that is "severed" or extracted within a specified taxing jurisdiction.

community services. Kentucky collects a severance tax on coal at a rate of 4.5% of the gross value of mined coal in the state. Revenue from this tax is distributed as follows:

- 50% is allocated to Kentucky's general fund.
- 35% is allocated to the local government economic development fund, where it is available as grants for eligible counties to use on projects helping to diversify their economies.
- 15% is allocated to local government economic assistance funds, which are revenue-sharing funds that cities and counties in coal-impacted regions receive automatically.

The marked decline in coal production in recent years has reduced severance tax revenues available to Kentucky's General Fund and to coal counties, straining already tight state and local budgets even further. In 2015, coal severance tax receipts totaled only 62% of 2009 receipts, and the forecast for the biennium estimates is that in 2018 they will decline by \$185 million from 2009 receipts.³⁴ The Kentucky Center for Economic Policy has warned that the 62% drop in state coal severance tax receipts in 2015 would have long-term implications and jeopardize the ability of counties and institutions to fulfill their obligations to education, health and human services, parks, county jails, fire and rescue, and sanitation.³⁵ In Letcher County, Kentucky, where two-thirds of the coal jobs were lost in 2015, a 65% decline in coal severance tax revenues has forced the county to severely reduce services. The county once received \$400,000 to \$600,000 a quarter from the tax, but received only \$170,000 in the most recent quarter. The county was forced to close five senior citizen centers, it transferred the recycling center to the city of Whitesburg, raised the tax on garbage collection, cut out overtime and funding to the sheriff's office, and stopped funding community centers.³⁶

Similar declines and local impacts have taken place in virtually all states with coal severance taxes. For example:

- Boyd County, Kentucky suffered a 50% drop in severance taxes, leading to drastically reduced funds to nonprofit agencies such as child advocacy agencies.
- The Wise County, Virginia severance tax collections in 2008 were \$12.8 million. By 2016 they had declined to \$2.4 million -- a decrease of over 80%.³⁷
- Delta County, Colorado warned it faces a \$70 million payroll loss as well as reduced property taxes to fund schools, libraries, communities, and county

³⁴Kentucky Center for Economic Policy, "Coal County Services Harmed by Severance Tax Collapse at Time of Transition," <http://kypolicy.org/coal-county-services-harmed-by-severance-tax-collapse-at-time-of-transition/http://revenue.ky.gov/Pages/index.aspx,Coal> ;Past, Present and Future

³⁵Ibid.

³⁶*The Daily Independent*, "Coal Severance Expected to Decline," http://www.dailyindependent.com/news/localnews/coal-severance-expected-to-decline/article_aef8339e-d9f6-5348-97af-0f931e770492.html.

³⁷U.S. Conference of Mayors, "Coal's Decline Has Knocked a Big Chunk of Revenue From This County's Budget," <http://www.routefifty.com/2016/07/wise-county-virginia-coal-budget/129813/>.

operations. The loss of property tax revenues from just one mine (Bowie) exceeded \$1.2 million.³⁸

- The Greene County, Pennsylvania assessment office warned municipalities and school districts that their new annual budgets should reflect a \$50 million decline in county property assessments.³⁹

Decreasing tax revenues combined with the continuing outmigration of young families has placed the public school system in jeopardy in many communities, leading to layoffs of teachers, closures of schools, and curtailment of both academic and extracurricular activities due to lack of funds to renovate buildings and purchase appropriate educational materials. These adverse impacts have been widespread throughout coal country, and the potential impact of coal's decline on the next generation is especially troubling; for example:

- Eight coal field school districts in southern Virginia lost over 2,200 students in three years. Dickinson County alone lost \$10 million in tax revenue during the 2016 fiscal year.⁴⁰
- Northern West Virginia school districts eliminated 276 teaching positions in just one year, as tax revenues fell from \$8 million to \$4 million.⁴¹
- 12 school districts in Eastern Kentucky will lose \$4.3 million this year with the decline of the severance tax revenues. The Knott County school district alone will lose \$1 million.⁴²
- The South Routt County, Colorado school district lost \$1 million in property taxes when the Twentymile coal mine could not pay its property taxes.⁴³

The impact of decreasing severance tax revenues does not stop at high school. For example, due at least in part to declining severance tax revenues the state of Kentucky has significantly reduced its budget allocation for higher education over the past decade – Figure II-5. State officials fear that these major reductions in state allocations to college budgets, coupled with widespread unemployment and underemployment, are in danger of putting a college education out of reach for many high school graduates.⁴⁴

³⁸*Delta County Independent*, "Conversation Highlights the Human Impact of Layoffs," <http://www.deltacountyindependent.com/coal-conversation-highlights-the-human-impact-of-layoffs-cms-3703>.

³⁹National Public Radio, "Decreased Local Value Hurts Greene County's Tax Base," <https://stateimpact.npr.org/pennsylvania/2012/11/27/decreased-coal-value-hurts-greene-countys-tax-base/>.

⁴⁰*The Roanoke Times*, "Will Richmond Do Anything About the School Funding Crisis?" http://www.roanoke.com/opinion/editorials/editorial-will-richmond-do-anything-about-the-school-funding-crisis/article_b28e1a67-71da-5011-93ab-1bb6533b73c3.html.

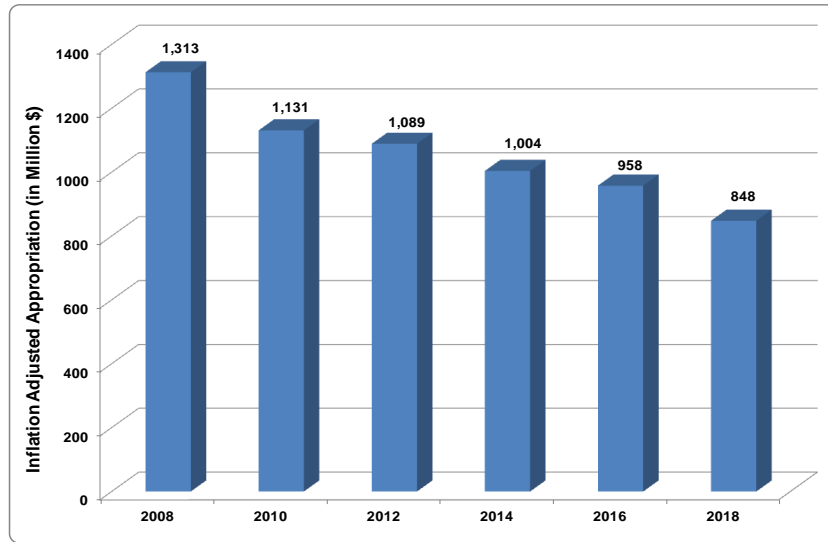
⁴¹"West Virginia is About to Lay Off Hundreds of School Employees," <http://weheartwv.com/2016/03/03/west-virginia-school-layoffs/>.

⁴²*Lexington Herald Ledger*, "Coal Industry's Decline Mean Less Tax Money for School Districts," <http://www.kentucky.com/news/local/education/article131512139.html>.

⁴³*Denver Post*, "Coal Giants Hiccup Causes Turmoil in Dependent Colorado Towns," <http://www.denverpost.com/2016/06/23/coal-giants-hiccup-causes-turmoil-in-dependent-colorado-towns/>.

⁴⁴Kentucky Center For Economic Policy, "Governor's Budget Proposal Would Worsen College Affordability," <http://kypolicy.org/governors-budget-proposal-would-worsen-college-affordability>.

**Figure II-5
Decline in Kentucky Postsecondary School Funding**



Source: Kentucky Center for Economic Policy

II.D. Coal and the Railroads

The U.S. is connected by the best freight railroad system in the world. For two centuries, freight railroads have linked businesses across the nation and played a cornerstone role in the nation’s economic development. Critically, as noted by the American Association of Railroads, “No single commodity is more important to America’s railroads than coal.”⁴⁵

Nearly 600 freight railroads operate in the U.S. The seven “Class I” railroads, with revenue of at least \$450 million (BNSF, CN, CO, CSX, KCS, NS, and UP), account for about 70% of freight rail mileage, 90% of employees, and 94% of revenue. Each Class I railroad operates in multiple states with thousands of miles of track. Total operating revenue for Class I railroads in 2016 exceeded \$65 billion.⁴⁶ Non-Class I railroads (short line and regional railroads) range in size from small operations handling a few carloads to multi-state companies close to Class I size. Together, these firms earn several billion dollars in revenue annually.

Freight railroads operating in the U.S. form an integrated, 140,000-mile system that provides the world’s safest, most productive, and lowest-cost freight rail service. The U.S. leads the world in freight rail at 1,770 billion ton-miles in 2014, followed by China and Russia with 1,373 billion ton-miles and 1,290 billion ton-miles, respectively. Europe had only 240 billion ton-miles in freight rail. On average, five million tons of goods are

⁴⁵American Association of Railroads, “Freight Rail Traffic Data,” <https://www.aar.org/Pages/Freight-Rail-Traffic-Data.aspx#annualrailtraffic>.

⁴⁶American Association of Railroads, “Overview.” <https://www.aar.org/BackgroundPapers/Overview%20of%20America%27s%20Freight%20RRs.pdf>.

delivered using Class I Railroads each day. Coal transportation, the most important commodity for U.S. railroads, was responsible for 39 % of tonnage, 17 % of carloads, and 19% of revenue for all U.S. Class I Railroads in 2014.⁴⁷

In 2014 alone, the operations and capital investments of major U.S. freight railroads supported approximately 1.5 million jobs (1.1% of all U.S. workers -- nearly nine jobs for every railroad job), nearly \$274 billion in economic output (1.6 % of total U.S. output), and \$88 billion in wages (1.3% of total U.S. wages). Railroads also generated nearly \$33 billion in tax revenues. These impacts include direct, indirect, and induced effects across the U.S. economy.⁴⁸ Research has found that "Railroads maintain high paying jobs within the sector and create numerous jobs in related industries that collectively spur significant economic activity. Significant capital investments by railroads and the steady presence of a coast-to-coast network that can reliably deliver goods at a cost effective rate generates a ripple effect. Railroad spending means job growth, dollars to communities and global competitiveness."⁴⁹

The five major coal-transporting U.S. railroads are:

- BNSF Railway
- Canadian National Railway
- CSX Transportation
- Norfolk Southern Railway
- Union Pacific Railroad

Railroads derive more revenue from coal than from any other commodity. Coal accounts for, by far, the largest share of railroads' gross revenues – nearly 20%. However, more significant, coal accounts for up to 33% of railroad profits.⁵⁰ Using these revenue and profit averages, we estimate in Table II-1 the revenues and profits of these five railroads that are generated by coal.

The bottom line is that these five railroads in recent years derived about \$5 - \$6 billion in *profits* from coal. Thus:

- "As coal production and shipments go, so do rail profits."⁵¹
- "Union Pacific generates profits at a rate that rivals those of the best tech, pharmaceutical, and financial services companies. In 2014, Union Pacific posted

⁴⁷American Association of Railroads, "Railroads and Coal," <https://www.aar.org/BackgroundPapers/Railroads%20and%20Coal.pdf>

⁴⁸Ibid, Daraius Irani, Professor of Economics, Towson University, "New Report Finds Freight Railroads Greatly Impact National-Local Economies," www.aar.org/newsandevents/Press-Releases/Pages/New-Report-Finds-Freight-Railroads-Greatly-Impact-National-Local-Economies.aspx, and <https://www.aar.org/BackgroundPapers/Overview%20of%20America%27s%20Freight%20RRs.pdf>.

⁴⁹Daraius Irani, op. cit.

⁵⁰*U.S. News and World Report*, "Railroads Expected to Get Back On-Track In 2016," <http://money.usnews.com/investing/articles/2016-01-12/railroads-expected-to-get-back-on-track-in-2016>.

⁵¹Nomura Securities International, <http://money.usnews.com/investing/articles/2016-01-12/railroads-expected-to-get-back-on-track-in-2016>.

\$5.18 billion in net profits on sales of \$24 billion, for a return-on-revenues ratio of 21.6%. By that measure, the railroad company ties Apple (21.6%) and beats J.P. Morgan (21.3%), Goldman Sachs (21.1%), Intel (20.9%), Google (20.2%), and Pfizer (18.4%)."⁵²

- "BNSF hauls enough coal to power one of every 10 homes in the nation."⁵³
- "The railroads were the Internet stocks of the 1800s, but they still have pricing power and they're still vital to the economy. The rail industry will be back, it's just a matter of timing. We just need to have coal traffic stabilize."⁵⁴

Table II-1
Major U.S. Railroads and Their Dependence on Coal
(Dollars in billions)

RR	Annual Revenues	Annual Profits	Coal-Dependent Revenues	Coal-Dependent Profits
BNSF	\$22	\$4.2	\$4.4	\$1.40
CN	\$12.1	\$3.5	\$2.4	\$1.17
CSX	\$11.8	\$2.0	\$2.3	\$0.67
NSR	\$10.5	\$1.6	\$2.1	\$0.53
UP	\$24	\$5.2	\$4.8	\$1.73
Total	\$80.4	\$16.5	\$16.0	\$5.50

Source: Management Information Services, Inc.

As shown in Figure II-6, about 70% of coal transported in the United States is moved by rail. Another 13% is moved by barge and 11% by truck. In 2009, coal constituted almost 25% of total freight rail carloads. By 2015, coal's share fell to about 13% with projections that even fewer carloads would be loaded in future years – Figure II-7. In 2008, Class I railroads originated 7.7 million carloads of coal. By 2015 this figure had decreased 29% to 5.4 million carloads -- a decline of nearly 20,000 trainloads.⁵⁵

Given the importance of the coal industry to the railroad industry it is not surprising that the recent declines in coal production have had significant collateral adverse impacts on railroads.⁵⁶ Reduced freight cars of coal mean fewer jobs in the railroad industry and railroad industry jobs have a negative multiplicative impact on communities at large, since one job in the freight rail industry supports nine other jobs throughout the economy, including retail, manufacturing, transportation, and warehousing. As rail tons of coal and coal's share of freight car loads declined (Figures II-7, II-8, and II-9) so also did the

⁵²*Fortune*, "The Railroad With Better Profit Margins than Google," <http://fortune.com/2015/06/04/union-pacific-railroad/>.

⁵³*BNSF Fact Sheet*, 2016.

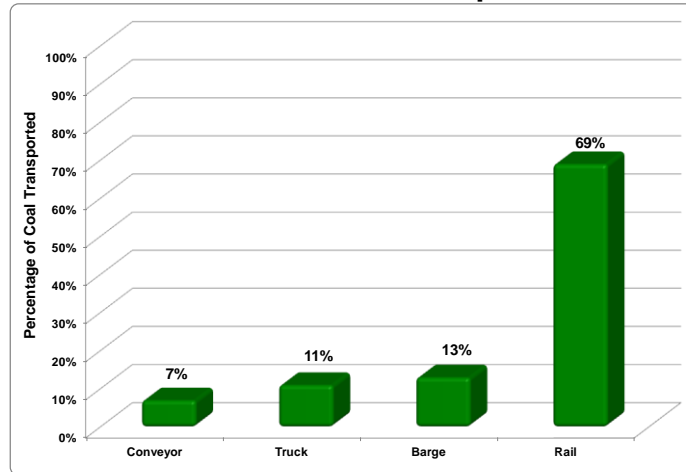
⁵⁴*Fortune*, "The Railroad With Better Profit Margins than Google," op cit.

⁵⁵"Coal in Decline," National Railway Labor Conference <http://raillaborfacts.org/coal-decline-impact-railroads/>.

⁵⁶National Coal Council, <http://www.nationalcoalcouncil.org/page-NCC-Studies.html>.

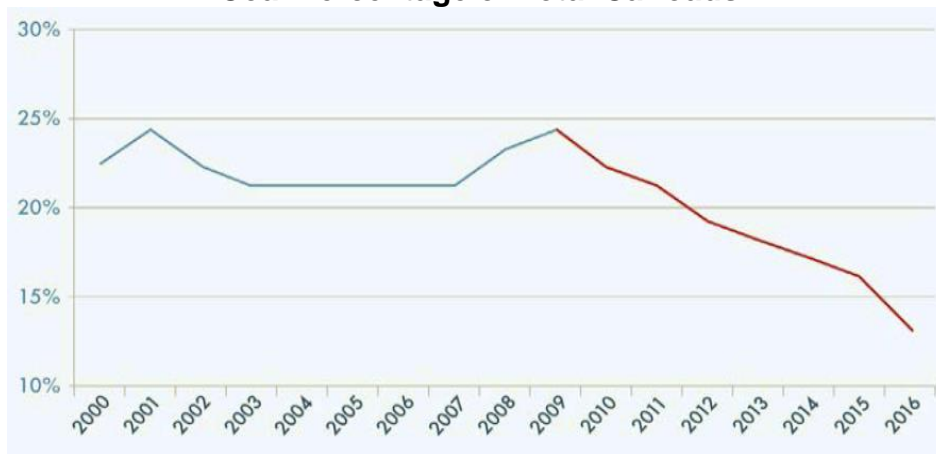
revenues generated by coal shipments.⁵⁷ In 2011 gross revenue from coal for Class I railroads was \$16.4 billion. By 2015 revenue from core had declined over 25 % to \$12.1 billion.

Figure II-6
The Modes of Coal Transportation



Source: National Railway Labor Conference

Figure II-7
Coal Percentage of Total Carloads



Source: National Railway Labor Conference

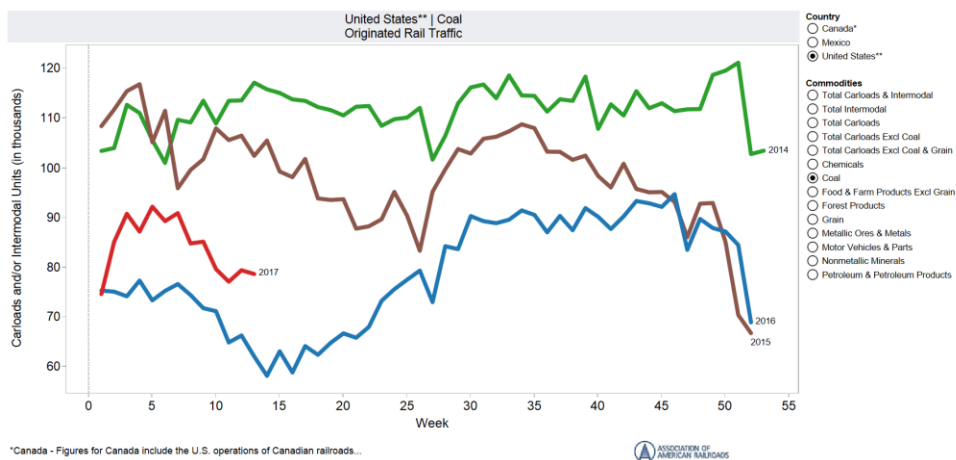
⁵⁷American Association of Railroads, "Freight Rail Traffic Data," op. cit.

Figure II-8
Class 1 Rail Tons of Coal



Source: American Association of Railroads.

Figure II-9
Coal Rail Traffic, 2014-2017



Source: American Association of Railroads.

Rail transportation and coal-fired power generation are heavily interdependent, with railroads accounting for 70 percent of coal shipments to power plants, and coal accounting for about 20 percent of rail business. Alternative shipping methods include truck, barge, and conveyor. Truck shipping is considered uneconomical beyond 50 miles; barges are limited by the reach of navigable waterways; conveyors only work in cases where the mine is adjacent to the plant. Coal's share of U.S. electricity generation has fallen sharply in recent years, and rail coal traffic has suffered accordingly. In 2008, the peak year for U.S. rail coal traffic, Class I railroads originated 7.7 million carloads of coal. In 2015, they originated 5.4 million carloads, down 29% -- nearly 20,000 fewer trainloads of coal in 2015 than in 2008.⁵⁸

⁵⁸American Association of Railroads, "Railroads and Coal," op. cit.

Further, lower revenues for railroads forced railroads to reduce planned expenditures and investments in infrastructure. For example, Union Pacific plans to spend \$3.75 billion on capital improvements in 2017 -- down 13% from its recent \$4.3 billion expenditure. At the same time, BNSF reduced its capital spending plans by 26% - from \$5.8 billion to \$4.3 billion. Such decisions are being made throughout the industry and have adverse impacts on employment in other sectors of the economy.⁵⁹

These declines in revenues and capital spending have led to substantial job losses. Railroads have been steadily laying off workers and closing terminals as coal cargos decline.⁶⁰ In 2016 alone, over 8,600 railroad workers lost their jobs, signifying an almost 4% decline in industry employment in just one year. The approximately 170,000 freight railroad employees are among America's most highly compensated workers. In 2015, the average U.S. Class I freight railroad employee earned wages of \$86,300 and fringe benefits of \$34,600, for total average compensation of \$120,900. By contrast, the average wage per full-time equivalent U.S. employee in domestic industries in 2015 was \$59,400 (just 69% of the comparable rail figure) and average total compensation was \$73,300 (just 61% of the rail figure).⁶¹

⁵⁹*Omaha World Herald*, "Freight Volume Decline Continues," http://www.omaha.com/money/buffett/railroads-freight-volume-decline-continues/article_d4bcf113-b469-507d-b12c-28c60b68c89f.html.

⁶⁰National Railway Labor Conference, "Coal in Decline: The Impact on Railroads," <http://raillaborfacts.org/coal-decline-impact-railroads/>.

⁶¹American Association of Railroads, "Overview," *op. cit.*; American Association of Railroads, "Economic Impact of U.S. Freight Railroads," [https://www.aar.org/BackgroundPapers/Economic %20 Impact %20of %20US%20Freight%20Railroads.pdf](https://www.aar.org/BackgroundPapers/Economic%20Impact%20of%20US%20Freight%20Railroads.pdf).

III. THE JOB IMPACTS OF THE U.S. COAL INDUSTRY

III.A. U.S. Coal Mining Jobs

U.S. employment in coal mining peaked in 1923, when there were 863,000 coal miners. Since then, mechanization has greatly improved productivity in coal mining, so that employment has declined at the same time coal production increased. As shown in Figure III-1, the average number of coal mining employees declined from 174,000 in 1985 to about 65,000 in 2015. This was below the previous low of 70,000 in 2003, and the lowest number of U.S. coal miners in at least 125 years.

Figure III-1
Average Annual Number of U.S. Coal Miners, 1985 To 2015

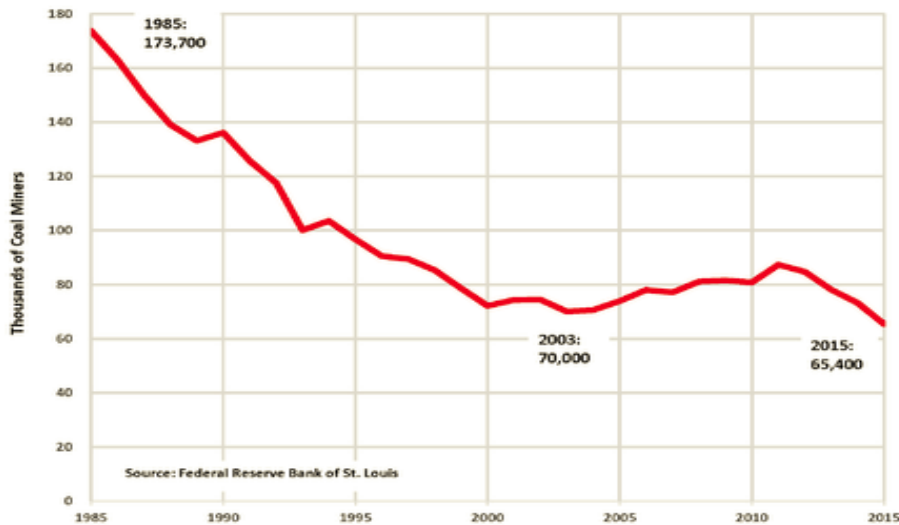
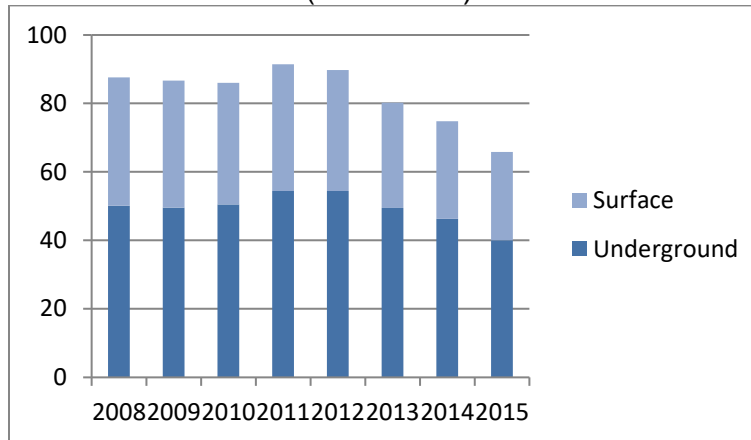


Figure III-2 shows that underground mining jobs comprise the majority of U.S. coal mining jobs. In 2008, they comprised about 61% of the jobs, and in 2015 about 58% of the jobs.

Table III-1 shows coal mining employment by state in 2011 and 2015. This table shows that West Virginia has the most coal mining jobs, followed by Kentucky, Pennsylvania, Wyoming, Illinois, Indiana, Alabama, and Virginia. Alaska, Arkansas, Kansas, Missouri, and Oklahoma have very few coal mining jobs.

Figure III-2
U.S. Coal Mining Employment by Mine Type, 2008-2015
(thousands)



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

Table III-1
Coal Mining Employment by State, 2011 and 2015

State	2011	2015	Change '11-'15
Alabama	4,756	3,212	-32%
Alaska	136	113	-17%
Arizona	419	403	-4%
Arkansas	70	75	7%
Colorado	2,405	1,642	-32%
Illinois	4,105	4,146	1%
Indiana	3,540	3,311	-6%
Kansas	8	7	-13%
Kentucky	18,634	9,821	-47%
Louisiana	259	307	19%
Maryland	488	359	-26%
Mississippi	224	330	47%
Missouri	26	15	-42%
Montana	1,251	1,330	6%
New Mexico	1,292	1,130	-13%
North Dakota	1,169	1,261	8%
Ohio	3,006	2,309	-23%
Oklahoma	184	161	-13%
Pennsylvania	8,665	6,633	-23%
Tennessee	505	276	-45%
Texas	2,936	2,689	-8%
Utah	1,797	1,211	-33%
Virginia	5,261	2,993	-43%
West Virginia	23,307	15,490	-34%
Wyoming	7,039	6,635	-6%
Refuse Recovery	129	112	-13%
Total	91,611	65,971	-28%

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

The driving force of these community problems lies in the critical loss of coal related jobs that impact local areas. It is one thing to look at tables and statistics on the rapid decline of coal jobs over the past five years, but it is another to actually identify smaller, but very important, examples of what is happening virtually every week in coal communities across the nation. For example:

- Wyoming. In March 2016, the two largest coal mines in the U.S. announced massive layoffs. Peabody Energy cut 235 people at North Antelope Rochelle, or 15 percent of the workforce at America's largest mine. Arch Coal said it was cutting 15 percent, or 230 people, at its Black Thunder Mine near Wright.⁶²
- Pennsylvania. In July 2012, PBS Coals Inc. and its affiliate company, RoxCoal Inc., laid off about 225 workers as part of an immediate idling of some deep and surface mines in Somerset County.⁶³
- Illinois. In February 2016, Alliance coal announced the layoffs of 275 people in White and Hamilton Counties.⁶⁴
- Alabama. In October 2015, North American Coal Corporation officially closed its Jasper operations, making it the most recent in a series of layoffs impacting Alabama's coal industry. The closure will impact 118 workers, according to federal WARN notices filed with the Alabama Department of Commerce.⁶⁵
- Indiana. In May and June 2016, Triad Mining LLC permanently terminated about 75 employees of its Freeland Mine operations in Edwardsport, effectively idling the complex. In January 2016, Vigo Coal Co. announced that it would lay off 66 employees in Indiana and Illinois. In November 2016, Gibson County Coal LLC notified Indiana officials it would idle production at the Gibson Mine in Princeton, eliminating 120 jobs. In October 2016, United Minerals Co. LLC and UMI LLC announced 138 layoffs at several mines in southeast Indiana.⁶⁶

III.B. Coal Mining Jobs in Appalachia

Figure III-3 shows EIA's U.S. coal supply regions. Accordingly, here we define Appalachian coal as that mined in the states of Alabama, Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia.⁶⁷

⁶²http://trib.com/business/energy/wyoming-s-two-largest-coal-mines-announce-layoffs/article_0d217a3a-5a9d-5b1d-8d0d-8a5081724bb2.html.

⁶³<http://www.post-gazette.com/business/businessnews/2012/07/21/Two-coal-companies-downsize/stories/201207210107?pgpageversion=pgevoke>.

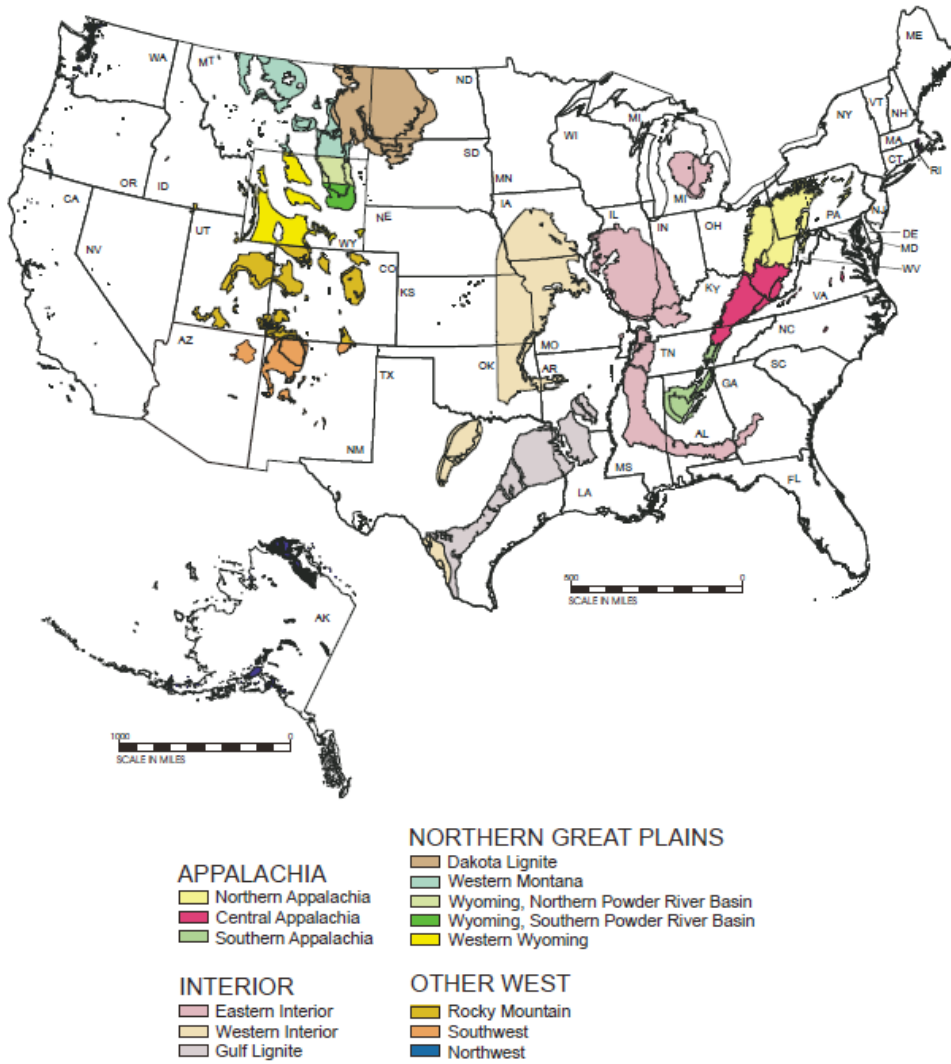
⁶⁴<http://ieefa.org/275-layoffs-at-alliance-coal-in-illinois/>.

⁶⁵<http://www.bizjournals.com/birmingham/news/2015/10/23/more-layoffs-hit-alabama-coal-industry-in-jasper.html>.

⁶⁶<https://www.ibj.com/articles/57919-continued-coal-layoffs-in-indiana-mirror-dire-state-of-industry>.

⁶⁷The Appalachian Regional Commission includes Mississippi as part of Appalachia. Here MISI does not, in order to be consistent with EIA conventions. Coal mining employment in Mississippi is less than 0.5% of the U.S. total. The Appalachian region also includes parts of Georgia, New York, North Carolina, and South Carolina, but there are no coal mining jobs in these states.

**Figure III-3
U.S. Coal Supply Regions**



Source: EIA

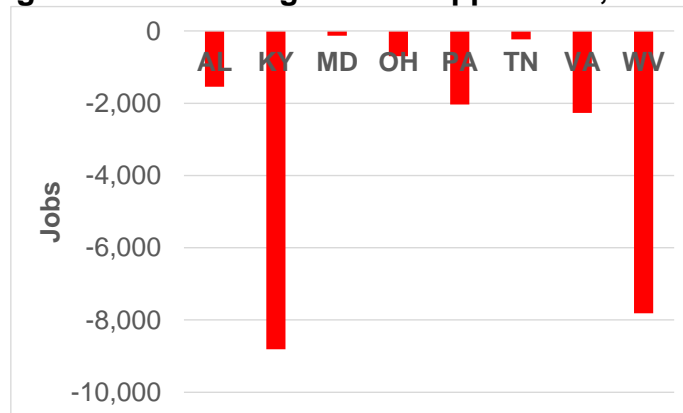
Coal mining employment in Appalachia has decreased significantly and rapidly since 2011. In the five year period 2011 – 2015, Appalachia lost more than 23,500 coal mining jobs -- 36% of its total. By contrast, Table III-1 shows that nationwide over the same period coal mining jobs decreased 28%.

As shown in Table III-2, Figure III-4, and Figure III-5, 71% of the Appalachian coal mining job losses were concentrated in two states: Kentucky (more than 8,800 jobs lost) and West Virginia (more than 7,800 jobs lost).

**Table III-2
Appalachian Coal Mining Employment by State, 2011 and 2015**

	2011	2015
AL	4,756	3,212
KY	18,634	9,821
MD	488	359
OH	3,006	2,309
PA	8,665	6,633
TN	505	276
VA	5,261	2,993
WV	23,307	15,490
Total	64,622	41,093

**Figure III-4
Changes in Coal Mining Jobs in Appalachia, 2011-2015**

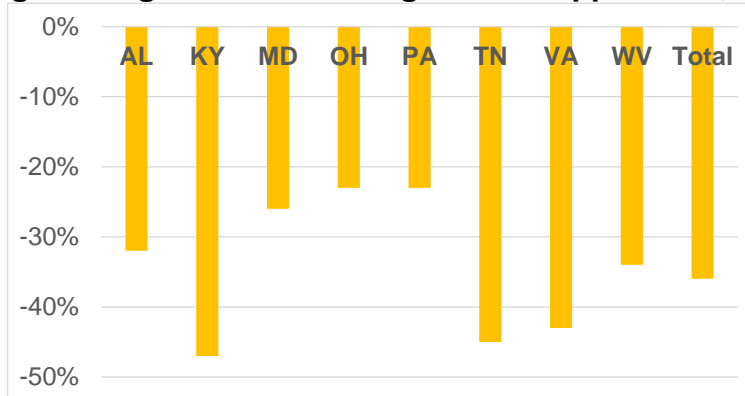


Source: U.S. Mine Safety and Health Administration.

Figure III-5 shows the percentage of coal jobs lost in each state between 2011 and 2015. This figure illustrates that, in percentage terms:

- Kentucky, Tennessee, and Virginia lost more than 40% of their coal mining jobs.
- West Virginia and Alabama lost in excess of 30% of their coal mining jobs.
- Maryland, Ohio, and Pennsylvania lost more than 20% of their coal mining jobs.
- In total, Appalachia lost 36% of its coal mining jobs.

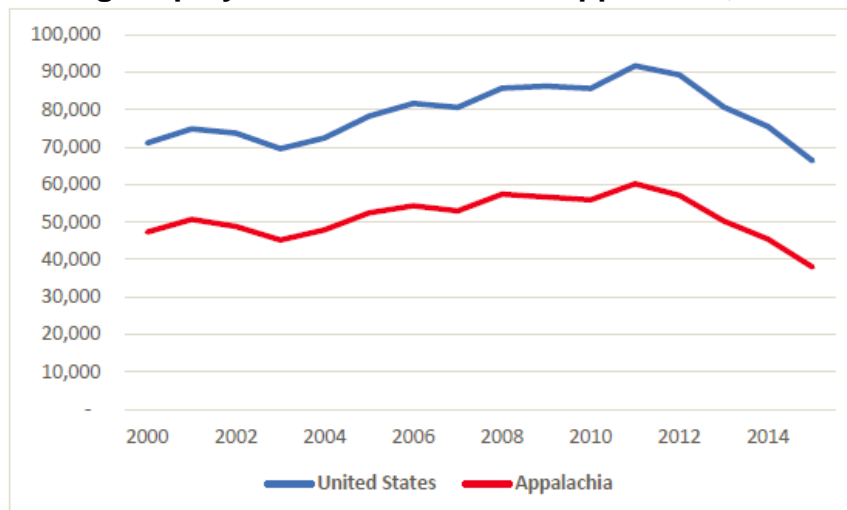
Figure III-5
Percentage Changes in Coal Mining Jobs in Appalachia, 2011-2015



Source: U.S. Mine Safety and Health Administration.

As shown in Figure III-6, since 2000 the total number of coal mining jobs in the Appalachian Region closely tracked the national trend. Appalachia contained about two-thirds of all U.S. jobs in coal mining production from 2000 to 2011, since coal mining is more labor intensive in Appalachia than the western and interior regions. However, with the rapid decline in Appalachian coal mining jobs since 2011, the Appalachian share of all U.S. coal jobs declined to 57 percent in 2015, its lowest point in at least 15 years. As noted, while the U.S. lost 28 percent of coal mining jobs from 2011 to 2015, coal mining jobs in Appalachia decreased by 36 percent.

Figure III-6
Coal Mining Employment in the U.S. and Appalachia, 2000 to 2015

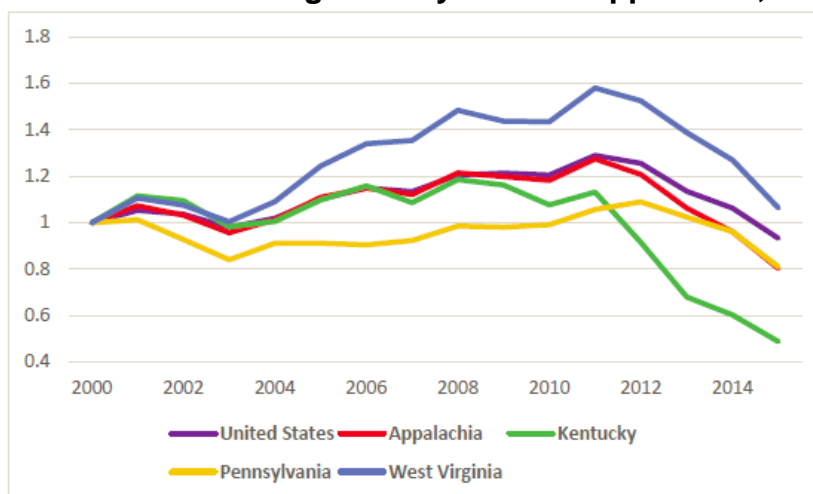


Source: U.S. Mine Safety and Health Administration.

Nevertheless, Appalachia still generates the majority of coal mining jobs nationwide, with the Illinois Basin and the Western Region each accounting for fewer than 20,000 jobs. The majority of coal mining jobs in Appalachia are in the Central and Northern regions – see Table 3-1 and Figure III-3.

The overall trend from 2000 to 2015 reveals interesting year-to-year dynamics that vary among the largest coal-producing Appalachian states, as shown in Figure III-7. For example, West Virginia experienced a significant increase in jobs between 2003 and 2011, but with a rapid decline in jobs between 2011 and 2015. In fact, the decrease in coal mining jobs in the state over the past few years (more than 7,800) was so severe that by 2015 the number of coal jobs in the state had declined to about the level of the year 2000. Other states saw relatively flat coal mining job growth during the 2000s, but experienced substantial job losses between 2011 and 2015. That is, of the 25,400 coal mining jobs lost in the U.S. from 2011 to 2015, 93 percent were in Appalachia, a regional loss of 23,530 direct jobs in mining (not including indirect job losses).

Figure III-7
Growth Index of Coal Mining Jobs by State in Appalachia, 2000 - 2015



Source: U.S. Mine Safety and Health Administration.

However, as shown in Table III-3 and Figure III-8, about one-third of total coal mining employment is comprised of contractors and these jobs data are not included in most estimates of coal mining employment. Unfortunately, these estimates are not available at the state or county level, but only at the national level.⁶⁸

⁶⁸The U.S. Mine Safety and Health Administration cannot present contractor employment below the national level. Therefore, the widely used coal jobs estimates attributed to either a county or state reflect operator employment only, and exclude contractors. See U.S. Department of Labor, Mine Safety and Health Administration, “Coal Mine Employment by State (CY 2009 - 2015),” June 2017.

Coal and mineral mining contractor employment data are collected by company in the U.S. Mine Safety and Health Administration mine safety survey, not by mine. Thus, for example, there is no differentiation for an engineering company that may have its corporate headquarters office in Morgantown, West Virginia and how many employee-hours were spent in mines in West Virginia, Virginia, Pennsylvania, or Ohio mines -- all of which may be within 50 miles of the corporate headquarters office.

Table III-3

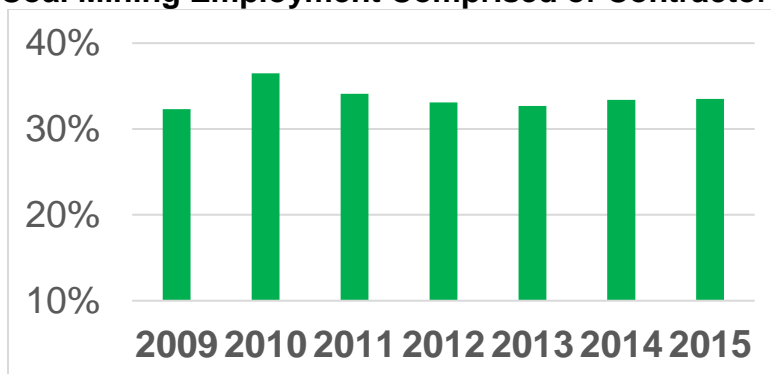
Coal Mine Employment by State* (CY 2009 - 2015)							
State	CY 2009	CY 2010	CY 2011	CY 2012	CY 2013	CY 2014	CY 2015
AK	119	127	136	145	127	123	114
AL	4,415	4,520	4,877	5,114	4,362	3,858	3,300
AR	46	52	94	74	70	111	103
AZ	425	422	419	432	405	387	403
CO	2,459	2,320	2,438	2,537	2,185	1,831	1,648
IL	3,777	3,814	4,307	4,587	4,264	4,226	4,171
IN	3,486	3,481	3,679	3,943	3,757	3,926	3,369
KS	31	36	8	6	6	10	12
KY	19,665	18,798	19,384	16,925	13,414	12,306	10,276
LA	263	264	266	270	278	298	307
MD	424	461	529	491	421	408	387
MO	23	23	26	32	24	20	15
MS	200	232	255	254	309	323	330
MT	1,168	1,207	1,252	1,234	1,247	1,318	1,329
ND	1,037	1,114	1,169	1,233	1,241	1,292	1,313
NM	1,424	1,400	1,403	1,372	1,293	1,175	1,133
OH	3,121	2,932	3,132	3,232	3,214	2,995	2,416
OK	265	218	193	212	204	183	164
PA	8,076	8,175	8,655	8,913	8,412	7,863	6,690
TN	800	630	545	388	327	278	317
TX	2,580	2,796	2,950	2,934	2,891	2,806	2,768
UT	2,031	1,866	1,865	1,644	1,486	1,413	1,308
VA	4,800	5,149	5,458	5,271	4,783	3,946	3,200
WA	65	65	60	42	41	30	35
WV	23,081	22,474	24,729	24,216	21,587	19,714	16,662
WY	7,045	6,861	7,039	7,034	6,697	6,635	6,654
Total Operator Employment*	90,826	89,437	94,868	92,535	83,045	77,475	68,424
Total Contractor Employment*	43,483	46,648	49,083	45,811	40,401	38,826	34,456
TOTAL*	134,309	136,085	143,951	138,346	123,446	116,301	102,880

*Employment statistics are comprised of two cohorts: (1) operator employment and (2) contractor employment. Since contractor employment statistics are collected on a more aggregate level than that of operator employment, MSHA cannot present contractor employment at the county or state level. Therefore, employment numbers attributed to either a county or state reflect operator employment only; and, contractor employment is exclusively represented, in total, for its respective calendar year or quarter.

Source: U.S. Mine Safety and Health Administration.

Exclusion of these contractor employment estimates from the state estimates represents a serious undercount of coal mining jobs. For example, in 2015 contractors accounted for 34% of all coal mining jobs – Figure III-8. To remedy this undercount and to provide more robust estimates of coal mining jobs by state in Appalachia, we prorated the contractor jobs to each of the states in Appalachia according to the percentage that contractor jobs comprised of the national total in each year.⁶⁹ The results of this procedure are given in Table III-4.

Figure III-8
Percent of Coal Mining Employment Comprised of Contractors, 2009-2015



Source: U.S. Mine Safety and Health Administration.

Table III-4
Appalachian Coal Mining Employment by State, 2009-2015*

	2009	2010	2011	2012	2013	2014	2015
AL	6,525	6,879	7,398	7,645	6,842	5,791	4,963
KY	29,065	28,611	29,406	25,302	19,313	18,471	15,455
MD	627	702	802	734	626	612	582
OH	4,613	4,463	4,751	4,832	4,776	4,495	3,634
PA	11,936	12,442	13,130	13,325	12,500	11,802	10,602
TN	1,182	959	827	580	486	417	477
VA	7,094	7,837	8,280	7,880	7,108	5,923	4,813
WV	34,114	34,205	37,514	36,203	32,078	29,591	25,060
TOTAL	95,156	96,098	102,108	96,501	83,729	77,102	65,586

*Including contractors.

Source: U.S. Mine Safety and Health Administration and MISI.

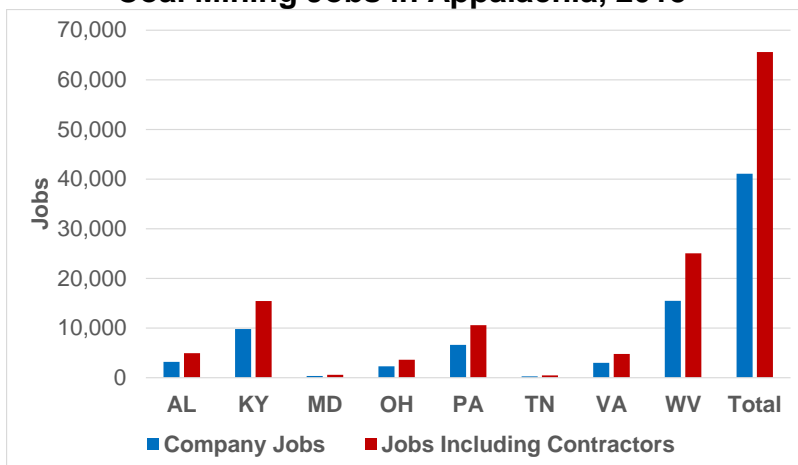
This table indicates that, including contractor jobs, coal mining employment in Appalachia:

- Totaled more than 95,000 in 2009
- Increased to over 102,000 in 2011
- Decreased to about 65,600 in 2015.

⁶⁹While prorating contractors by actual mine company employees is crude, it is the best that can be done. Even researching and identifying the company headquarters location of the hundreds of contractors nationwide would not measurably improve this estimate.

Thus, as shown in Figure III-9, in 2015, there were about 66,000 coal mining jobs in Appalachia – not 41,000.

**Figure III-9
Coal Mining Jobs in Appalachia, 2015***



*Including contractors.

Source: U.S. Mine Safety and Health Administration and MISI.

Coal jobs in Appalachia increased more than seven percent between 2009 and 2011, and then decreased steeply by 53 percent between 2011 and 2015. By 2015, employment was 31 percent lower than in 2009. These direct job losses can be translated into total job losses, which are the sum of the direct, indirect, and induced jobs lost:⁷⁰

- Direct jobs are those created directly in the specific activity or process.
- Indirect jobs are those created throughout the required interindustry supply chain.
- Induced jobs are those created in supporting or peripheral activities.
- Total jobs are the sum or all of the jobs created.
- For simplicity, MISI includes induced jobs in the indirect category.

The employment concept used here is a full time equivalent (FTE) job in the U.S.⁷¹ An FTE job is defined as 2,080 hours worked in a year's time, and adjusts for part time and seasonal employment and for labor turnover. The FTE concept is the standard used in economic analyses and normalizes job creation among full time, part time, and seasonal employment.

The U.S. multiplier for coal mining jobs is about 3 to 4, while the Appalachian regional job multipliers for coal mining jobs are in the range of 2-3. On the basis of extensive review of the research we estimate that the Appalachian regional job multiplier for coal mining jobs in Appalachia is about 2.5 and that the national job multiplier for coal

⁷⁰See Management Information Services, Inc., *Development of Economic and Job Impacts Analysis Tool and Technology Deployment Scenario Analysis*, report prepared for the U.S. Department of Energy, National Energy Technology Laboratory, DOE/NETL-402/092509, September 2009

⁷¹An FTE job is defined as 2,080 hours worked in a year's time, and adjusts for part time and seasonal employment and for labor turnover.

mining jobs in Appalachia is about 3.5.⁷² That is, for every coal mining job in Appalachia we estimate that:

- 2.5 jobs are created in the Appalachian region
- 3.5 jobs are created in the U.S. as a whole

⁷²See Regional Input-Output Modeling System (RIMS II), Regional Product Division, Bureau of Economic Analysis https://www.bea.gov/regional/pdf/rims/RIMSII_User_Guide.pdf; King Institute For Regional Economic Studies, "Economic Impacts of Job Losses in the Coal Mining Industry," King University School of Business, Kires Paper No. 7, February 2013; Pennsylvania Economy League of Greater Pittsburgh, "The Economic Impact of the Coal Industry in Pennsylvania," Prepared for the Pennsylvania Coal Alliance, March 2014; King Institute For Regional Economic Studies, "Replacing Coal Mining Jobs: Marginal Economic Impacts of Selected Industries in Southwest Virginia," King University School of Business, KIRES Report No. 12, January 2015; Roger Bezdek and Robert Wendling, "The Return on Investment of the Clean Coal Technology Program in the USA," *Energy Policy*, March 2013, Vol. 54, pp. 104-112; Management Information Services, Inc., "Employment Impact Analysis of Coal Carbon Capture and Sequestration Retrofits," prepared for the National Energy Technology Laboratory, April 2015; National Mining Association, "The Economic Contributions of U.S. Mining (2012)," September 2014; McDowell Group, "Energy and Economic Impacts of Coal in Interior Alaska," report prepared for Usibelli Coal Mine, Inc., November 2013; James C. Peach and Meghan Starbuck. 2009. The Economic Impact of Coal Mining in New Mexico. Prepared for the Department of Energy. DOE Award Number: DE-NT0004397, 2009; Pennsylvania Economy League of Southwestern Pennsylvania, LLC. 2010, "The Economic Impact of the Coal Industry in Pennsylvania," prepared for Families Organized to Represent the Coal Economy, Inc., 2010; Frederick Sparrow, "Estimating the State and Regional Benefits of the Mining and Use of Illinois Basin Coals," prepared for the Center for Coal and Technology Research, Energy Center at Discovery Park, 2009; Eric C. Thompson, Mark C Berger, Steven N. Allen, and Jonathan M. Roenker, "A Study of the Current Economic Impacts of the Appalachian Coal Industry and its Future in the Region," Center for Business and Economic Research, Gatton College of Business and Economics, University of Kentucky, 2001; Ramboll Environ, "Economic Analysis of Proposed Stream Protection Rule, prepared for the National Mining Association, Washington, D.C., October 2015; Philip Watson, Joshua Wilson, Dawn Thilmany, and Susan Winter, "Determining Economic Contribution and Impacts: What is the Difference and Why do we Care?" *Pedagogy in Regional Studies*, Vol. 37, No 2 (2007), pp 1-15; "The Economic Impacts of a Coal Mining Facility in Vermillion and Champaign Counties, Illinois," Regional Development Institute, Northern Illinois University, DeKalb, IL, September 2012; Timothy Considine, "Powder River Basin Coal: Powering America," *Natural Resources*, Vol. 4 (2013) pp. 514-533; Management Information Services, Inc., *Development of Economic and Job Impacts Analysis Tool and Technology Deployment Scenario Analysis*, op. cit.; Roger Bezdek, "Economic, Employment, and Energy Stimulus From Clean Coal Technology Deployment," chapter 2 in *Harnessing Coal's Carbon Content to Advance the Economy, Environment, and Energy Security*, National Coal Council, Washington, D.C., June 2012; "Employment and Other Economic Benefits from Advanced Coal Electric Generation with Carbon Capture and Storage," report prepared for the Industrial Union Council, AFL-CIO; the International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers, and Helpers; the International Brotherhood of Electrical Workers; the United Mine Workers of America; and the American Coalition for Clean Coal Electricity, by BBC Research and Consulting, Denver, Colorado, February 2009; Building a U.S. Coal-to-Liquids (CTL) Industry: Requirements and Implications. Report prepared for DOE under the technical direction of the National Energy Technology Laboratory by Noblis, October 2007; Roger Coupal, Robert Godby, David Bell, David Taylor, Jamison Pike, and Thomas Foulke, "An Economic Impact Analysis of Proposed Tax Incentives to Attract Integrated Gasification Combined Cycle Power Generation Facilities to Wyoming," report prepared for the Wyoming Infrastructure Authority by University of Wyoming, School of Energy Resources and Office of Research, January 9, 2007; Adam Rose and Dan Wei, "The Economic Impacts of Coal Utilization and Displacement in the Continental United States, 2015," report prepared for the Center for Energy and Economic Development, Inc., Alexandria, Virginia, by the Pennsylvania State University, July 2006; Management Information Services, Inc. and SAIC, *Economic Impacts of U.S. Liquid Fuel Mitigation Options*, report prepared for the National Energy Technology Laboratory by July 2006.

For example, it has been estimated that in 2011 the coal mining industry in Pennsylvania generated in the state nearly 13,900 jobs directly and about an additional 22,300 jobs indirectly -- Table III-5.⁷³ The 22,300 indirect and induced jobs were in industry sectors that supply goods and services to the coal industry, as well as in industries across the entire economy as employees of the coal industry and its supply chain spend their income on various goods and services. This table shows the top 11 industries in which the largest number of jobs were generated as a result of coal mining in the state. The largest indirect job impact was in the Food services and drinking places sector – over 1,400 jobs, followed by the Architectural, engineering and related services sector – over 1,100 jobs, and the Securities, investments, and related activities sector – nearly 1,100 jobs.

**Table III-5
Employment Impact in Pennsylvania of the
Pennsylvania Coal Industry: Top 11 Industries**

Industry	Direct Jobs	Indirect and Induced Jobs	Total Jobs
Coal mining	13,886	463	14,349
Food services and drinking places	-	1,433	1,433
Architectural, engineering, and related services	-	1,102	1,102
Securities, investments, and related activities	-	1,079	1,079
Truck transportation	-	744	744
Wholesale trade	-	726	629
Real estate	-	694	694
Management of companies and enterprises	-	693	693
Private hospitals	-	677	677
Other mining support activities	-	648	648
Offices of physicians, dentists, and other health practitioners	-	626	626
Total, top 11	13,886	8,888	22,774
Total, all Industries	13,886	22,310	36,187

Source: Pennsylvania Coal Alliance and MISI.

MISI thus estimates that for every coal mining job in Appalachia 2.5 jobs are created in the Appalachian region and 3.5 jobs are created in the U.S. as a whole. These estimates as applied to the data in Table III-3 yield the results illustrated in Figure III-10. This figure indicates that coal mining jobs in Appalachia created in the Appalachian region:

- A total of 238,000 jobs in 2009
- A total of 255,000 jobs in 2011
- A total of 164,000 jobs in 2015

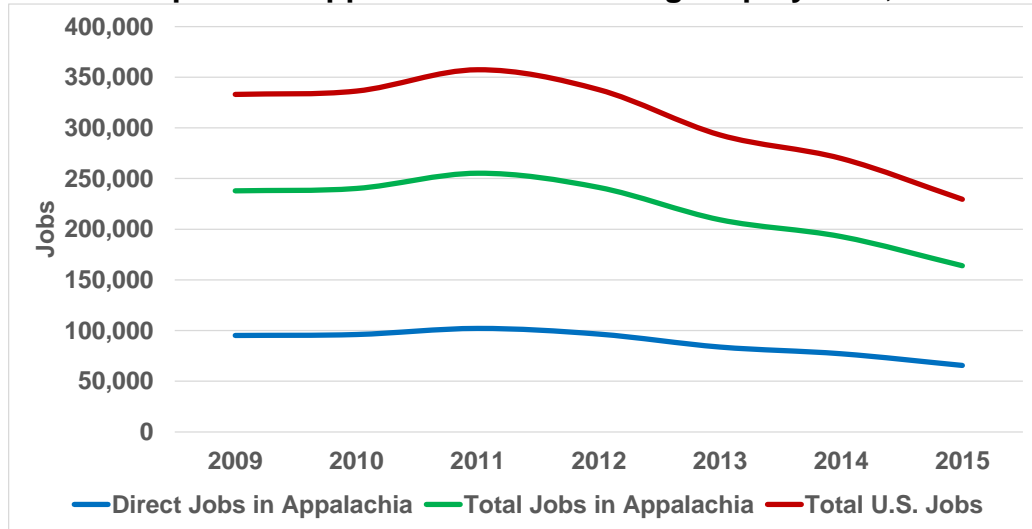
Thus, the total job loss (direct and indirect) in Appalachia between 2011 and 2015 due to declining Appalachian coal employment was 91,000 jobs.

⁷³See Pennsylvania Economy League of Greater Pittsburgh, op. cit.

Figure III-10 also indicates that coal mining jobs in Appalachia created in the U.S. as a whole:

- A total of 333,000 jobs in 2009
- A total of 357,000 jobs in 2011
- A total of 230,000 jobs in 2015

Figure III-10
Total Job Impacts of Appalachian Coal Mining Employment, 2009-2015*



*Including contractors and indirect jobs.

Source: Management Information Services, Inc.

Thus, the total job loss (direct and indirect) in the U.S. between 2011 and 2015 due to declining Appalachian coal employment was 127,000 jobs. These estimates indicate that the jobs impacts of Appalachian coal mining are much greater than generally realized. For example, the data in Table III-2 indicate that there was a loss of 23,000 jobs in Appalachian coal mining between 2011 and 2015. However, Figure III-9 indicates that the total impacts of the loss of Appalachian coal mining jobs between 2011 and 2015 were:

- 91,000 jobs in Appalachia
- 127,000 jobs in the U.S.

Table III-6 and Figure III-11 illustrate the actual total job impacts on the Appalachian states of the loss of coal jobs between 2011 and 2015. They illustrate that:

- 91,300 jobs were lost in these eight states
- 34,900 jobs – nearly 40 percent of the total – were lost in Kentucky
- 31,100 – 34 percent of the total – were lost in West Virginia
- Nearly three quarters of the jobs – 66,000 – were lost in these two states.

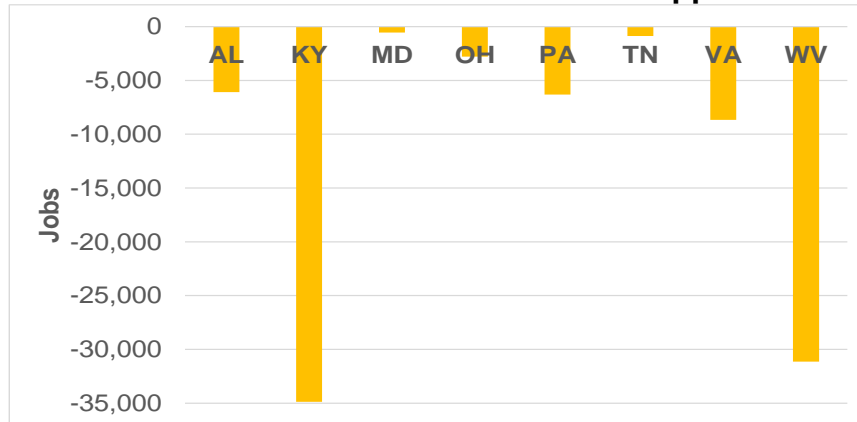
**Table III-6
Total Coal Related Job Losses in Appalachia, 2011 - 2015**

	2011	2015	Loss
AL	18,495	12,408	6,088
KY	73,515	38,638	34,878
MD	2,005	1,455	550
OH	11,878	9,085	2,793
PA	32,825	26,505	6,320
TN	2,068	1,193	875
VA	20,700	12,033	8,668
WV	93,785	62,650	31,135
Total	255,270	163,965	91,305

*Including contractors and indirect jobs.

Source: Management Information Services, Inc.

**Figure III-11
Total 2015 Coal Related Job Losses in Appalachia**



*Including contractors and indirect jobs.

Source: Management Information Services, Inc.

Since the labor force in Kentucky is nearly three times as large as that in West Virginia, the impact in the latter state was nearly three times as severe. The job losses in West Virginia comprised more than 4% of jobs in the state, whereas the job losses in Kentucky comprised less than 2% of jobs in the state.

The bottom line here is that the loss of coal mining jobs was devastating in both states:

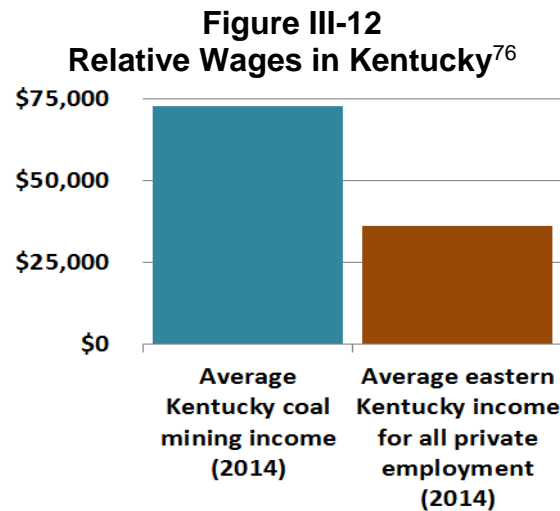
- Kentucky’s 2015 unemployment rate was 5.4%.⁷⁴ Without the loss of nearly 35,000 coal-related jobs, the state’s unemployment rate that year would have been about 3.5% -- essentially full employment. That is, without the loss of coal-related jobs, Kentucky in 2015 would have enjoyed full employment.

⁷⁴“Kentucky’s Annual Jobless Rate Falls to 5.4%,” <https://kylmi.ky.gov/gsipub/index.asp?docid=579>.

- West Virginia’s 2015 unemployment rate was 6.8%.⁷⁵ Without the loss of over 31,000 coal-related jobs, the state’s unemployment rate that year would have been less than 3% -- full employment. That is, without the loss of coal-related jobs, West Virginia, instead of experiencing a recessionary unemployment rate of near seven percent, would have enjoyed full employment.

In other words, the coal-related job losses in Appalachia were actually four times as large as is generally supposed and the job losses in the U.S. were nearly six times as large as is generally supposed. As discussed below, the loss of nearly 100,000 jobs in Appalachia over a five year period had devastating consequences – especially for Kentucky and West Virginia.

The loss of coal mining jobs is sorely felt in Appalachia, since these are among the best paying jobs in the region. For example, Figure III-12 shows that a coal mining job in eastern Kentucky pays more than twice as well as the average private job in the state. As another example, in Belmont County, Ohio the average weekly wage of a service job is about \$575, whereas coal miners in Belmont County make an average of \$1,600 per week – three times as much.



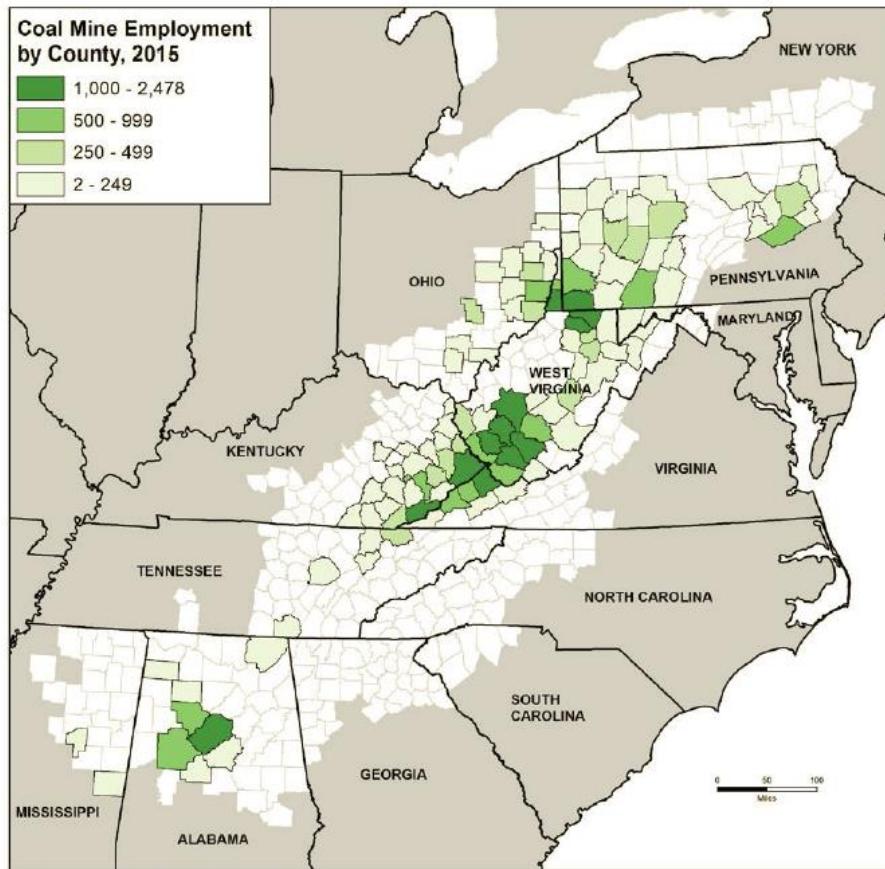
Source: U.S. Bureau of Labor Statistics

Figure III-13 illustrates the concentration of coal mining jobs by county in Appalachia.

⁷⁵“Unemployment Rate in West Virginia From 1992 to 2016,” <https://www.statista.com/statistics/190813/unemployment-rate-in-west-virginia-since-1992/>.

⁷⁶Cleveland Federal Reserve Bank, Eastern Kentucky: A Region in Flux,” <https://www.clevelandfed.org/newsroom-and-events/publications/forefront/ff-v7n01/ff-20160302-v7n01-05-eastern-kentucky-a-region-in-flux.aspx>; “Coal Jobs continue to Disappear in Eastern Kentucky as Population Drops,” *Lexington Herald Leader*, <http://www.kentucky.com/news/state/article93017917.html#storylink=cpy>; http://www.cleveland.com/opinion/index.ssf/2016/07/why_trumps_message_resonates_i.html.

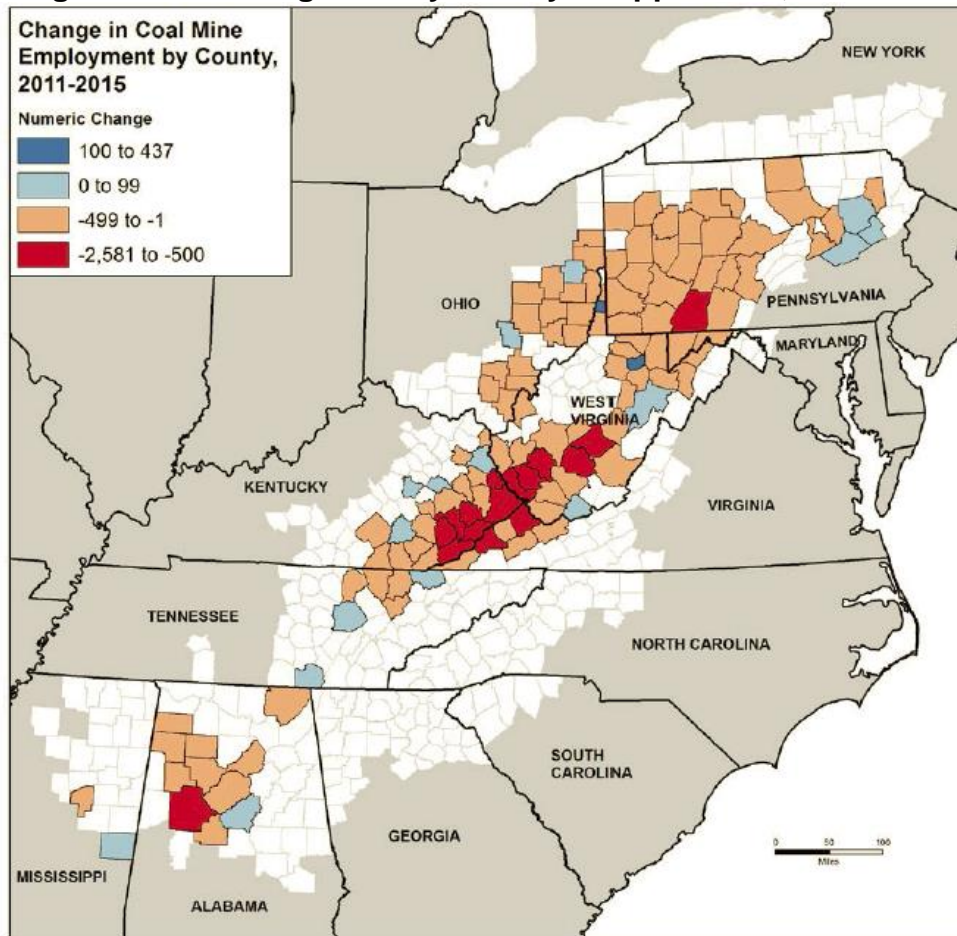
**Figure III-13
Coal Mining Jobs by County in Appalachia, 2015***



*Direct coal mining jobs, excluding contractors.
Source: U.S. Mine Safety and Health Administration, U.S. Bureau of Labor Statistics, and Appalachian Regional Commission.

Figure III-14 shows the coal mining job losses in Appalachia between 2011 and 2015. It illustrates that 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. Kentucky experienced a coal mining job decline of nearly 50 percent, while both Tennessee and Virginia experienced coal mining job losses in excess of 40 percent. Coal mining job losses were widespread throughout West Virginia, Pennsylvania, eastern Kentucky, and southeastern Ohio. In Virginia, the job losses were concentrated in six counties in the southeastern part of the state, and in Alabama they were concentrated in 11 counties in the northern part of the state. Thus, the loss of coal mining jobs is evidenced in eastern Kentucky, southern West Virginia, and the far western part of Virginia. Job losses are still prevalent through Pennsylvania and other parts of Appalachia, but the heaviest jobs losses are concentrated in the core of the region which, unfortunately, also tends to correspond to the highest levels of overall economic and job distress, as illustrated in Figure III- 14.

Figure III-14
Change in Coal Mining Jobs by County in Appalachia, 2011 to 2015*



*Direct coal mining jobs, excluding contractors.
 Source: U.S. Mine Safety and Health Administration, U.S. Bureau of Labor Statistics, and Appalachian Regional Commission.

Table III-7 illustrates the extent of the coal mining job losses throughout Appalachia between 2011 and 2015. It shows that:

- There were over 100 counties that experienced significant job losses
- There were 27 counties that experienced job losses in excess of 500
- 13 of the 17 counties where job losses exceeded 500 are located in either Kentucky or West Virginia
- Pennsylvania and West Virginia each contained about one-fourth of the counties that experienced job losses
- Nearly half, 25, of West Virginia's 55 counties experienced job losses, and in five of these more than 500 jobs were lost
- 42% (28) of Pennsylvania's 67 counties experienced job losses
- 18% (21) of Kentucky's 120 counties experienced job losses, and in eight of these more than 500 jobs were lost

- 18% (16) of Ohio’s 88 counties experienced job losses
- 15% (10) of Alabama’s 67 counties experienced job losses

**Table III-7
Counties Experiencing Coal Mining Job Losses, 2011-2015***

State	1 to 499 jobs lost	> 500 jobs lost	Total
Alabama	9	1	10
Kentucky	13	8	21
Maryland	2	0	2
Ohio	16	0	16
Pennsylvania	27	1	28
Tennessee	4	0	4
Virginia	4	2	6
West Virginia	20	5	25
Total	95	17	102

*Direct coal mining jobs, excluding contractors.

Source: U.S. Mine Safety and Health Administration, U.S. Bureau of Labor Statistics, Appalachian Regional Commission, and MISI.

Table III-8 shows that there were relatively few Appalachian counties that gained coal mining jobs between 2011 and 2015. It illustrates that:

- Only 18 counties gained jobs
- Only three counties gained more than 100 jobs
- Only two states had counties that gained more than 100 jobs
- No state had more than four counties that gained jobs

Data on coal mining industry concentrations by county illustrate the heavy economic dependence on coal mining in specific Appalachian counties. Location quotients (LCs) measure how concentrated jobs in coal mining are in a county, compared to the national average concentration. Any county with a concentration greater than 1.0 indicates that it has disproportionately more jobs in coal than the U.S. as a whole. Most U.S. counties have no coal mining employment. However, as shown in Figure III-15, in Appalachia, there are 52 counties with a LC of 20 or more, meaning that coal mining is at least 20 times more important to local jobs than in the U.S. as a whole, and some Appalachian counties have location quotients that exceed 100. Of the 17 Appalachian counties with LCs of 150 or more, coal mining represents 10 percent or more of the total jobs in the county. These are extraordinarily high levels of industry concentration and they are also generally associated with recent coal mining job losses, as illustrated in Figure III-15. Most important, counties with LCs greater than 20 have economies and job markets that are especially susceptible to changes in the fortunes of the coal mining industry.

**Table III-8
Counties Experience Coal Mining Job Gains, 2011-2015***

State	0 to 99 jobs gained	> 100 jobs gained	Total
Alabama	1	0	1
Kentucky	4	0	4
Maryland	2	0	2
Ohio	2	1	3
Pennsylvania	3	0	3
Tennessee	2	0	2
Virginia	1	0	1
West Virginia	2	2	4
Total	15	3	18

*Direct coal mining jobs, excluding contractors.

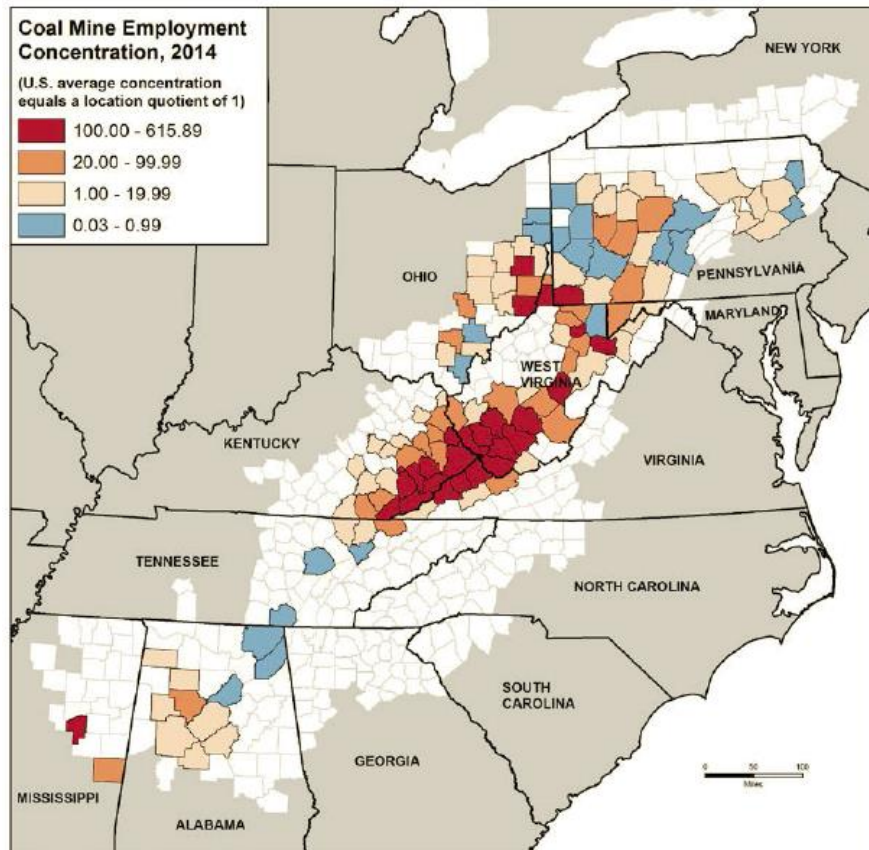
Source: U.S. Mine Safety and Health Administration, U.S. Bureau of Labor Statistics, Appalachian Regional Commission, and MISI.

Table III-9 shows that:

- There are 27 counties with LCs between 20 and 99.
- There are 25 counties with LCs greater than 100
- Of the 52 counties with LCs greater than 20, 37% (19) are in West Virginia and 29% (15) are in Kentucky.
- Of the 25 counties with LCs greater than 100, 40% (10), are in West Virginia and 32% (8) are in Kentucky.
- No other state has more than six counties with LCs that exceed 20, and three states – Alabama, Maryland, and Tennessee – have only one county with an LC greater than 20.

As noted, of the 52 counties with LC's greater than 20, 19 (37%) are in West Virginia and 15 (29%) are in Kentucky. Thus, these two states contain two-thirds of the Appalachian counties most heavily dependent on coal mining. Further, of the 25 counties that have LCs greater than 100, 10 (40%) are in West Virginia and eight (32%) are in Kentucky. Thus these two states have nearly three quarters of the Appalachian counties the most highly dependent on coal mining jobs. Ominously, these are the counties that have, by far, suffered the most from recent coal mining job losses and will be the most negatively impacted by future job losses.

Figure III-15
Coal Mining Jobs Concentration (Location Quotient) by County, 2014*



*Direct coal mining jobs, excluding contractors.

Source: U.S. Mine Safety and Health Administration, U.S. Bureau of Labor Statistics, and Appalachian Regional Commission.

Table III-9
Counties Most Dependent on Coal Mining Jobs*

State	LC 20 to 99.9	LC > 100	Total
Alabama	1	0	1
Kentucky	7	8	15
Maryland	1	0	1
Ohio	3	3	6
Pennsylvania	4	1	5
Tennessee	1	0	1
Virginia	1	3	4
West Virginia	9	10	19
Total	27	25	52

*Direct coal mining jobs, excluding contractors.

Source: U.S. Mine Safety and Health Administration, U.S. Bureau of Labor Statistics, Appalachian Regional Commission, and MISI.

In particular, West Virginia has been seriously harmed by recent coal mining job losses and is at risk for future impacts of job losses. Unfortunately, this state is especially vulnerable, since:

- The recent loss of coal-related jobs in the state meant the difference between West Virginia experiencing a deep recession and the state achieving full employment.
- It is a relatively small state heavily dependent on coal mining and lacks a diverse economy – unlike states such as Ohio, Pennsylvania, and Virginia.
- The state is one of the most impoverished to begin with.⁷⁷
- Among all of the states it has the lowest portion of its population employed – less than 40 percent.⁷⁸
- It is one of the few states forecast to experience continually declining population over the next two decades, and its population loss of four percent by 2040 is forecast to be the largest percentage loss among all states.⁷⁹

The Appalachian Regional Commission uses an index-based county economic classification system to identify and monitor the economic status of Appalachian counties. ARC developed a national index of county economic status through a comparison of each county's averages for three-year average unemployment rate, per capita market income, and poverty rate with national averages. The resulting values are summed and averaged to create a composite index value for each county. Each county in the nation is then ranked, based on its composite index value, with higher values indicating higher levels of distress. Each Appalachian county is classified into one of five economic status designations: 1) Distressed counties are the most economically depressed and rank in the worst 10 percent of U.S. counties; 2) At-Risk counties are those at risk of becoming economically distressed and rank between the worst 10 percent and 25 percent of the nation's counties; 3) Transitional counties are those transitioning between strong and weak economies and rank between the worst 25 percent and the best 25 percent of U.S. counties; 4) Competitive counties are those that are able to compete in the national economy but are not in the highest 10 percent of U.S. counties, and ranking between the best 10 percent and 25 percent of U.S. counties; 5) Attainment counties are the economically strongest counties and rank in the best 10 percent of U.S. counties.⁸⁰

⁷⁷Center for American Progress, "Talk Poverty – West Virginia 2015," Washington, D.C., 2016.

⁷⁸The U.S. national ratio of employment to population is about 45% – 46%. However, this ratio differs significantly among the states, from a high of about 54% in New Hampshire to a low of less than 40% in West Virginia.

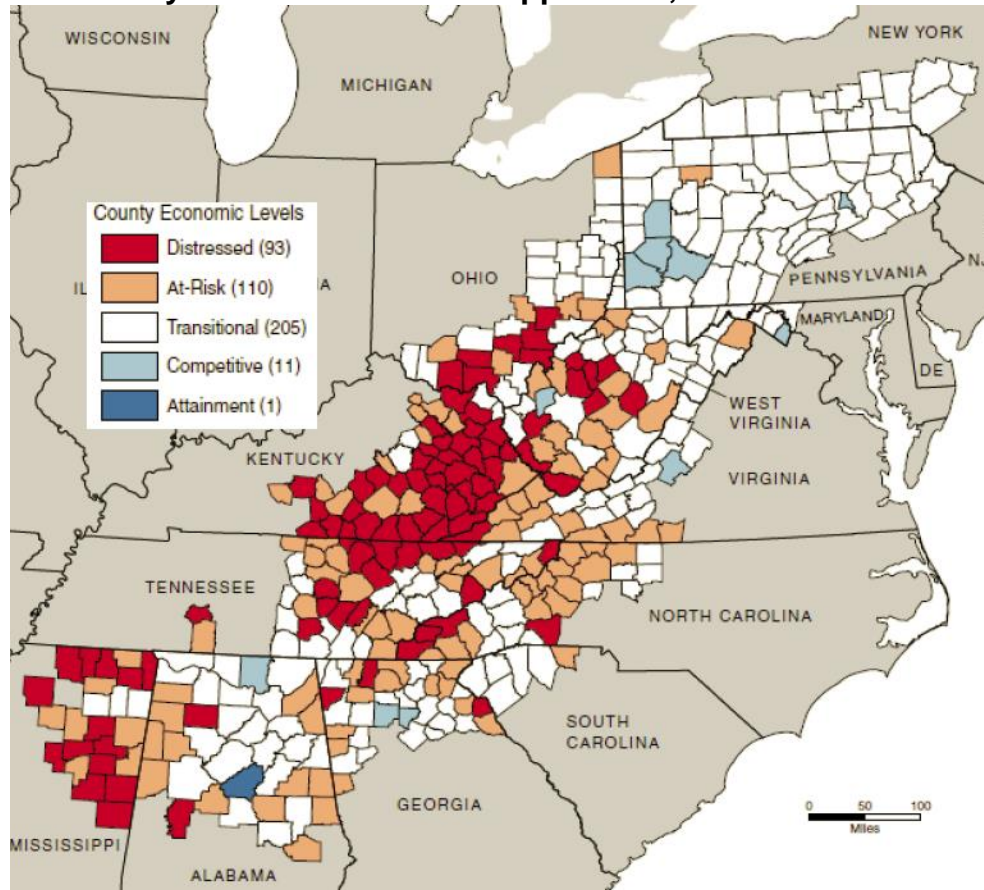
⁷⁹U.S. Bureau of Labor Statistics, "Employment Projections, 2014-24," December 2015; Mitra Toossi, "Labor Force Projections To 2024: The Labor Force is Growing, But Slowly," *Monthly Labor Review*, December 2015; U.S. Census Bureau, "Population Projections," <http://www.census.gov/population/projections/>; U.S. Census Bureau, "U.S. Census Bureau Projections Show a Slower Growing, Older, More Diverse Nation a Half Century From Now," <http://www.census.gov/newsroom/releases/archives/population/cb12-243.html>; Pew Research Center, "Census Bureau Lowers U.S. Growth Forecast, Mainly Due to Reduced Immigration and Births," Washington, D.C., December 2012, <http://www.pewsocialtrends.org/2012/12/14/census-bureau-lowers-u-s-growth-forecast-mainly-due-to-reduced-immigration-and-births>; Weldon Cooper Center for Public Service, Demographics Research Group, "Observed and Total Population for the U.S. and the States, 2010-2040," May 2016, www.coopercenter.org/demographics.

⁸⁰See http://www.arc.gov/research/MapsofAppalachia.asp?MAP_ID=105).

Figure III-16 illustrates an alarming economic situation for Appalachia. Of the 430 counties indexed:

- 203 are either distressed or at-risk
- Only 11 are competitive
- Only 1 is in attainment – Shelby County, Alabama.

Figure III-16
County Economic Status in Appalachia, Fiscal Year 2016



Source: U.S. Bureau of Labor Statistics, U.S. Bureau of Economic Analysis, U.S. Census Bureau, and Appalachian Regional Commission.

To make matters even worse, these findings pertain to the direct coal jobs impacts (excluding contractors) given in Table III-2. As discussed, the total job impacts in Appalachia from coal mining job losses are nearly five times as severe as indicated in this table. Thus, the negative impacts in the region of coal mining job losses are truly dire. However, if current coal mining jobs can be saved and new jobs created, the impacts in Appalachia will be much more significant than is generally recognized.

III.C. Coal Mining Jobs in the Western and Interior Regions

Table III-10 and Figures III-17 and III-18 show the changes in coal mining jobs in the Interior and Western regions between 2011 and 2015. In the Interior region, coal mining employment decreased by only about one percent – 64 jobs. However, the job changes within the region varied markedly:

- In some states, such as Louisiana and Mississippi, jobs increased substantially.
- In several states, such as Oklahoma, jobs decreased substantially.
- In other states, such as Illinois, Kansas, and Missouri, the number of jobs changed little.

In the Western region, coal mining employment decreased by 13 percent – 2,330 jobs. However, the job changes within the region varied markedly:

- In some states, such as Montana and North Dakota, jobs increased.
- In most of the states, jobs decreased substantially.
- In Arizona the number of jobs changed little.

In comparing the three coal mining regions, it is clear that Appalachia suffered by far the most jobs losses both in total and in percentage terms.

- Appalachia lost 36% of its coal mining jobs – 23,529 jobs.
- The Interior region lost 1% of its coal mining jobs – 64 jobs.
- The West lost 13% of its coal mining jobs – 2,330 jobs.
- The total job loss in Appalachia was ten times as large as the total job loss in the Interior and Western regions combined.
- Nationwide over the same period coal mining jobs decreased 28%.

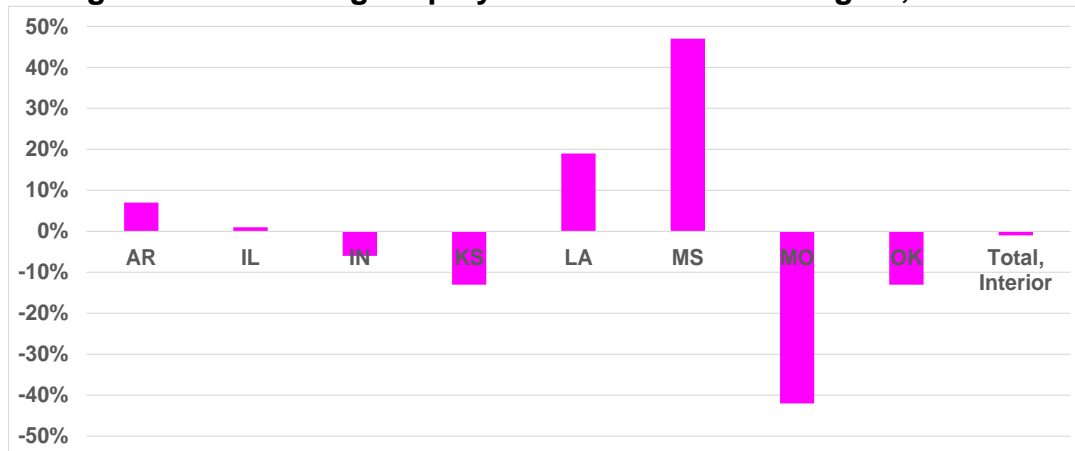
As in section III.B, to provide more robust estimates of coal mining jobs by state in the Interior and Western regions we prorated the contractor jobs to each of the states in the regions according to the percentage that contractor jobs comprised of the national total in each year. The results are given in Table III-11, which shows the estimates of coal mining employment including contractors in the two regions in 2011 and 2015. This table indicates that over this period coal mining employment decreased in the Interior region by about 200 jobs and by about 3,400 jobs in the Western region.

Table III-10
Coal Mining Employment by State, 2011 and 2015, West and Interior Regions

State/Region	2011	2015	Change '11-'15
Interior			
Arkansas	70	75	7%
Illinois	4,105	4,146	1%
Indiana	3,540	3,311	-6%
Kansas	8	7	-13%
Louisiana	259	307	19%
Mississippi	224	330	47%
Missouri	26	15	-42%
Oklahoma	184	161	-13%
Total, Interior	8,416	8,352	-1%
West			
Alaska	136	113	-17%
Arizona	419	403	-4%
Colorado	2,405	1,642	-32%
Montana	1,251	1,330	6%
New Mexico	1,292	1,130	-13%
North Dakota	1,169	1,261	8%
Texas	2,936	2,689	-8%
Utah	1,797	1,211	-33%
Wyoming	7,039	6,635	-6%
Total, West	18,444	16,114	-13%

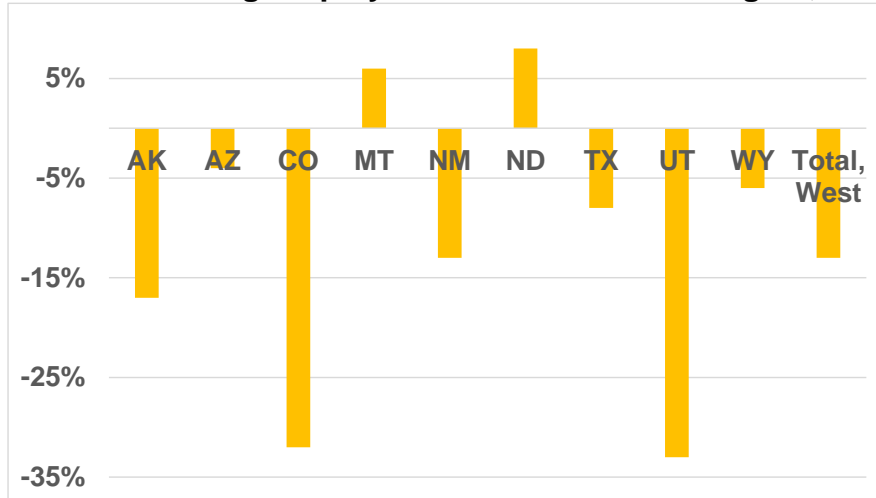
Source: U.S. Department of Labor, Mine Safety and Health Administration.

Figure III-17
Changes in Coal Mining Employment in the Interior Region, 2011 - 2015



Source: U.S. Department of Labor, Mine Safety and Health Administration, 2016.

Figure III-18
Changes in Coal Mining Employment in the Western Region, 2011 - 2015



Source: U.S. Department of Labor, Mine Safety and Health Administration, 2016.

Table III-11
Coal Mining Employment by State, 2011 and 2015, West and Interior Regions*

State/Region	2011	2015
Interior		
Arkansas	110	117
Illinois	6,450	6,466
Indiana	5,563	5,163
Kansas	13	11
Louisiana	407	479
Mississippi	352	515
Missouri	41	23
Oklahoma	289	251
Total, Interior	13,224	13,025
West		
Alaska	214	176
Arizona	658	628
Colorado	3,779	2,561
Montana	1,966	2,074
New Mexico	1,130	1,762
North Dakota	1,261	1,966
Texas	4,613	4,193
Utah	2,824	1,889
Wyoming	6,635	10,347
Total, West	28,982	25,597

*Including contractors.

Source: U.S. Department of Labor, Mine Safety and Health Administration and MISA.

IV. FORECASTS

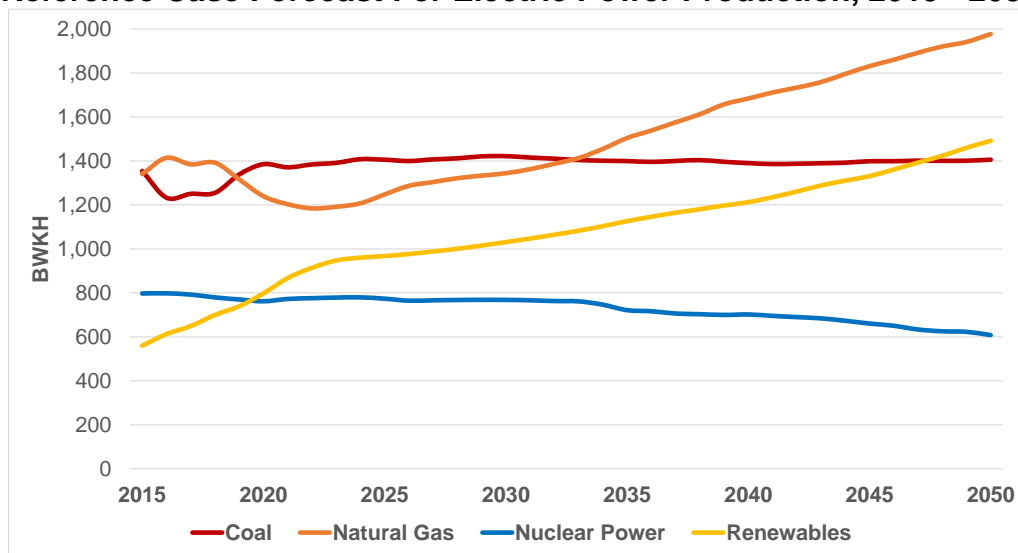
In this chapter, MISI estimates the potential employment and jobs impacts of the U.S. coal industry, coal power generation, and related industries and technologies through 2050 under seven alternate economic and energy scenarios.⁸¹

IV.A. The Reference Case

The Reference Case for the forecasts and scenarios is the *AEO 17* “no CPP” side case.⁸² Reference Case forecasts for electric power production are shown in Figure IV-1. This figure shows that, without the CPP, EIA forecasts that:

- Coal power generation will reach a low of 1250 BkWh in 2017.
- Coal power generation will increase to 1400 BkWh by 2023.
- Coal will provide about 1400 BkWh through 2050.
- Coal power generation will exceed natural gas power generation beginning in 2019 and will continue to do so until 2033.
- Coal power generation will exceed renewable power generation until 2048.
- Coal power generation will exceed nuclear power generation by nearly a factor of two through 2050.

Figure IV-1
Reference Case Forecast For Electric Power Production, 2015 - 2050



Source: U.S. Energy Information Administration.

⁸¹The basic MISI methodology and model are documented in *Development of Economic and Job Impacts Analysis Tool and Technology Deployment Scenario Analysis*, op. cit.

⁸²*AEO 2017*.

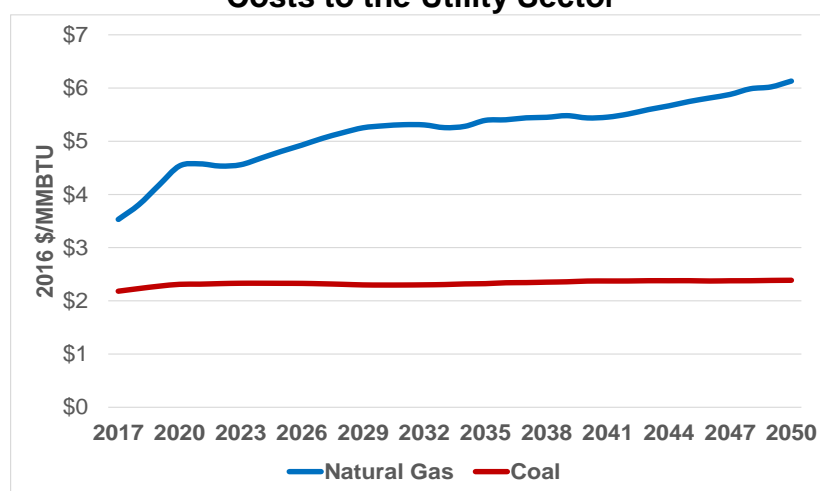
In this study, MISI focused on the economic and job impacts of increased coal utilization and production in the U.S. over the next several decades. There are a number of reasons why the U.S. may require more coal in the future than is currently anticipated. These include:

- Increased power demand resulting from population growth
- Increased power demand generated by economic growth
- Increased requirements for steel, cement, and other materials required for new infrastructure
- A resurgence in U.S. manufacturing – see Chapter IV
- Dramatic increases in natural gas exports
- Reduced subsidies and mandates for renewable energy
- Constraints on expansion of hydro opportunities
- An aging nuclear fleet, with few new nuclear plants being built

It should also be recognized that EIA forecasts that natural gas costs to the utility sector will increase much more rapidly than coal costs through 2050. Figure IV-2 shows the standard *AEO 17* reference case (including the CPP) forecasts for the real (2016\$) prices of natural gas and coal to utilities.⁸³ Over the forecast period:

- Natural gas increases (in real 2016 dollars) at an annual average rate of 2.1% and coal increases 0.3%.
- In 2017, natural gas is 60% more expensive than coal; by 2050, it is 2.6 times as expensive as coal.

Figure IV-2
Costs to the Utility Sector



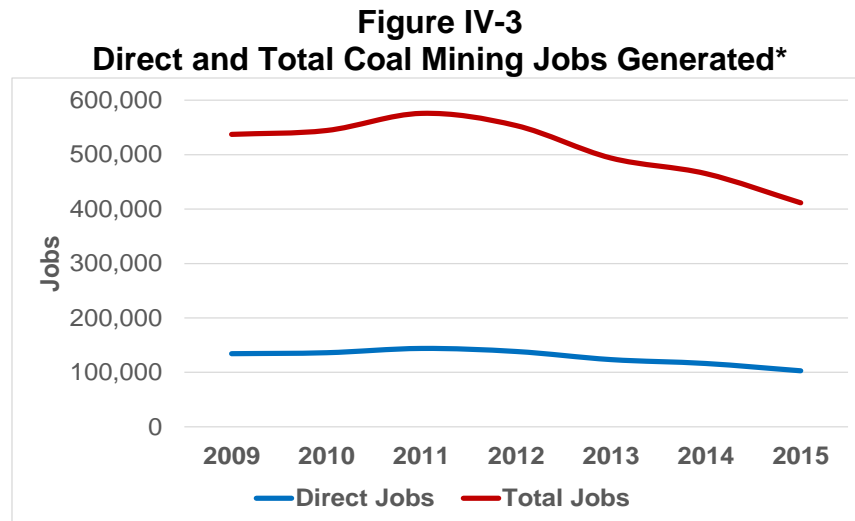
Source: U.S. Energy Information Administration.

This increasing price difference will tend, over time, to shift demand to coal power generation.

⁸³*AEO 2017*.

Figure IV-3 shows the direct and the total jobs generated by the coal mining industry in recent years. This figure shows that after peaking in 2011, the total jobs created by the industry declined continually and significantly through 2015. Specifically:

- In 2009, the industry generated nearly 540,000 jobs
- In 2011, job creation peaked at more than 575,000 jobs
- By 2013, the jobs created declined nearly 15 percent to 490,000
- By 2015, the jobs created declined nearly 30 percent from 2011 to about 400,000



*Including contractors

Source: Management Information Services, Inc.

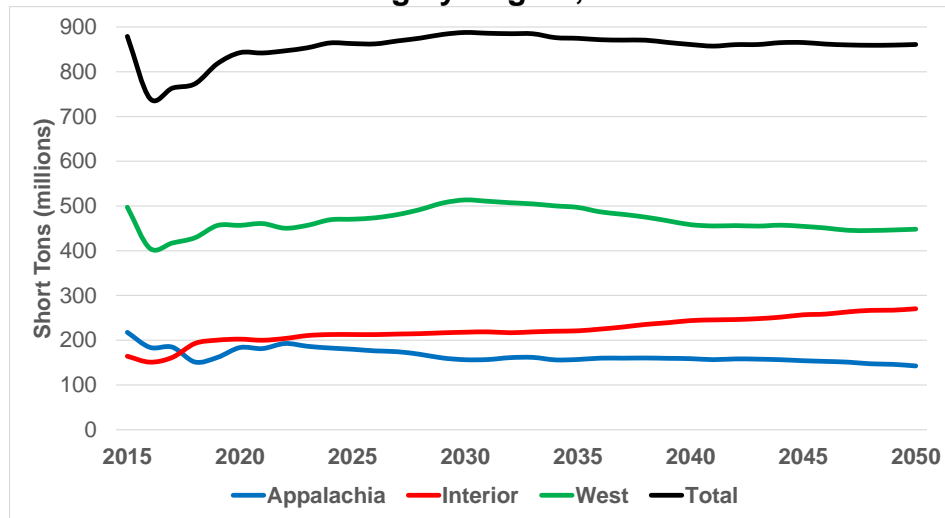
As shown in Figure IV-4, under the *AEO 2017* no CPP reference case U.S. coal mining output increases until 2030 and then declines gradually through 2050. Coal production in the Western region generally follows this pattern. However, throughout the period, coal production in Appalachia continues to decrease gradually while production in the Interior region increases gradually. Similar shifting patterns of coal production occur under the scenarios described in Section IV-B. This is noteworthy because coal mining productivity is nearly three times the U.S. average in the Western region, it is about ten percent below the U.S. average in the Interior region, and less than half the U.S. average in Appalachia.

Figure IV-5 shows that the total jobs generated by coal mining under the Reference case decline continually throughout the forecast period. This is due to the fact that, while U.S. coal production is flat or declining over the next several decades, coal mining productivity continues to increase. Thus, every year slightly less labor input will be required to produce a given volume of coal.⁸⁴ Accordingly:

⁸⁴For example, in the early 1920s the U.S. employed nearly 900,000 coal miners, whereas by 2015 about 100,000 coal miners produced more coal than during the 1920s. MISI assumed that productivity in the coal mining industry would increase at the average annual rate of the U.S. economy in the *AEO 2017* no CPP Reference Case – 1.7 percent annually.

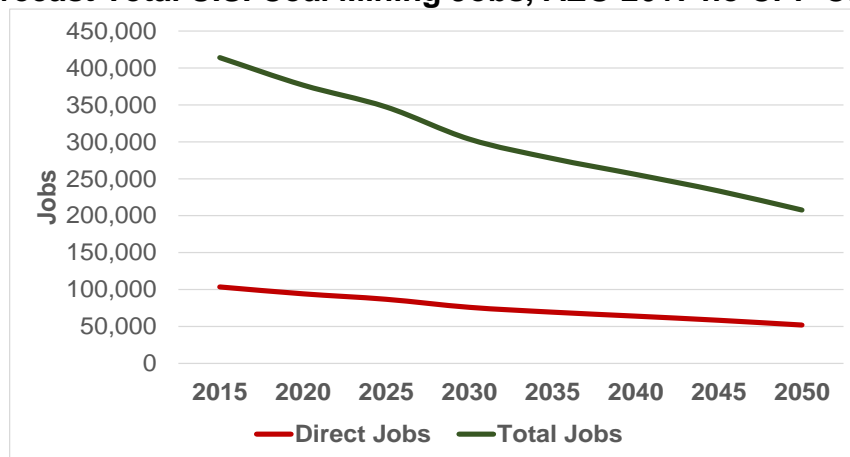
- In 2030, over 300,000 total jobs are generated by the coal mining industry.
- In 2040, about 256,000 total jobs are generated by the coal mining industry.
- In 2050, less than 210,000 total jobs are generated by the coal mining industry.
- By 2050, 64 percent fewer jobs are being generated by the coal mining industry than in 2015.

Figure IV-4
Forecast U.S. Coal Mining by Region, AEO 2017 no CPP Case



Source: U.S. Energy Information Administration.

Figure IV-5
Forecast Total U.S. Coal Mining Jobs, AEO 2017 no CPP Case*



*Including contractors.

Source: Management Information Services, Inc.

Under the Reference Case, there are no new coal plants constructed through 2050. In addition, the AEO 2017 “no CPP reference case” shows continuing, minimal CO₂ EOR through 2050. Since virtually all of this CO₂ currently comes from natural sources, under the Reference Case we assume this will continue through 2050. That is, in the Reference Case, there is virtually no coal-related EOR or saline sequestration and

therefore no incremental EOR pipelines or saline pipelines. Thus, all of the EOR and saline CAPEX and pipeline activity in the 6 scenarios will be incremental above the reference case of zero.

IV.B. Forecast Scenarios

MISI used a version of the U.S. Energy Information Administration's forecasting model, the National Energy Modeling System (NEMS), to examine the potential impact on coal and coal-related jobs of various assumptions and scenarios – the version "NETL CTUS-NEMS." NETL CTUS-NEMS is an integrated model of the U.S. energy system linked to a macroeconomic model.⁸⁵

The impacts on coal and coal-related jobs of the following scenarios were forecast and analyzed:

1. **"Reference Case":** *AEO 17* No CPP side case.
2. **Scenario 2: "High Economic Growth Case":** Assumes 2.6% average annual GDP growth, 2%/yr. increase in electricity demand, & lower EOR O&M costs.
3. **Scenario 3: "High Growth, CCS TC Case":** Scenario 2 with CCS tax credits.
4. **Scenario 4: "High Growth, CCS TC, PG Case":** Scenario 3 with DOE CCS R&D program goals achieved.
5. **Scenario 5: "High O&G Prices Case":** Scenario 2 with natural gas prices that escalate from \$3.30 in 2015 to \$10.50/mmBtu in 2050.
6. **Scenario 6: "High O&G Prices/CCS TC Case":** Scenario 5 plus CCS tax credits.
7. **Scenario 7: "High O&G Prices/CCS TC/PG Case":** Scenario 6 with DOE CCS R&D program goals achieved.

The assumptions in these scenario are summarized in Table IV-1. Note:

- The Trump Administration is seeking to achieve growth of 3%, or higher, and its FY 2018 budget request reflects this.⁸⁶ The 2.6% average annual GDP growth corresponds to the *AEO 2017* high growth case, whereas in the *AEO 2017* no CPP reference case the growth rate is 2.1%.⁸⁷ It was not possible to use a growth rate higher than 2.6% in any of the scenarios because the growth rate is exogenous to the NETL CTUS-NEMS model and is obtained from IHS.
- High economic growth alone leads to higher natural gas prices than in the Reference Case.
- The 111b restriction remains in place in all of the scenarios.⁸⁸

⁸⁵For an overview of NEMS, see U.S. Energy Information Administration, "NEMS Documentation," <https://www.eia.gov/outlooks/aeo/nems/documentation/>.

⁸⁶The White House FY 2018 budget assumes that economic growth will reach 3% by 2020 and remain there. <https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/budget/fy2018/budget.pdf>.

⁸⁷*AEO 2017*, op. cit.

⁸⁸EPA's final "Carbon Pollution Standard for New Power Plants" was developed under Section 111(b) of the Clean Air Act. Section 111(b) calls for a standard that "reflects the degree of emissions limitation

- With the CCS tax credit,⁸⁹ it is expected that new coal plants with CCS will be built, but not coal plants without CCS.
- In the cases without the program goals, the rate of CCS technology learning is reduced from the AEO 2017 Reference Case assumptions. The default assumptions specify a learning rate that leads to cost reductions as the amount of new capacity builds increase.⁹⁰ There is also a minimum learning rate specified that reduces the cost of the sequestration component by 20% by 2035.
- In the cases without the R&D program, it is assumed that these learning rates are reduced because there is no U.S. government spending on R&D, although there still may be some internationally.
- The O&M costs for EOR are assumed to be lower than in the reference case in all of the other scenarios.⁹¹

**Table IV-1
Forecast Scenarios**

Scenarios	O&G Prices	Economic Growth	Electricity Demand	CCS Tax Credits ⁹²	CO ₂ Capture Technology	EOR O&M
1. No CPP Reference Case	Reference	Reference	Reference	No	Reference	Reference
2. High Economic Growth Case	Reference	High	High	No	Low Learning	Low Costs
3. High Growth, CCS TC Case	Reference	High	High	Yes	Low Learning	Low Costs
4. High Growth, CCS TC, PG Case	Reference	High	High	Yes	R&D Program Goals	Low Costs
5. High O&G Prices Case	High	High	High	No	Low Learning	Low Costs
6. High O&G Prices/CCS TC Case	High	High	High	Yes	Low Learning	Low Costs
7. High O&G Prices/CCS TC/PG Case	High	High	High	Yes	R&D Program Goals	Low Costs

Source: MISI and NETL.

achievable through the application of the best system of emissions reduction which (taking into account the cost of achieving such reduction and any non-air quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated." See <https://www.c2es.org/federal/executive/epa/ghg-standards-for-new-power-plants>.

⁸⁹This tax credit is modeled on proposed tax credits of \$35/ton CO₂ for EOR and \$50/ton CO₂ for geologic storage.

⁹⁰This is the classic "x% improvement for y doublings."

⁹¹EIA used to impose a limit on the number of EOR projects as a calibration factor. More recently, it increased the O&M costs for EOR instead. MISI analysis indicates that these costs appear to be high, although there are no firm data to indicate what they should be. In these cases, MISI chose to be optimistic about the opportunities for EOR, and used EIA's older, lower cost values for EOR.

⁹²Modeled on proposed tax credits of \$35/ton CO₂ for EOR and \$50/ton CO₂ for geologic storage.

The employment concept used is a full time equivalent (FTE) job in the U.S. – as discussed in Section III.B.⁹³ MISI estimated the total (direct, indirect, and induced) jobs:

- Direct jobs are those created directly in the specific activity or process.
- Indirect jobs are those created throughout the required interindustry supply chain.
- Induced jobs are those created in supporting or peripheral activities.
- Total jobs are the sum of all of the jobs created.
- For simplicity, MISI will include induced jobs in the indirect category.

Following the convention in *AEO 2017*, all dollar estimates are expressed in terms of constant 2016 dollars. The other standard conventions of the EIA AEO reports were also adhered to.

The scenarios allow estimation of the effects of different policies and assumptions on the coal industry and related sectors of the economy. For example:

- All of the alternate scenarios will indicate the impacts of a higher economic growth rate, compared to that used in the Reference Case.
- Scenario 2 indicates the combined impact of higher economic growth and higher electricity demand growth.
- Scenario 3 indicates the marginal impacts of CCS tax credits.
- Scenario 4 indicates the marginal impacts of CCS tax credits combined with achievement of the DOE R&D program goals.
- Scenario 5 indicates the marginal impacts of higher oil and natural gas prices.
- Scenario 6 indicates the marginal impacts of higher oil and natural gas prices combined with CCS tax credits.
- Scenario 7 indicates the marginal impacts of higher oil and natural gas prices combined CCS tax credits and the achievement of the DOE R&D program goals.

Each scenario can be compared to the Reference Case or to another scenario to identify the marginal impacts of a specific policy or set of policies. For example, comparison of scenarios 5 and 2 will indicate the marginal effects only of higher oil and natural gas prices. Comparison of scenarios 6 and 3 will indicate the marginal effects of CCS tax credits with and without higher oil and natural gas prices. And so forth.

NETL estimates that the construction schedule for building a tranche of pipeline is three years: 17.1 percent in year 1, 37.5 percent in year 2, and 45.4 percent year 3. CAPEX expenditures and jobs were estimated using this phased capital vintage model approach. The same construction schedule was used for both the EOR and the saline pipelines. The economic and jobs impacts of this activity were estimated based on relevant published estimates of the economic and jobs impacts of pipeline construction and pipeline O&M and the economic and jobs profile of the oil and gas pipeline and related structures construction industry (NAICS 23712). The jobs created by the pipeline

⁹³An FTE job is defined as 2,080 hours worked in a year's time, and adjusts for part time and seasonal employment and for labor turnover.

deployment are the sum of the jobs created during the construction of the pipelines and the O&M jobs as the pipelines come on line.

In deriving the economic and employment effects of new coal plant construction we used the distribution of expenditures that NETL CTUS-NEMS estimates as the construction schedule for building the different types of plants, given in Table IV-2.

**Table IV-2
NETL CTUS-NEMS Coal Plant Construction Schedule**

Coal Plant Type	Portion of Expenditures				
	Year 1	Year 2	Year 3	Year 4	Year 5
Advanced Without Sequestration	0.15	0.3	0.4	0.15	--
Advanced With Sequestration	0.15	0.3	0.4	0.15	--
Advanced With Partial Sequestration	0.10	0.3	0.25	0.20	0.15
Conventional	0.15	0.3	0.4	0.15	--

Source: NETL

The jobs created by the new coal plant deployments are the sum of the jobs created during the construction of each of the plants and the O&M jobs created at each plant as it comes on line. The job creation estimates are derived on the basis of recent studies of the total (direct, indirect, and induced) jobs created by advanced coal plant construction and by the O&M of these plants, the vintage capital investment schedules and costs, and the O&M schedules and costs. Labor productivity in plant O&M was assumed to increase about 1% annually. Labor productivity in EOR O&M was also assumed to increase about 1% annually.

IV.C. Simulation Results

IV.C.1. Coal Mining Impacts

Future coal production is of special interest here, and Figure IV-6 shows U.S. coal production under the Reference Case and under each scenario. This figure indicates that the scenarios have dramatic effects on U.S. coal production and that the impacts increase as the forecast period lengthens. For example, by 2030:

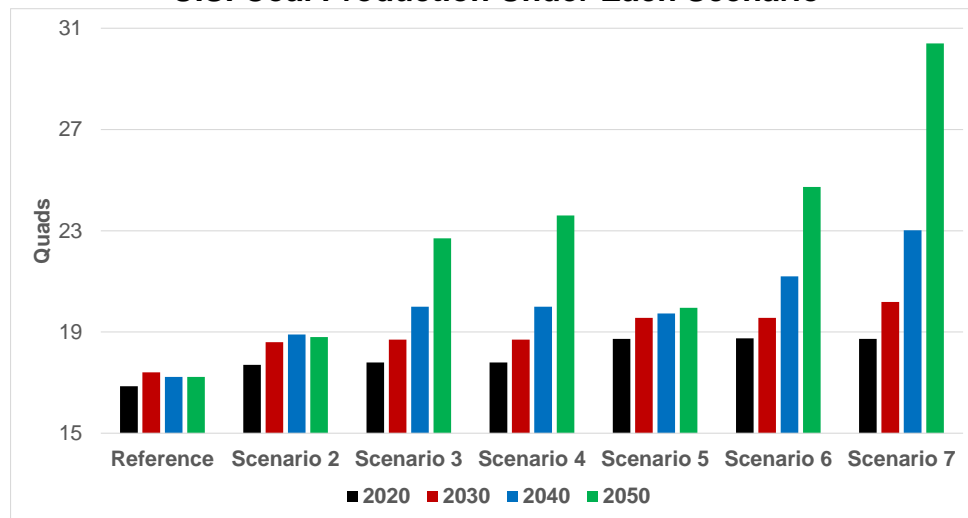
- Coal production under Scenario 2 exceeds coal production under the Reference case by seven percent.
- Scenario 3 coal production exceeds Reference Case production by eight percent.
- Scenario 4 coal production exceeds Reference Case production by eight percent.
- Scenario 5 coal production exceeds Reference Case production by 12 percent.
- Scenario 6 coal production exceeds Reference Case production by 12 percent.
- Scenario 7 coal production exceeds Reference Case production by 16 percent.

By 2050:

- Coal production under Scenario 2 exceeds coal production under the Reference case by nine percent.

- Scenario 3 coal production exceeds Reference Case production by 32 percent.
- Scenario 4 coal production exceeds Reference Case production by 37 percent.
- Scenario 5 coal production exceeds Reference Case production by 16 percent.
- Scenario 6 coal production exceeds Reference Case production by 44 percent.
- Scenario 7 coal production exceeds Reference Case production by 76 percent.

**Figure IV-6
U.S. Coal Production Under Each Scenario**



Source: MISI and NETL.

By 2050 it is clear that coal production under Scenario 7 significantly exceeds coal production under all of the other scenarios. Specifically, in that year:

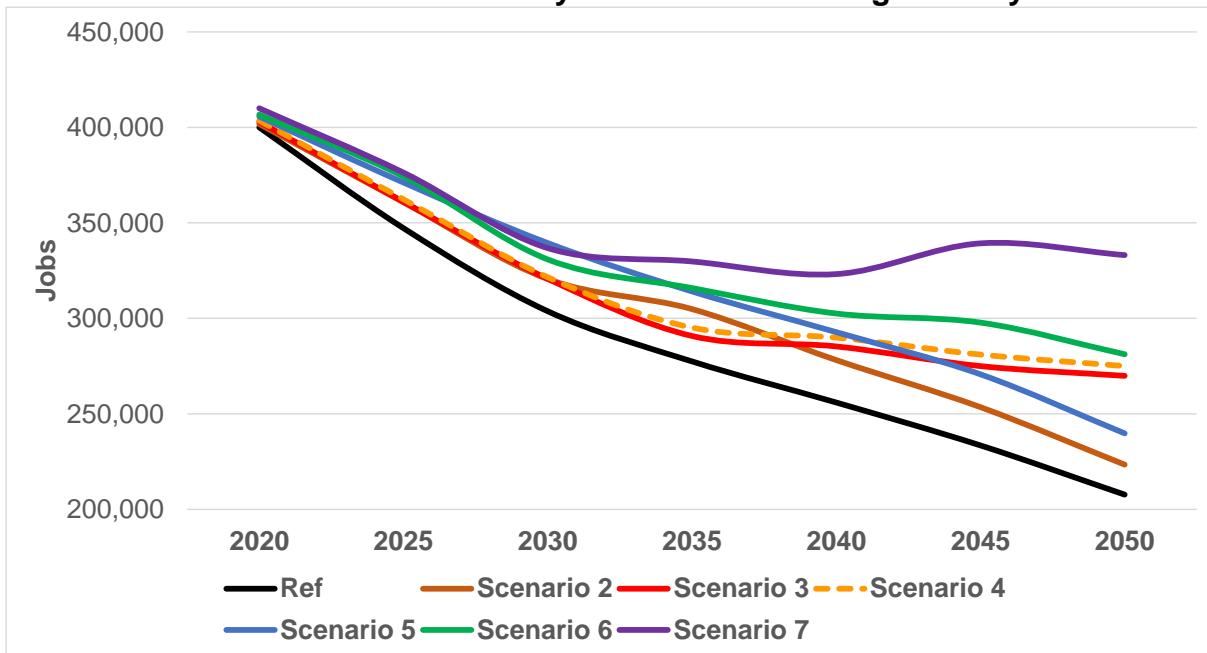
- Scenario 7 coal production exceeds Reference Case production by 76 percent.
- Scenario 7 coal production exceeds Scenario 2 production by 62 percent.
- Scenario 7 coal production exceeds Scenario 3 production by 34 percent.
- Scenario 7 coal production exceeds Scenario 4 production by 29 percent.
- Scenario 7 coal production exceeds Scenario 5 production by 52 percent.
- Scenario 7 coal production exceeds Scenario 6 production by 23 percent.

Figure IV-7 shows the total jobs generated by the U.S. coal mining industry over the forecast period. This figure shows that under all of the scenarios except Scenario 7 the total number of jobs generated by the coal mining industry decreases continually over through 2050. This is due primarily to continued increase in productivity in the coal mining industry over the next three decades.⁹⁴ Under Scenario 7, the total jobs generated by the U.S. coal mining industry decrease until 2040, increase from 2040 to 2045, and then decrease from 2045 to 2050. Nevertheless, assuming continued increases in coal mining

⁹⁴MISI assumed that productivity in the coal mining industry would increase at the average annual rate of the U.S. economy in the AEO 2017 no CPP Reference Case – 1.7 percent annually.

productivity, under all of the scenarios significantly fewer jobs are generated by the coal industry in 2050 than in 2020.

Figure IV-7
Total Jobs Generated by the U.S. Coal Mining Industry



Source: MISI.

Compared to the reference case:

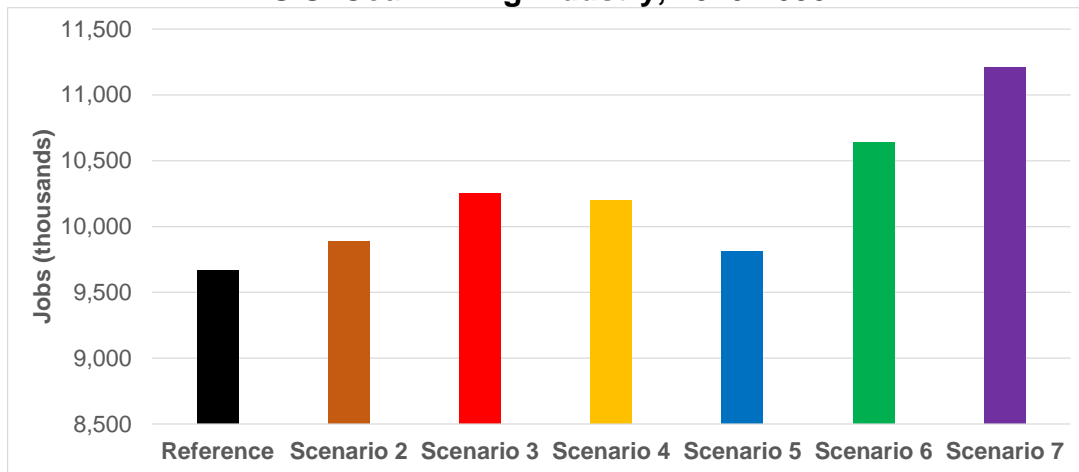
- 16,000 more jobs are generated under Scenario 2 by the coal mining industry in 2030, and 15,000 in 2050
- 18,000 more jobs are generated under Scenario 3 by the coal mining industry in 2030, and 59,000 in 2050
- 19,000 more jobs are generated under Scenario 4 by the coal mining industry in 2030, and 67,000 in 2050
- 36,000 more jobs are generated under Scenario 5 by the coal mining industry in 2030, and 32,000 in 2050
- 27,000 more jobs are generated under Scenario 6 by the coal mining industry in 2030, and 73,000 in 2050
- 33,000 more jobs are generated under Scenario 7 by the coal mining industry in 2030, and 125,000 in 2050

Figure IV-8 shows the total cumulative job-years generated by the U.S. coal mining industry over the forecast period. A job-year is defined as one FTE job created in one year. This figure shows that under each scenario significantly more jobs are generated

by the coal mining industry over the period 2020 – 2050 than under the Reference Case. Specifically:

- Under Scenario 2, over 900,000 more jobs are generated.
- Under Scenario 3, over a million more jobs are generated.
- Under Scenario 4, 1.1 million more jobs are generated.
- Under Scenario 5, 1.2 million more jobs are generated.
- Under Scenario 6, nearly 1.5 million more jobs are generated.
- Under Scenario 7, nearly two million more jobs are generated.

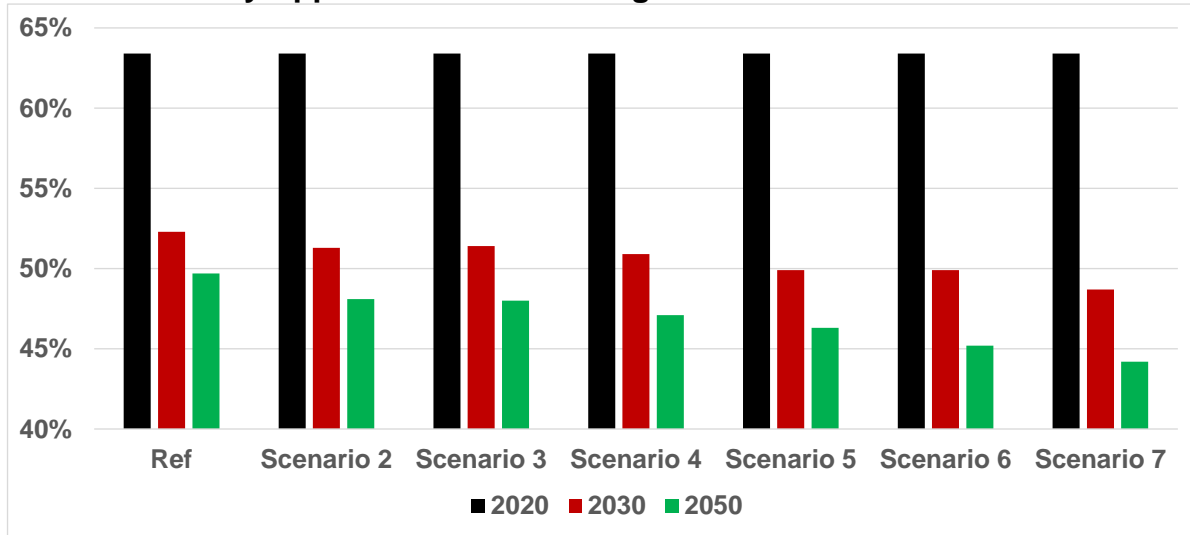
Figure IV-8
Total Cumulative Job-Years Generated by the
U.S. Coal Mining Industry, 2020-2050



Source: MISI.

Figure IV-9 shows the percent of total coal mining-generated jobs created by Appalachia coal mining under the Reference Case and each scenario in 2020, 2030, and 2050. This figure shows that the percentage of jobs generated by Appalachian coal mining is lower under Scenario 7 than in the Reference Case. However, under Scenario 7 many more jobs in total are being created than in the Reference case. Thus by 2050, 50,000 more jobs are generated by Appalachian coal mining under Scenario 7 than under the Reference Case, and most of these jobs will be generated within Appalachia. In other words, even though under Scenario 7 a smaller percentage of the total jobs generated by coal mining will be generated by Appalachian coal mining, many more jobs will still be created in Appalachia under this scenario.

Figure IV-9
Percent of Total Coal-Generated Jobs Created
by Appalachian Coal Mining Under Each Scenario

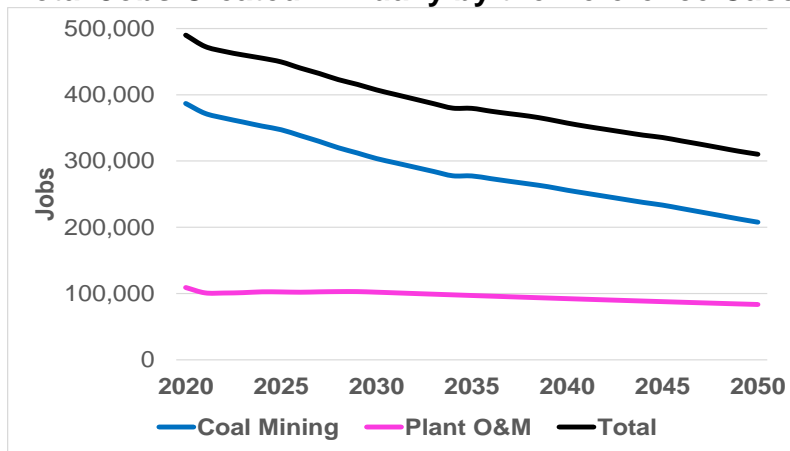


Source: MISI.

IV.C.2. Scenario Summaries

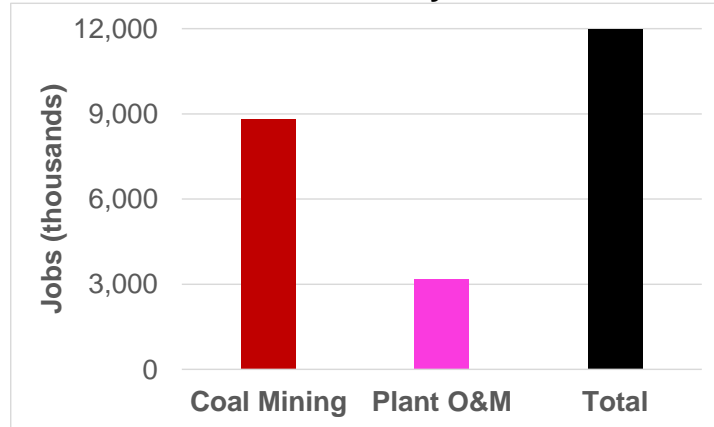
Figures IV-10 through IV-23 summarize the total jobs created annually and the total job-years generated 2020-2050 by the Reference Case and by each scenario.

Figure IV-10
Total Jobs Created Annually by the Reference Case



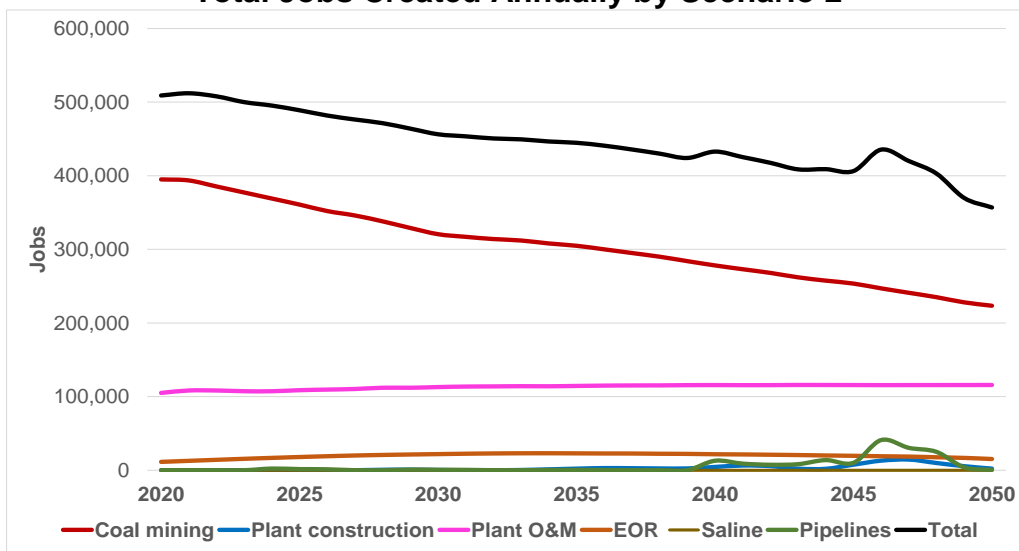
Source: MISI.

Figure IV-11
Total Cumulative Job-Years Generated by the Reference Case, 2020-2050



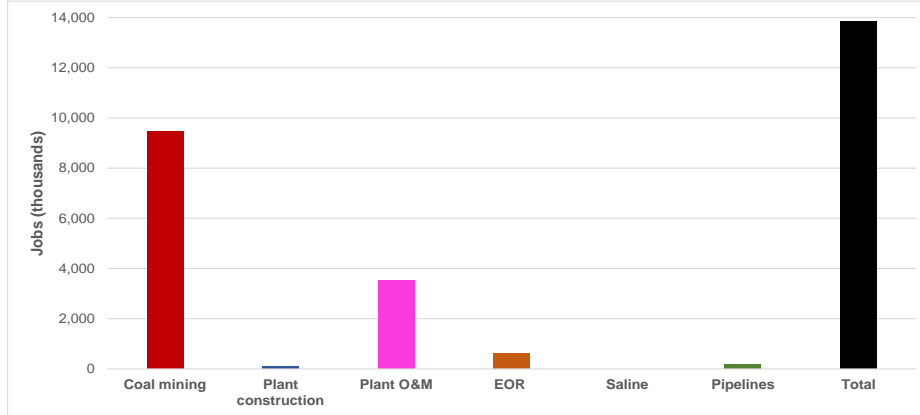
Source: MISI.

Figure IV-12
Total Jobs Created Annually by Scenario 2



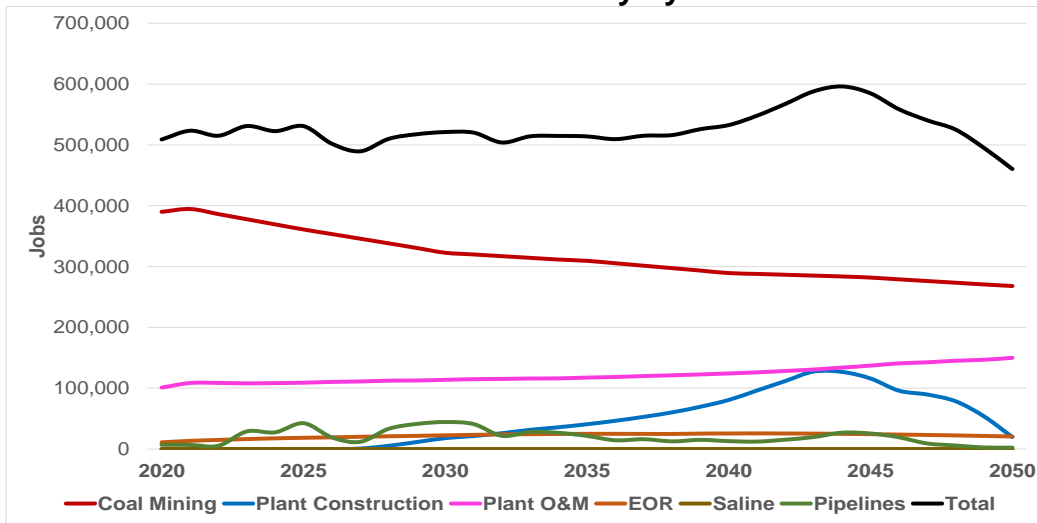
Source: MISI.

Figure IV-13
Total Cumulative Job-Years Generated by Scenario 2, 2020-2050



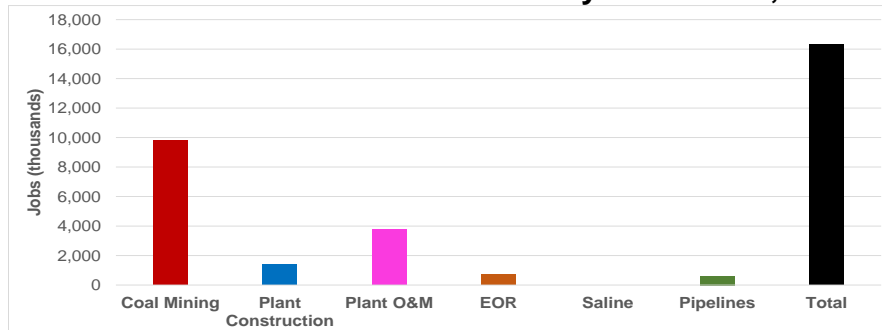
Source: MISI.

Figure IV-14
Total Jobs Created Annually by Scenario 3



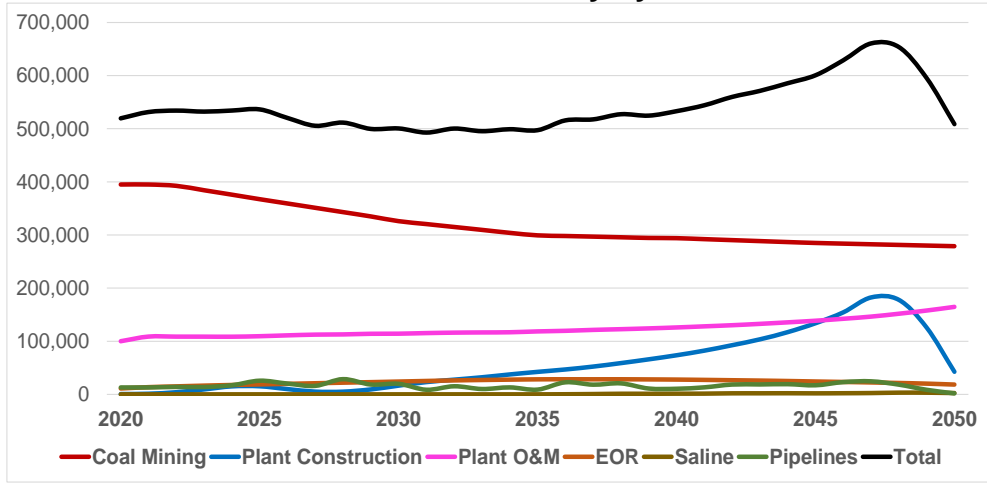
Source: MISI.

Figure IV-15
Total Cumulative Job-Years Generated by Scenario 3, 2020-2050



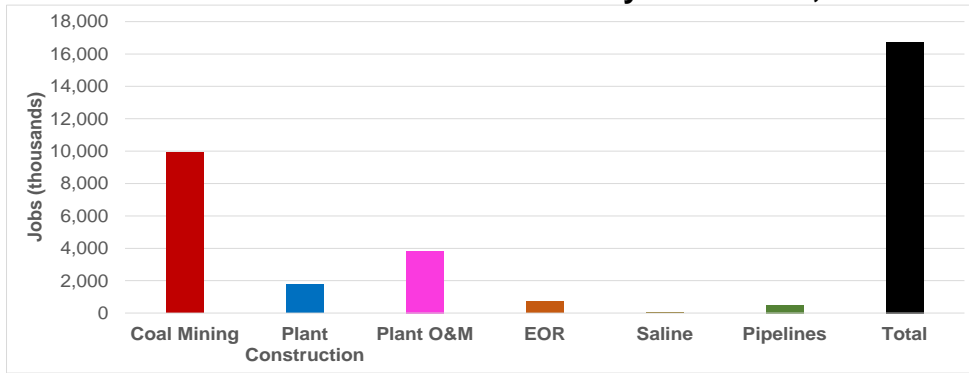
Source: MISI.

**Figure IV-16
Total Jobs Created Annually by Scenario 4**



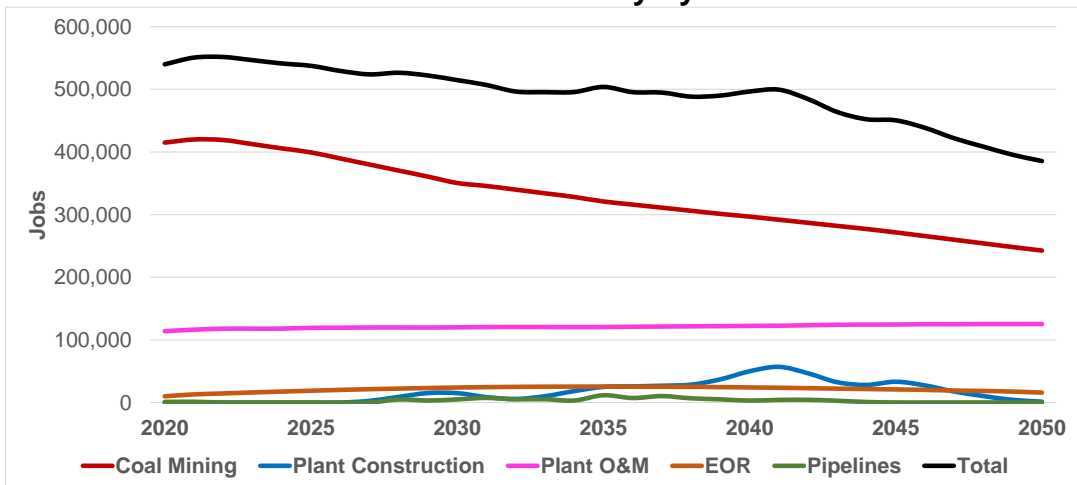
Source: MISI.

**Figure IV-17
Total Cumulative Job-Years Generated by Scenario 4, 2020-2050**



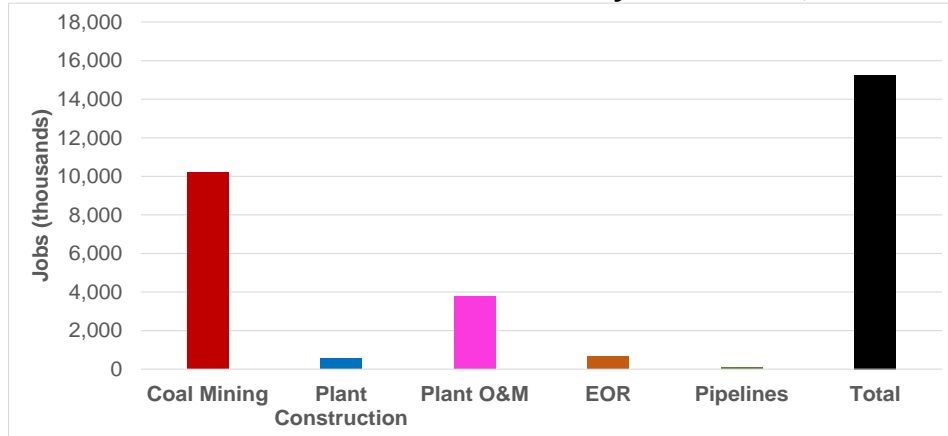
Source: MISI.

**Figure IV-18
Total Jobs Created Annually by Scenario 5**



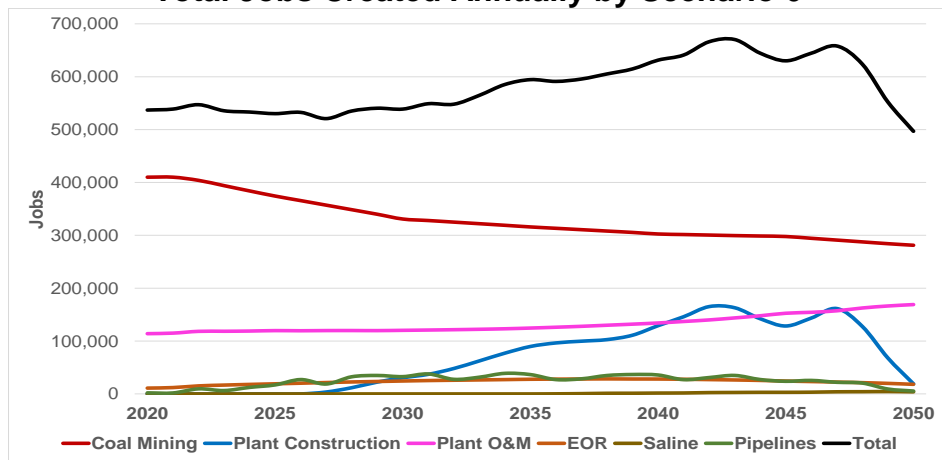
Source: MISI.

Figure IV-19
Total Cumulative Job-Years Generated by Scenario 5, 2020-2050



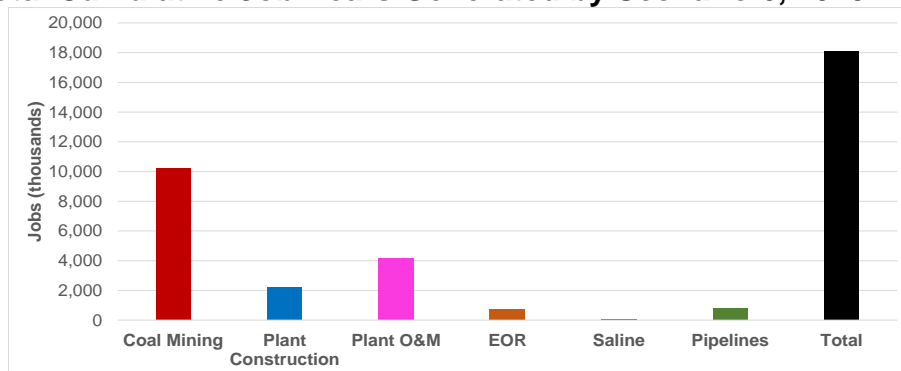
Source: MISI.

Figure IV-20
Total Jobs Created Annually by Scenario 6



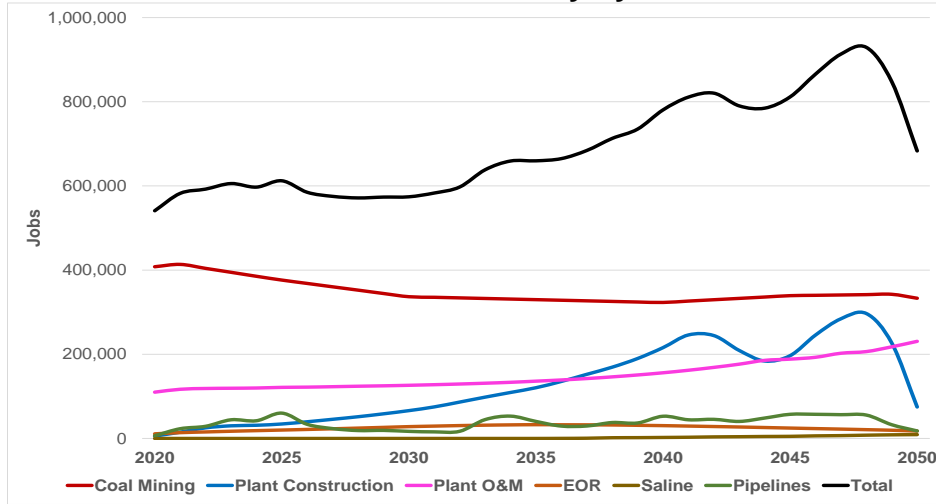
Source: MISI.

Figure IV-21
Total Cumulative Job-Years Generated by Scenario 6, 2020-2050



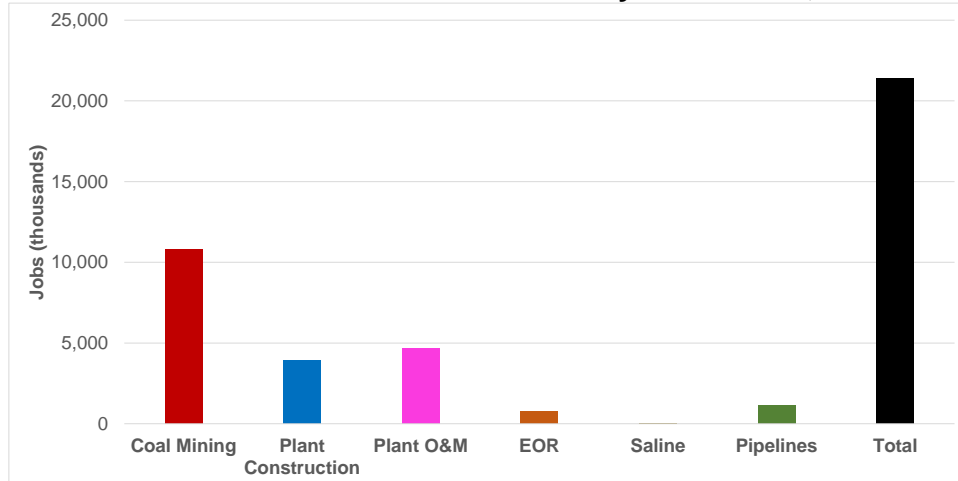
Source: MISI.

**Figure IV-22
Total Jobs Created Annually by Scenario 7**



Source: MISI.

**Figure IV-23
Total Cumulative Job-Years Generated by Scenario 7, 2020-2050**



Source: MISI.

Figures IV-10 through IV-23 illustrate the job creation patterns of the Reference Case and the scenarios. They illustrate both similar and differing patterns. Some examples of these are given below.

In all of the scenarios, the coal mining industry generates the most jobs over the forecast period, both annually and in total. In most cases coal mining generates about 60% of the total jobs created. The two major exceptions are the Reference case, in which it generates over 70% of the jobs, and Scenario 7, where it generates about 50% of the jobs. In the Reference Case, coal mining generates such a large portion of the jobs because there is no new plant construction, EOR, saline, or pipelines. In Scenario 7, on the other hand, while many more jobs are generated by the coal mining industry than

under the Reference Case, there are also large numbers of jobs generated by new plant construction, EOR, saline, and pipelines.

In all of the scenarios, coal plant O&M generates the second largest number of jobs over the forecast period and, usually, annually as well. Plant O&M is required on existing plants and on new plants that are built. However, over the forecast period the differential in job creation between coal mining and plant O&M continually decreases. This is due the fact that, first, additional plant O&M jobs will be required as new plants come on-line. Second, and more significant, the rate of labor productivity in the coal mining industry increases at a more rapid rate than plant O&M productivity. Thus, over time, the difference between the number of jobs created by coal mining and plant O&M gradually declines.

In only three scenarios does the number of jobs created annually by new plant construction exceed those generated by plant O&M:

- In Scenario 4, the number of jobs created annually by new plant construction exceeds those generated by plant O&M over the period 2046-2048.
- In Scenario 6, the number of jobs created annually by new plant construction exceeds those generated by plant O&M over the period 2041-2043 and in 2047.
- In Scenario 7, the number of jobs created annually by new plant construction exceeds those generated by plant O&M over the periods 2037-2043 and 2045-2049.

The number of jobs created by pipelines and EOR are relatively small in all of the scenarios. They are relatively the largest in Scenarios 6 and 7. In both of these scenarios, pipelines generate about 5% of the total jobs over the forecast period, and EOR generates about 4%. However, in Scenario 7, pipelines generate about 10% of the total jobs in 2025 and 8% in 2034. In Scenario 6, pipelines generate a high of about 7% of the total jobs in 2031. EOR never generates more than about four or five percent of the total jobs in any one year in any of the scenarios.

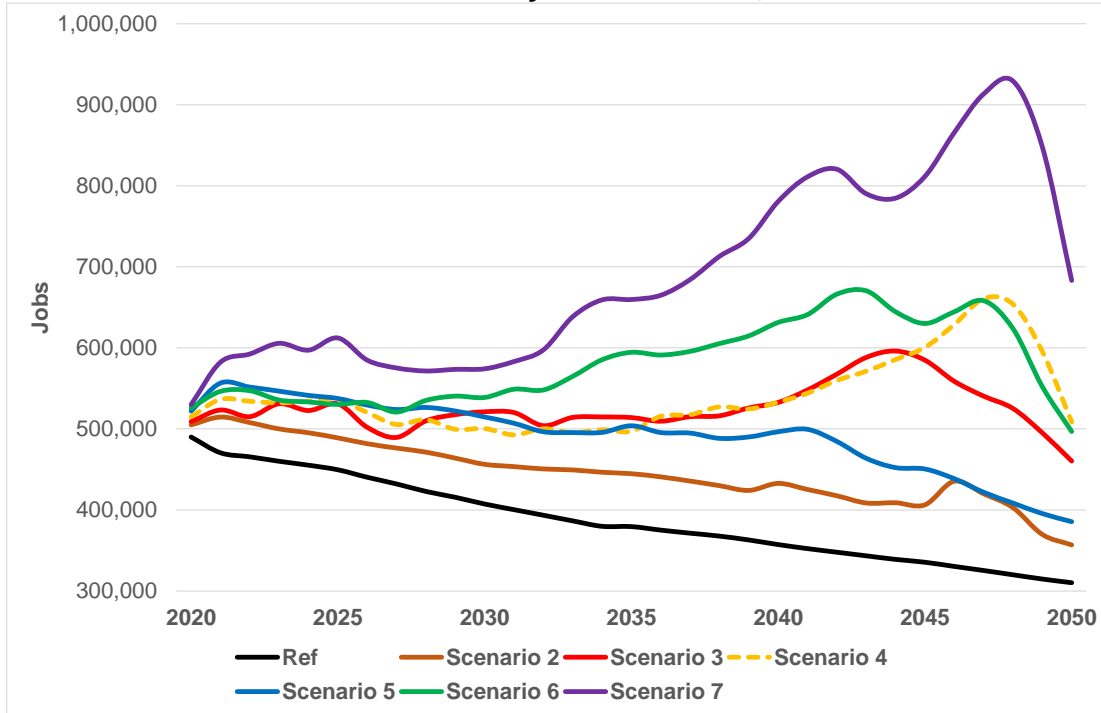
Saline sequestration comprises the smallest portion of jobs created in any of the scenarios. In several of the scenarios there is no saline sequestration, and in those scenarios where there is saline sequestration it accounts for less than one percent of the total jobs generated. Saline sequestration generates the largest number of jobs under scenario 7, but even in this scenario it accounts for only 0.3% of the total jobs generated.

IV.C.3. Comparison of Scenario Results

Figure IV-24 shows the total number of jobs created annually (directly and indirectly) by the seven technologies combined: Coal mining, new coal plant construction, coal plant O&M, EOR, saline sequestration, and pipelines. Specifically:

- Under the Reference Case, the total number of jobs generated declines continuously, from about 480,000 in 2020 to about 310,000 in 2050. In 2050, about 170,000 fewer jobs are created than in 2020.
- Under Scenario 2, the jobs created also decline continuously, from 521,000 in 2020 to about 360,000 in 2050. However, there are two variations in this trend: there is a slight upward trend in jobs between 2039 and 2040, and another increase between 2045 and 2046. In 2050, about 160,000 fewer jobs are created than in 2020.
- Under Scenario 3, the number of jobs created fluctuates between 2020 and 2037, increases substantially between 2037 and 2044, and then decreases significantly between 2044 and 2050. In 2050, about 70,000 fewer jobs are created than in 2020.
- Under Scenario 4, the number of jobs declines irregularly between 2020 and 2033, increases substantially between 2033 and 2047, and then decreases significantly between 2047 and 2050. In 2050, about 40,000 fewer jobs are created than in 2020.
- Under Scenario 5, the number of jobs declines irregularly between 2020 and 2034, increases between 2034 and 2041, and then decreases significantly between 2041 and 2050. In 2050, about 175,000 fewer jobs are created than in 2020.
- Under Scenario 6, the number of jobs declines irregularly between 2020 and 2027, increases irregularly between 2027 and 2043, decreases between 2043 and 2045, increase between 2045 and 2047, and then decreases significantly between 2047 and 2050. In 2050, about 55,000 fewer jobs are created than in 2020.
- Under Scenario 7, the number of jobs increases irregularly between 2020 and 2025, decreases irregularly between 2025 and 2029, increases between 2029 and 2042, decreases between 2042 and 2044, increases significantly between 2044 and 2048, and then decreases sharply between 2048 and 2050. In 2050, about 120,000 more jobs are created than in 2020.

**Figure IV-24
Total Jobs Generated by All Scenarios, 2020 - 2050**



Source: MISI.

Several patterns of job generation are clear:

- Under the Reference Case and Scenarios 2 and 5, job creation generally declines over the entire forecast period.
- Under Scenarios 3, 4, and 6, annual jobs created tend to increase until the early to mid-2040s and then decrease significantly by 2050.
- Under Scenario 3, job creation peaks in 2044, under Scenario 4, job creation peaks in 2047, under Scenario 6, job creation peaks in 2042 and again in 2047.
- Under Scenario 7, significantly more jobs are created every year than under the Reference Case or under any of the other scenarios, and its peak year of job creation is 2048.
- In 2048, Scenario 7 creates 610,000 more jobs than the reference Case, 525,000 more jobs than Scenario 2, 400,000 more jobs than Scenario 3, 280,000 more jobs than Scenario 4, 550,000 more jobs than Scenario 5, and 300,000 more jobs than Scenario 6.
- In 2048, Scenario 7 creates three times as many jobs as under the Reference Case, more than twice as many jobs as Scenarios 2 and 5, nearly twice as many jobs as Scenario 3, 50% more jobs than Scenario 6, and 40% more jobs than Scenario 4.
- Scenario 7 is the only scenario that creates more jobs in 2050 than in 2020.
- The sharp decline in jobs in the later years in Figure IV- 24 results from the model's timeline for building new plants and the associated construction jobs.

Figure IV-25 shows the total job-years generated by all scenarios over the forecast period. This figure illustrates that all of the six alternate scenarios generate significantly more job-years than under the Reference Case. Specifically, whereas under the Reference Case just under 12 million jobs are generated:

- Scenario 2 generates 13.8 million jobs
- Scenario 3 generates 16.3 million jobs
- Scenario 4 generates 16.8 million jobs
- Scenario 5 generates 15.3 million jobs
- Scenario 6 generates 18.1 million jobs
- Scenario 7 generates 21.4 million jobs

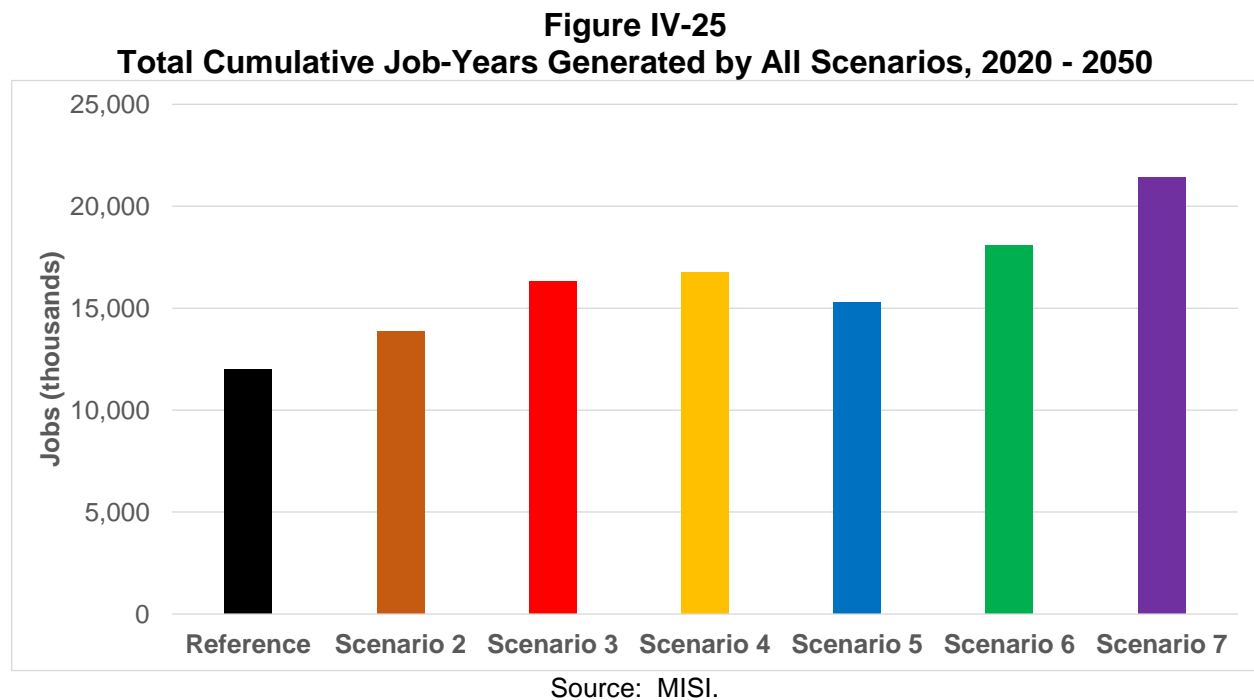
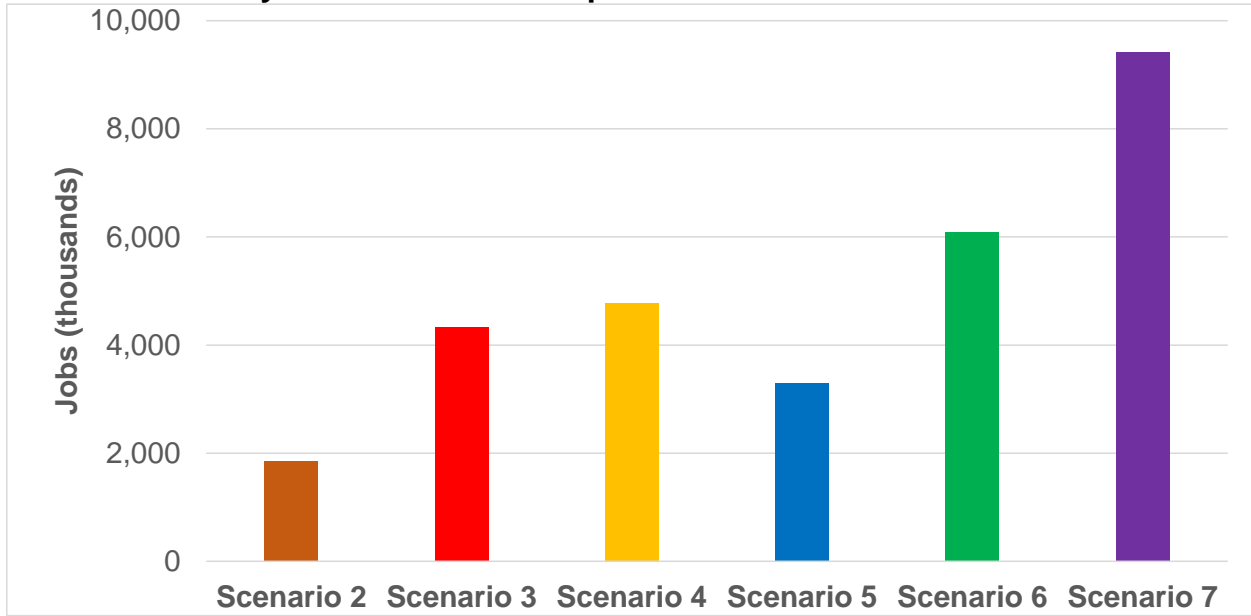


Figure IV-26 shows the increased job-years generated by each scenario compared to the reference case. Specifically, compared to the reference case:

- Scenario 2 generates 1.8 million more jobs – 15% more jobs
- Scenario 3 generates 4.3 million more jobs – 35% more jobs
- Scenario 4 generates 4.8 million more jobs – 40% more jobs
- Scenario 5 generates 3.3 million more jobs – 28% more jobs
- Scenario 6 generates 6.1 million more jobs – 51% more jobs
- Scenario 7 generates 9.4 million more jobs – 80% more jobs

Figure IV-26
Increased Job-Years Generated 2020-2050
by Each Scenario Compared to the Reference Case



Source: MISI.

IV.C.4. Policy implications of the Scenarios

The results of the scenarios permit us to derive implications for job-creation policies – especially coal-related jobs. Table IV-3 summarizes the marginal job impacts of the scenarios. Each cell of this table shows the difference in jobs created by subtracting the jobs generated by the scenario in the first column from those generated by the corresponding scenario in the first row.

Table IV-3
Marginal Job Impacts of the Scenarios
 (Jobs in millions)

	Ref	SCN 2	SCN 3	SCN 4	SCN 5	SCN 6	SCN 7
Ref.	--						
SCN 2	1.8	--					
SCN 3	4.3	2.5	--				
SCN 4	4.8	3.0	0.5	--			
SCN 5	3.3	1.5	-1.0	-1.5	--		
SCN 6	6.1	4.3	1.8	1.3	2.8	--	
SCN 7	9.4	7.6	5.1	4.6	6.1	3.3	--

Source: MISI.

It is clear that higher future economic growth and commensurate increases in electricity demand alone will increase the demand for coal and for coal-related jobs. Over the forecast period under Scenario 2, which assumes a higher growth rate for GDP and

for electricity than under the reference case, 900,000 more jobs are generated by the coal mining industry and 1.8 million jobs in total are generated – an average of about 60,000 jobs per year.

More generally, all of the scenarios assumed a GDP growth rate of 2.6%, compared to the Reference Case growth rate of 2.1%. As noted, the Administration seeks to attain a GDP growth rate of 3% annually. Since employment growth is closely tied to economic growth, it is likely that achieving a 3% growth rate instead of 2.6% would generate approximately 15% more jobs over the forecast period in each of the scenarios. Thus, achieving the Administration's goal of a 3% growth rate implies that:

- Scenario 2, instead of generating 1.8 million more jobs than the Reference Case, may generate about 2.1 million more jobs
- Scenario 3, instead of generating 4.3 million more jobs than the Reference Case, may generate about 5 million more jobs
- Scenario 4, instead of generating 4.8 million more jobs than the Reference Case, may generate about 5.5 million more jobs
- Scenario 5, instead of generating 3.3 million more jobs than the Reference Case, may generate about 3.8 million more jobs
- Scenario 6, instead of generating 6.1 million more jobs than the Reference Case, may generate about 7 million more jobs
- Scenario 7, instead of generating 9.4 million more jobs than the Reference Case, may generate about 11 million more jobs

Comparing the jobs created by the different scenarios indicates the marginal impact of different assumptions and policy options. For example:

- Scenarios 2, 3, and 4 hold the economic growth assumption and the rate of electricity growth constant. Accordingly, the marginal impact of the CCS tax credits (the difference between Scenario 2 and Scenario 3) is generation of about 2.5 million additional jobs over the forecast period.
- The marginal effect of including achievement of the DOE R&D program goals in addition to the CCS tax credits (the difference between Scenario 2 and Scenario 4) is generation of about 3 million additional jobs over the forecast period.
- The marginal effect of achieving the DOE R&D program goals with the CCS tax credits in place (the difference between Scenario 3 and Scenario 4) is generation of about 0.5 million additional jobs over the forecast period.
- Scenarios 5, 6, and 7 assume the same high economic and electricity growth as scenarios 2, 3, and 4, but assume higher oil and natural gas prices. Thus, the marginal effects of assuming higher oil and natural gas prices are estimated by comparing Scenarios 2 and 5. This indicates that the marginal effect of higher oil and natural gas prices alone is the generation of about 1.5 million additional jobs over the forecast period.
- The marginal effects of assuming higher oil and natural gas prices in conjunction with CCS tax credits are estimated by comparing Scenarios 2 and 6. This indicates that the marginal effect of both higher oil and natural gas prices and CCS tax

credits is the generation of about 4.3 million additional jobs over the forecast period.

- The marginal effects of assuming higher oil and natural gas prices in conjunction with CCS tax credits and achieving the DOE R&D program goals is indicated by the difference between Scenario 5 and Scenario 7. This indicates that the marginal effects of the combined tax credits and FE program goals is the generation of about 6.1 million additional jobs.
- The marginal effects of achievement of the DOE R&D program goals in a high oil and gas price environment with CCS tax credits in place is the difference between Scenario 6 and Scenario 7. This indicates that the marginal impacts are the generation of an additional 3.3 million jobs over the forecast period.
- The marginal effects of achievement of the DOE R&D program goals in a high oil and gas price environment with CCS tax credits in place compared to the Reference Case is the difference between the Reference Case and Scenario 7. This indicates that the marginal impacts are the generation of an additional 9.4 million jobs over the forecast period.

The marginal impacts of achieving the DOE R&D program goals are:

- In the environment of moderate oil and gas prices and with CCS tax credits in place, the generation of about 500,000 jobs.
- In the environment of high oil and gas prices and with CCS tax credits in place, the generation of about 3.3 million jobs.

The marginal impacts of the CCS tax credits are:

- Compared to the Reference Case, between 4.3 million and 6.1 million additional jobs, depending on the level of oil and natural gas prices.
- In the environment of moderate oil and gas prices, the generation of about 2.5 million additional jobs.
- In the environment of high oil and gas prices, the generation of about 2.8 additional million jobs.

Thus, the marginal impacts of achieving the DOE R&D program goals in conjunction with CCS tax credits are:

- Compared to the Reference Case, between 4.8 million and 9.4 million additional jobs, depending on the level of oil and natural gas prices.
- In the environment of higher economic growth and moderate oil and gas prices, the generation of about 3 million additional jobs.
- In the environment of higher economic growth and high oil and gas prices, the generation of about 6.1 additional million jobs.

The major policy implications of the scenario results include:

1. A higher rate of economic growth will substantially increase the demand for coal and will significantly increase the number of coal-related jobs generated – the number of jobs created will increase by more than 15%, from less than 12 million to nearly 14 million.
2. The Administration’s goal of achieving 3% GDP growth, instead of the 2.6% hypothesized here, will likely further increase the number of coal-generated jobs by as much as an additional 15%. Under the conditions of scenario 7, this would mean more than 3.2 million additional coal-generated jobs would be created.
3. All of the scenarios would significantly increase the number of coal-related jobs generated every year above those created under the Reference Case.
4. The major job impacts of all of the scenarios would occur between the early 1930s and the mid-1940s.
5. The largest job increases occur within the high oil and natural gas prices environment utilizing both CCS tax credits and DOE R&D.
6. Even in an environment of moderate oil and natural gas prices, utilizing both CCS tax credits and DOE R&D substantially increases the number of jobs created.
7. To maximize job creation tax credits are not sufficient; rather, DOE R&D is still required.
8. The full maximization of job creation is achieved using both CCS tax credits and DOE R&D within a high oil and natural gas prices environment. This results in the creation of an additional 9.4 million jobs – nearly 315,000 jobs per year over the forecast period.
9. Even in a moderate oil and natural gas prices environment maximization of job creation occurs using both CCS tax credits and DOE R&D. This results in the creation of nearly 5 million additional jobs – about 170,000 jobs per year over the forecast period.
10. The marginal impacts of the DOE program are significant. In a moderate oil and natural gas prices environment the R&D program creates about an additional 500,000 jobs; in a high oil and natural gas prices environment the program creates about an additional 3.3 million jobs – and as many as 3.8 million jobs with 3% economic growth.

The bottom line here is that to maximize job creation both CCS tax credits and the DOE R&D program need to be implemented in a coordinated manner. This will help stimulate economic growth which will, in turn, create even more jobs.

IV.D. State-Level Implications

Analysis of state-level impacts is outside of the scope of this analysis. In particular, NETL CTUS-NEMS is ill-suited to conduct state-level impact analyses.⁹⁵ Nevertheless, the effects on specific states of the simulations conducted here are important and of obvious interest. Even though the job impacts of the scenarios are only in the range of about 0.5 percent of the forecast future U.S. labor force, they will be of much greater

⁹⁵See U.S. Energy Information Administration, “NEMS Documentation,” op. cit.

impact for specific states, sectors, industries, and occupations. While we cannot simulate the detailed economic and jobs impacts on states, we can derive here the likely approximate potential impact on one relevant state – West Virginia.

MISI estimates that under Scenario 7, in 2030 West Virginia would gain about 35,000 – 40,000 total jobs and in 2040 would gain about 70,000 – 80,000 total jobs. MISI compared these job estimates with estimates of the future changes in the state's population and labor force.⁹⁶ This permitted derivation of estimates of the potential impacts of Scenario 7 on the economy and labor market in the state. MISI found that under Scenario 7:

- In 2030, West Virginia would gain enough jobs to comprise between about four and five percent of its total employment in that year.
- In 2040, West Virginia would gain enough jobs to comprise between about seven and nine percent of its total employment in that year.

In other words, the economic and employment effects of the situation illustrated by Scenario 7 would mean the difference between recessionary conditions in the state and full-employment prosperity. There are two major reasons for this. First, Scenario 7 generates the most jobs of any of the scenarios.

However, second, West Virginia is one of the few states forecast to lose population and jobs over the next several decades.⁹⁷ Thus, any jobs created in the future will comprise an increasingly large portion of employment in the state. On the other hand, job creation in the state of the magnitude of that shown in Scenario 7 may be sufficient to halt and even reverse the forecast population and jobs losses forecast for the state. This is because the bleak economic future of the state is the primary cause of continuing and forecast net out-migration and employment declines in West Virginia. Thus, the implications of the positive economic and jobs effects illustrated by Scenario 7 are of special significance to states such as West Virginia.

It is important to note that a disproportionately large share of the jobs created will be created in the specific coal mining regions of certain states. These include, for example, in addition to West Virginia, southwestern Pennsylvania, southeastern Ohio, eastern Kentucky, and southwestern Virginia.

⁹⁶Derived from Weldon Cooper Center for Public Service, Demographics Research Group, "Observed and Total Population for the U.S. and the States, 2010-2040," May 2016, www.coopercenter.org/demographics.

⁹⁷Illinois, Maine, and Vermont are also forecast to lose population.

IV.E. Occupational Job Implications

The number of jobs created is important, but it is also important to disaggregate the employment generated by the scenarios into occupations and skills. While an occupational/skill disaggregation is outside of the scope of this analysis, insight into this issue can be gained by examining related studies.

It is clear that the jobs generated will be disproportionately concentrated in fields related to the construction, energy, utilities, mining, industrial, technology, and related sectors, reflecting the requirements of the scenarios and their supporting industries. For example, the National Coal Council, at the request of the Secretary of Energy, conducted a study focused on the CCS emissions from the combustion of fossil fuels for power generation and from using coal to make alternative fuels, chemicals, and other products.⁹⁸ The study found that advanced coal technology, coupled with CCS EOR, could lead to annual revenues of \$200 billion in industry sales, \$60 billion in federal, state, and local taxes, and to the creation of over one million jobs.⁹⁹ It also found that such a large-scale initiative would create an especially robust labor market and greatly enhanced employment opportunities in many industries and in professional and skilled occupations such as chemical, mechanical, electronics, petroleum, and industrial engineers; electricians; sheet metal workers; geoscientists; computer software engineers; skilled refinery personnel; tool and die makers; computer controlled machine tool operators; industrial machinery mechanics, electricians; oil and gas field technicians, machinists, engineering managers, electronics technicians, carpenters; welders; and others. However, it is also found that numerous jobs will also be created at all skill levels for occupations such as laborers, truck drivers, security guards, managers and administrators, secretaries, clerks, service workers, and so forth.

Accordingly, the importance of the scenarios developed here for jobs in some occupations is much greater than in others. Some occupations, such as those listed initially above, will benefit greatly from the employment requirements generated by the scenarios. This is hardly surprising, for most of these jobs are clearly related to the construction, energy, utilities, scientific, and industrial sectors. Nevertheless, while workers at all levels in all sectors will greatly benefit from the initiatives, as noted, disproportionately large numbers of jobs will be generated for various professional, technical, and skilled occupations. For example, Table IV-4 shows the estimated job impacts among major occupational and skill groups created by one of the NCC initiatives in 2030. This table indicates that, while the jobs created are disproportionately for skilled, technical, and professional workers, numerous jobs in all categories are generated.

⁹⁸National Coal Council, "Harnessing Coal's Carbon Content to Advance the Economy, Environment, and Energy Security," June 2012. The Secretary also requested that the study address the storage of CO₂ and its use for EOR or the production of other products.

⁹⁹Ibid.

Table IV-4
Jobs Created by the NCC Initiative in 2030
 (Selected occupations)

Occupation	Jobs
Accountants and auditors	3,450
Bookkeeping and accounting clerks	6,670
Brickmasons and blockmasons	1,650
Carpenters	6,160
Cashiers	4,630
Cement masons and concrete finishers	2,880
Civil engineers	800
Computer programmers	1,130
Construction laborers	11,650
Cost estimators	2,040
Drywall and ceiling tile installers	1,770
Electricians	7,500
Excavating and loading machine operators	1,380
Executive secretaries and administrative assistants	4,510
First line construction supervisors	7,920
Heating, air conditioning, and refrigeration mechanics	1,240
Industrial engineers	750
Industrial machinery mechanics	1,160
Janitor and cleaners	3,700
Machinists	1,220
Management analysts	910
Mechanical engineers	830
Mobile heavy equipment mechanics	1,030
Operating engineers	5,040
Painters	3,210
Plumbers	5,650
Security guards	2,190
Shipping and receiving clerks	1,980
Sheet metal workers	2,220
Software engineers	1,390
Structural iron and steelworkers	1,070
Truck Drivers	8,720
Welders	1,960

Source: National Coal Council and MISI.

It should also be noted that the scenarios developed here will generate many jobs across a new spectrum of work activities, skill levels, and responsibilities, and some of these currently do not have occupational titles defined in federal or state government occupational classifications and standards. In addition, many of these new jobs require different sets of skills than current jobs, and training requirements must be assessed so that this rapidly growing sector of the U.S. economy and labor market has an adequate pool of trained and qualified job applicants. At some point in the future, many of these occupations will grow in the number of employees classified in the occupation and the

federal government will add them to the employment classification system.¹⁰⁰ Until that time, economic and employment analysis and forecasting is usually conducted using the current set of U.S. Department of Labor occupational titles.¹⁰¹ Identifying and analyzing the new jobs that will be created by the scenarios was outside the scope of the current study.

¹⁰⁰These new jobs will span a broad range of skills, educational requirements, and salaries and new occupational titles and definitions will be required.

¹⁰¹These are listed in the *2010 Standard Occupational Classification Code*, U.S. Department of Labor, Bureau of Labor Statistics, February 2010.

V. THE IMPORTANCE OF COAL IN U.S. MANUFACTURING

V.A. Manufacturing and the Economy

Manufacturing is of critical importance to the U.S. economy and jobs,¹⁰² and coal is critical to the manufacturing industry. The manufacturing sector is essential for a competitive and innovative economy, since:

- Manufacturing has a higher job multiplier than other sectors.¹⁰³
- There is a close linkage between innovation and manufacturing, and manufacturing generates high skilled, high-wage jobs.¹⁰⁴
- It creates spillover benefits to local regions.¹⁰⁵
- Manufacturing firms provide 70% of U.S. innovations and more than 90% of private sector patents.¹⁰⁶
- For the past two decades manufacturing productivity has increased at twice the U.S. average.¹⁰⁷
- Manufacturing dominates exports, accounting for 60% of U.S. exports' value.¹⁰⁸
- Manufacturing creates intersections of innovation and production and involves a virtuous cycle: The "industrial commons," -- ecosystems of innovative know-how, process engineering, and workforce skills required for innovation in manufacturing industries.

¹⁰²For a recent analysis, see Louis Uchitelle, *Making It: Why Manufacturing Still Matters*, New York: The New Press, 2017.

¹⁰³The manufacturing job multiplier is greater than 4, and some manufacturing sectors have multipliers closer to 7. See Keith D. Nosbusch and John A. Bernaden, "The Multiplier Effect: There Are More Manufacturing Related Jobs Than You Think," *Manufacturing Executive*, March 2012; and Timothy J. Considine, "Economic Impacts of the American Steel Industry," University of Wyoming, 2011. Touring a new factory in Batesville, Mississippi, where GE is building jet engines for the Boeing 787 Dreamliner, GE CEO Jeffrey Immelt (who was chair of the President's Council on Jobs and Competitiveness) acknowledged Lesly Stahl's observation that the highly automated plant requires fewer direct employees than factories of old. But then he stated "You're going to have fewer people that do any task. In the end, it makes the system more productive and more competitive. But when you walk through Mississippi, for every person that was in that plant, there are probably seven or eight jobs in the supply chain." CBS News *60 Minutes*, "The Jobs Czar: General Electric's Jeffrey Immelt," interview with Lesley Stahl, aired October 9, 2011.

¹⁰⁴The average U.S. manufacturing worker earns \$78,000/yr. (pay and benefits) compared to the \$57,000/yr. for the average U.S. worker.

¹⁰⁵"Making in America: U.S. Manufacturing Entrepreneurship and Innovation," The Executive Office of the President, June 2014.

¹⁰⁶See David Autor, David Dorn, and Gordon H. Hanson, *Foreign Competition and Domestic Innovation: Evidence from U.S. Patents*, National Bureau of Economic Research, November 2016; Susan Helper, Timothy Krueger, and Howard Wial, "Why Does Manufacturing Matter? Which Manufacturing Matters? A Policy Framework," Brookings Institution, February 2012.

¹⁰⁷National Association of Manufacturers, "Top 20 Facts About Manufacturing," 2017, <http://www.nam.org/Newsroom/Top-20-Facts-About-Manufacturing/>. "The correlation between exports, manufacturing and good-paying jobs is clear." U.S. Under Secretary of Commerce, January 2012.

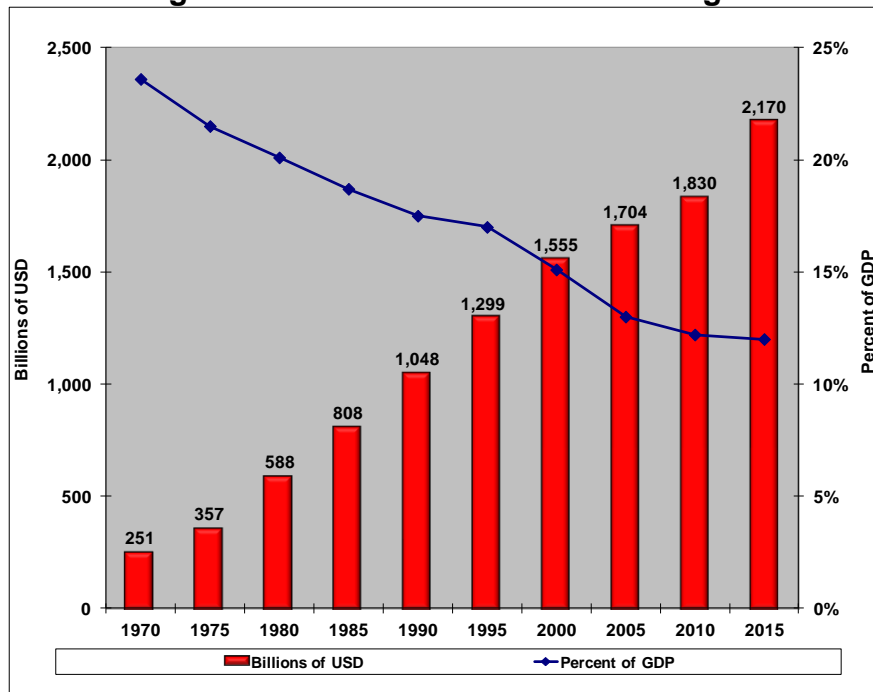
¹⁰⁸See McKinsey Global Institute, "Manufacturing the Future: The Next Era of Global Growth and Innovation," November 2012. U.S. manufacturing exports rank third in the world, after EU and China and are 30% larger than Japan's.

- Manufacturing generates high skilled, high-wage jobs: The average U.S. manufacturing worker earns \$80,000/yr. (pay plus benefits) compared to \$57,000/yr. for the average U.S. worker.
- “If an auto plant opens up, a Wal-Mart can be expected to follow. But the converse does not hold: A Wal-Mart opening definitely does not bring an auto plant with it.”¹⁰⁹

Thus, serious economic harm will result from allowing U.S manufacturing to atrophy, and coal is critically important for a U.S. manufacturing renaissance.

While U.S. manufacturing output has been increasing, its share of the U.S. economy has been declining for the past half-century. As illustrated in Figure V-1, in 1970, manufacturing comprised nearly 25% of the U.S. economy, but by 2015 it had declined to about half of that – 12%.

Figure V-1
Manufacturing GDP in Dollars and as a Percentage of U.S. GDP



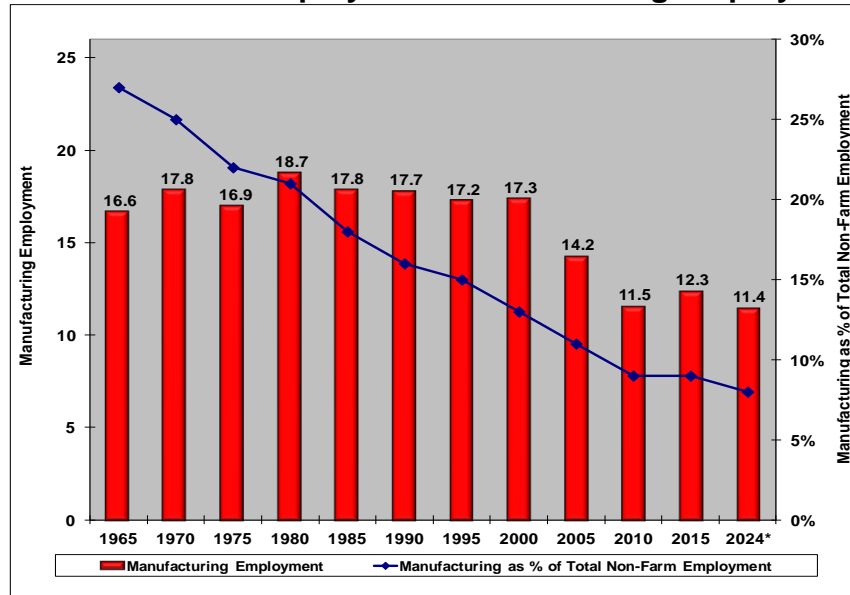
Source: U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, and MIsI.

U.S. manufacturing jobs have decreased nearly every year for the past three decades: One of every five U.S. jobs used to be in manufacturing, but at present it is one of every 12 jobs – Figure V-2. The dramatic loss of manufacturing jobs over the past decade was a break from the past and cannot be explained by productivity and technology gains. Since 2000, the manufacturing sector lost one third of its jobs -- six million jobs.¹¹⁰

¹⁰⁹Gene Sperling, Director of the White House National Economic Council, March 2012.

¹¹⁰Mark Muro, “Manufacturing Jobs Aren’t Coming Back,” *MIT Technology Review*, November 28, 2016.

Figure V-2
Manufacturing Employment as a Percent of
Total Non-Farm Employment Manufacturing Employment



*Forecast

Source: U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, and MSL.

The U.S. is currently attempting to facilitate a "renaissance" in American manufacturing: The Trump Administration is striving to strengthen domestic manufacturing to create jobs and has announced a Manufacturing Jobs Initiative.¹¹¹ Coal generated electricity is required for this, since it provides the U.S. with an important industrial competitive advantage.

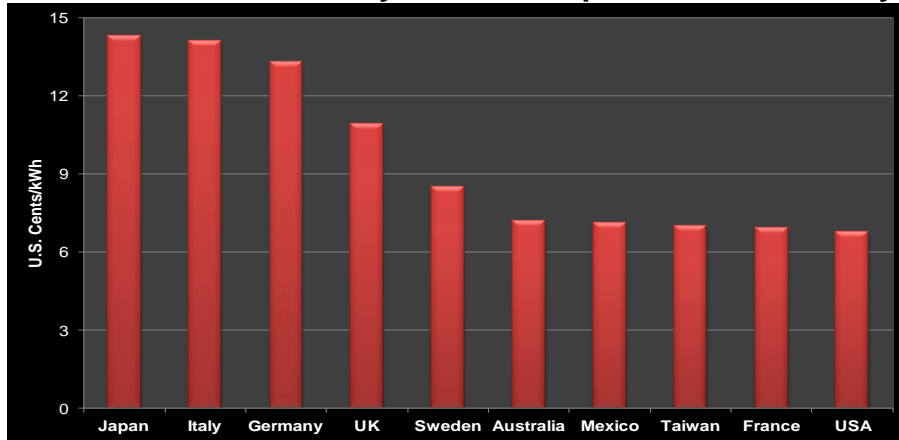
V.B. Electricity Prices as a Competitive Advantage

U.S. industrial electricity prices are a strong competitive advantage for manufacturing – Figure V-3. As noted by the EU Commission, “Electricity prices are of particular importance for international competitiveness, as electricity represents a significant portion of total energy costs faced by industrial businesses.”¹¹² Conversely, price matters and rising electricity costs hurt industry and destroy jobs.

¹¹¹“President Trump Announces Manufacturing Jobs Initiative,” the White House, January 27, 2017.

¹¹²“Eurostat Statistics Explained, Energy Price Statistics,” November 2011, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Energy_price_statistics.

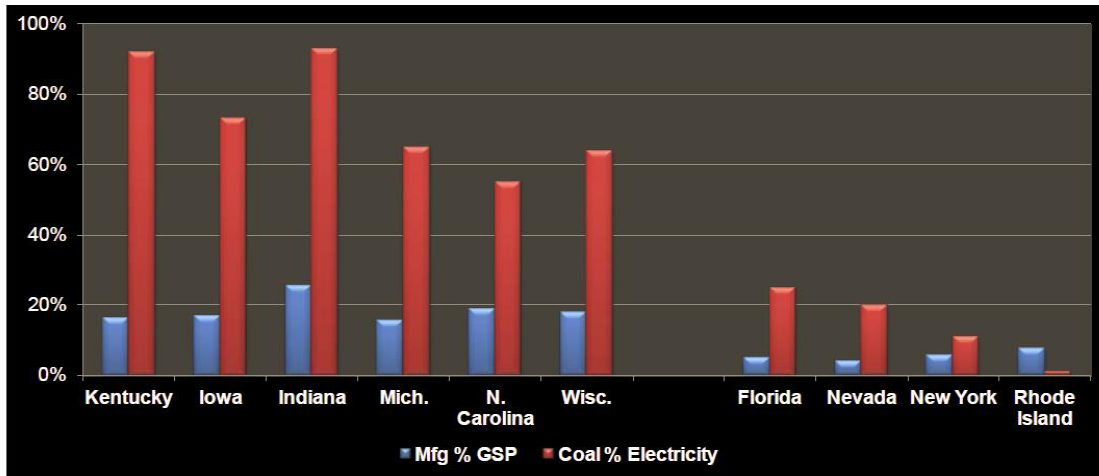
Figure V-3
U.S. Industrial Electricity Prices Compared Internationally



Source: U.S. Energy Information Administration, NUS Consulting, and MISI.

This competitive advantage is true in the U.S. inter-regionally as it is for the U.S. internationally. As illustrated in Figure V-4, there is a close relationship between the reliable, affordable electricity provided by coal and a state's manufacturing output, and states with the most manufacturing generate most of their electricity with coal.

Figure V-4
Percent of Gross State Product (GSP) Compared To the Percent of State Electricity Generated by Coal



Source: U.S. Energy Information and National Association of Manufacturers.

V.C. Manufacturing, Electricity, and Coal

U.S. manufacturing is critically dependent on the reliable, affordable electricity provided by coal power plants. As noted by the National Association of Manufacturers, the manufacturing sector has a huge stake in ensuring that the U.S. has a dependable supply of affordable energy.¹¹³ Specifically:

- Lower energy costs facilitate superior performance of U.S. industrial firms
- New electric technologies are replacing existing fuel-based technologies
- Productivity is driven by technology, and new technology is increasingly electric
- Advanced manufacturing technologies (AMTs) require stable, reliable, uninterrupted electric power
- Productivity growth is the highest in electric-dominant industries
- U.S. manufacturing productivity is twice as high as two decades ago, and electric technologies enabled by low-cost electricity facilitated this
- Electric technologies are the primary source of new equipment
- AMTs are more electricity intensive and more energy efficient
- New AMTs will be electricity dependent and require more electricity
- Electrotechnologies will dominate new technology and productivity growth

The automotive industry provides an instructive example of the importance of electricity and electro-technologies. A major disruptive trend in the auto industry is the continuation of pervasive cost pressures as international competition, input price trends, and increased demand for consumer electronics increase costs for North American producers.¹¹⁴ Input costs are rising steadily and it is forecast that in the coming decade global commodity prices will continue to rise.¹¹⁵ For example, the prices of steel and petroleum -- two of the most important commodities for the auto industry -- increased by 30 and 250 percent, respectively, between 2001 and 2010. During that same time period content suppliers were forced to absorb input cost increases of 50 percent.¹¹⁶ The U.S. auto industry is thus undergoing critical changes, and cost pressures continue to affect its competitiveness and faces increasing competition from Mexico and other nations.¹¹⁷

The U.S. does have one important advantage over most of its competitors: Reliable, high quality, low-cost electricity – Figure V-3. This has been critical in the past for the automotive industry, and will be even more important in the future. It is currently an important competitive advantage and it is one input cost over which the U.S. has control. Most important perhaps, automotive manufacturing in the future will become

¹¹³National Association of Manufacturers, “Competing to Win: Energy in Focus,” 2013.

¹¹⁴The changing composition of the modern automobile is also driving up input costs, particularly with regard to IT systems and new battery technologies for hybrid and electric cars.

¹¹⁵“U.S. Manufacturing on Track to Nearly Double Export Markets by End of 2015,” Nissan North America, Irvine, California, 2013.

¹¹⁶“Auto Industry Top Trends 2017,” <https://www.spratings.com/documents/20184/1481001/ITT+2017+Autos/bd697013-7750-4a77-be74-e6936c79a7bf>; International Trade Administration, “Trends in U.S. Vehicle Exports,” Washington, D.C.: U.S. Department of Commerce, 2013.

¹¹⁷Center for Automotive Research, “Automotive Outlook Q4 2016,” Ann Arbor, 2016, and Sean McAlinden and Yen Chen, “After the Bailout: Future Prospects for the U.S. Auto Industry,” Ann Arbor, 2012.

even more electricity intensive and dependent on emerging electro-technologies. As noted, electricity is increasingly critical for all manufacturing. In particular, advanced electro-technologies are especially important in automotive manufacturing and these technologies include:¹¹⁸

- Materials with engineered properties created through the development of specialized process and synthesis technology.
- Nanotechnology, including materials, devices, or systems at the atomic, molecular, or macromolecular level, with a scale measured in nanometers.
- Micro-electromechanical systems, including devices and systems integrating microelectronics with mechanical parts and a scale measured in micrometers.
- New technology and systems that enhance and improve the manufacturing process.
- Advanced computing and electronic device technology related to advanced automotive, manufacturing materials, information, and processing technology.
- Design, engineering, testing, and diagnostics related to advanced automotive, manufacturing, information, and processing technology.

For example, the automotive industry is increasingly reliant on electronic solutions, electronics account for 40 percent of automotive production costs, and they will be increasingly important in the future.¹¹⁹ If present trends continue, electronic component costs will soon comprise the majority of materials/components costs. The main factor behind the rapid increase in the proportion of electronic components used in motor vehicles is the crucial role that electronics plays in developing optimal technological solutions to the four main issues that automakers currently face:

1. Improving drivability
2. Enhancing safety features
3. Lowering environmental burden
4. Realizing greater operational reliability.

The effective application of electronics technology is absolutely vital to the automotive industry as viable solutions to these four key issues.¹²⁰

Twenty-first century vehicle manufacturing is experiencing the “Third Industrial Revolution” and will increasingly require mass customization and individualized production, 3-D printing, additive manufacturing, digitalization of manufacturing, nanotechnology, continuing manufacturing processes, next generation ultra-precision production systems, emerging smart system products, new production chains that apply nano and micro scale features rapidly onto large (and continuous) multi-material substrates, fine feature generation processes for multi-material processing, including

¹¹⁸“Advanced Automotive, Manufacturing, Materials, Information,” www.gvsu.edu/.

¹¹⁹Center for Automotive Research, “Advanced Information Technology Solutions: An Engine of Innovation,” <http://www.cargroup.org/wp-content/uploads/2017/02/Advanced-Information-Technology-Solutions-An-Engine-of-Innovation.pdf>; TechnoAssociates, Nikkei Business Publications, Inc., 2013.

¹²⁰Ibid.

effective quality control, and related technologies.¹²¹ All of these will be highly dependent on high quality, abundant, reliable, affordable electricity.¹²² Coal is essential to provide this electricity.

In particular, several electricity-dependent trends will affect production process and platform design in automotive manufacturing in the coming years, including digital modeling, simulation, and visualization; advances in industrial robotics; and additive manufacturing.¹²³ Adoption rates for these technologies vary widely, but the trend is clear.

Digital modeling, simulation, and visualization. Using inputs from product development and historical production data (such as order data and machine performance), vehicle manufacturers can apply advanced computational methods to create a digital model of the entire manufacturing process. A "digital factory," including all machinery, labor, and fixtures, can simulate the production systems. In addition, ubiquitous sensor technologies (such as cameras and transponder chips) help to "synchronize" simulation and reality at every point in the production timeline. Leading automobile manufacturers have used this technique to optimize the production layout of new plants, and companies have developed simulations to significantly improve the reliability of complex production lines¹²⁴

Vehicle manufacturers are also using big data techniques and analytics to manage complex manufacturing processes and supply chains, and big data facilitates greater experimentation at the product design stage. Toyota, Fiat, and Nissan have reduced new-model development time by 30 to 50 percent by allowing designers and manufacturing engineers to share data quickly and create simulations to test different designs and choice of parts and suppliers.¹²⁵

Advances in industrial robotics. Nearly two million industrial robots are currently in use worldwide, 150,000 are being sold annually, and the numbers and uses are increasing dramatically. Robot use is highly skewed by region and by industry, the automotive sector is one of the major users of robots, and robots are more concentrated in advanced economies where wages are higher and the workforce is more highly

¹²¹Bill O'Neill, "An Exploration of Future Manufacturing Technologies in Response to the Increasing Demands and Complexity of Next Generation Smart Systems and Nanotechnology," Centre for Industrial Photonics Institute for Manufacturing, Department of Engineering, University of Cambridge, March 2012.

¹²²"The manufacturing sector has a huge stake in ensuring that the U.S. has a dependable supply of affordable energy." National Association of Manufacturers, 2013. See Business Roundtable, "Reliable, Affordable Energy," http://businessroundtable.org/sites/default/files/energy_1.pdf.

¹²³*Manufacturing the Future: The Next Era of Global Growth and Innovation*, McKinsey Global Institute. McKinsey & Company, 2012.

¹²⁴*Improved Manufacturing Processes Save Company One Billion Dollars*, U.S. Department Energy, www.energy.gov.

¹²⁵Tata Consultancy Services, "Manufacturing: Big Data Benefits and Challenges," <http://sites.tcs.com/big-data-study/manufacturing-big-data-benefits-challenges/>, and Dan Somers. "Manufacturing 4.0: From Industrialisation to Data-Driven Product Lifecycle," <http://www.citizenekkk.com/manufacturing-4-0-industrialisation-data-driven-product-lifecycle/>.

educated.¹²⁶ Across manufacturing industries, robots are used increasingly to reduce variability, increase speed in repetitive processes, get around ergonomic restrictions, and improve plant utilization and productivity.¹²⁷ Rapid adoption is being driven largely by falling costs, and average robot prices have declined by 40 to 50 percent relative to labor compensation since 1990.¹²⁸ Another factor is the growing variety and complexity of tasks that robots can perform with the integration of machine learning and natural language processing. In addition, manufacturers are installing robots to meet demands for higher quality from customers and regulators and to match competitors. Robotics can also help manufacturers adapt to changes in the global labor market, such as the aging of working-age populations and rising labor costs in developing economies. The automotive industry is the most important customer of industrial robots and has substantially increased investments in industrial robots worldwide. In recent years it has accounted for about 40 percent of new industrial robot purchases.¹²⁹

Additive manufacturing. Additive manufacturing (AM) refers to a wide set of technologies, including 3-D printing, that build up solid objects from small particles.¹³⁰ AM technologies -- selective laser sintering, fused deposition modeling, and stereolithography -- are key technologies for industrial AM. These technologies are used over a range of products, materials, and sizes, with no single technology capable of covering the entire range. The automotive industry is one of the primary users and, while AM manufacturing consumes large amounts of electrical energy per unit of product, it mitigates the need for large amounts of raw material in the supply chain. AM can be a truly transformative force for manufacturing flexibility by reducing prototyping and development time, reducing material waste, eliminating tooling costs, enabling complex shapes and structures, and simplifying production runs. Some experts believe AM is nearing an inflection point, as new advances enable more applications, reduce costs, and increase adoption by downstream industries.¹³¹

The U.S. steel industry provides another salient example of the importance of U.S. manufacturing, and a study by Dr. Timothy Considine estimated the contributions of the American steel industry to the U.S. economy in 2010.¹³² In that year, the U.S. steel industry directly employed more than 139,000 workers and contributed \$17.5 billion in value added (GDP).¹³³

¹²⁶International Federation of Robotics, *World Robotics 2013: Industrial Robots* 2013.

¹²⁷Automate 2015, "New Era of Industrial Robots, <http://www.roboticstomorrow.com/article/2015/04/automate-2015-new-era-of-industrial-robots/5840/>.

¹²⁸Georg Graetz and Guy Michaels, "Robots at Work," London School of Economics, June 2016.

¹²⁹Automat 2015, op. cit.

¹³⁰"Additive Manufacturing," <http://www.autodesk.com/solutions/product-development-innovation-platform?mktvar002=678083&mkwid=so4gtGZuF|pcrid|160088329613|pkw|additive%20manufacturing|pmt|e|pdv|c|&&gclid=CPWO6p2CrNMcFdSPswodbt8ASA>; Wohlers Report 2012: *Additive Manufacturing and 3D Printing State of the Industry*, Wohlers Associates, 2012.

¹³¹McKinsey Global Institute, op. cit.

¹³²Considine, "Economic Impacts of the American Steel Industry," op. cit.

¹³³He defined the steel industry to include two sectors: Iron and steel mills and ferroalloys and steel product manufacturing from purchased steel.

However, the economic contribution of the steel industry to the U.S. economy, goes far beyond these sector specific measures because steel companies purchase inputs from many other sectors of the U.S. economy. Further, the steel industry contributes to household income, which then induces additional rounds of stimulus to the economy as households spend this income on goods and services. For example, during 2010 the steel industry purchased more than \$20 billion of materials produced in other industries, \$8 billion of services, \$5 billion of energy products, \$4.5 billion of machinery, \$4.4 billion from wholesale and retail trade sectors, more than \$4 billion of transportation services, and generated \$12.4 billion in labor income. Clearly, the steel industry supports businesses and jobs in many sectors of the U.S. economy.

To map these interdependencies, Considine utilized interindustry analysis to estimate these indirect or supply chain impacts as well as the impacts induced by the spending of household income contributed directly and indirectly by the steel industry.¹³⁴ His economic impact study found that the steel industry directly contributed \$17.5 billion of value added, \$40 billion indirectly via supply chain spending, and induced another \$35.8 billion as households spent their income generated from these activities – Table V-1. This table shows that in terms of net contribution to the U.S. economy the steel industry contributed \$93.4 billion to gross domestic product during 2010. In addition, the steel industry directly employed over 139,000 workers, supported another 360,986 workers indirectly through the supply chain, and induced spending by households that supported another 443,002 jobs in other sectors of the economy. In total the steel industry supported 943,045 jobs in the U.S. economy during 2010.

Considine estimated that with higher levels of steel sales during 2011, the U.S. steel industry contributed \$101.2 billion to GDP and generated \$22.9 billion in tax revenues at the federal, state, and local level, for a gross economic output of over \$246 billion. Since steel is the most prevalent material in the economy, the steel industry is highly interrelated with other economic sectors, as reflected in the ripple effect on employment. He estimated that every job in the U.S. steel industry creates seven jobs in the U.S. economy. For 2011, the industry directly employed 150,700, and given the multiplier effect, supported more than 1,022,000 jobs in total.

Table V-1
Economic Contributions of the U.S. Steel Sector, 2011
(Millions of Current Dollars)

	Direct	Indirect	Induced	Total
Employment	150,700	391,213	480,096	1,022,009
Value Added	18,996	43,405	38,811	101,211
Gross Output	90,461	88,365	67,387	246,213
Total Taxes	4,006	10,043	8,856	22,905

Source: Considine, “Economic Impacts of the American Steel Industry.”

¹³⁴He used the IMPLAN system, available from MIG, Inc.

The largest single use of coal in the steel industry is as a fuel for the blast furnace, either for the production of metallurgical coke or for injection with the hot blast.¹³⁵ Coal is also used for making steam and electricity, as a source of carbon addition in steel making processes, and in direct smelting of iron processes. In addition, electricity purchased from outside sources is largely generated from pulverized coal combustion and therefore has an indirect influence on steel making operations.¹³⁶ The requirements of coals purchased for coke making are much different from those used in other processes. Only a unique class of coals possessing very specific properties and composition are suitable for the making of a quality coke for blast furnace use.

Without ample electricity generation it is impossible to liquefy metal or power heavy-duty furnaces and machinery. Even more significant, it is impossible to make steel without coal. Steelmaking begins with metallurgical coal, which is used to make coke, and combining coke with iron ore yields steel.

Coal is thus essential for steel production. Iron ore is not iron, but iron combined with oxygen as well as a mix of other elements. To extract the iron from the ore, carbon is used to remove the oxygen resulting in iron and carbon dioxide. Steel is much stronger than iron, and to make steel carbon is added to the iron. The carbon atoms are between their larger iron atoms and the bonds of the carbon is what gives the additional strength. There is simply no way wind, solar, or even hydroelectric power is going to replace coal or some source of carbon in making steel.¹³⁷

Without coal, the U.S. would need to import all of the steel currently used to manufacture vehicles, military equipment, and numerous other industrial products. The U.S. domestic steel industry is already struggling to stay competitive against subsidized imports. U.S. steel producers cannot afford the twin, added expenses of higher energy costs and imported metallurgical coal. This highlights the intersection of coal, steel, and manufacturing. Remove one, and the other two are lost.

The world is fundamentally dependent on steel production, and steel production is fundamentally dependent on the large-scale use of coal.¹³⁸ At present, nearly half of the world's steel is made in China, with Chinese steel production increasing by over 500 percent since 2000. China's steel industry consumes almost seven percent of the world's coal, and if its steel industry was a country, it would rank sixth in total primary energy consumption globally, ranking above both Germany and Canada.

¹³⁵Gareth D. Mitchell, "Coal Utilization in the Steel Industry, The Pennsylvania State University, <http://www.steel.org/making-steel/how-its-made/processes/processes-info/coal-utilization-in-the-steel-industry.aspx>.

¹³⁶Except for coke making, the requirements for a quality coal product are straightforward. For pulverized coal combustion, whether taking place in a combustion unit or in the blast furnace, the coal must deliver a known and consistent calorific value, be reasonably low in ash yield or have a relatively benign ash chemistry and meet environmental standards for sulfur and nitrogen oxide emissions. In addition, it must be relatively easy to grind and to handle.

¹³⁷Steven Capozzola, "Killing Coal Means Burying America's Steel Industry Too, *Climate Dispatch*, March 20, 2016.

¹³⁸Robert Wilson, "Steeling Ourselves for More Coal," the Breakthrough Institute, January 2014.

The current vast disparities in steel consumption suggest that a significant increase in overall steel consumption is inevitable and desirable. However, limits are being reached as to how efficiently steel can be produced. Because energy has always been 35 – 40% of the cost of steel production, producers have already sought and applied every available option for energy efficiency and existing production processes are already extremely energy efficient.¹³⁹ Thus, despite some possibilities to improve the rationality of steel use, it is clear that there will be a need to mine hundreds of millions of tons of coal each year to produce steel for decades, and more likely, generations to come.

The U.S. steel industry thus provides a compelling example of the importance of electricity, and the steel sector is very concerned about increased electricity costs and reliability issues. Electricity costs directly impact the steel sector bottom line, reducing competitiveness and jeopardizing jobs. Reliable energy at lowest possible cost is a core part of business planning and profit or loss: In the steel industry, a 1 ¢/kWh increase in electricity cost imposes additional costs of \$9 billion per year.¹⁴⁰ Electricity costs affect investment decisions and jobs, and steelmakers are one of the largest and most interruptible customers for utilities. In New Jersey, a steel mill was closed due to mounting kWh base charges. Thus, “If electricity prices do not remain affordable and if electric supply is not reliable, the economic recovery is at risk along with manufacturing jobs.”¹⁴¹

V.D. Electricity, Coal, and the Third Industrial Revolution

Electricity is critical for the third industrial revolution: The first started in Britain in the late 18th century and originated in the textile industry; the second occurred in the U.S. in the early 20th century driven by assembly line techniques; and the third revolution is occurring in the 21st century.¹⁴² This most recent revolution involves:

- Mass customization and individualized production
- 3D printing
- Additive manufacturing¹⁴³
- Digitalization of manufacturing
- Nanotechnology continuing manufacturing processes
- Genetic engineering and manufacturing.

¹³⁹“Energy Efficiency in Existing Processes,” UIT Cambridge LTD, 2012, <http://www.withbotheyesopen.com/read.php?c=7>.

¹⁴⁰Congressional testimony of Darren MacDonald, Director of Energy, Gerdau Steel, before the U.S. House of Representatives Energy and Commerce Committee, Subcommittee on Energy and Power, February 8, 2012.

¹⁴¹*Ibid.*

¹⁴²Robert J. Gordon, *The Rise and Fall of American Growth: The U.S. Standard of Living Since the Civil War*, Princeton University Press, 2016.

¹⁴³Additive manufacturing consumes a large amount of electrical energy per unit of product, but mitigates the need for large amounts of raw material in the supply chain. See Phil Reeves, “Additive Attractions,” <https://www.theengineer.co.uk/issues/the-engineer-sustainability-supplement/additive-attractions/>.

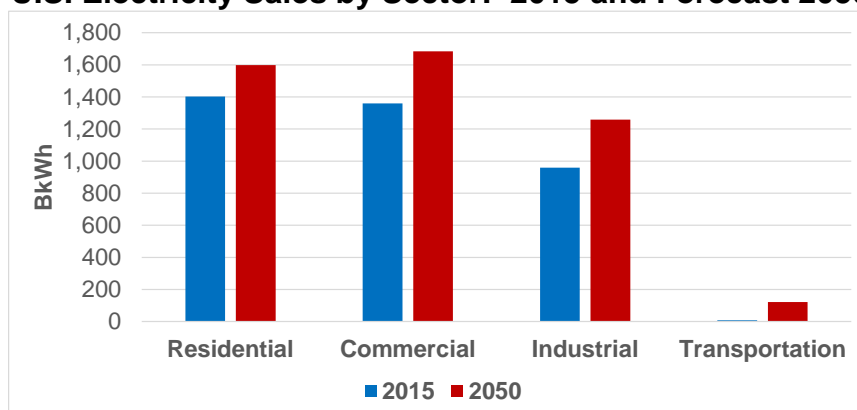
This third revolution is extremely dependent on high quality, reliable, affordable electricity, and coal is essential to provide this electricity.

Figure V-5 shows electricity sales by sector under the EIA *AEO 2017* no CPP case, and illustrates that between 2015 and 2050:

- Residential electricity sales increase 14%, from 1,400 BkW in 2015 to 1,599 BkW in 2050 – an average annual increase of 0.4%
- Commercial electricity sales increase 24%, from 1,358 BkW in 2015 to 1,685 BkW in 2050 – an average annual increase of 0.6%
- Industrial electricity sales increase 26%, from 999 BkW in 2015 to 1,258 BkW in 2050 – an average annual increase of 0.8%.

Thus, industrial electricity consumption increases more rapidly than in any other sector, and increases from less than 26% of the total in 2015 to 27% in 2040.

Figure V-5
U.S. Electricity Sales by Sector: 2015 and Forecast 2050



Source: U.S. Energy Information Administration.

It should also be noted that there has been a significant and continuing energy transformation occurring in the U.S. economy over the past five decades. The U.S. is increasingly dependent on electricity: During the 1970s, electricity accounted for less than 40% of all non-transportation energy use, whereas at present that share is 55 percent and continues to increase. This has occurred primarily due to vast increases in computing, communications, and related infrastructure, which requires a reliable and always-available electricity.¹⁴⁴

¹⁴⁴“A New Mine Marks Bright Spot in Troubled Coal Industry,” *Wall Street Journal*, <https://www.wsj.com/articles/a-new-mine-marks-bright-spot-in-troubled-coal-industry-1496145600>.

VI. THE IMPORTANCE OF COAL IN REGIONAL ECONOMIES AND JOBS

Coal plants are among the largest industrial facilities and major employers in many local areas, and they pay a large share of local property taxes. The plants provide high quality, well-paying jobs and support local business. Most important, these plants provide reliable, affordable electricity that powers local industry, business, and commerce. Without this power, local businesses and economies wither and jobs disappear. In this chapter:

- Assess the importance of coal power plants to the surrounding local areas
- Estimate the benefits of the reliable, affordable electricity provided to local business, commerce, and jobs
- Estimate the impacts on local economies and jobs of the higher electricity costs resulting from coal plant closures
- Conduct a specific case study of the local economic and job impacts of a coal plant closing

VI.A. Impacts of Coal Plant Shutdowns

Much attention has been paid to recent coal mining job losses. However, much less attention has been given to the critical role of coal power in supporting local and regional economies and jobs. Coal plants are among largest industrial facilities and major employers in many local areas, and they pay a large share of local property taxes. Their taxes are the mainstay of local school systems, and these schools are often among best in the state. Their taxes also support local governments and help pay for police, firefighters, teachers, EMTs, libraries, etc. The plants provide the type of high quality, well-paying jobs often “not available elsewhere” and support local business, stores, restaurants, vendors, and others. Most important, these plants provide reliable, affordable electricity that powers local industry, business, and commerce. Without this power, local businesses and economies will wither and jobs will disappear. MISI assessed specific coal plants’ importance for local areas and found that, for example:

- The Huntley Generating Station, a coal-fired plant near Buffalo, New York shut down in March 2016. It was the largest taxpayer in the town of Tonawanda, and its shutdown left the town, the local school district, and the county with a \$6 million funding gap. According to town supervisor Joseph Emminger, "Are we going to replace the 6 million dollars? Probably not."¹⁴⁵
- The San Juan Generating Station is the largest property taxpayer (\$7 million annually) in San Juan County, New Mexico.
- The Eastlake, Ohio plant closing in 2015 will cost the town \$4 million per year in taxes, and will be devastating the Willoughby-Eastlake City schools.

¹⁴⁵80 people lost their jobs, the Kenmore-Town of Tonawanda School District lost almost \$3 million in tax revenue, the Town of Tonawanda lost about \$2 million, and Erie County will lose around \$800,000. <https://www.eenews.net/energywire/2017/04/18/stories/1060053203>; <http://buffalonews.com/2015/08/27/closing-of-aging-huntley-power-plant-will-force-a-difficult-but-manageable-transition>.

- The Glen Lyn plant in Glen Lyn, Virginia, which closed in 2015, provided 25% of the town budget.
- When the Rivesville, West Virginia coal plant closed in 2012, the town lost 20% of its budget.
- The 2014 closure of Salem Harbor Station in Salem, Massachusetts eliminated the town's largest taxpayer, reducing tax revenues by \$5 million per year.
- Colstrip Generating Station, Montana, pays over \$6 million annually in taxes, and is the major funder of the local school system.
- Plant Scherer, Georgia, pays more than \$6 million annually in property taxes -- 25% of the Monroe County Schools local funding
- Wateree Station, Eastover, South Carolina pays over \$5 million per year in property taxes, and is a major funder of local schools.
- Local school districts lost 14% of their revenue when the AEP Muskingum plant in Ohio closed, and according to school district treasurer Cliff Reinhardt "While the plant's closure will hurt the city, it will create an even deeper budgetary hole for the Willoughby-Eastlake City Schools District. The revenue the district receives from the plant is estimated at \$1.8 million. Our guess is that that entire \$1.8 million will disappear."¹⁴⁶

Coal plants provide good jobs that hard to replace. For example:

- Giles County, Virginia Administrator Chris McKlarney stated "The Glen Lyn plant provided stable, well-paying positions with good benefits in places where they are hard to find."¹⁴⁷
- Avon Lake City Council member Robert James testified "The type of quality jobs at Avon Lake plant are hard to find in the Cleveland area."¹⁴⁸
- According to Salem, Massachusetts Mayor Kim Driscoll, closing the Salem Harbor Station is "not like losing a Dunkin' Donuts."¹⁴⁹
- "Not only are good-paying jobs being lost at the Armstrong Power Plant; jobs will be lost in ancillary industries, support services, and by small coal-mining operations." Dave Battaglia, chairman, Armstrong County, Pennsylvania Board of Commissioners.¹⁵⁰

¹⁴⁶City Lab, "What Happens to a Small Town When Its Coal Plant Shuts Down?" <http://www.citylab.com/work/2012/02/what-happens-small-town-when-its-coal-plant-shuts-down/1102/>.

¹⁴⁷"Power Plant Closures to Cost U.S. Towns Jobs and Taxes," *San Diego Union Tribune*, <http://www.sandiegouniontribune.com/sdut-power-plant-closures-to-cost-us-towns-jobs-taxes-2011dec20-story.html>

¹⁴⁸Testimony of Robert K. James, Member of the Avon Lake City Council, Before the U.S. House of Representatives Committee on the Judiciary Subcommittee on Regulatory Reform, Commercial and Antitrust Law, "The Obama Administration's Regulatory War on Jobs, the Economy, and America's Global Competitiveness," February 28, 2013, https://judiciary.house.gov/_files/hearings/113th/02282013/James%2002282013.pdf.

¹⁴⁹NBC News, "EPA Rules Threatening Aging Power Plants," http://www.nbcnews.com/id/45715768/ns/business-going_green/t/new-epa-rules-threatening-aging-power-plants/#.WPV1MdLyu70.

¹⁵⁰"County Commissioners Believe Armstrong Power Plant Closing Could Have Far Reaching Consequences," Armstrong County Press Release, <http://co.armstrong.pa.us/countynews/press-release/389-county-commissioners-believe-armstrong-power-plant-closing-could-have-far-reaching-consequences>.

- “With 100 good-paying jobs, the Eastlake plant is among the top employers in town. Closing the plant is a huge hit.” Eastlake, Ohio mayor Ted Andrzejewski.¹⁵¹
- Midwest Gen plant closures may cost over 1,000 jobs, and according to the IBEW “If the plants go through bankruptcy, union contracts could be voided, voiding labor agreements on pay, benefits, and pensions.”¹⁵²
- Adams County, Ohio Auditor David Gifford stated “Losing these plants would have an enormous negative impact on our communities. We depend on them for tax dollars, and jobs, and they are a substantial source of revenue for our schools.”¹⁵³
- San Juan County, New Mexico CEO Kim Carpenter expressed a much darker view regarding a possible plant closure. “It’s going to be a major blow to this area, as seven out of 10 taxpayers in San Juan County are related to the power industries. We’re staring at losing hundreds of hundreds of jobs.”¹⁵⁴

MISI assessment of specific plants and the local economy impacts of their closing documented this. For example, the Avon Lake Generating Station in Ohio 20 miles west of Cleveland provides baseload electric capacity, load-following capability to the grid, and essential peaking capacity and black start capability, and the facility plays an important role in providing reliable and affordable electricity. NRG planned to shut the plant in 2015, but reversed its decision.¹⁵⁵

The immediate impact of a plant closure would have been more than 80 plant jobs lost and over 170 jobs in total lost. The City of Avon Lake would have lost \$350,000 in taxes annually and put police, fire, and paramedic services and jobs at risk. Local schools will have lost \$4 million annually: Teacher layoffs would have been required and school programs for students with special needs lost. Most serious, plant closure would have meant that consumers in northeast Ohio will pay much more for their electricity. Thus, for example:

- Catholic Charities of Cleveland warned that “High energy costs resulting from the loss of power plant would have a devastating effect on the people of Ohio, particularly the poor and the elderly.”¹⁵⁶
- Avon Lake City Councilman Robert James stated “This facility plays an important role in providing a reliable and affordable supply of electricity. The loss of power plants has a very real impact on the communities in which they are located.”¹⁵⁷

¹⁵¹City Lab, op. cit.

¹⁵²“Illinois Coal Plants: Midwest Generation, After Closing Chicago Plants, May Abandon State,” *Huffington Post*, http://www.huffingtonpost.com/2012/03/05/illinois-coal-plants-midw_n_1321336.html; <http://www.chicagobusiness.com/article/20120302/NEWS11/120309969/midwest-generation-weighs-complete-exit-from-illinois>.

¹⁵³“DPL Considers Closing Power Generating Plants in County,” *The People’s Defender*, <http://www.peoplesdefender.com/2016/12/02/dpl-considers-closing-power-generating-plants-in-county>.

¹⁵⁴“What Shuttering Coal Plants Means For Energy Jobs,” CNBC, <http://www.cnbc.com/2015/04/13/what-shuttering-coal-plants-means-for-energy-jobs.html>.

¹⁵⁵http://www.cleveland.com/avon-lake/index.ssf/2013/06/nrg_energys_avon_lake_plant_co.html.

¹⁵⁶Testimony of Robert K. James, op. cit.

¹⁵⁷Ibid.

- Avon Lake Mayor Greg Zilka stated “News that the plant may close is very disheartening. We already have difficulty keeping local businesses. I hope this plant can be saved. I shudder to think what impact this will have on the schools. Avon Lake Plant closing will highly impact the community’s energy costs and quality of life.”¹⁵⁸

Electricity costs are important: Electricity price increases act like a tax increase, reducing incomes of energy consumers and ratepayers, while the supply-side impacts from price increases depress business development, economic output, and jobs. MISI identified dozens of business and thousands of jobs that would be negatively affected by plant closures. Examples of businesses and jobs near the Avon Lake plant include:

- Ford Motor Co., 1,900 jobs
- Invacare Corp., 730 jobs
- PolyOne Corp., 580 jobs
- Ridge Tool Co., 525 jobs
- U.S. Steel Corp., 525 jobs
- Bendix Commercial Vehicle Systems, 400 jobs
- Republic Engineering Products, 400 jobs
- Forest City Technologies, 350 jobs
- Elyria Foundry, Co., 330 jobs
- Parker Hannifin Nichols Airborne Division, 330 jobs
- Diamond Products, 300 jobs
- ShurTech Brands, 280 jobs
- Consun Food Industries, 270 jobs
- CAMACO Lorain Manufacturing, 250 jobs
- Crane Aerospace and Electronics, 240 jobs.

Another example is the J.R. Whiting plant, located in Luna City on the Lake Erie shoreline of southeastern Michigan, which closed in April 2016. The immediate impact of the plant closure was more than 70 plant jobs lost and 150 jobs in total lost. “Closing these older coal-fired power plants will further increase the price of electricity as utilities build new power plants and pass on the costs to electricity consumers. Natural gas will be needed to replace the loss of coal production because wind and solar are not dependable forms of energy, but it takes huge quantities of natural gas to replace coal electrical generation.” Accordingly, at the same time it was shutting down Whiting, Consumers Energy proposed hiking its electric-rates by \$147 million.

Mayor Mary Liske and other local officials were dismayed, since the plant generated \$3 million annually -- 68% of the Luna City tax base. According to Mayor Liske: “The plant is Luna's largest employer. When it ceases operations, not only will the city be losing money, but also jobs. The future looks rocky, and the loss of the power plant is

¹⁵⁸Cheryl Higley, “GenOn on Track With Closing Plant,” http://www.cleveland.com/avon-lake/index.ssf/2012/04/geon_on_track_with_closing_pla.html; <http://www.morningjournal.com/article/MJ/20120301/NEWS/303019947>.

just the beginning. With all of the issues together, we're concerned that we won't be able to recover. This will require the county to step in and make up any deficiencies. The City will need to qualify for grant monies. Ultimately, this will cost the taxpayers of Monroe County and will require a tax increase to the citizens. This is nothing more than an indirect tax hike on the citizens of Michigan. When a community loses over 50% of its tax revenue along with the jobs that are provided by the plant, Houston we have a problem! The plant happens to be Luna Pier's largest employer. When it ceases operations, not only will the city be losing money, but also jobs."¹⁵⁹

The plant's closure will devastate Monroe County and Southeastern Michigan and Northwestern Ohio economies. "This means higher electricity prices and the higher prices will make it even more difficult for businesses and manufacturers in Michigan."¹⁶⁰ Examples of businesses and jobs near the Whiting plant at risk include:

- Automotive Components Holdings LLC, 3,100 jobs
- National Galvanizing LP, 1,000 jobs
- Plastech, 720 jobs
- LA-Z-BOY, 550 jobs
- Guardian Industries Corp, 540 jobs
- Tenneco, 450 jobs
- Macsteel Monroe, 380 jobs
- Metalforming Technologies, 160 jobs
- TWB Company LLC, 303 jobs
- MTS Seating, 250 jobs
- Holcim, 250 jobs
- Ort Tool and Die, 150 jobs

Thus, the impacts of coal plants closings on electricity rates, availability, and reliability and on local businesses and jobs is the most damaging outcome, and the damage far exceeds the direct effects of the plants' closings.

VI.B. The Huntley Generating Station Closure

VI.B.1. Background

The Huntley Generating Station, located in Tonawanda, was one of the few remaining coal-fired power plants in New York State, and first began producing electrical power in 1916. Huntley consisted of six units, placed into service between 1942 and 1958. Units 1 and 2 (totaling 180 MW) were retired in 2005; Units 3 and 4 (totaling 200 MW) were retired in 2007. The remaining two units, each 218 MW, were placed into

¹⁵⁹"Luna Pier to Face Some Trying Times," 13abc.com, April 23, 2012; <http://www.toledoblade.com/Nation/2011/12/03/Luna-Pier-coal-fired-power-plant-to-shut-in-15.html>; <https://craigwright.wordpress.com/2012/01/06/the-bain-report-articles-that-affect-you-and-your-family-for-monday-january-9-2012/>.

¹⁶⁰Ibid.

service in 1957 and 1958 and were retired in March 2016. All of the coal burned at Huntley was sourced from the Powder River Basin in Wyoming. Huntley is owned and operated by New Jersey-based NRG Energy, the largest competitive power generation company in the U.S. It operates 100 power plants in 18 states.

At one time, there were seven operating coal power plants in the New York State. At present there are three, and Governor Andrew Cuomo has called for the elimination of all coal-burning power plants by 2020.¹⁶¹

VI.B.2. Fiscal and Jobs Impacts

The 2016 closure of the Huntley Generating Station in Tonawanda, New York created severe revenue problems for the Town of Tonawanda, its Highway Department, Erie County, and the Ken-Ton School District – Figure VI-1. Huntley was the largest taxpayer in the town of Tonawanda, and its shutdown left the town, the local school district, and the county with a huge funding gap.

**Figure VI-1
NRG Huntley 2012 Tax Payments**

Taxing Jurisdiction	2012 Payment (in \$ millions)
Town of Tonawanda	3.0
Town of Tonawanda Highway Department	1.0
Erie County	4.0
Ken-Ton School District	7.9
Total	15.9

Source: Institute for Energy Economics and Financial Analysis

By far the largest and most important NRG tax payment for Huntley was to the Ken-Ton School District, and tax payments to the district declined significantly. The budget for 2012 for the district was \$135 million (against a planned expenditure program of \$147 million).¹⁶² Tax payments from the Huntley plant constituted 5.9% of actual district expenditures for 2012. The full impact of plant closure will likely not be felt until 2017 and 2018.

¹⁶¹New York State Energy Research and Development Authority, “Governor Cuomo and Brown Reaffirm Commitment to Exceeding Targets of Clean Power Plan,” <https://www.nyserda.ny.gov/About/Newsroom/2017-Announcements/2017-03-28-Governor-Cuomo-and-Brown-Reaffirm-Commitment-to-Exceeding-Targets-of-Clean-Power-Plan>.

¹⁶²<http://www.kenton.k12.ny.us/cms/lib/NY19000262/Centricity/Domain/1791/06g2-THE%20Plan%2012.6.12-Bud-get%20Projections-BOE.pdf>.

The Ken-Ton district suffers from a combination of forces that have reduced its revenues and weakened budget balance: Property tax caps, school aid limitations, federal funding uncertainty, and state priorities not aligned with local needs. Despite increasing property values, the loss of Huntley property tax revenues for the school district budget created significant fiscal risks for the district.¹⁶³

For several years, Huntley operated off the tax rolls and under a payment-in-lieu-of-taxes agreement with the Erie County Industrial Development Agency ECIDA. Under the PILOT, the Kenmore Tonawanda Union Free School District annually received about \$3 million in revenue, the Town of Tonawanda \$2.2 million, and Erie County just under \$800,000. That revenue was lost when Huntley closed.¹⁶⁴ The implication was that residents would have to pay more in local taxes to compensate or lose vital services.

The plant shutdown thus left the local community anxious about jobs and public services. The State of New York tried to soften the effects with a transition fund -- the Electric Generation Facility Cessation Mitigation Program. The fund sets aside \$30 million per year to help communities, such as Tonawanda, cope with the loss of their power plants. Lawmakers subsequently extended the assistance period from five years to seven years, and reduced the step-down in assistance from year to year. The latest New York State budget, passed in April 2017, extended the assistance to seven years and increased the fund size to \$45 million in 2020.¹⁶⁵ There is no firm phase-out date for the fund. However, the transition assistance fund is not infinite or indefinite.

The funding is available to localities facing a significant reduction in property tax revenues with the loss of an electric-generating plant. This includes all local governments, ranging from school districts to special districts. Specifically, the funding will be available to localities experiencing a reduction in property tax or PILOT payment revenues paid by a power plant of at least 20 percent, and the state assistance will be paid annually on a first-come, first-served basis.¹⁶⁶ It covers 80 percent of the tax losses that a locality had suffered due to a power plant that has shut down since June 2015. Counties, cities, towns, villages, school districts and special districts were among those eligible, but they had to reapply each year. This new state fund is currently compensating for about 80 percent of lost Huntly tax revenues, and it has given local officials seven years to plan how to adjust to life after Huntley.

In 2013, a working group was formed, comprising town, school district, county and Erie County Industrial Development Agency officials, as well as a national consultant with expertise in the field of coal-powered generating plants. The group met periodically, and once NRG formally announced its intentions to retire Huntley it began reaching out to

¹⁶³Cathy Kunkel, David Schlissel, and Tom Sanzillo, "Huntley Generating Station: Coal Plant's Weak Financial Outlook Calls For Corporate and Community Leadership," Institute for Energy Economics and Financial Analysis, January 2014.

¹⁶⁴Local officials urge state action on Huntley Generating Station, <http://www2.erie.gov/exec/index.php?q=press/local-officials-urge-nys-action-huntley-power-station>

¹⁶⁵"N.Y.'s Steely Coal Towns Brace for Transition," <https://www.eenews.net/energywire/2017/04/18/stories/1060053203>.

¹⁶⁶"Assemblyman Robin Schimminger Reports to You," Spring 2016.

state and federal elected officials to make them aware of the impacts the plant closing would have on the community in terms of lost revenue, cuts in services, and jobs lost. The coalition had a number of goals, and some of them are ongoing. Among them are maintaining school funding, protecting workers and helping them to find good-paying jobs, reconnecting the city to its riverfront, creating and sustaining a new tax base, protecting rate-payers, and improving the environment and residents health.¹⁶⁷

Well before the closure, Tonawanda officials began planning for life after Huntley. They realized that without the tax revenues from Huntley, local governments and school districts would have to reduce services, raise taxes, or both. In February 2016, a month before Huntley's closure, Tonawanda was awarded a \$160,000 grant from the federal Economic Development Administration to develop a long-term economic plan. The EDA grant is allowing the town, in conjunction with the University at Buffalo's Regional Institute, to develop a long-term plan to address what should be done with the facility and what should be done to cope with the loss of tax revenue from the plant.¹⁶⁸

There remains deep concern over the future of the Huntley site. Specifically, local officials worry about how much of it has to be remediated, at what cost, and who will pay for it. The town currently has relatively little information on the site, which is owned by NRG. NRG is evaluating options for the site and is preparing reports on the future of the site.

Planning is in the early of the process, and there may be a wide range of possibilities. Some of the options being explored include using the site to produce biofuels, converting it into a public space or office space, building a museum on the site, and building condos. Local officials remain open to the possibilities, but want to act expeditiously. They are acutely aware of abandoned steel factories in nearby towns that have languished for decades, and "We can't get complacent, just because we got the aid; that's not a good thing."¹⁶⁹

As well as a sudden hole in local budgets, the Huntley closure left the Tonawanda area with the loss of about 80 jobs at the plant. The loss of 80 plant jobs created a total job loss of over 200 jobs in the local area, including direct and indirect jobs. This total job loss had the potential to increase the local unemployment rate in Erie County by about one percentage point. In fact, the county unemployment rate increased from 5.3% in February 2016 to 5.6% in February 2017.¹⁷⁰

¹⁶⁷Mike Ferguson, "Lessons From Closing N.Y. Power Plant May Help in Colstrip", http://billingsgazette.com/news/local/lessons-from-closing-n-y-power-plant-may-help-in/article_4eae6446-f328-52c4-b170-1b3e94fc2efc.html.

¹⁶⁸Joseph Emminger, "Huntley closes, leaving question of what's next for Tonawanda?" http://www.kentonbee.com/news/2016-03-02/Editorial/Huntley_closes_leaving_question_of_whats_next_for_.html?print=1.

¹⁶⁹*ibid.*

¹⁷⁰"Employed, Unemployed, and Rate of Unemployment By Place of Residence For New York State and Major Labor Areas, May 2017," <https://www.labor.ny.gov/stats/pressreleases/prtbur.pdf>.

NRG had both a defined benefit and a 401K plan for its employees.¹⁷¹ Those union and nonunion employees eligible for retirement received their benefit packages. Plant employees were released in stages between March 31 and June 30, 2016. They received severance packages based on either collective bargaining agreements or NRG's executive severance policy.¹⁷² NRG transferred some of the Huntley employees to other facilities, and DuPont, General Motors, and tire maker Sumitomo Corporation have facilities nearby which may offer opportunities for some of the unemployed workers. Nevertheless, most of the lost jobs have yet to be replaced.

VI.B.3. Rate Impacts

The closure of the Huntley Generating Station is not only costing Western New York jobs, and millions of dollars in lost tax revenues, but it is also greatly increasing electricity costs. Research conducted by Congressman Brian Higgins' office found that since the closing of the Huntley power plant in March 2016, the wholesale price of electricity in Western New York has become unstable, resulting in average wholesale rate increases between 42% and 91%.¹⁷³

Higgins stated the "We have been following this closely and have serious concerns about the long-term impact these market increases could have on Western New York residential and business consumers if left unaddressed. NYPA has the capacity to fix this problem, and must fix this problem, as their federal mandates demand."¹⁷⁴

The New York Power Authority (NYPA) estimates indicate that there is enough power production capacity at Niagara Falls to meet the supply shortfall caused by the Huntley closure, but that transmission constraints between the Niagara Power Project and Buffalo prevent this. These constraints amount to as much as 12% of the Niagara Power Project's total output. The Niagara Power Project was authorized by Congress through the 1957 Niagara Redevelopment Act and its original 1958 license from the Federal Power Commission; this authorization was renewed by its subsequent 2007 license from the Federal Energy Regulatory Commission. Under this law and their license, the Authority is mandated not only to produce the share of Niagara hydropower allocated to the U.S. by international treaties, but to "make such power available at the lowest rates reasonably possible to encourage the widest possible use."¹⁷⁵

In a letter to NYPA, Congressman Higgins noted the rate increases and called on NYPA to proactively enhance transmission and/or production to help stabilize rates and protect consumers from steep increases.¹⁷⁶ "Prices for electricity could double over the

¹⁷¹NRG Energy, 2012 10K, Note 13: Benefit Plans and Other Postretirement Benefits.

¹⁷²Dan Miner, "NRG Energy Officially 'Retires' Tonawanda Huntley Plant," *Buffalo Business First*, March 2, 2016.

¹⁷³"Higgins Warns of Electricity Rate Spikes Following Huntley Plant Closure," <https://higgins.house.gov/media-center/press-releases/higgins-warns-of-electricity-rate-spikes-following-huntley-plant-0>.

¹⁷⁴Ibid.

¹⁷⁵Ibid.

¹⁷⁶Ibid

next several months for both residential and businesses.”¹⁷⁷ Higgins emphasized that NYPA has the responsibility and has the capacity to offset the loss of electricity generated at the Huntley Station, but NYPA officials contend that to deliver the replacement power requires improvement in the state’s energy grid.

VI.C. Coal and the Rural Electric Co-operatives

Poverty in the rural areas comprising coal country has been well documented. These areas had already fallen significantly behind on quality-of-life variables even before coal mines and coal plants began to close. However, the closure of coal facilities has greatly accelerated the decline. In particular, the widespread network of Rural Cooperatives has been placed at risk by policies forcing the retirement and closure of operating coal power plants.

Rural electric cooperatives in the U.S. have a long history of providing reliable and affordable power to farms, villages and small communities throughout the nation. When the Rural Electrification Act (REA) was signed by President Roosevelt in 1935 less than 10% of farms had electricity. Currently, that figure is 99%. These not-for-profit electric providers serve 2,500 of our 3,134 counties, reaching remote areas where consumers are truly “at the end of the line.” Co-ops serve over 2 million farms in support of a food production network that is the envy of the world. It would be difficult to find a greater energy success story than America's vibrant network of rural electric cooperatives.

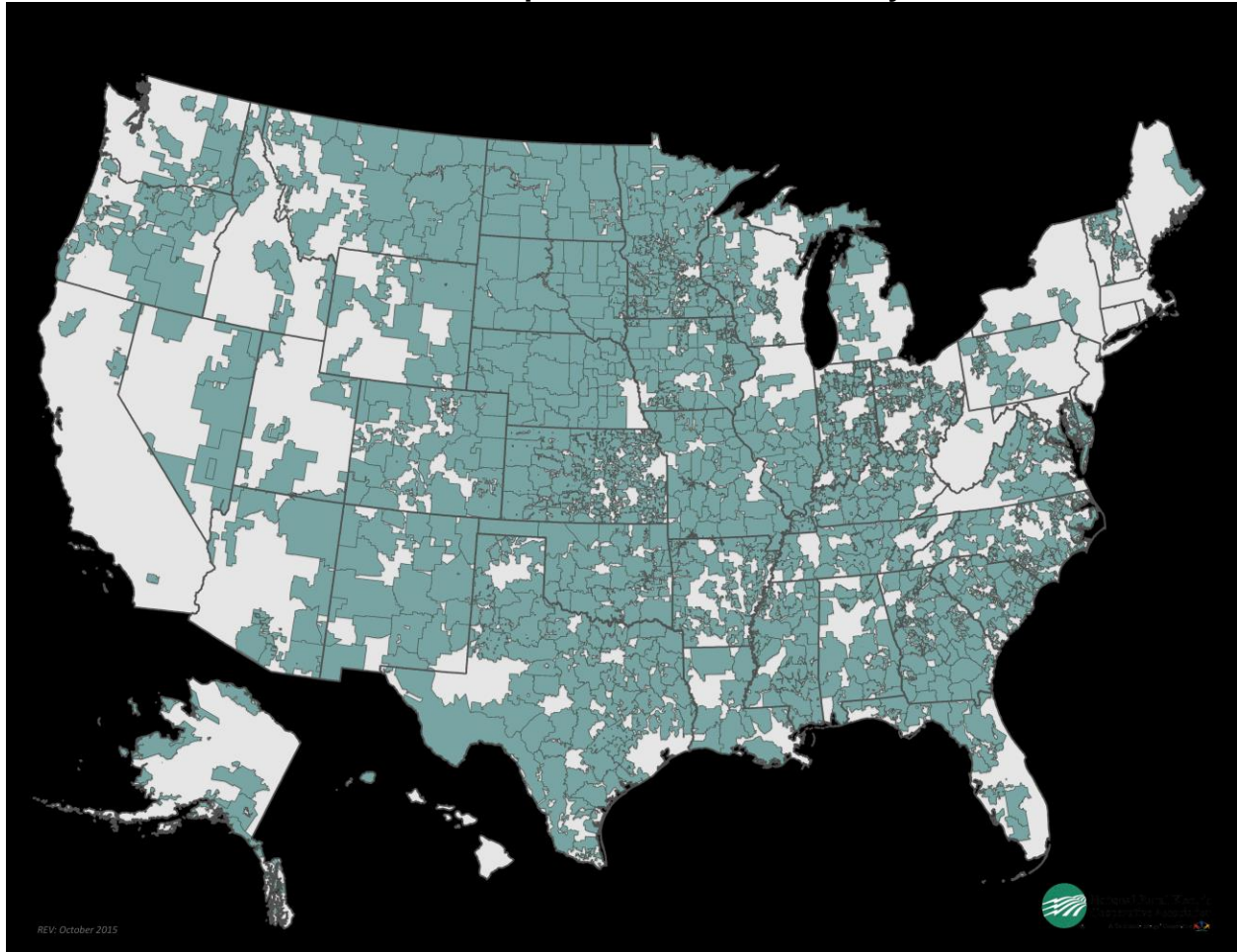
In the U.S., 838 not-for-profit, consumer-owned electric cooperatives provide electricity to 42 million people in 47 states.¹⁷⁸ Their service territories, which collectively cover 75% of the U.S. landmass, are illustrated in Figure VI-1.

Co-ops are an integral part of the \$400 billion U.S. electric utility industry, and function to provide safe, reliable, and affordable energy to their consumer-members on a not-for-profit basis. Distribution cooperatives are the foundation of the rural electric network, delivering electricity to retail customers. Generation & transmission cooperatives (G&Ts) provide wholesale power to distribution co-ops through their own generation or by purchasing power on behalf of the distribution members. In addition to electric service, electric co-ops are involved in their communities, promoting development and revitalization projects, small businesses, job creation, improvement of water and sewer systems and assistance in delivery of health care and educational services.

¹⁷⁷“Downside of Huntley Closure: Lost Taxes, Jobs, Higher Electricity Costs,” <http://wivb.com/2016/05/05/downside-of-huntley-closure-lost-taxes-jobs-higher-electricity-costs/>.

¹⁷⁸National Rural Electric Cooperative Association, <http://www.electric.coop/>.

Figure VI-1
Electric Cooperative Service Territory



Source: National Rural Electric Cooperative Association

Co-ops:¹⁷⁹

- Own assets worth \$164 billion
- Own and maintain 2.6 million miles (or 42%) of the nation's electric distribution lines
- Deliver 11 percent of the total kilowatt hours sold in the U.S. each year
- Generate nearly 5 percent of the total electricity produced in the U.S. each year
- Employ 72,000 people in the U.S.

Rural co-operatives obtain nearly 70% of their electricity from coal.¹⁸⁰ They are thus are disproportionately impacted by coal plant closures:

¹⁷⁹National Rural Electric Cooperative Association, <http://www.electric.coop/>.

¹⁸⁰Ibid.

- Nearly 70% of their power depends on coal plants with many years of continued viable operation
- Co-op members must continue paying for plants they were prematurely forced to close
- Higher power costs shutter businesses, drive layoffs, and destroy jobs in co-op service territories
- Closures result in outmigration of young adults unable to find jobs in economically depressed areas
- Closures lead to population declines and place economic burden on an increasingly older constituency
- Closures have implications for poverty and social justice, since co-ops serve 93% of America's "Persistent poverty counties"

The National Rural Electric Cooperative Association (NRECA) strongly opposed the CPP, contending that it unlawfully usurps the states' proper role in regulating the electric sector. NRECA contended that the "ill-advised proposal" is rife with "misinformed statements and Pollyannaish judgments."¹⁸¹

NRECA's position is due to the fact that it is much more difficult and costly for most co-ops than for other electric utilities to reduce their CO₂ emissions levels to where EPA mandates them to be in 2030. The nation's co-ops are extremely dependent on coal-fired generation -- the de-facto target of EPA's proposed rule, with, as noted, coal producing nearly 70 percent of power sold by the more than 800 cooperatives. By contrast, less than 37 percent of all electric utility power in the U.S. is produced by coal.

Also, the fundamentally rural geography of many cooperatives is a challenge to the extent of capital expenditures that may be needed to meet the CPP. Not only are there fewer customers over a co-op's service territory than for an investor-owned or public power utility, but, as noted, NRECA members provide service in 327 of the nation's 353 "persistent poverty counties."

NRECA contends that the CPP goes far beyond what the Clean Air Act authorizes EPA to do and "believes the Clean Air Act was never intended, and should not be used, to regulate stationary source greenhouse gas emissions such as CO₂. The unique regulatory framework EPA is using to develop greenhouse gas requirements in no small way contributes to their challenge in developing a regulation that is either reasonable or achievable. Ultimately, our members think that if we're going to have a carbon policy, that policy should be written by Congress, not shoehorned in, pounding a square peg into a round hole."¹⁸²

A major concern for NRECA's members is the potential for EPA's rule to leave "stranded" a large amount of investment that has been made in cooperative generation and environmental controls to comply with previous EPA rules. "There are some big no-

¹⁸¹Rod Kuckro, "Coal-heavy Electric Cooperatives Take Hard Line on EPA Clean Power Plan," *Energywire*, December 15, 2014.

¹⁸²*Ibid.*

nos we need EPA to avoid. One of those big no-nos is creating stranded assets. We have a number of members who built coal plants in the late '70s and early '80s during the time of the Fuel Use Act, when pretty much gas was off the table and nuclear, thanks to price increases and Three Mile Island, was off the table. Cooperatives were growing rapidly at that stage and needed to build new power plants, and so we built what was available at the time. Roughly two-thirds of all co-op-owned coal generation facilities were built during that period. They still have useful life. And we need to make sure this rule doesn't force our members to scrap those with remaining mortgages on those units and environmental controls that have been added since they were constructed. We think it is utterly ridiculous that it is a potential outcome. It would potentially force some of our co-ops to really no longer exist. And that's an unacceptable outcome."¹⁸³

In January 2017, NRECA joined utilities and 29 states and state agencies in petitioning the U.S. Supreme Court to halt implementation of the CPP, which it contends is already inflicting harm on electric co-ops. NRECA stated that "EPA itself predicts the closure or curtailment -- this year -- of many coal-fired power plants that would remain online absent the rule. If that doesn't meet the judicial criteria for 'immediate and irreparable harm' required to trigger a stay, what does?"¹⁸⁴

NRECA argued that for each power plant retired or curtailed, co-ops and other utilities must carefully plan and implement changes to the electric system to replace the lost generation -- requiring a very significant outlay of expenses over the next few years. This will lead to lost jobs, economic harm to rural communities, and unrecoverable costs where power plants are shut down before the end of their remaining useful life. "As not-for-profits serving 93 percent of America's persistent poverty counties, electric co-ops are especially concerned about the significant electric rate increases this would impose on some of our nation's most vulnerable citizens -- families living on fixed incomes or in poverty."¹⁸⁵

As an example, NRECA identified Basin Electric Power Cooperative, a not-for-profit regional wholesale electric generation and transmission cooperative that owns and/or operates 13 electric generating units in four western states that will be directly impacted by the rule. Unless the court stays the rule and extends compliance dates, Basin Electric estimates it will have to spend about \$330 million just in the next two years in costs attributed solely to complying with the rule. The co-op's total compliance costs are projected to reach \$5 billion.

NRECA estimated that total compliance costs for electric cooperatives could reach \$28 billion over the 2022-2030 compliance period. "Immediate and irreparable harm already is occurring -- and will continue -- unless the court halts the Clean Power Plan while separate litigation over its legality plays out."¹⁸⁶

¹⁸³bid.

¹⁸⁴"NRECA Takes Case Against Clean Power Plan to the Supreme Court," <https://www.electric.coop/nreca-takes-case-clean-power-plan-supreme-court/>.

¹⁸⁵bid.

¹⁸⁶bid.

NRECA notes that “America’s electric co-ops have a lot riding on how the Clean Power Plan litigation plays out, because the rule hits not-for-profit, consumer-owned electricity providers and their members especially hard. Instead of crafting sensible regulations to address power plant carbon emissions, EPA issued a rule that would significantly restructure the power sector, far exceeding its legal authority and burdening electric co-ops with a disproportionate share of the costs. The rule would force many co-ops to prematurely shutter coal-fired power plants on which they’re still repaying loans. Members of those co-ops would be charged twice for their electricity—once to continue paying down the loans on assets that are no longer generating revenue, and again for the cost of purchasing replacement power from somewhere else.”¹⁸⁷

“We’re especially concerned about the burden on low-income families. Electric cooperatives serve 93 percent of the nation’s persistent poverty counties, so we recognize first-hand the importance of affordable power. And unlike investor-owned utilities, co-ops don’t have shareholders or excess revenues to help offset the rule’s costs -- those costs are borne entirely by their consumer-members.”¹⁸⁸

NRECA further notes that “Ironically, many of the co-op facilities threatened by the Clean Power Plan were built during a period when Presidents Ford and Carter and Congress told co-ops and other utilities to build coal-fired power plants. In fact, the Powerplant and Industrial Fuel Use Act of 1978 essentially placed natural gas, one of the fuels of choice today, off limits. The Act was implemented just as co-ops needed to build more generation to meet growing demands.”¹⁸⁹

¹⁸⁷“Statement by NRECA CEO Jim Matheson on Clean Power Plan Oral Arguments,” <https://www.electric.coop/statement-by-nreca-ceo-jim-matheson-on-clean-power-plan-oral-arguments/>.

¹⁸⁸Ibid.

¹⁸⁹Ibid.

VII. FINDINGS AND RECOMMENDATIONS

VII.A. Findings

Current State of the U.S. Coal Economy

- The economic and societal costs of coal mine closures in the U.S. are substantial.
- Jobs in the coal industry are some of the highest paying positions in the coal regions.
- The U.S. is connected by the best freight railroad system in the world, and coal is its most important single commodity. Coal accounts for 20% of railroads' gross revenues and for up to 33% of railroad profits.
- Appalachian coal mining employment has decreased significantly and rapidly: Between 2011 and 2015, Appalachia lost 36% of its total coal mining jobs.
- About 30-40% of total coal mining employment consists of contractors and these jobs data are not included in state estimates of coal mining employment. Exclusion of these contractor employment estimates from the state job data represents a serious undercount of coal mining jobs.
- For every coal mining job in Appalachia, 2.5 jobs are created in the Appalachian region and 3.5 jobs are created in the U.S. as a whole.
- Including contractors, the coal mining-related jobs in Appalachia totaled 238,000 in 2009, 255,000 in 2011, and 164,000 in 2015.
- The coal mining-related jobs in the U.S. as a whole totaled 333,000 in 2009, 357,000 in 2011, and 230,000 in 2015.
- In 2015, there were 91,000 fewer total (direct and indirect) coal-related jobs in Appalachia than in 2011, and 230,000 fewer jobs in the U.S. as a whole.
- The coal-related job losses in Appalachia were actually four times as large as is generally recognized, and the job losses in the U.S. were nearly six times as large.
- The loss of nearly 100,000 jobs in Appalachia between 2011 and 2015 had devastating consequences.
- Between 2011 and 2015, nearly 40% of the total Appalachian jobs lost were lost in Kentucky and 34% of the total were lost in West Virginia. The loss of these jobs was devastating in both states.
- The economic situation in Appalachia is dire: Of 430 counties, 203 are either distressed or at-risk, only 11 are competitive, and only one is in attainment.

Forecast Scenarios

- The U.S. may require more coal in the future than is currently anticipated.
- The scenarios analyzed have dramatic effects on U.S. coal production, and these impacts increase as the forecast period lengthens.
- MISO estimated the total number of jobs created annually by the six technologies: Coal mining, new coal plant construction, coal plant O&M, EOR, saline sequestration, and pipelines.

The scenario results have implications for job-creation policies:

- Higher economic growth and increases in electricity demand will increase the demand for coal and coal-related jobs. Over the forecast period under Scenario 2, which assumes a higher growth rate for GDP and for electricity than under the Reference Case, 900,000 more jobs are generated by the coal mining industry and 1.8 million jobs in total are generated – an average of about 60,000 jobs/yr.
- All of the scenarios assumed a GDP growth rate of 2.6%, compared to the Reference Case growth rate of 2.1%. The Administration seeks to attain 3% annual growth. Achieving a 3% growth rate instead of 2.6% would likely generate about 15% more jobs over the forecast period in each of the scenarios.

Comparing the jobs created by the different scenarios indicates the marginal impacts of different assumptions and policy options. The marginal impacts of achieving the DOE R&D program goals are:

- In the environment of moderate oil and gas prices and with CCS tax credits in place, the generation of about 500,000 jobs.
- In the environment of high oil and gas prices and with CCS tax credits in place, the generation of about 3.3 million jobs.

The marginal impacts of the CCS tax credits are large:

- Compared to the Reference Case, between 4.3 million and 6.1 million additional jobs, depending on the level of oil and natural gas prices.
- In the environment of moderate oil and gas prices, the generation of about 2.5 million additional jobs.
- In the environment of high oil and gas prices, the generation of about 2.8 additional million jobs.

Thus, the marginal impacts of achieving the DOE R&D program goals in conjunction with CCS tax credits are:

- Compared to the Reference Case, between 4.8 million and 9.4 million additional jobs, depending on the level of oil and natural gas prices.
- In the environment of higher economic growth and moderate oil and gas prices, the generation of about 3 million additional jobs.
- In the environment of higher economic growth and high oil and gas prices, the generation of about 6.1 additional million jobs.

The major policy implications of the scenario results include:

1. A higher rate of economic growth will substantially increase the demand for energy, including coal, and will substantially increase coal-related jobs.
2. The Administration's goal of 3% GDP growth will further increase the number of coal-related jobs by as much as 15% -- more than 3.2 million additional jobs would be created, for a total of nearly 25 million coal-related jobs.
3. The largest job increases occur within the high oil and natural gas prices environment utilizing both CCS tax credits and DOE R&D.
4. Even in an environment of moderate oil and natural gas prices, utilizing both CCS tax credits and DOE R&D greatly increases the number of jobs created.

5. Full maximization of job creation is achieved using both CCS tax credits and DOE R&D within a high oil and natural gas prices environment. This results in the creation of an additional 9.4 million jobs – 315,000 jobs per year.
 6. The marginal impacts of the DOE program are substantial. With moderate oil and natural gas prices, the R&D program creates an additional 500,000 jobs; in a high oil and natural gas prices environment the program creates about 3.3 million additional jobs – and nearly 4 million jobs with 3% economic growth.
- The major finding is that to maximize job creation both CCS tax credits and the DOE R&D program need to be implemented in a coordinated manner. This will help stimulate economic growth which will, in turn, create even more jobs.
 - West Virginia could gain enough jobs to comprise 4%-9% of its total employment, and this would mean the difference between recessionary conditions in the state and full employment prosperity.
 - The number of jobs created is important, but it is also important to disaggregate jobs into occupations and skills.

The Importance of Coal in Manufacturing

- Manufacturing is of critical importance to the U.S. economy and jobs, and coal is critical to the manufacturing industry.
- Serious economic harm will result from allowing U.S manufacturing to atrophy, and coal is critically important for a U.S. manufacturing renaissance.
- While U.S. manufacturing output has been increasing, its share of the U.S. economy has been declining for the past half-century.
- U.S. manufacturing jobs have decreased every year for the past three decades.
- The Administration seeks to facilitate a U.S manufacturing renaissance and to create manufacturing jobs. Coal is essential for this, since manufacturing depends critically on the reliable, affordable electricity provided by coal power plants.
- U.S. industrial electricity prices are a strong international competitive advantage for domestic manufacturing.
- This competitive advantage is true in the U.S. inter-regionally as well. There is a close relationship between the reliable, affordable electricity provided by coal and a state's manufacturing output, and states with the most manufacturing generate most of their electricity with coal.
- The U.S. steel industry provides a salient example of the importance of U.S. manufacturing, and every job in the steel industry creates seven jobs in U.S. economy. It is impossible to make steel without coal.
- The world is fundamentally dependent on steel production, and steel production is fundamentally dependent on the large-scale use of coal.

The Importance of Coal in Regional Economies and Jobs

- Coal plants are among largest industrial facilities and major employers in many local areas.

- They pay a large share of local property taxes and their taxes are mainstays of local school systems.
- These taxes also support local governments: Police, firefighters, teachers, EMTs, libraries, etc.
- Coal power plants provide high quality, well-paying jobs often “not available elsewhere.”
- They support local business, stores, restaurants, vendors, etc.
- Most important: Coal plants provide reliable, affordable electricity that powers local industry, business, and commerce.
- Without this power, local economies will wither.
- The widespread network of rural electric cooperatives has been placed at risk by policies forcing the retirement and closure of viable coal power plants.

VII.B. Recommendations

The research conducted here has identified a number of potential initiatives and areas requiring further research. These include:

1. Regional disaggregation is required, especially at the state level of detail. There is great interest in data at this level and there will be a large and influential audience for the estimates. For example, the findings here indicate that the DOE R&D program will have very substantial, positive economic and jobs benefits throughout the forecast period and will yield high benefit-cost ratios. The implications of determining the benefits to specific states and regions are obvious, for the debate at the state and regional level inevitably revolves around “jobs, jobs, jobs.”
2. While the current study examined the economic and jobs benefits of various scenarios, it did not estimate potential environmental impacts and improvements. These include PM reductions, water quality improvement, air quality improvement, and impacts on other criteria indicators, in line with articulated clean air and water goals. These environmental impacts could be estimated in physical terms such as emissions, runoffs levels, etc., or they could be monetized. This would lend additional credibility to the findings and potentially increase interest in them. However, nonmarket values are subject to substantial debate, and would be controversial. Thus, it may be preferable to report only the physical improvements.
3. A high coal export scenario due to potential demand from China and Asia should be analyzed. U.S. coal exports peaked at 126 million tons in 2012, but by 2016 had declined to 60 million tons. The *AEO 2017* no CPP case forecasts that U.S. exports will not exceed 60 million tons until 2021 and by 2050 will reach only 80 million tons – and even the *AEO High Economic Growth Case* does not appreciably increase coal exports through 2050. However, given the increasing demand for coal in Asia, a hypothesized high U.S. coal export case needs to be analyzed. Such a case is consistent with the Administration’s goals, and development of it will allow identification and assessment of the jobs effects and implications of increased U.S. coal exports.

4. The detailed indirect coal-related jobs impacts by sector, industry, and occupation/skills, as well as new and emerging occupations, need to be estimated. MISI research indicates that many of the jobs generated under the scenarios are in industries and occupations not necessarily linked to coal or related industries and are, instead, created throughout the interindustry supply chain and in supporting activities. While some illustrative examples of these are included in the current report, a detailed analysis of this issue must necessarily be the subject of rigorous research.
5. Chapter VI assessed the impacts on local economies and jobs resulting from coal plant closures and contains examples of the effects of coal plant closings. However, it did not examine the reasons for the plants' closings. Analysis of the specific reasons for individual coal plants closing, e.g., EPA regulations, natural gas prices, changes in electricity markets, etc. is thus required, as well as examination of the effect on subsequent rates, local economies, and local jobs. This is a critical issue, especially at the state and local level, and a detailed analysis of this issue is required.
6. The net fiscal impact of coal miners' unemployment are poorly understood, and this deficiency needs to be remedied. These net fiscal impacts include welfare costs, Medicaid, SNAP, unemployment compensation, etc., and are a critically important issue – especially at the state, regional, and local levels. These costs need to be estimated and considered in any assessment of the effects of coal miners' job losses, as well as the benefits of the coal-related jobs created. While some illustrative examples of these costs are included in the current report, a detailed analysis of this issue is required.
7. A Presidential Executive Order (EO) issued on April 25, 2017 established an Interagency Task Force on Agriculture and Rural Prosperity, which includes the Secretary of Energy, to “Identify Legislative, Regulatory, and Policy Changes to Promote in Rural America Agriculture, Economic Development, Job Growth, Infrastructure Improvements, Technological Innovation, Energy Security, and Quality of Life.” The current study provides some limited information relevant to this EO. For example, it analyzed the importance of coal to U.S. rural electric cooperatives. These cooperatives include 75% of the U.S. land mass, serve 93% of the nation's “persistent poverty counties,” and rely upon coal plants for nearly 70% of their electric power. However, a more comprehensive analysis of this issue and its implications is required.
8. This report identified coal mining job losses and estimated differing levels of jobs that would be created under alternate scenarios. However, it is also useful to analyze the drivers that have affected coal job losses, and determine what portions of jobs have been lost as a result of each driver. These drivers include automation, EPA regulations, natural gas prices, changing electricity market conditions, and others. It is necessary to identify these drivers and determine the importance of

each of them. Identifying the relative impact of each driver would allow a more robust analysis of the jobs that can reasonably be gained in the future.

9. An important question to be addressed is “How many coal jobs could realistically be expected to come back given natural gas competition?” Another relevant question is “What would be the cost to government if it supported bringing back coal jobs above and beyond what may occur from reducing regulations alone?” These are important questions, especially given the conventional wisdom concerning the competitiveness of natural gas as an electricity generation fuel. Accordingly, detailed examination of these questions is warranted.¹⁹⁰
10. The current report contains a plethora of useful data and estimates, many of which break new ground and which contradict current thinking, and develops a large amount of information that has direct relevance to ongoing economic, energy, and environmental policy debates. It is important that the findings be publicized and distributed in the media, in the scholarly literature, and at appropriate professional venues. The findings can be used to prepare white papers, summaries, abstracts, and one-pagers appropriate for widespread distribution, articles for publication in peer-reviewed national and international energy and policy journals, and presentations at relevant professional conferences, seminars, and meetings.

¹⁹⁰For example, it would be useful to have an estimate of the number of coal jobs that could be gained by regulatory reform alone. Some estimates put the impact of shale gas on coal generation at 50% and the impact from renewables at 15% to 20%, which means 30% to 35% are related to automation/productivity improvements and regulations. Research is required to determine if these estimates are realistic.

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