Managing the Employment Impact of Energy Transition in Pennsylvania Coal Country

BLUEGREEN ALLIANCE

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Executive Summary

As America's energy system transitions to cleaner sources of energy, certain regions of the country that are highly dependent on fossil fuels are likely to witness significant economic changes. To provide a sense of what that might look like at a sub-state regional level, this report analyzes the employment impact of the transition to clean energy in southwest Pennsylvania.

We examine a region spanning 12 counties surrounding Pittsburgh that is highly dependent on fossil fuels, especially coal. The region is a major producer and exporter of electricity, 74 percent of which came from coal in 2012. It is also one of the nation's leading producers of coal, and is the fastest-growing producer of gas due to the Marcellus shale boom. Looking at the region today, we find that the economic impact of these industries is relatively small, with coal, gas and electric power accounting for less than 2 percent of overall direct employment in 2012. However, certain rural counties are highly dependent on them (for example, coal mining accounted for 14 percent of the workforce and 29 percent of the tax base in one county) and these jobs are typically more likely to be full-time, secure, well-paid union jobs relative to the workforce as a whole.

To provide insight into how that energy mix might change over time, we construct four plausible future electricity scenarios for the region based on projections from the EIA and EPA. Two of the cases involve no policy action, a third approximates the effect of the EPA's Clean Power Plan, and the fourth is a 'worst case' scenario for coal. Importantly, we find that in all cases the coal industry sees a significant decline. With coal capacity falling from 71 percent to between 54 percent and 43 percent by 2030, and generation from 74 percent to between 64 percent and 45 percent by 2030, the writing is on the wall for the coal industry in this region. On the other hand, all cases saw a significant increase in gas, renewable energy and energy efficiency. Growth in renewables and efficiency were particularly sensitive to policy action, suggesting that government has a key role in supporting this sector.

Based on these scenarios, we use two economic models to estimate the impact on employment. Based on this modeling (which, though inexact, provides useful insights) we conclude that:

1. ***Energy transition will lead to significant net increases in employment in energy.*** This is true in all scenarios, with between 20,713 and 80,279 net job-years created by 2030. This is so even within this particular region of the state surrounding Pittsburgh.
2. ***There is a temporal mismatch between short-term jobs created and long-term jobs lost.*** We project a big increase of 27,290 – 75,814 job-years in the first five years, in plant construction and retrofitting. But we also project a smaller loss of 6,577-23,234 job-years across the 15-year period, in long-term operating and maintenance jobs.
3. ***Renewable energy and energy efficiency creates more jobs than fossil fuels.*** Renewable energy and efficiency are more labor-intensive than fossil fuels. The faster the transition to clean energy, the greater the increase in jobs — even in this region.
4. ***But clean energy creates different types of jobs than those supported by fossil fuels.*** Construction and manufacturing see the biggest job gains, and utilities and mining see the biggest job losses. The jobs created by clean energy are also less likely to be male-dominated, less likely to be permanent, and less likely to be union than the status quo.
5. ***Employment projections of this kind are inherently uncertain.*** Due to the mix of technological, market and economic uncertainty involved, the projections in this report

should be regarded with caution. In particular, the work in this report could be improved with better data, modeling tools, and resources.

These insights imply that for policymakers, the challenge lies not in the *number* of jobs created and lost (despite much commentary from industry and politicians). Our focus on a fossil fuel-dependent 12-county region suggests that this is so even at the regional level (although at the local level, some towns and municipalities are likely to see net job losses). The big challenge for policy makers lies instead in the transition between different *types* of jobs, at different times in the future. In particular, it will be important to clarify what kind of re-skilling and re-training is required for workers in the energy industry, and to ensure that a safety net exists to protect workers' benefits and pensions and the tax base of particular municipalities in the interim.

Our final section considers the policy options open to the state government to confront this challenge. We review lessons learnt from similar policy interventions in forestry, trade adjustment and military realignment in the past, before evaluating four policy options in detail — no action, gas development, clean energy development, and worker transition. We conclude that there are no easy answers, but that the worker transition policy package (combining compliance with the Clean Power Plan with a well-funded worker transition package) provides the optimal mix of budgetary, economic, environmental, equity and certainty costs and benefits. Finally, we recommend next steps and opportunities for more research to improve this analysis.

1. Introduction

In the last five years, America's electric power system has undergone massive change. Since 2008 the deployment of 'fracking' technology has seen vast new shale gas reserves developed, with gas production in states lying over the Marcellus Shale increasing dramatically (by 1600 percent from 2008 and 2013 in Pennsylvania alone).[i] This 'shale revolution' has seen gas prices fall and new natural gas-fired power plants become increasingly cheap and thus competitive with coal-fired electricity generation.[ii] Combined with new policies to reduce air pollution from the power sector, such as the Environmental Protection Agency's (EPA) Mercury and Air Toxics Standard (MATS), the gas boom has pushed coal-fired power into a steep decline. Coal-fired plants have been dispatched less often and in many cases closed altogether, with coal's share of generation falling from 50 percent in 2004 to 39 percent by 2013, and 10.2 gigawatts (GW) of coal-fired capacity retired in 2012 alone (see **Appendix A**).[iii]

The BlueGreen Alliance—for whom this report has been prepared—has an important stake in this transition. The BlueGreen Alliance is a coalition of 15 of the largest unions and environment organizations from across the US and Canada, with 15 million members and supporters.[iv] Its membership includes utility workers, steel workers, railway workers and construction workers, all of whom have a direct stake in the electricity industry (both fossil fuels and clean energy). It includes millions of parents, workers, students and citizens who have a personal interest in maintaining a clean and healthy environment.

In that context, this report starts to answer some of the key questions facing southwest Pennsylvania. Section 2 describes salient features of the southwest Pennsylvania region that is the focus of this report, providing background on its energy, economy and demography. Section 3 asks what sort of electricity system the region could expect over the next 15 years, and what impact the EPA's soon-to-be-implemented Clean Power Plan could have on that. Section 4 asks what impact those changes could have on employment in the region, using both an engineering-based analysis focused on direct and indirect jobs, and an input-output modeling analysis that expands the focus to induced impacts. Section 5 looks at policy options available to the newly elected state government to manage that transition, and makes recommendations to protect workers in the transition to clean energy. Section 6 sums up and recommends next steps.

This report should not be regarded as a final or complete analysis. Many of the questions it examines are inherently difficult to determine with certainty, and many of the answers suggested could be greatly improved with more resources—including more time, more personnel, more funding and more modeling capacity. This report aims to provide insight as to the scale and nature of the challenge facing the region, and explores opportunities and needs for state government action to ensure a just transition.

2. Background

2.1 Defining the Southwest Region

Southwest Pennsylvania can be defined in a number of ways. The Bureau of Labor Statistics tracks statistics for the Pittsburgh Metropolitan Statistical Area (MSA) as including the seven counties of Allegheny, Armstrong, Beaver, Butler, Fayette, Washington and Westmoreland.[v] The Southwest Partnership for Regional Economic Performance (PREP) defines the region as including nine counties—the same ones used in the MSA, plus Greene and Indiana counties—and the Southwest Pennsylvania Commission includes Lawrence County in their 10 county working region.[vi] Other definitions include counties in adjacent states, such as that used by the Power of 32—a public-private leadership collaborative that is developing an energy plan for a 32 county region spanning Pennsylvania, West Virginia, Maryland and Ohio.[vii]

Each of these is an acceptable definition of the southwest region's economy, but for this report we are interested in the area that best captures the transformation in the state's coal industry. Most of Pennsylvania's coal mines are located in the southwest of the state (see **Appendix B**), with coal production heavily concentrated in Greene (61 percent of total production in 2011), Washington, Somerset, Clearfield and Armstrong counties which together accounted for 85 percent of total production in 2011.[viii] Employment is similarly concentrated in this region, with 86 percent of bituminous coal mining employees located in 5 counties (Greene, Somerset, Indiana, Armstrong and Clearfield) and 65 percent located in Greene and Somerset alone.[ix]

Coal-fired power plants are similarly concentrated in the southwest of the state, although to a lesser degree than mines (see **Appendix C**). Pennsylvania's five largest coal-fired generators by capacity are located in the counties of Beaver (Bruce Mansfield plant), Indiana (Homer City plant), Westmoreland (Conemaugh plant), Armstrong (Keystone plant) and Fayette (Hatfield's Ferry plant, closed in 2014).[x] The employment picture seems similar: although electric utility employment is not broken down by fuel type, Allegheny and Beaver counties rank 2nd and 3rd highest in the state, with Indiana ranking 7th, and the rest of the top 10 counties all located in the east of the state.[xi]

For the purposes of this report, we have therefore selected a 12 county region including Allegheny, Armstrong, Beaver, Butler, Cambria, Clearfield, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland counties, to capture the major centers of coal production, coal-fired electricity generation and coal employment in the southwest. We will refer to this as '**the southwest region**' through the rest of this report (see **Appendix D**).

2.2 Regional Overview

The southwest region had a combined population of 2.79 million people in 2012—roughly the same size as Nevada, and around a fifth of Pennsylvania's total population (see **Appendix E**). Allegheny County (home to Pittsburgh) had 44 percent of that population, with Washington and Westmoreland counties the next two most populous (with 7 percent and 13 percent respectively). [xii] The age distribution in the southwest region was roughly equal to Pennsylvania as a whole, but some counties (including Westmoreland, Somerset, Fayette and Armstrong) had a higher share of persons over the age of 65 (around 20 percent compared to 17.1 percent).[xiii]

The region had a higher share of white persons than the state as a whole (89 percent v 83.2 percent), and a low share of black (8 percent v 11.5 percent) and Latino (2 percent v 6.3 percent) persons. This story was different between counties; with Allegheny County more diverse (81.3 percent white, 13.3 percent black, 1.8 percent Latino) than the whiter rural counties. [xiv]

Per capita and median household income for the region broadly matched the state as a whole; however, this masks significant disparities within the region. Fayette County, for example, has a significantly lower median household income than the state as a whole ($39,115 v $52,548), and 6 other counties have median household incomes lower than $45,000 (Armstrong, Cambria, Clearfield, Greene, Indiana and Somerset).[xv] The unemployment picture is similar: annual average unemployment in the southwest region in 2013 was the same as for Pennsylvania as a whole (7 percent), but counties like Somerset (9 percent) Fayette (8.5 percent) Cambria (8.6 percent) and Clearfield (8.4 percent) experienced significantly higher rates of unemployment.[xvi] However, the 12 counties of the southwest region fare better economically than most counties in the Appalachian Regional Commission's jurisdiction (for example, in Kentucky or West Virginia) (see **Appendix F**).

With Pittsburgh a historic center of steel and industry, manufacturing remains the region's number one industry sector by GDP and among the top five in employment.[xvii] Educational and Health Services is the region's other major employer, and the fastest-growing industry sector by employment is mining led by the oil and gas boom in the region since 2008.[xviii] The Cluster Project at the Harvard Business School identifies the five top clusters by employment to be in Business Services (led by Corporate Headquarters), Education and Knowledge Creation, Distribution and E-Commerce, Hospitality and Tourism and Upstream Metal Manufacturing, with Coal Mining, Oil and Gas Production and Electric Power Generation and Transmission also ranking high.[xix]

Politically, the southwest region (like PA as a whole) is "purple." The current Governor is Tom Wolf, a Democrat elected in November 2014 to replace Republican Tom Corbett. However, Republican majorities currently hold both houses of the state legislature. Within the southwest region, Allegheny County is solidly democratic while the other counties are solidly Republican; however, even in these counties support can fluctuate by up to 15 percent, as the comparison between the 2012 Presidential and 2014 Gubernatorial races shows (see **Appendix E**).

2.3 Regional Electricity System

Pennsylvania is a big part of the national energy picture. Among the states, Pennsylvania ranks 3rd in total energy production, 4th in coal production, and 2nd in gas production, with much of this concentrated in the southwest region.[xx] It is the 4th largest generator of electricity and the single largest electricity exporter of any state, and ranks 5th in the nation in electricity consumption.[xxi] Coal is the largest fuel source, accounting for 40 percent of electricity generation (measured in MWh) in 2013 compared to 35 percent from nuclear, 21 percent from gas and 4 percent from renewables.[xxii] The southwest region is inextricably linked with this broader picture. Although our focus in this report is on these 12 counties, it is important to remember that this region is not an island. As part of the PJM Interconnection—and as a major exporter of energy—the region is tightly intertwined with the broader energy picture.

Electricity data is typically not published at the county level, so to create a picture of the electricity system for the southwest region, we build our own dataset from the bottom up. We compile a regional generation and capacity mix using plant-level data published by the EIA, matching up the plants in these counties with data on their capacity, fuel type and generation for the year 2012 (the most recent year for which data is available).[xxiii] From this we can see that the region has 17,217 MW of summer capacity, 71.3 percent of which is coal, 12.8 percent gas, 10.5 percent nuclear, 4.5 percent renewables and 1 percent petroleum. It also generated 91.18 GWh of power in 2012, 73.6 percent of it from coal, 9 percent from gas, 15.6 percent from nuclear and 1.7 percent from renewables (see **Appendix G**). However, this has already changed greatly. If we amend this 2012 data to remove the coal-fired plants that have been retired since this data came out, we see total capacity and generation fall by 18.1 percent and 13.5 percent respectively, and coal's share of the capacity and generation mix falls to 66 percent and 69 percent respectively of the total, revealing the pace of coal's decline.[xxiv]

Obtaining information on electricity demand (sales) and prices for the region is harder, since sales and price data are only published at an electricity market module level and a utility level, both of which overlap our 12-county region and make disaggregation impossible. We use state and utility-level data to arrive at rough baseline estimates (see **Appendix H**). We estimate demand by taking retail electricity sales for the state as a whole (144.7 million MWh) and multiplying it by the proportion of the state's population that lies in the southwest region (21.8 percent), which gives us total retail sales of 31.6 million MWh for 2012.[xxv] For prices, we can arrive at a rougher estimate of the price in the region by taking a weighted average of average retail prices of the four investor-owned utilities (IOUs) and five rural electric cooperatives that supply the region, and arrive at a figure of 10.9 c/kWh for 2012—lower than the state average of 12.1 c/kWh.[xxvi]

Since the southwest region is also a major producer of coal, oil and gas, we also build a dataset for coal and gas production in the southwest region (see **Appendix I**). Using Energy Information Administration (EIA) data on coal production by county, we find that the region produced 51.3 million short tons of mostly bituminous coal in 2012, 17.5 percent of all coal production in Appalachia that year.[xxvii] For oil and gas the EIA does not release county-level production data, so we build our own estimates using state-level EIA data on dry production, and county-level data on gross withdrawals from the U.S. Department of Agriculture (USDA), to infer regional dry production.[xxviii] We find that the southwest region produced 839,623 MMcf of natural gas in 2012—37 percent of the state's production, and 25.4 percent of production from the EIA's 'Northeast' region in that year.

2.4 Energy Employment

As mentioned above, the energy industry is an important part of the PA economy, and even more so of that of the southwest region. However, obtaining reliable data on energy employment in the southwest region is difficult. The Bureau of Labor Statistics' (BLS) Quarterly Census on Employment and Wages (QCEW) and the Census Bureau's County Business Patterns (CBP) surveys both collect employee and payroll data by county by industry.[xxix] However, the publication of both of these datasets is restricted for confidentiality reasons, meaning that we cannot compile an accurate employment-by-industry-by-county picture for the region. We must therefore rely on secondary sources (i.e. industry figures), and on inferences made from state and MSA-level data, to compile our own estimates of regional employment by industry.

For coal production, we are able to use data from the EIA and the Mine Safety and Health Administration to show that there were an annual average of 7,413 employees at coal mines and processing plants in the southwest region in 2012 (see **Appendix I**). For the electric power and oil and gas production industries, we are forced to make estimates of energy employment in the region based on figures released by the BLS for the Pittsburgh MSA (including 7 of our 12 counties) and the state as a whole (see **Appendix J**), informed by the region's share of statewide production. In this way, we estimate that 5,962 people were directly employed in the electric power industry, and 7,528 people in the oil and gas industry in the southwest region in 2012.

Note, however, that these are direct jobs only—they do not include indirect or induced jobs that the energy industry supports in the region. In 2012 the Allegheny Conference estimated that Greater Pittsburgh (defined as a 10 of our 12 counties) was "home to almost 1,000 companies, 41,000 direct energy jobs, and a $19 billion economic impact, or 16 percent of the 10-county region's economy."[xxx] For Pennsylvania as a whole, the electric power industry estimated that it provided 16,532 direct jobs, 21,675 indirect jobs and 31,709 induced jobs in Pennsylvania (including generation, transmission and distribution), and contributed $1.1 billion in federal and $1.7 billion in state and local taxes. [xxxi] In 2010, the coal industry estimated its employment at 8,724 direct jobs, 32,853 indirect jobs, and $3.25 billion in direct economic output—an estimate for the state as a whole but, based on the above, likely to be concentrated in the southwest region.[xxxii] A 2009 report by GTech Strategies found that Southwestern Pennsylvania (the Pittsburgh 11-county MSA) had close to 18,000 jobs in green industries.[xxxiii]

These are not particularly big numbers in the context of the regional economy. The southwest region employed 1.26 million workers in 2012, meaning that coal, gas and electric power direct employment in that year was just 1.7 percent of the total. Contrary to the often-heard rhetoric of the importance of "energy jobs," the energy sector provides relatively few direct jobs, even in the southwest region (which has a higher share of these jobs than most parts of the country). However, many of these jobs are concentrated in particular communities. In Greene County for example, which accounted 61.2 percent of the state's bituminous coal production in 2011,[xxxiv] direct coal employment accounts for 14 percent of the total county workforce,[xxxv] and coal mining provides 29 percent of total county tax revenues.[xxxvi] The next 4 highest-producing countries in the state—Washington, Somerset, Clearfield & Armstrong, which along with Greene account for 85 percent of total state production—rely on coal for between 6-18 percent of county tax revenue and between 0.8-3.2 percent of total employment.[xxxvii]

Nationally, jobs in the coal, gas and power industry have some notable characteristics. To begin with, they have a much higher rate of union membership and coverage than other industries. In the electric power industry, for example, 29.7 percent of workers were covered by a union contract in 2012—more than double the rate of coverage in Pennsylvania (14.4 percent) and the nation (12.5 percent) that year.[xxxviii] However, coal mining has a 19.4 percent coverage rate, and oil & gas extraction have a far lower union coverage rate of 5 percent. Employment in these industries is also very male, with the share of females working in electric power (22.1 percent), coal mining (9.2 percent) and oil & gas extraction (20 percent) far lower than the workforce as a whole (47 percent).[xxxix] Jobs in these industries also seem to have a higher share of full-time work (84 percent for transportation and utilities and 92 percent for mining and oil and gas, compared to 76 percent for all industries),[xl] and average hourly earnings significantly higher than in the economy as a whole (as of December 2012, $34.90 for utilities, $34.31 for oil & gas and $27.89 for mining, compared to $23.71 for the workforce as a whole).[xli]

3. Future Electricity System Scenarios

This section outlines various future electric power scenarios for the southwest region, with a particular focus on changes in capacity and generation, energy efficiency, demand, prices and electricity bills. However, it is important to recognize what these scenarios are and are not. Projecting changes in the electricity system years into the future is inherently uncertain, due to the unpredictability of changes in technology, and in the demographic and economic fundamentals that drive regional supply and demand in an electricity market. Further, although more sophisticated modeling tools with the capacity to capture dynamic interactions between supply, demand, prices and industry composition in projections exist, they are expensive and we have not used them in this analysis. The following should therefore be seen not as predictions of the future, but as plausible scenarios for the purpose of informing policy discussion.

3.1 Business as Usual

This scenario is based on the Reference Case described by the Energy Information Administration (EIA) in their latest Annual Energy Outlook 2014 (AEO 2014). The EIA is required to form these projections based on current policy, so these do not include the projected impacts of the EPA's Clean Power Plan or any other proposed energy policy.[xlii] Several commentators regard these estimates as conservative, especially for renewable energy and energy efficiency.[xliii]

Since the EIA does not publish electric power projection data at either a state or a county level, we use their projections for the Reliability First Corporation West (RFC-W) electricity market module that includes southwestern PA as well as Ohio, Indiana, West Virginia and parts of other states. An imperfect but reasonable proxy, this region has a profile that is similar to the southwest region, with similar retail electricity prices (11.3 c/kWh for RFC-W, compared to our 10.9 c/kWh estimate for the southwest and 12.75 c/kWh for Pennsylvania) and a share of coal capacity and generation that is higher than the state as a whole (55 percent and 59 percent respectively for RFC-W, compared to 38 percent and 39 percent respectively for PA) but lower than southwestern PA (with 65.8 percent and 69.4 percent respectively).[xliv]

In RFC-W in the Reference Case, coal's share of capacity falls from 55 percent to 45 percent from 2013 to 2030, from 70.68 GW to 57.53 GW, with natural gas rising from 25 percent to 37 percent.[xlv] Renewable capacity increases from 5.6 percent to 5.9 percent (7.18 GW to 7.65 GW) while nuclear falls 2 percent. The change in generation is less pronounced with coal falling from 65 percent to 58 percent while gas rises from 8 percent to 18 percent. Electricity demand rises from 498 billion kWh to 568.5 billion kWh, while prices increase from 9.68 c/kWh to 14.32 c/kWh (all-sector average) in nominal terms. Note that—even without new policy action—the EIA is projecting that coal's share of power capacity will fall significantly.

We build a rough, but plausible, BAU Case for the southwest region based on this projection. We do this by applying the same percentage changes in capacity and generation by fuel type to the southwest region's electricity sector developed in section 2.3 above. We then adjusted this to reflect realities and remove absurd results (for example, assuming that the region's one nuclear facility would not shut down 14 percent of capacity, and adjusting implied capacity factors to a reasonable level). Notably, the southwest region has already seen a decline in coal capacity greater than its proportionate share of that projected for RFC-W as a whole. We therefore assume (conservatively) that no more coal units would be shut down, but also that no new coal units would be built in the southwest region. This leads us to the projections in **Appendix K**.

Figure 1: Capacity Mix in 2012

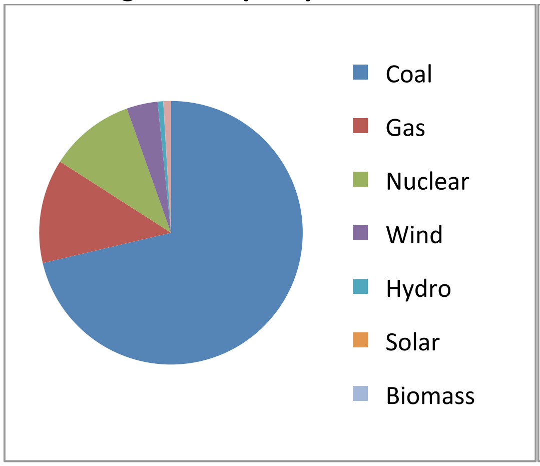
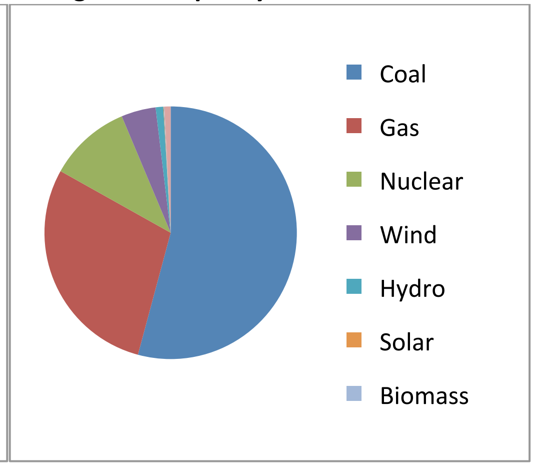


Figure 2: Capacity Mix in 2030



To estimate changes in electricity demand (i.e. sales) and prices in the southwest region, we apply the percentage change in demand and prices projected for the RFC-W region in the AEO 2014 to our baseline estimates for the southwest region. This is an imperfect approach, as it does not allow prices in the southwest region to adjust to regional changes in supply and demand. However, since the AEO 2014 price projections already capture these dynamics to some degree, we consider it a reasonable approximation. This method gives us a price increase of 22 percent in real terms (2012$) from 10.9 c/kWh to 13.3 c/kWh, and a big 13 percent *increase* in demand (retail sales) from 66.7 thousand GWh in 2012 to 75.5 thousand GWh in 2030.[xlvi]

3.2 Accelerated Coal Retirements

This case is based on the "Accelerated Coal Retirements" Case in the EIA's AEO 2014, and is also based on current policy settings and excludes the EPA Clean Power Plan. In the AEO 2014, the case represents a scenario where market pressures lead to higher coal costs, and assumes lower mine productivity, higher transport costs, and a 3 percent increase in annual O&M costs.[xlvii] For our purposes, then, we can consider it a sort of 'worst case' scenario for coal (absent policy changes). In this scenario, by 2030 coal's share of the capacity mix in RFC-W falls even further to 34 percent by 2030 as its share of generation falls to 42 percent. Demand grows slightly less by 11 percent to 558 billion kWh by 2030, and prices increase slightly more by 28 percent to 11.2 c/kWh in real terms. [xlviii]

We apply these projected changes to the southwest region using the same methodology as above (see **Appendix L** for full results). The decline in coal's share of capacity is even steeper, falling from 71 percent to 49 percent by 2030, with gas rising even faster to claim 35 percent of capacity up from 13 percent in 2012. The capacity factor of both coal and gas plants increases, somewhat offsetting this shift in generation terms, such that whilst overall capacity falls, total generation increases. Notably, renewables do not grow significantly in either this scenario or in the BAU Case (above). This suggests that without policy action (an assumption of both cases in the AEO 2014), renewable energy is unlikely to grow significantly. Demand (total sales) rises to 74.1 thousand GWh, and average retail prices to 13.9 c/kWh (2012$) by 2030.

Figure 3: Capacity Mix in 2012

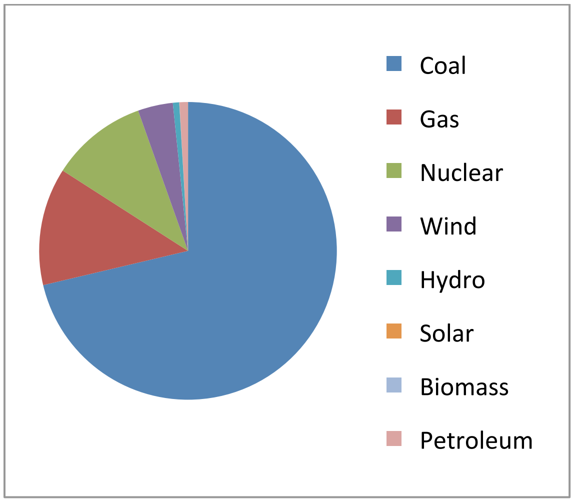
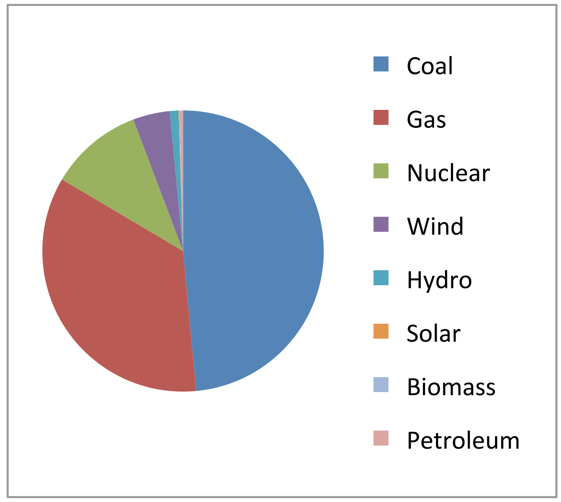


Figure 4: Capacity Mix in 2030



3.3 Clean Power Plan

This case is based on the EPA's proposed Clean Power Plan, and in particular on the Regulatory Impact Analysis (RIA) that was released with the proposal on June 2, 2014.[xlix] The EPA's proposal set emission reduction targets for each state based on EPA's estimates of the extent to which they could improve efficiency at existing coal-fired power plants, switch to natural gas generators, switch to zero-emissions generation (i.e. renewables and nuclear) and improve energy efficiency. Based on these scenarios for each state, they then modeled the impact on the national electricity system using the Integrated Planning Model (IPM) (the same model used by system operators to ensure reliability), and came to projections of changes in capacity, generation, demand, rates and bills. EPA's proposal and modeling covered two different options with different compliance timetables, and two different state and regional scenarios (depending on whether states chose to work separately or together in regions). For the purposes of this report, we will focus on the Option 1 Regional scenario proposed and modeled by EPA.

EPA did not release the full results of their modeling, but did extract some of the results in their RIA at a national, state and electricity market module level of resolution. We therefore use this information to construct a "Clean Power Plan" case for our region. There are two challenges with doing this. The first is that the EPA extracted the results of their modeling in terms of percentage changes from the Base Case, but did not include the Base Case itself, which is likely not the same model run as the AEO 2014 Reference Case. The second is that the EPA released many of their results at a national or electricity market module level only, meaning that we have to "downscale" the data to our region. We confront these challenges by taking the projected national percentage changes in capacity and generation, applying them to the baseline 2030 figures for the southwest region (from section 2.3 above), and making adjustments to ensure that the results are reasonable (for example, ensuring that total capacity and generation figures match up, and that capacity factors remained plausible and broadly constant over time). This approach involves several stages of approximation, so we have extracted the scenario in more detail in **Appendix M**. Without access to the modeling results from EPA, or to modeling capacity to do this work ourselves, these cases should not be regarded as a projection of the impact of the EPA's Clean Power Plan—particularly since such an outcome depends on how the state chooses to implement it. It is, however, a plausible scenario based on the modeling done by the EPA, and we consider it useful to provide insights for policymakers.

We should also note that the impact of the Clean Power Plan could be significantly more positive than EPA's projections. PJM Interconnection recently confirmed that the costs of action and the impact on coal-fired power plants could be lower if states work together and adopt regional approaches (as we recommend in Section 5 of this report).[l] Further, if states adopt more renewable energy and energy efficiency than that projected by the EIA, then this would reduce the employment impact both by creating more jobs in these cleaner industries and by reducing the amount of coal capacity that would need to shut down to meet the EPA's carbon intensity targets.[li] This scenario may therefore be worse than the reality.

The EPA projected that their plan would lead to a significant decline in coal capacity and generation (by 19 percent and 25 percent respectively by 2030) with the bulk of this occurring by 2020.[lii] By 2020 this would be met with an increase in gas capacity in generation, but by 2030 gas' share of capacity and generation also declines (by 10 percent and 6 percent respectively), as carbon pollution from gas is subjected to tighter restrictions. The lion's share of this decline in capacity and generation came from a decline in capacity and generation overall, to 91 percent and 89 percent of business-as-usual respectively. However, renewable energy also makes significant gains in capacity and generation (up 9 percent and 2 percent in absolute terms, and far higher in terms of share of total) by 2030. Demand in Pennsylvania fell steadily and significantly by 12.1 percent from business-as-usual by 2030, slightly higher than the national decrease of 11.13 percent by 2030. [liii] National electricity bills initially increased by 2.7 percent by 2020, before falling by 5.4 percent from BAU by 2025 then 8.7 percent by 2030.[liv]

For our EPA Case in the Southwest Region, we find that declines of the same magnitude leave the region with overall capacity of 15,533 MW and generation of 93,014 GWh. Of this, coal falls to 48 percent of capacity and 57 percent of generation, and gas maintains its 29 percent share of capacity and rises four points to 22 percent of generation by 2030. We include in our scenario an increase in renewable energy that is higher than that projected by the EPA for the nation as a whole, with all sources (wind, hydro, solar and biomass) doubling capacity and generation in absolute terms, rising from 6 percent to 10.6 percent of capacity and from 2.3 percent to 5 percent of generation by 2030. In the southwest region, demand fell by 12.1 percent from 75.5 thousand GWh to 66.4 thousand GWh, and prices rose by 0.4 percent from 13.3 to 13.35 c/kWh by 2030 ($2012). For more detail, see the full results in **Appendix M**.

Figure 5: Capacity Mix in 2030

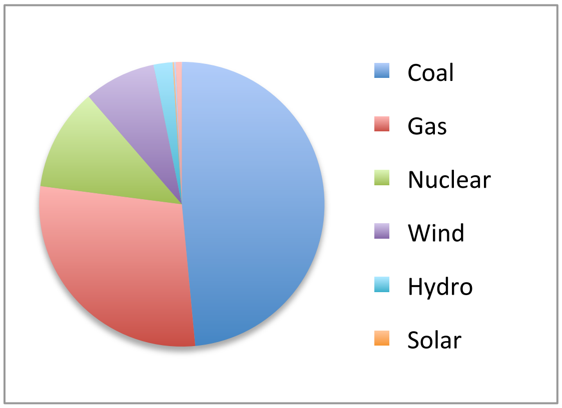
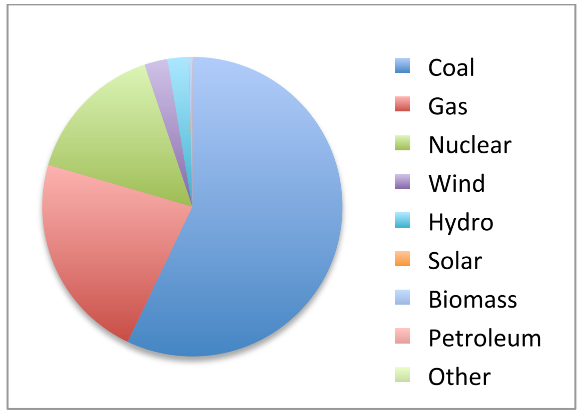


Figure 6: Generation Mix in 2030



3.4 Beyond Case

Similar to the EPA Case described above, in this case we applied the projections from the EPA's RIA to a different baseline—the Accelerated Coal Retirements Case described in section 3.2 above—to give a sense of a "worst case" scenario for coal where market forces and environment policy cumulate. It is important to note, however, that this does *not* represent a situation where the Clean Power Plan is adopted and market forces turn sour for coal. In that scenario, the closure of coal capacity due to market forces would be fully credited towards states' targets under the Clean Power Plan, reducing the impact on the system. This case goes above and beyond the Clean Power Plan, to proxy for further policy actions that might be taken.

In this case, we find that coal ceases to be the dominant fuel source in the southwest region, falling to 43 percent of capacity and 45 percent of generation by 2030, with gas rising to 35 percent of capacity and 35 percent of generation. Renewables increase to a similar share of capacity, and total capacity and generation fall to a level only slightly higher, than in the Clean Power Plan case described in section 3.3. The key difference here is the magnitude of the shift from coal into gas-fired generation. Demand fell from 74.1 thousand GWh to 65.16 thousand GWh, and prices fell from 13.9 c/kWh to 13.96 c/kWh. The full scenario is laid out in **Appendix N**.

Figure 7: Capacity Mix in 2030

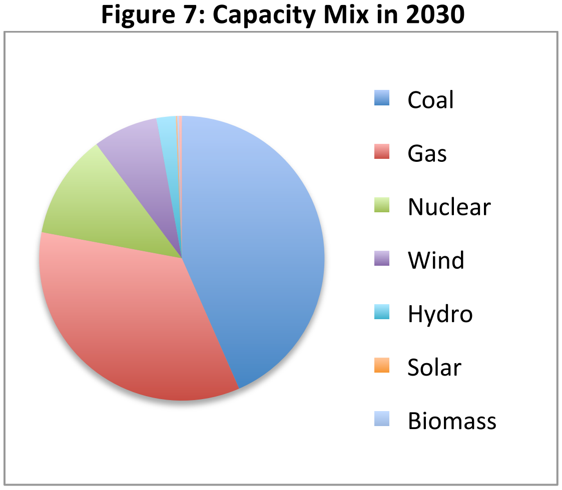
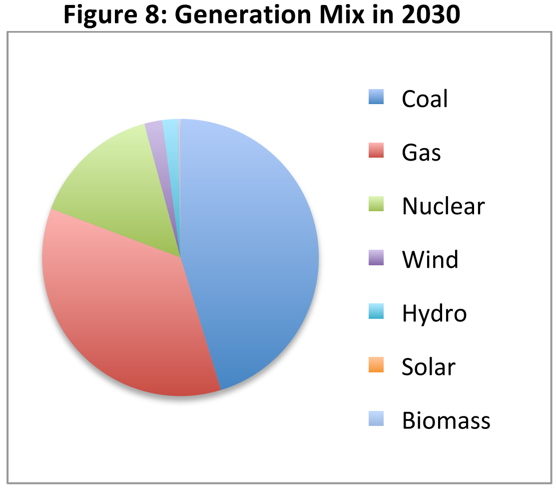


Figure 8: Generation Mix in 2030



4. Employment Impact

This section outlines the potential impact that the changes in the southwest region's energy system could have on the economy and employment in the above scenarios.

4.1 Introduction

Estimating the economic and employment impacts of changes in the energy system and the regulatory environment is inherently uncertain. This is for several reasons, including:

- **Energy Uncertainty.** The relationship between production levels and employment is not linear. It can change over time as technology changes—particularly where 'younger' technologies such as renewable energy are concerned. Other factors such as geology can also play a role: for example, the decline in coal production in Appalachia over the last decade has not been matched by a decline in coal mining employment, due to declining labor productivity driven by more difficult-to-access coal deposits.[lv]
- **Policy Uncertainty.** The interactions between the effects of environment policy on labor supply and demand can be difficult to capture.[lvi] Large complex policies such as the Clean Power Plan can affect employment in different ways and in different directions simultaneously, making the final impact hard to pin down.
- **Economic Uncertainty.** Employment changes in one industry due to one set of policy changes are just a fraction of the broader employment picture. Unforeseen economic changes such as a recession, or the move of another major industry in or out of a region, can mean that employment changes in one sector get lost in the "noise." Even when the economy is at full employment, jobs lost in one sector will primarily be reallocated from one productive sector to another in the long run, with little effect on net employment.[lvii]

The EPA's RIA conducted a review of academic literature on calculating employment impacts of clean energy policies, and found them to be limited and focused in Europe.[lviii] All told, estimates of the employment impact of energy policies must be regarded as inherently unreliable.

That said, these estimates are everywhere. The jobs impact of energy and environment policies is frequently a major component of the policy debate, and of support or opposition for a policy, meaning that employment estimates are frequently made and debated. In the last five years, economic consultants and not-for-profit organizations have published a range of reports on the employment impact of energy transition (the academic literature is far more limited).[lix] Most of these are based on projected changes in the electricity system derived from dynamic models, although some of them construct energy scenarios for the purpose of providing a range of economic possibilities (as we have done). Most of them combine an engineering-based analysis of the impact on direct jobs using tools such as the Jobs and Economic Development Impact (JEDI) model released by the National Renewable Energy Laboratory (NREL), with an input-output model-based analysis of the impact on indirect and induced impacts on output, earnings and employment in a study region, using modeling tools such as IMPLAN, REMI or RIMS II. In the following sections, we take the same two approaches for the southwest region.

Several estimates have already been made for scenarios similar to those we are considering. The EIA does not release employment projections in their Annual Energy Outlook, and only releases historical employment data for coal production.[lx] However, Chapter 6 of the EPA's RIA for their proposed Clean Power Plan included an analysis of the likely employment impact of the rule (see **Appendix O** for a summary). The analysis included both an engineering-based estimate of direct and indirect employment impact, and an input-output model-based estimate of induced employment impact. The RIA did not release these results at a state or regional level. At a national level they estimated a net decrease of 79,900 job-years from BAU by 2026-2030 from changes in capacity and generation.[lxi] This actually included a short-term increase of job-years by 25,900 in 2017-20 driven by construction of new plants and heat rate upgrades on existing plants, offsetting an otherwise steady decline. This loss of jobs in generation was far offset by increases in employment related to energy efficiency, which added 78,800 jobs (not job-years) by 2020, 112,000 by 2025 and 111,800 by 2030.[lxii] However, EPA acknowledged that the estimate of energy efficiency employment impact was less certain than that for changes in capacity and generation. If we were to apply EPA's national job estimates to the southwest region proportionate to population (an unlikely outcome, but a useful yardstick) then by 2030 we would expect to see a net decrease of 709 job-years in power generation, and a net increase of 992 new jobs in energy efficiency, relative to BAU.

Although the EPA did not release state-level employment projections, a similar study commissioned by the Natural Resources Defense Council (NRDC) and conducted by Synapse Economics did.[lxiii] Its analysis was based on the NRDC's proposal for regulations limiting greenhouse pollution from the power sector, which was similar to what the EPA proposed. Their study included an original run of the IPM model to reach dynamic projections of the impact on the electricity system, which they then converted into spending changes and fed into an IMPLAN input-output model to reach estimates of direct, indirect and induced employment impacts. They found a net increase of 8,700 jobs by 2020 relative to BAU (comprised of 9,600 direct jobs, 1,800 indirect jobs and 2,700 jobs lost due to shifts in expenditure away from energy) for Pennsylvania as a whole. The bulk of this figure again comes from new jobs in energy efficiency (estimated at 8,300 in 2020) and new jobs in construction on coal-fired generation (1,300 in 2020, presumably due to upgrades or new advanced coal capacity), with an estimate of just 500 jobs lost in coal-fired generation by 2020 relative to BAU.

4.2 Engineering-Based Analysis — Direct & Indirect Jobs

In this section we estimate job impacts for our four scenarios directly, based on power plant cost and employment data from the JEDI model, and EPA's own methodology. These "napkin numbers" have different strengths and weaknesses than the input-output model used in section 4.3, so although we consider them less reliable overall, we include them for contrast.

There are five main drivers of the employment impact of these reforms:

- new plants built;
- old plants retired;
- heat rate improvements at existing (coal-fired) plants;
- changes in fuel production; and
- energy efficiency upgrades.

To this list could also be added the change in household spending due to lower or higher electricity bills, and the "expenditure shift" job change as spending is directed away from the energy industry towards other parts of the economy. We are not able to calculate these in this report, but based on other analyses they are likely to be positive and negative respectively.[lxiv]

4.2.1 Plant Construction & Retirement

The change in generating capacity (i.e. retiring old plants and building new plants) accounts for the bulk of change in direct jobs, and is also the safest category for which to calculate the change in direct jobs. There are a number of ways to calculate these, but for our purposes we use the National Renewable Energy Laboratory's (NREL) Jobs and Economic Development Impact (JEDI) model. The JEDI model covers coal, gas, wind, solar, hydro and oil capacity (our analysis excludes biomass, nuclear and oil due to modeling limitations, but these are a very minor part of the regional energy story anyway). Designed to estimate the economic impact of new power plants, it contains detailed data on the upfront installation costs, fixed operations and maintenance (O&M) costs and variable O&M costs (including fuel costs) for running them (see **Appendix P**). This cost data is tailored to each state, and is updated regularly.

The model can also be used to arrive at job estimates, since it contains built-in IMPLAN multipliers for each state. However, there are two big caveats to this. First, the JEDI model does not produce "direct" and "indirect" job estimates *per se*—the model instead estimates "Onsite Labor Impact" and "Local Revenue and Supply Chain Impacts," which should not be directly compared with "direct and indirect" estimates (*eg* those we derive from the I-O model in the next sub-section). Second, the JEDI model is not tailored to the southwest region. The multipliers are for the state of PA as a whole, and the "local shares" of spending (i.e. the amount assumed to stay within the state) are national defaults that are not tailored to the state. For this reason, we do not consider these estimates as reliable as those derived from the I-O model in the next sub-section. However, we still include them here to complement those results (see **Appendices Q, R, S & T** for full results from the JEDI model).

As the summary table below shows, each of the four scenarios yields a net-positive employment number in jobs terms, but a net-negative number in terms of job-years. This reflects the mismatch between the large number of short-term jobs created in the Construction phase, and the smaller number of longer-term jobs lost in the Operating phase, in each case. This net loss in operating jobs reflects the fact that both gas-fired power plants and renewable energy generators require fewer employees to operate than coal-fired power plants. The construction jobs will be concentrated in the first five years (2015-2020) when plants are being built and shut down, whereas the operating jobs lost span almost the entire period 2015-2030.

Summary - Direct & Indirect Jobs - Capacity Changes					
	Units	**BAU**	**Accel**	**CPP**	**Beyond**
Construction					
Onsite	Jobs	6,811	7,839	12,414	13,215
Supply Chain*	Jobs	5,211	5,860	9,663	9,988
Onsite	Job-Years	8,883	9,868	21,545	22,305
Supply Chain*	Job-Years	5,782	6,420	12,181	12,495
Operating					
Onsite	Jobs	(260)	(378)	(456)	(557)
Supply Chain*	Jobs	(2,364)	(3,321)	(5,164)	(5,895)
Onsite	Job-Years	(3,651)	(5,999)	(6,307)	(8,274)
Supply Chain*	Job-Years	(35,762)	(60,310)	(73,182)	(92,501)
Total Onsite	*Job-Years*	*5,232*	*3,870*	*15,238*	*14,031*
*Total Supply Chain**	*Job-Years*	*(29,980)*	*(53,890)*	*(61,002)*	*(80,007)*

These supply chain jobs figures are gross, and are not adjusted to reflect the proportion that is actually located in the southwest region. They are likely too high. We have included them here for background only.

4.2.2 Heat Rate Improvements at Existing Coal-Fired Plants

One of the key building blocks that EPA expects states to use to reduce their emissions is heat rate improvement (HRI)—upgrading the existing coal-fired generator fleet to make them more energy efficient. EPA proposed a 6 percent improvement in the heat rate of Pennsylvania's coal fleet, to account for 15 percent of the total reductions required from the state by 2030.[lxv] Since EPA did not specify the amount of plant upgrades state-by-state, we apply its national estimates to the southwest region on a pro-rata basis (likely to understate the figure, since the region has more coal-fired plants) to estimate 6,067 MW in the CPP Case and 5,334 MW in the Beyond Case. [lxvi]

We adopt the EPA's method for calculating the employment impact of these upgrades, assuming a central capital cost of $100/kW (based on EPA's comprehensive literature review, with a low figure of $40 and a high figure of $150). [lxvii] We then allocate this between four types of labor (construction and boiler making, engineering and management, equipment supply and materials supply), obtain labor productivity figures for those industries, adopted the productivity growth rate used by EPA to project future productivity rates, and multiply capital spending by productivity to reach a jobs estimate. Using this method we project` a net increase of 3,952 job-years, but with a considerable range (from 1,581 to 5,928).

Direct & Indirect Jobs — CPP Case — Heat Rate Improvements

Clean Power Plan Case - HRI - Direct & Indirect Jobs						
Description	**Source**	**Units**	**Share**	**Central**	**Low**	**High**
Upgrades		MW	-	6,067	6,067	6,067
Cost	EPA	$000/MW	-	100	40	150
Boilermaking & Construction	EPA	$000/job	40%	78.5	78.5	78.5
Engineering and Management	EPA	$000/job	20%	141.0	141.0	141.0
Equipment Supply	EPA	$000/job	30%	458.0	458.0	458.0
Materials Supply	EPA	$000/job	10%	424.0	424.0	424.0
Boilermaking & Construction	EPA	Job-Years**		3091	1237	4637
Engineering and Management	EPA	Job-Years**		861	344	1291
Equipment Supply*	EPA	Job-Years**		397	159	596
Materials Supply*	EPA	Job-Years**		143	57	215
Total Direct		*Job-Years***		*3,952*	*1,581*	*5,928*
*Total Indirect**		*Job-Years***		*1,258*	*503*	*1,887*

**These indirect jobs figures are gross, and are not adjusted to reflect the proportion that is actually located in the southwest region. We have included them here for background only.*
*** To count these as job-years, we had to assume that the $000/job labor productivity figures used by EPA were for FTE jobs. We were unable to verify this from EPA documents.*

For the Beyond Case, we applied the same methodology to reach a central estimate of 3,457 job-years, with a range of 1,390 – 5,212 (see **Appendix U**). The EPA projected that these HRI upgrades would occur in 2015-2020, suggesting that these add to the 'front-loaded' temporal imbalance noted in the section above. They also compound the job-type imbalance described above, with the bulk of these new short-term jobs created in boilermaking and construction.

4.2.3 Changes in Fuel Consumption and Production

One of the major employment implications of changes in coal- and gas-fired capacity is the consequent change in coal and gas extraction and production. Some of these changes are captured in the indirect job impact projected by the JEDI model (see s 4.2.1 above). However, because of their importance to the southwest region (which has a relatively high concentration of coal and gas production) we calculate them separately here based on the EPA's methodology.

We can extrapolate changes in coal mining jobs from EIA and EPA projections on changes in coal production. Taking projections for the Appalachia mining region (of which the southwest region is part) we apply them to 2012 production data for the southwest region, assuming that the region's share of Appalachian production stays constant. We then use 2012 labor productivity data (in both employees/short ton and labor hours/short ton terms) to estimate the change in employment, assuming that labor productivity is held constant. This leads us to the figures laid out below. Note that although EIA projections account for changes in the global coal market and non-thermal coal, EPA's projections are for electric power coal only, requiring us to assume that the rest of the coal market (including coking coal and coal exports) remains constant. [lxviii]

	Units	2012	BAU (2030)	Accel (2030)	CPP (2030)	Beyond (2030)
Production						
Appalachia	000 short tons	292,976	253,461	208,795	166,607	137,247
Southwest	000 short tons	51,377	44,448	36,615	29,217	24,068
Employment						
Southwest	employees	7,413	6,413	5,283	4,216	3,473
Southwest	labor hours	16,425,072	14,209,722	11,705,653	9,340,444	7,694,450

Calculating natural gas production jobs is more difficult since the data are less readily available, and because historical data on natural gas production in Pennsylvania in the last five years has changed dramatically. We use state-level dry production data from the EIA, and county-level gross withdrawals data from the USDA, to estimate the region's production in 2012. We then take projected changes in production for the Northeast region from the AEO 2014, and projected national changes in gas consumption by the power sector from the EPA, and to estimate future production in the southwest region in our four scenarios. Assuming a fixed labor productivity figure (average annual employees/MMCF), we reach the estimates below.

	Units	2012	BAU (2030)	Accel (2030)	CPP (2030)	Beyond (2030)
Dry Production						
Northeast	tcf	3.309	6.571	7.035	6.480	6.936
Southwest	MMcf	839,624	1,667,403	1,784,924	1,644,166	1,760,048
Employment						
Southwest	ave. annual jobs	7,528	14,950	16,003	14,741	15,780

Some of these assumptions are a stretch. Labor productivity is unlikely to remain fixed, production of coal and gas for non-electric power purposes is unlikely to remain fixed, and oil and gas production and employment is particularly volatile and hard to predict. That being so, we consider this methodology to be weak (despite the EPA adopting it in its RIA), and the results to be useful only as illustrative "back of the envelope" estimates of employment impact.

4.2.4 Energy Efficiency

Energy efficiency employment is the hardest to estimate, with the EPA acknowledging that there is no accepted peer-reviewed methodology for calculating these jobs. [lxix] This is in large part due to the wide range of activities that can be undertaken to improve energy efficiency, from purchases of more energy efficient products, to residential or commercial building upgrades, to industrial machinery upgrades and purchases.[lxx] However, energy efficiency upgrades is also where the bulk of projected job growth lies in many existing studies. The EPA's proposed Clean Power Plan projected that 22 percent of Pennsylvania's required emissions reductions would come from energy efficiency improvements.[lxxi] We therefore attempt to estimate efficiency jobs—for the Clean Power Plan Scenario at least—to give a sense of possible impacts.

The EPA developed an estimate of employment impact by developing a $/MWh cost-of-saved-energy figure and a jobs-per-million-dollars multiplier, and applying this to their estimates of additional savings under their proposed plan.[lxxii] They derived their jobs multiplier by dividing historical change in employment in this sector by historical change in expenditure, to reach an incremental jobs-per-spending multiplier of 2.56 jobs per $1 million of expenditure (in $2011). The EPA acknowledged the crudeness and limitations of this approach, which does not account for workers displaced elsewhere in the economy, does not account for imports, and does not account for changes in labor productivity.[lxxiii] They derived their cost-of-saved-energy figures from literature reviews, and reached a first-year cost of $550/MWh in 2017 rising to $770/MWh in 2030, and a levelized cost of $65.1/MWh in 2017 rising to $91/MWh by 2030.[lxxiv] This figure is necessarily crude due to the many types of energy efficiency investments that can be made, and because it does not account for the 'rebound' effect (where energy efficiency reduces demand, which reduces prices, which incentivizes more energy use). Moreover, it is relatively high: the EPA's levelized cost of saved energy of 6.51 c/kWh in 2017 compared to a 4.7 c/kWh figure adopted by Synapse Economics in their analysis of the NRDC's s 111(d) proposal, and a range of 1.3-5.6 c/kWh compiled by the American Council for an Energy Efficiency Economy (ACEEE) in their review of the cost of utility-funded energy efficiency programs between 2009-12.[lxxv]

Since the EPA's estimates are dependent on national averages, and since our projections of demand and savings in the southwest region are derived from national averages, we estimate energy efficiency jobs in the southwest region simply by multiplying the estimated national change by the southwest region's current share of the national population (0.89 percent). This gives us an estimate of a net increase of 699 jobs by 2020, 993 jobs by 2025, and 992 jobs by 2030. Note, however, that these cannot easily be converted into job-years, since the EPA's methodology does not allow us to distinguish between part-time and full-time jobs. If we assume, however, that these jobs are 50 percent full-time and 50 percent part-time (2.5 days per week), and we stretch these annual estimates over the period (assuming 699 jobs in each year of 2015-20, for example), then we can reach a very rough estimate of 10,069 additional job-years by 2030 relative to BAU.

4.2.5 Summary

The table below summarizes our back of the envelope estimates. We have indicated in the "strength" column the strength of the methodology used to reach these. Each of these methodologies has its flaws, and we do not regard these numbers to be as accurate as those reached with the input-output model, below. However, we have included them here for illustrative purposes. In each case, there is a net increase in total direct job-years, driven by the near-term boom in construction of new power plants that overshadows the long-term loss of power plant operating jobs. However, in each case we also see a decline in indirect job-years, driven overwhelmingly by the loss of employment in the supply chain for coal-fired power plants. The Clean Power Plan increases both of these—short-term construction job increases, and long-term operating job losses—but still leads to a net increase in direct job-years overall.

Summary – Direct Jobs – All Scenarios

Type	Method	Strength	Units	BAU	ACCEL	CPP	Beyond
Capacity Change							
Onsite Labor	JEDI	Medium*	Job-years	5,232	3,870	15,238	14,031
HRI Upgrades							
Direct	EPA	Medium**	Job-years	0	0	3,952	3,457
Fuel Production							
Direct Coal	EPA	Low	Jobs	(1,000)	(2,130)	(3,197)	(3,940)
Direct Gas	EPA	Low	Jobs	7,422	8,475	7,213	8,252
Energy Efficiency							
Direct	EPA	Low	Jobs/year	N/A	N/A	992	992
Direct	EPA	Low***	Job-Years	N/A	N/A	10,069	10,069
Total							
Direct	*Sum*	*Low*	*Job-years*	*5,232*	*3,870*	*30,251*	*28,549*

* Uncertainty flows from mismatch between "onsite labor" and "direct jobs,", which likely leads to an underestimate.
** Uncertainty flows from the crudeness of the methodology based on national labor productivity extrapolates.
*** Uncertainty flows from the crudeness of the methodology, and the rough conversion into job-years.

4.3 Input-Output Analysis — Direct, Indirect & Induced Jobs

4.3.1 Introduction & Limitations

To build on our rough engineering-based analysis, in this section we use an input-output model to estimate the potential employment impact of our future electricity scenarios.

Input-output tables capture the relationship between various industries, such that we can estimate the impact of a change in one industry on the other.[lxxvi] The benefit of these models is that they allow us to estimate the impact not just on direct and indirect jobs, but also on induced jobs (i.e. changes in employment due to changes in spending by workers), and non-employment impacts on output and earnings as well. Several of these models also allow us to do this on a regional basis, including the model that we have used for this section—the Regional

Impacts Modeling System II (RIMS II) developed by the Bureau of Economic Analysis (BEA). [lxxvii] We have obtained RIMS II multipliers specifically for the southwest region.

However, it is important to be clear about the limitations of this type of model:

- **Backwards Only**. Many I-O models, including RIMS II, are "backwards linkages only." They capture the impact of closing a coal-fired power plant on upstream industries (e.g. coal mining) but not downstream industries (eg electricity users).[lxxviii]
- **Fixed Relationships**. The amount of inputs (eg coal) required to produce an output (eg electricity) may change over time due to technology, or with changes in production due to economies of scale. The I-O model cannot capture these. [lxxix]
- **No Supply Constraints**. If a good (eg coal) was in high demand we might expect shortage conditions and price increases. The I-O model does not capture this. [lxxx]
- **No Time Dimension**. RIMS II is a static model—that is, the changes it models are assumed to be made and to take effect throughout the economy instantly. [lxxxi]
- **Industry homogeneity**. RIMS II assumes that all firms within an industry face the same conditions (i.e. prices, efficiency), which may not be realistic. [lxxxii]
- **Local Inputs**. RIMS II is tailored to the southwest region, so it knows which inputs can be bought in that region and which must be imported. However, it assumes that if an input *can* be purchased locally that it *will*, which may not be correct. [lxxxiii]
- **No regional feedback**. RIMS II will capture interactions within the southwest region, but it cannot capture interactions between it and other regions. [lxxxiv]
- **No taxation effects**. When I-O models are applied to public spending on projects, they do not account for debt or taxes levied to support that spending or the welfare costs that they incur, thus underestimating the costs and exaggerating the net benefits.[lxxxv]

For all these reasons, I-O models can provide useful data about economic interactions, but should *not* be treated as certain estimates of the economic effects of future policy changes. Despite this, I-O models are frequently used in policy reports to make claims about the economic impact of future projects or policies. For this reason, we conduct an I-O analysis here despite its limitations, both to give a sense of the results of our modeling in comparison to other I-O-based analyses, and to be clear about the limitations of these sorts of analyses and urge caution in interpreting their findings.

4.3.2 Input-Output Tables Overview

The input in the RIMS II I-O tables is a spending change: the incremental spending (in millions of 2010 dollars) per industry. To convert our electricity scenarios into an I-O input, we therefore need to calculate the change in spending by industry for each of our variables (power plant additions and retirements, heat rate improvements, energy efficiency upgrades, and electricity bill savings). In the following analysis, we have been unable to calculate heat rate improvements and electricity bill savings through the RIMS II model, and have limited our focus to power plants and energy efficiency. The easiest of these to calculate is power plant additions and retirements. To do this, we take spending figures for each power plant type from the JEDI model, and allocate them between NAICS industry codes according to a similar study conducted by the Political Economy Research Institute (PERI) in 2014 (see **Appendix V** for details of this allocation).[lxxxvi]

Using this allocation, we can compare the job creation potential of each source of power by fuel type in the southwest region. The table below sets out how many jobs would be created by each additional $1 million of spending on each source of electricity generation, specifically in the southwest region. The first two columns indicate the number of jobs that would be created in the region by spending $1 million on capital investment and on operation & maintenance. However, this does not account for the very different shares of capital and operating spending for each generation type. Column 3 draws on JEDI data to compare the annual capital-to-O&M spending ratio for each generation type (based on EIA levelized cost figures for plants entering service in 2019),[lxxxvii] and the last two columns apply that ratio to indicate the number of jobs-per-year created in each phase in the southwest region.

Marginal Labor Intensity of Power Generation in the Southwest Region

Direct & Indirect Jobs (Type I Multipliers)						
Plant	**Units**	**Capital**	**Operating**	**Cap/Op Ratio**	**Capital**	**Operating**
Coal	jobs/extra $1mil	5.97	0.69	62.76%	3.75	0.26
Gas	jobs/extra $1mil	6.98	1.59	21.57%	1.5	1.25
Oil	jobs/extra $1mil	6.98	1.12	30.04%	2.1	0.79
Wind	jobs/extra $1mil	9.56	8.4	79.83%	7.63	1.69
Solar	jobs/extra $1mil	10.61	8.4	88.08%	9.35	1
Hydro	jobs/extra $1mil	9.58	5.6	85.21%	8.16	0.83
Direct, Indirect & Induced Jobs (Type II Multipliers)						
Plant	**Units**	**Capital**	**Operating**	**Cap/Op Ratio**	**Capital**	**Operating**
Coal	jobs/extra $1mil	9.15	1.12	62.76%	5.74	0.42
Gas	jobs/extra $1mil	10.72	2.46	21.57%	2.31	1.92
Oil	jobs/extra $1mil	10.72	1.77	30.04%	3.22	1.24
Wind	jobs/extra $1mil	14.51	12.71	79.83%	11.58	2.56
Solar	jobs/extra $1mil	15.62	10.15	88.08%	13.75	1.52
Hydro	jobs/extra $1mil	14.22	9.24	85.21%	12.12	1.37

These multipliers show that, for all plant types, more jobs are created in construction than in O&M. However, there is a marked difference between fossil and renewable generation, with renewable energy sources creating more than twice as many jobs in the construction phase than fossil sources, but roughly the same number of operating jobs.

We can also attempt to calculate these for energy efficiency, although this is harder because (as mentioned before) the activities that comprise these industries are more diverse. Energy efficiency improvements are typically categorized by residential, commercial and industrial sectors. We draw on the same report from PERI to devise an allocation of spending by NAICS industry code, also set out in **Appendix V**, and assume that the energy efficiency spending projected in EPA's proposed Clean Power Plan is allocated 30 percent residential, 30 percent commercial and 40 percent industrial. Using these inputs, we find that energy efficiency has the job intensity **below**. Note that energy efficiency improvements do not have the same capital/operating phase distinction that power plants do (since energy efficiency work is in a sense all capital phase work) but is expected to be distributed more evenly over time (in fact rising each year towards 2030, rather than concentrated in 2015-20 as the power plant capital spending and jobs are). These could therefore help ameliorate the 'temporal mismatch' in power plant jobs over time.

Labor Intensity - Energy Efficiency			
Sector	**Units**	**Direct & Indirect**	**Direct, Indirect & Induced**
Residential	jobs/extra $1mil	8.74	12.97
Commercial	jobs/extra $1mil	7.55	11.18
Industrial	jobs/extra $1mil	9.84	14.44
*Combined**	*jobs/extra $1mil*	*8.83*	*13.02*

** This assumes a distribution of 30% residential, 30% commercial and 40% industrial.*

It is also interesting to compare the types of jobs that are created by each generation type, drawn from the I-O tables for the southwest region (see **below**). Well over half of the jobs created in building new power plants are in construction and manufacturing, with renewable sources having a slightly higher share of construction than manufacturing. In the O&M phase, we see a higher share of jobs in utilities and mining with a relatively low share in construction and manufacturing. However, renewable sources have a significantly lower share of jobs created in this category, with professional, scientific and technical jobs claiming a larger share. Taken together with the job numbers from above, this suggests that in general terms, we would expect a shift from fossil generation to renewable generation to favor employment in the construction and manufacturing industries, at the expense of employment in the mining and utilities sector. In the next section, we apply these multipliers to our four electricity scenarios.

Share of Jobs (Direct & Indirect) Created in Southwest Region, by Plant Type and Industry

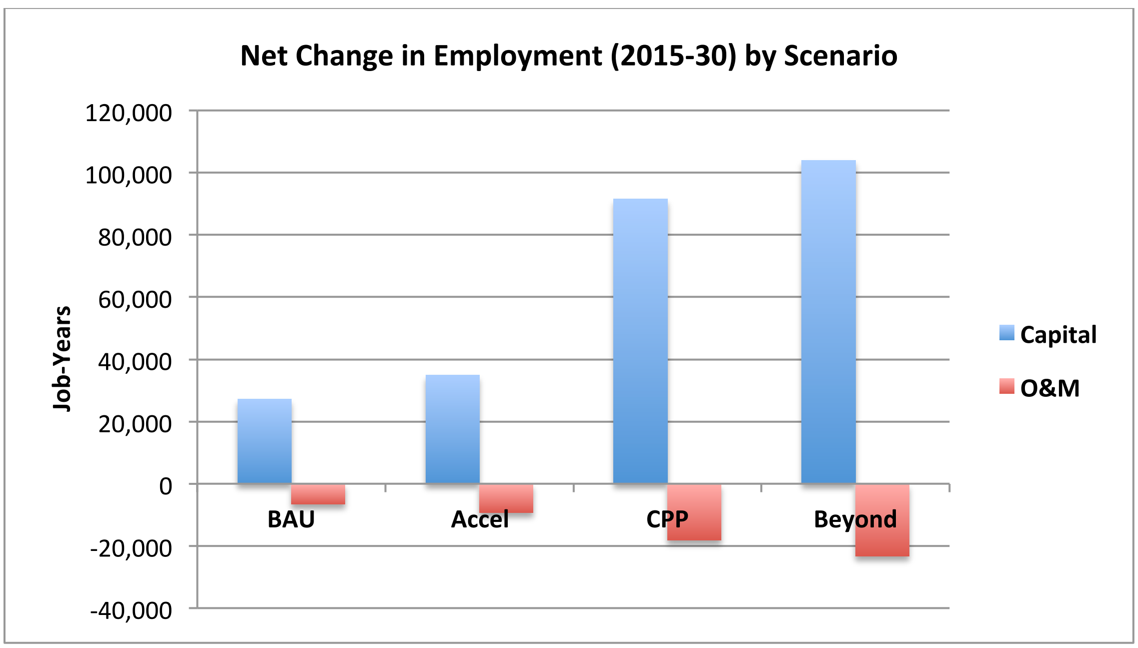
Capital Spending						
Type	**Construction**	**Manufact'in g**	**PS&T***	**MA&W****	**Mining**	**Other**
Coal	14%	57%	5%	5%	0.4%	19%
Gas	8%	58%	5%	8%	0.4%	21%
Oil	8%	58%	5%	8%	0.4%	21%
Wind	22%	47%	8%	4%	0.5%	19%
Solar	23%	38%	18%	4%	0.4%	17%
Hydro	42%	24%	11%	5%	0.6%	17%
O&M Spending						
Type	**Utilities**	**Mining**	**PS&T***	**Manufact'ing**	**Construction**	**Other**
Coal	18%	41%	7%	5%	2%	27%
Gas	11%	44%	6%	6%	4%	29%
Oil	5%	9%	9%	6%	6%	65%
Wind	6%	1%	34%	3%	1%	55%
Solar	6%	1%	34%	3%	1%	55%
Hydro	29%	6%	23%	3%	4%	35%
Energy Efficiency Spending						

Type	Construction	Manufact'ing	PS&T*	MA&W**	Mining	Other
Residential	28%	45%	4%	3%	1%	19%
Commercial	32%	41%	4%	3%	1%	19%
Industrial	16%	28%	35%	5%	0%	16%
Combined	25%	37%	16%	4%	0%	18%

*Professional, Scientific and Technical Services ** Management, Administration and Waste Services

4.3.3 Model Results

We took spending figures for power plants (derived from JEDI cost data) and energy efficiency (derived from EPA cost and savings estimates) (see **Appendix W** for details), combined them with the industry allocations drawn from PERI (described above and in **Appendix V**), and put these into the RIMS II I-O model to estimate employment impact for each scenario. The full results of the modeling are set out below, and a comparison of the results of our I-O model and engineering-based analysis results is set out in **Appendix X**. We used both Type I Final Demand Multipliers (covering direct and indirect jobs) and Type II Final Demand Multipliers (covering direct, indirect and induced jobs). Note, however, that these estimates are not complete, as they capture plant changes and energy efficiency only. The omission of heat rate improvements, and additional household spending due to electricity bill savings, make them conservative.



All four cases show a net increase in job-years, in both direct and indirect and induced terms. This net increase ranges from 20,713 direct and indirect job-years (the equivalent of ~1,381 full-time jobs over the period) in the BAU Case to 80,729 direct and indirect job-years (~5,382 full-time jobs over the period) in the Beyond Case. Even if we add in net induced job-years created (bringing our total net increase to 30,713 job-years in the BAU Case and 146,641 job-years in the Beyond Case) this is less than 0.6 percent of the current labor force of the southwest region.

However, this net increase in job-years masks a significant increase in capital phase jobs, and a significant decrease in O&M phase jobs. This suggests a temporal mismatch between the creation of large numbers of short-term jobs and the loss of smaller numbers of long-term jobs. In direct and indirect jobs terms, this ranges from 27,290 capital job-years (~6,823 FTE jobs over 4 years) and -6,577 O&M job-years (~438 jobs over 15 years) in the BAU Case, to in the Beyond Case (excluding energy efficiency, which is spread over the period) 75,813 capital job-years (18,953 FTE jobs over 4 years) and -23,234 O&M job-years (1,549 FTE jobs over 15 years). This implies a significant transition challenge for regional policymakers.

Change in Employment (2015-30) by Fuel Type, Phase and Scenario

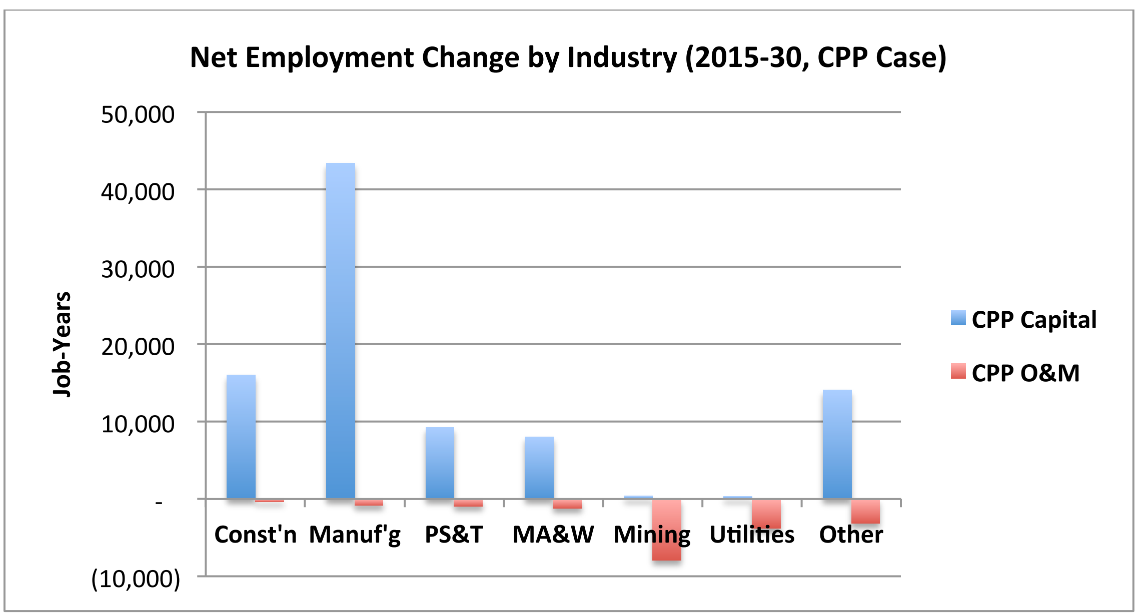
BAU Case								
	Units	**Coal**	**Gas**	**Wind**	**Solar**	**Hydro**	**EE**	***Total***
Capital								
Direct & Indirect	Job-years	-	23,851	1,689	587	1,164	-	*27,290*
Induced	Job-years	-	12,820	875	276	563	-	*14,535*
O&M								
Direct & Indirect	Job-years	(9,789)	2,929	204	22	56	-	*(6,577)*
Induced	Job-years	(6,273)	1,586	104	11	37	-	*(4,535)*
Accelerated Coal Retirements								
	Units	**Coal**	**Gas**	**Wind**	**Solar**	**Hydro**	**EE**	***Total***
Capital								
Direct & Indirect	Job-years	-	32,213	953	587	1,140	-	*34,893*
Induced	Job-years	-	17,315	494	276	552	-	*18,637*
O&M								
Direct & Indirect	Job-years	(13,434)	3,956	115	23	45	-	*(9,295)*
Induced	Job-years	(8,609)	2,142	59	12	29	-	*(6,368)*
Clean Power Plan								
	Units	**Coal**	**Gas**	**Wind**	**Solar**	**Hydro**	**EE**	***Total***
Capital								
Direct & Indirect	Job-years	-	43,329	11,872	1,867	6,295	28,149	*91,512*
Induced	Job-years	-	23,290	6,154	880	3,047	41,539	*74,910*
O&M								
Direct & Indirect	Job-years	(25,239)	5,322	1,432	71	260	-	*(18,155)*
Induced	Job-years	(16,174)	2,881	734	37	169	-	*(12,354)*
Beyond Case								
	Units	**Coal**	**Gas**	**Wind**	**Solar**	**Hydro**	**EE**	***Total***
Capital								
Direct & Indirect	Job-years	-	58,954	8,745	1,867	6,247	28,149	*103,963*
Induced	Job-years	-	31,689	4,533	880	3,024	41,539	*81,664*
O&M								
Direct & Indirect	Job-years	(31,849)	7,241	1,055	72	248	-	*(23,234)*
Induced	Job-	(20,410)	3,919	541	37	161	-	*(15,752)*

years		

It also suggests that although net change in job-years may be low, the "churn" is high, so a larger number of workers may be affected. If we look at the total number of job-years affected (i.e. do not subtract negative job-years from positive job-years), we can see that 40,585 job-years are changed in the BAU Case, and 65,154 job-years are changed in the Beyond Case. Assuming that there is no movement of workers between these jobs (an unrealistic assumption), this could translate into up to 7,761 jobs in the BAU Case and 12,084 jobs in the Beyond Case—between 0.45 and 0.7 percent of the labor force of the southwest region being "churned."

Given that we have estimated direct employment in coal mining, electric power and oil and gas production in the southwest region to be 7,697, 5,962 and 7,528 jobs in 2012 (see **Appendix J**), these changes could therefore amount to a significant share of jobs in the regional energy industry. This could have significant implications for unions, companies and communities who are particularly concentrated in the energy industry, even if it does not have a major effect on employment in the economy of the southwest region as a whole. We have not been able to break the change in job-years down by county, but certain counties (eg Greene) could experience significant shifts in employment opportunities over the coming 15 years.

We can also see that in the transition, some industries fare better than others. The chart **below** shows the change in job-years in key industries for the Clean Power Plan Case (which has a similar pattern to the other three scenarios, see **Appendix Y** for chart data and all scenarios). Note that the high-level nature of these categories may obscure even greater variations within industry groups. Within mining, for example, a large loss of coal mining jobs and a significant increase in oil and gas production jobs is likely to be captured in one net job number, despite the differences in these jobs.



4.4 Employment Characteristics

Even if jobs created and jobs lost are similar in number, they may not be similar in type. Whilst we cannot identify the characteristics of the jobs lost in the southwest region, we can draw inferences from national job characteristics data drawn from the BLS Current Population Survey (CPS). We have extracted some of this data for key industries (see **Appendix Z**). From this, we can compare the characteristics of jobs in the big "loss" industries of Utilities and Mining with the big "gain" industries of Construction, Manufacturing, PS&T and MA&W.

Each of these industries has a higher share of full-time workers than the national average of 75 percent. In particular, mining (92 percent) utilities (84 percent) and manufacturing (89 percent) have much higher shares, and construction (82 percent) a significantly higher share, suggesting that the net loss of job-years driven by mining and utilities could see a reduction in stable full-time jobs in the southwest region (albeit one that is offset by the short-term growth in manufacturing job-years). Overall, this effect is unlikely to be significant. But this depends a lot on jobs in the energy efficiency industry, which accounts for a large share of the capital jobs, and is likely to be created more evenly over the 15-year period. If work in this industry is proportionately more part-time than in the rest of the construction & manufacturing sectors, this could be difficult.

In terms of gender, the shift in employment is modest overall. All of these industries have a lower proportion of women in the workforce than the national average, suggesting that energy employment will shift from one set of predominantly male industries to another. The exception to this is the growth in PS&T and MA&W job-years, which have a much higher share of female employment. In terms of race, the shift is similarly ambiguous, with the growth in construction and MA&W likely to favor Latino workers (although probably not in the southwest region) and the shift to Manufacturing and PS&T likely to favor Asian workers relative to BAU.

The most significant shift is in union membership. The utilities industry has a far higher rate of union coverage (26.9 percent) than the national average (12.5 percent) and the state average (14.4 percent). Although the number of jobs in this industry is likely too low to affect the economy-wide rate of union coverage (even in the southwest region), the net decline in job-years in utilities could see Locals in some areas hit hard. In each of our other selected industries other than construction (13.7 percent) the rate of union coverage is lower than the national average, with mining (7 percent) and manufacturing (10.5 percent) noticeably lower, and PS&T (1.8 percent) and MA&W (4.9 percent) far below the national and state average. This implies a net shift from union to non-union jobs in the southwest region based on energy transition (but not including changes across the economy).

The big question for policy makers is the skills gap between growth and contraction sectors. If, for example, workers likely to be laid off from the utilities and mining industries are able to find work in the construction and manufacturing industries (in particular, energy efficiency) then the net impact on employment in the energy the sector would be positive or at least modest, even accounting for frictional costs. In a sense these industries have a lot in common, and workers in each may share similar core competencies. However, it is likely that these workers will require retraining and support to be able to make that transition properly. A huge question for policymakers, therefore, is how to meet that skills and training gap to allow that transition. This question cannot be treated adequately in this report, and deserves further deeper research.

4.5 Conclusions & Takeaways

At this point it is worth pausing to consider what our analysis (both methodologies) has thus far shown (and what it has not) before proceeding to our analysis of the policy implications.

Insight #1: Energy employment estimates are uncertain, and must be treated with caution.

The first point that this analysis should convey is that estimates of the economic impact of changes in the electricity system are subject to a very high degree of uncertainty. This is for the three reasons mentioned in section 4.3.1 – energy uncertainty, policy uncertainty and economic uncertainty—all of which are exacerbated by modeling 15 years into the future. Further, the range of inputs and assumptions required to model this impact is such that desktop analysis is susceptible to error without direct industry input and/or considerable modeling resources. Finally, analyses at the sub-state regional level (such as this one) face additional challenges of data availability, requiring additional estimates and scope for error. For all these reasons, estimates of the employment impact of energy policy changes such as the Clean Power Plan should be met with skepticism, regardless of how confidently they are used.

Insight #2: All cases pose a temporal mismatch between capital job growth and O&M job loss.

In all of the cases outlined above, change in the energy system creates a large net increase in job-years in the short-term, but poses a smaller loss of net job-years in the long-term. It is hard to see a scenario in which this problem does not arise, based on the relatively low O&M labor-intensity of gas and renewable generation. This, along with the relatively high level of 'churn' in jobs in the energy sector, poses a challenge for policymakers—not in the *number* of jobs created and lost, but in the *type* and *timing* of those jobs. Energy efficiency could offer a solution to this (since it creates jobs throughout the period), but more needs to be known about how reliably we can expect jobs in this industry and what kind of jobs they are.

Insight #3: Clean energy creates more jobs than fossil energy, but of a different kind.

On a MW-for-MW and $-for-$ basis, we have seen that renewable energy creates more jobs than fossil energy for the southwest region (in direct, indirect and induced terms). However, these jobs are of a different kind to those currently existing in fossil energy. In some cases this can be a strength—for example, renewable energy is labor-intensive in the Professional, Scientific and Technical Services (PS&T) industry sector, which has a much higher proportion of women than utilities or mining, suggesting that the benefits of the energy industry could be shared more broadly. In other cases, however, this could be a weakness. Importantly, the jobs created in energy transition are likely to have far lower rates of union membership and coverage than existing energy jobs, posing challenges not just for unions but also for economic policymakers. Further, the differences in skills and training requirements between these jobs lost and jobs gained imply the potential for considerable friction in employment in affected communities.

Insight #4: There is more to this picture than we have been able to show here.

Finally, there are a number of things that our analysis so far has not considered. We have not considered the impact of these economic changes on state and federal taxes, and in particular, on the tax base of particular counties and municipalities which are particularly reliant on these industries. This can be a significant problem where large assets such as coal-fired power plants close, depriving counties of a large share of their property tax base and requiring either rate increases or municipal service reductions. We have not considered the impact of these changes on the pensions or benefits of workers in industries likely to be hit hard, such as coal miners or power plant workers, which may not easily "follow the worker" or even remain solvent in the midst of significant job churn and financial distress on the companies that employ them. Each of these factors merit consideration from policymakers, and therefore warrants further research.

These lessons will be important to bear in mind in the next and final section of the report, when we consider what action the state government could take to manage this transition optimally.

5. Policy Options

In light of the transitional impacts suggested by the analysis above, this section considers and evaluates what steps the state government might take to manage them.

5.1 Lessons Learnt

Although the changes now occurring in the electricity sector are novel, the problem of industrial restructuring and stranded workers and communities is not a new one.

The evidence suggests that the costs—both human and economic—of economic restructuring can be significant. A recent economic analysis of the impacts of the Clean Air Act Amendments in 1990, for example, found that the transactional costs of reallocating workers through the economy amounted to $9 billion in lost wages, driven largely by workers who did not find new jobs and lower earnings by those workers who did find new jobs.[lxxxviii] These costs were far below the estimated public health benefits of that particular environment policy, but well above assistance provided to affected workers. Similar studies have found that workers dislocated by plant closures can experience the impact for years after the event, with earnings up to 25 percent lower even 6 years after closure,[lxxxix] short-term mortality rates twice as high, and a life expectancy 1 to 1.5 years shorter.[xc] These costs can be compounded by spillovers to other industries in the region,[xci] wage spillovers (where the industry being downsized has relatively high wages and can influence wages in the region as a whole),[xcii] and "hidden unemployed" who leave the labor force altogether.[xciii] There is also evidence that some workers are harder-hit than others, with older workers and less skilled workers finding it much harder to find new employment, and finding shorter-term and less secure employment when they do.[xciv] Many of these studies looked specifically at the coal industry, and are consistent with the findings in our analysis in section 4. According to BLS data, the re-employment rate for the utilities industry is higher than for the workforce as a whole (69.4 percent compared to 61.3 percent), but is still not high.[xcv]

The experience with industrial restructuring and downsizing over the years has also provided a history of worker transition and assistance programs, across a wide range of industries and on a permanent or temporary basis. These include several permanent programs still in existence:

- **Trade Adjustment Assistance.** Established in 1962, this program provides income support, training, healthcare and job search assistance to workers laid off due to shifts in trade patterns, as well as some support for businesses.[xcvi]
- **Workforce Investment Act**. Originally the Job Training Partnership Act, this program provides training and job search assistance to workers through federal One-Stop centers, with a dislocated workers program for laid-off workers.[xcvii]
- **Unemployment Insurance**. Created in 1935, this state-level program overseen by the Department of Labor generally provides 26 weeks of benefits to workers replacing half of their previous wages, with extended benefits for the worst affected areas.[xcviii]
- **Department of Defense**. The Office of Economic Adjustment, and the Base Realignment and Closure Commission, both work with affected communities to provide economic development advice, strategy and finance to diversify.

They also include several temporary, policy-specific worker transition packages:

- **Timber Workers.** The Redwood Employee Protection Plan (REPP) in the late 1970s and the Northwest Economic Adjustment Initiative in the early 1990s provided income support, training, and economic development assistance to timber workers displaced by the creation of national parks in the Pacific Northwest.[xcix]
- **Clean Air Act**. The Clean Air Act Amendments of 1990 were accompanied by the Clean Air Employment Transition Assistance Program: a package of training and other assistance measures for affected workers.
- **NAFTA.** The U.S. Community Adjustment and Investment Program, which provided economic development assistance to communities affected by NAFTA, automatically included areas along the U.S. borders.
- **Railways.** The Regional Rail Reorganization Act of 1973 provided transitional assistance to workers affected by the failure of railroads in the Northeast and Midwest.

To this could be added a far wider range of *ad hoc* responses at the local or state level to the closure of particular plants, notably including the closure of the Levi Strauss factory in Roswell New Mexico,[c] the scheduled closure of the Centralia power plant in Washington, and the transition out of coal in Black Mesa in the Navajo Nation.[ci]

This experience with worker assistance and transition programs has provided some key lessons for future policy (discussed in more detail in a 2009 report from the Apollo Alliance and Cornell Global Labor Institute):[cii]

- **Resources**. Too many of the programs have provided income levels far below, support durations far too short of, or funding levels perennially cut below, the levels required to support workers and achieve the goals of the program.[ciii]
- **Eligibility**. Overly cumbersome eligibility criteria and processes have seen only a fraction of workers eligible for TAA assistance obtain it, whereas programs like the Rail Reorganization have pre-approved eligible workers.[civ]
- **Training**. Early programs were criticized for providing income support without requiring workers to train or search for new work.[cv] However, recent experience suggests that training requirements are often (a) too narrow, (b) too disconnected from local job opportunities, or (c) an obstacle to job-hunting.[cvi]
- **Economic Development.** The REPP experience showed that training and income support is not useful if the region remains economically undiversified and no jobs exist. Successful transition requires a focus on economic diversification, and training programs need to be matched to jobs available in the area.[cvii]
- **Community Involvement.** A key component of successful programs such as the NEAI, DoD programs and the response in Roswell has been engaging the community to lead the transition.[cviii] However, this experience also shows that some communities need support and outreach to engage successfully.
- **Monitoring and Evaluation**. A number of the programs have been found in hindsight to suffer from a lack of monitoring and evaluation, and a lack of opportunities for “mid-course corrections” in transition assistance.[cix]

5.2 Policy Options

There are a range of options that the state government might take to manage the transition of the southwest region's energy system and associated workforce:

- **No Action.** The state could take no action, and allow the electricity system and regional economy to adjust under existing policy settings and market conditions.
- **Worker Transition (public).** The state could provide a worker transition package similar to those above: for example, levying a "wires charge" to set up a "stranded communities" fund as recommended by the Utility Workers Union of America.[cx]
- **Worker Transition (private).** The state could leverage its regulatory power to encourage private employers to provide worker transition and retraining packages themselves, as was done with the Centralia power plant in Washington. [cxi]
- **Clean Energy Development.** The state could take action (including under the Clean Power Plan) to promote the clean energy industry, as a replacement for jobs likely to be lost in the fossil fuel industry.
- **Community Benefits Agreement.** The state could enact a set of policies that set minimum labor and environmental standards, either through regulations or by encouraging municipalities and firms to do this themselves. This would aim to increase the quality of new jobs created in industries such as construction & energy efficiency.[cxii]
- **Job Guarantee.** As a last resort the state could guarantee minimum-wage employment to any person laid off at a closed coal-fired power plant, similar to the federal hiring priority used by the DoD in base closures, or the approach taken by Ontario Power when they closed all of their coal-fired power plants.[cxiii]
- **Prioritize Funding.** The state could push for existing funding sources for the energy and fossil fuel industry (for example, the Abandoned Mines Lands, contaminated sites Superfund, or energy R&D funding) to be prioritized in areas hit hardest by the shift away from fossil fuel (such as the southwest region).[cxiv]
- **Community Congress.** The state could convene a community forum to engage the community in making hard decisions and tradeoffs for themselves. For an example of this, see the approach taken by the EPA with the Asarco smelter in Tacoma in the 1980s, or community involvement in the DoD's economic adjustment programs.[cxv]
- **Worker Cooperatives.** Where a plant is still profitable but is closed or shutdown for other reasons, the workers could decide to reopen the plant as a worker-owned cooperative burning a cleaner source of fuel (for example, biomass).[cxvi] However, coal-fired power plants may not fit into this category, since their retirements are driven by a weakening economic case for these plants.

Several of these options could be combined with one another, and each could be applied in many different ways. Further, a number of policies on this list or others similar to them have been included in the President's 2015 budget.[cxvii] In the next section, we evaluate four options.

5.3 Policy Evaluation

In this section we evaluate four alternative policy options facing the state government:

1. **No Action**. The state allows current policies and market forces to play out.

2. **Gas Development**. The state supports the gas industry in the southwest region, but provides no further transitional assistance to workers.
3. **Clean Energy Development**. The state supports the clean energy industry in the southwest region, but provides no further transitional assistance to workers.
4. **Worker Transition**. The state establishes a worker assistance package, funded by revenue from RGGI (which the state joins to fulfill its Clean Power Plan obligations).

We evaluate these options against five criteria:

1. **Budget.** The likely cost to the state government of the measure.
2. **Environment**. The likely impact on the environment and greenhouse pollution.
3. **Economic**. The likely economic impact, based on the analysis in section 4.
4. **Equity**. The fairness and equity implications for parties involved.
5. **Certainty**. The certainty with which the outcomes of policy can be predicted.

For each criterion, we score these options as Very Poor, Poor, Moderate, Good or Very Good.

5.3.1 No Action

In this option, the state government takes no policy action beyond what it has already committed to. Key state energy policies such as the Alternative Energy Portfolio Standard (AEPS) and the energy efficiency and conservation programs mandated by Act 129 remain at their current settings. Importantly, the state does not take any action as required under the EPA's proposed Clean Power Plan. This may not be possible in reality. Although the state legislature has already approved a bill effectively preventing the executive from preparing a state compliance plan (SCP) in compliance with the EPA's proposal,[cxviii] the EPA is required to prepare a Federal Implementation Plan (FIP) if the state does not submit a SCP, suggesting that Pennsylvania will end up implementing the EPA's proposal one way or another.[cxix] However, for the purposes of developing this policy option, we assume that the state has the option not to comply with the Clean Power Plan. In this option, two of our four scenarios become relevant—the BAU Case, and the Accelerated Coal Retirements Case.

Criteria	Score	Figure	Description
Budget	Moderate	$0	This scenario does not require any direct expenditure from the state government. However, it would not raise any additional revenue either. The decline in coal generation and production could have a negative effect on income tax rates, which our job-years analysis suggests may not be made up for by more tax revenue from growth in oil and gas.[cxx]
Economic	Moderate	N/A	As our employment estimates for the BAU and Accelerated Retirements Cases indicate, the transition in the energy sector is likely to lead to considerable instability in sectoral employment. This is likely to benefit some workers, but likely to cause big problems for others—particularly

			miners and utility workers. Furthermore, it is likely to cause significant economic distress for coal-dependent counties like Greene. Without any action from the state government, the flow-through economic impacts in these communities could be negative and high.
Environment	Very Poor	5.1 – 8.2 million additional tons of CO_2 per year	In the BAU Case, generation from both coal- and gas-fired power plants increases, raising greenhouse pollution by 8.2 million short tons of CO_2 per year, relative to 2012.[cxxi] In the Accelerated Retirements Case, generation from coal falls and gas generation grows even more, raising greenhouse pollution by 5.1 million short tons of CO_2 per year, relative to 2012. This brings total annual emissions from the power sector to between 75.3-78.4 million short tons of CO_2 per year that, all else equal, is a very high per capita level of emissions and a long way from a safe climate trajectory for Pennsylvania and the region.
Equity	Poor	N/A	This option shifts the burden of dealing with climate change to the world's poor. It also entails a number of "stranded workers" and "stranded communities", in counties like Greene and Somerset that are highly dependent on coal production and electric power. We can expect between 740 and 2,600 jobs over 15 years to be lost (including induced jobs, in gross terms), and a significant reduction in local tax revenue (and spending), neglecting the contribution that these "stranded communities" have made to the state's economy by providing power for the last half-century.
Certainty	Moderate	N/A	As mentioned above, our electricity scenarios are subject to considerable uncertainty. The difference between the BAU and Accelerated Retirements Cases alone is significant, in terms of both electricity and employment. However, the lack of policy intervention reduces the scope for additional unintended consequences.

5.3.2 Gas Development

In this option, the state government takes no action to support clean energy, curtail power sector emissions under the Clean Power Plan, or provide transitional assistance for stranded communities—instead resolving to promote the oil and gas industry in the southwest region in the hope that this will provide more economic opportunities. There is a range of state policy actions that could fall under the tent of "promoting the gas industry", including:

- regulatory reform to streamline approvals for new gas pipelines and gas wells;
- tax incentives to encourage the use of compressed natural gas (CNG) for transportation;
- tax incentives to encourage downstream gas industries (e.g. chemicals) in the region;
- a standard process (e.g., an auction) to allow gas companies access to private land;
- grants for workforce development in the region, to alleviate labor supply bottlenecks;
- increase research and development funding for gas production;
- reforming the tax regime to encourage more gas production in the region.[cxxii]

In this option, we include just two specific policy measures from this list:

1. an additional $20 million in workforce development grants for oil & gas over 2015-30;
2. dropping the governor's proposal for a 5 percent severance tax on natural gas extraction, an election commitment expected to be introduced in this year's budget.

Western Pennsylvania received $300-350 million for workforce development from all funding sources (federal, state and foundation) in 2011.[cxxiii] SHALENet, a training center based in Westmoreland County that has provided entry-level training to prospective oil and gas workers since 2010, was launched with $20 million in funding from federal sources.[cxxiv] Based on these figures, we expect that an additional $20 million would be enough to maintain SHALENet at current levels until 2020, or (if added to $20 million extra federal funds) to double its capacity.

In his election campaign last year, new Governor Tom Wolf campaigned on a commitment to introduce a 5 percent severance tax on natural gas production and use the revenues to fund education, infrastructure and clean energy—a proposal likely to be moved on early this year.[cxxv] Pennsylvania is the only major gas producing state in the country that does not have a severance tax, instead levying an "impact fee" which collects a significantly lower level of revenue, which is distributed to local communities affected by drilling.[cxxvi] The new tax faces considerable opposition from industry, who claim it will curtail production and employment.[cxxvii]

Criteria	Score	Figure	Description
Budget	Poor	- $177–615 million per year	The 5 percent severance tax has been estimated to raise between $443 and $881 million per year starting in 2015-16, which is $173 to $611 million more than the impact fee is estimated to raise that year.[cxxviii] However, revenues are highly contingent on the gas market and can change over time. The additional workforce development funding would cost $4 million per year for the first five years.
Economic	Moderate	N/A	Scrapping the severance tax is unlikely to have a major impact on production (around 1.19 percent less) due to the low marginal costs and high profits of gas production in the region.[cxxix] It is therefore unlikely to impact employment in the sector. Workforce investment could transition more displaced coal and electricity workers into oil and gas production, but concerns have been raised about the longevity of those jobs due to a history of large and rapid changes in production (and employment) in oil

			and gas.[cxxx]
Environment	Poor	5.1 – 8.2 million additional tons of CO_2 per year	This option likely entails the same environmental impact as the "no action" option described above. Even if the "Accelerated Coal Retirements" scenario proves to materialize, the government's stance of promoting gas fracking could raise the risk of additional methane leakage, water pollution, water overconsumption or more earthquakes if this translates into laxer regulation.
Equity	Moderate	N/A	This option attempts to support stranded workers and communities to transition into new economic opportunities in a booming and growing industry, and protects their share of the impact fee. However, it does so at the expense of underfunding education and infrastructure in the rest of the state, and by subsidizing workforce development programs that profitable oil and gas companies are likely able (but not necessarily willing) to fund for themselves.
Certainty	Poor	N/A	It is not clear that the historically mobile gas industry will continue to grow as it has, or that production will remain in the southwest region (as opposed to Ohio or West Virginia). It is not clear that workforce development will see local displaced workers trained and re-employed (unless that is a specific requirement). The budget impact of dropping the tax is also not clear.

5.3.3 Clean Energy Development

In this option, the state government implements the Clean Power Plan to meet the targets envisaged by the EPA: namely, a 31 percent reduction in greenhouse pollution from 2012 levels, comprised of HRI upgrades at coal capacity (15 percent of total), dispatching more gas capacity (14 percent), increasing renewable and nuclear generation (49 percent) and increasing energy efficiency (22 percent). Note that Pennsylvania is not necessarily required to use this share of "building blocks" to meet its overall emissions reduction target, but that for present purposes we assume that it will.

There are several policy tools that the state could use to achieve this goal. The state could create an emissions trading scheme, or join an existing one such as the Regional Greenhouse Gas Initiative (RGGI). It could strengthen the AEPS or the Energy Efficiency Resource Standard (EERS) to increase the requirements on utilities to obtain renewable energy or efficiency savings, or could boost the funding available to the Pennsylvania Energy Development Authority or the now defunct solar rebate program. It could directly require reductions in power plant pollution, or even power plant retirements, by strengthening regulation of existing generators or by concluding retirement agreements with generators.

For the purposes of evaluating this option, we assume that the state simply joins RGGI. Governor Tom Wolf raised this policy option on the campaign trail.[cxxxi] It has been suggested as an attractive course for Pennsylvania because it easily matches the technical requirements of EPA's proposed Clean Power Plan, and because it would afford Pennsylvania an additional year to submit its regional compliance plan.[cxxxii] It would also allow lowest-cost compliance across a multi-state region that better fits the dimensions of the PJM Interconnection, and has proven an effective policy (and source of clean energy revenue) in the past. However, joining RGGI would likely require the assent of the Republican state legislature. For the purposes of comparing options for the southwest region we use RGGI as our policy; however, this brushes over some important policy questions that deserve further attention.

Criteria	Score	Figure	Description
Budget	Moderate	$0	RGGI has been a potent source of revenue for member states in the past (since most allowances are auctioned), raising $912 million over the first 3 years of the program.[cxxxiii] The amount of revenue raised for PA would depend on the state's allowance budget under any future program, which could vary significantly. To give a sense of the potential order of magnitude, if we assume an allowance cap of 149.1 million short tons for PA in 2020 and of 119.9 million short tons in 2030,[cxxxiv] and assume that 80 percent of allowances are auctioned at prices of $5 in 2020 and $10 in 2030,[cxxxv] this would produce $596.5 million of revenue in 2020 and $959.1 million of revenue in 2030. However, most RGGI states have reinvested practically all of these revenues into renewable energy and energy efficiency deployment to achieve these carbon targets, so we assume revenue neutrality here (somewhat conservatively perhaps, given the scale of likely revenues as we approach 2030).
Economic	Poor	N/A	The relevant cases here are the "Clean Power Plan" and "Beyond" Cases. In both of these cases, we see employment effects magnified—both the large growth in short-term capital jobs in construction and manufacturing, and the smaller loss of long-term O&M jobs in mining and utilities. In the absence of a transition policy, this option is liable to exacerbate the problems described in the "no action" case, and create significant "stranded workers" and "stranded communities".
Environment	Good	-21.3 million additional tons of CO_2 per year	This option sees the greatest reduction in greenhouse pollution from the electric power sector in the southwest region, from 70.2 million short tons of CO_2 in 2012 down to 48.9 million short tons of CO_2 in 2030—a 30 percent reduction from 2012, and a 37.5 percent reduction from business-as-usual.[cxxxvi] The reduction in

Criteria	Score	Figure	Description
			dependence on coal is also likely to reduce other environmental externalities, such as water pollution and criteria air pollutants such as SO_2, NO_x, mercury and other air toxics.[cxxxvii]
Equity	Moderate	N/A	This option sees the southwest region assume its fair share of the responsibility for tackling dangerous climate change. However, it comes at the expense of abandoning "stranded workers" and "stranded communities" in parts of the southwest region who have played an important role in supporting the state's economy over the years, and who have borne a higher share of the health and social costs of coal, gas and electricity production.
Certainty	Moderate	N/A	The nature of an emissions trading scheme is that the cap provides certainty as to how much greenhouse pollution is allowed. However, the cost of those pollution reductions, and the economic impacts of that energy transition (especially in energy efficiency) remain uncertain.

5.3.4 Worker Transition

In this option, the state government complies with the Clean Power Plan (as in the scenario above), but also provides an assistance package for "stranded workers". This would include:

- up to 24 months income assistance and benefits for workers laid off from the coal industry (eligibility pre-determined), provided that they are enrolled in job re-training;
- training vouchers for those workers who are enrolled in job re-training, valid for courses up to 24 months in length, which they can use for a training institution of their choice;
- up to 3 months income assistance and benefits for those workers who are *not* enrolled in job re-training, provided that they are demonstrated to be looking for other jobs;
- giving priority to pre-determined regions with high numbers of displaced coal workers in distributing clean energy and energy efficiency funds, including from RGGI revenues;
- requiring that clean energy or energy efficiency businesses receiving funding from RGGI revenues (or other clean energy funding sources) give priority to these workers.

In this option the package is funded by setting aside part of the revenue from RGGI auctions, and firms contribute nothing to the worker transition package (a conservative assumption).

Criteria	Score	Figure	Description
Budget	Moderate	+ $350 - $887 million per year	To give a "back of the envelope" estimate of program cost, we take a "low" and "high" estimate. In the "low" estimate, 2,103 workers are displaced, 40 percent enroll in training and 60 percent use the

Criteria	Score	Figure	Description
		(transition package cost of $18 – 97 million per year, for 3 years, subtracted from RGGI revenues)	3 month job-search allowance, income assistance is 50 percent of an annual wage of $80,000,[cxxxviii] and training vouchers are $10,000 per year. In the "high" estimate, 2,654 workers are displaced, 80 percent enroll in training and 20 percent in the 3-month job search allowance, income assistance is 75 percent of an $80,000 salary, and training vouchers are for the same amount. This gives us a "low" estimate of $54.7 million, and a "high" estimate of $291.9 million, over the program. We assume that this is all spent in the first 3 years, at a cost of $18-97 million per year. This amounts to 4 – 22 percent of our RGGI revenue estimate for 2020. However, this cost could be incurred before RGGI revenues flow.
Economic	Moderate	N/A	The worker transition package would go a long way to supporting stranded workers. However, it only covers direct and indirect job losses, not induced job losses. Further, there is no guarantee that the package would lead to a strong economy overall in distressed counties in the southwest region, which may limit the effectiveness of the worker transition package if other job opportunities are not there.
Environment	Good	-21.3 million additional tons of CO_2 per year	This option provides the same environmental outcomes as "Clean Energy Development", above.
Equity	Good	N/A	This option sees the southwest region assume its fair share of the burden of facing climate change, whilst also honoring the contribution that coal communities have made to the state's economy in the past, and supporting them in the transition to a cleaner and healthier regional economic future.
Certainty	Poor	N/A	Although the environmental outcomes are fairly certain (see above), the performance of worker transition packages has been mixed in the past, and is highly contingent on broader forces in the regional economy. In particular, it is not clear that clean energy spending will have an impact locally.

5.4 Summary and Recommendation

Giving our “scores” values from 1-5, we give each option an equally weighted total “score”. Based on this assessment, the “Worker Transition” option appears to score highest. However, this involves considerable uncertainty and substantial trade-offs, suggesting no simple answer.

Criteria	**No Action**	**Gas Development**	**Clean Energy**	**Transition**
Budget	Moderate (3)	Poor (2)	Moderate (3)	Moderate (3)
Economic	Moderate (3)	Moderate (3)	Poor (2)	Moderate (3)
Environment	Very Poor (1)	Poor (2)	Good (4)	Good (4)
Equity	Poor (2)	Moderate (3)	Moderate (3)	Good (4)
Certainty	Moderate (3)	Poor (2)	Moderate (3)	Poor (2)
Total *(out of 25)*	***Moderate (12)***	***Moderate (12)***	***Mod-Good (15)***	***Good (16)***

6. Next Steps

As the analysis above has shown, the southwest region is facing some big changes to its electricity system. No matter what way you look at it, the coal industry in the region is likely to see a significant decline, implying a large amount of employment churn in the energy industry, and significant job losses in certain industries (notably mining and utilities).

However, even bigger economic opportunities will be created. Growth in labor-intensive energy sources like renewables and efficiency promise the creation of a larger number of jobs in construction and manufacturing. If workers in mining and utilities can retool for these industries, they can stay employed locally. Whether or not they can is a critical question.

The state government has a big opportunity of its own. By actively and thoughtfully complying with the Clean Power Plan, the state could greatly enhance net job-creation in clean energy, and raise very considerable amounts of economically efficient annual revenue ($596.9 - 959.1 million per year) that could be used to smooth the transition for affected workers and communities. At the same time, they could make deep cuts to pollution from power plants.

To take advantage of these opportunities, we recommend the following:

1. *For the state government*.
    a. Publicly commit to implementing the Clean Power Plan, to provide industry and workers with certainty, and to allow them to plan their future with confidence.
    b. Fund and publish further research (from the Three Rivers Workforce Investment Board, for example) into the "skills gap" between jobs likely to be lost and gained, and what training would facilitate transition between them.
    c. Fund and publish further research (from the Department of Energy, or the PJM Interconnection) into future scenarios for the state and/or region's electricity system, and the likely impact of the Clean Power Plan.
    d. Fund and publicize further research into the impact of energy transition on property tax revenue in affected areas, and the long-term security of pension funds in most affected industries (such as coal mining and utility workers).
    e. Begin talks with RGGI about options for joining, and commission further analysis from Treasury as to the revenues that could be raised from this scheme.
    f. Begin consultation with employers and unions as to the design of a transition assistance package, and assess departments' ability to deliver such a package.
    g. Petition the federal government to ensure that southwest Pennsylvania obtains funds from existing sources (e.g. Superfund or Abandoned Mines Land), and to expand these programs (for example through the POWER Plus plan).
2. *For workers and unions*.
    a. Inform workers that no matter what happens, the southwest region's energy industry is facing significant restructuring, and some jobs will be lost.
    b. Consult with workers on other job opportunities, and what kind of transition assistance and training would support them to make a transition.
3. *For environment groups.*
    a. Insist that a just transition for workers and communities that currently rely on fossil fuels must be part of any state plan to implement the Clean Power Plan.

b. Consider how the clean energy and efficiency industry could yield more secure, full-time, union jobs (e.g. industry standards or “pro-worker” certifications).

Appendices

Appendix A - Overview and causes of the transition from coal to gas in electricity

In the last 10-15 years, Pennsylvania, like much of the country, has seen tremendous changes in the coal industry, as both production and generation steadily decline. Coal has fallen from 57 percent of electricity generation in 2000 to 40 percent of generation in 2013 in Pennsylvania, a big decline that more or less shadows the national trend.[1] Natural gas has made up practically all of that difference, growing at an average annual growth rate of 19.3 percent between 2000 and 2017.[2] This has led to a string of closures of coal-fired power plants around the state, with coal's share of capacity falling from 51 percent in 2000 to 38 percent in 2012. This represents over 2,100 MW of coal-fired generation capacity already deactivated, and a further 1,200 MW scheduled to be retired after 2012.[3] These closures have been spread fairly evenly around the state until 2012; however, the closure of the larger Mitchell plant (300MW) and Hatfield's Ferry plant (1,710 MW) in 2013 concentrated these impacts in the southwest part of the state.[4]

This decline in coal-fired electricity generation is matched by declining coal production in Pennsylvania. Whilst national coal production has been steadily declining since 2000, the rate of decline in Pennsylvania has been even steeper, falling from just under 80 million short tons in 2000 to under 70 million in 2011 and projected to fall further still to under 60 million in 2017.[5] Employment in coal mining in Pennsylvania, on the other hand, follows a slightly different pattern. Whilst direct jobs in coal production has fallen by 68 percent from 1983 to 2010, most of this fall occurred before 2003, and employment has actually slightly increased since then. This mismatch is largely due to declining labor productivity, caused by increasingly hard to access mines and geological formations.[6] What impact the projected future declines in coal production will have on employment is unclear, due to the unpredictability of mine productivity and industry changes.

This steady decline in coal production and generation, often misattributed to federal environmental regulations, is the product of a number of factors. These include:

- *Competition from natural gas*. The expansion in gas production and decline in gas prices since 2008 has seen natural gas combined-cycle (NGCC) plants become more competitive and coal-fired plants dispatched less often. Since gas is often the marginal fuel, this also lowers wholesale electricity prices and the payments that coal-fired generators receive for the electricity that they produce.[7]
- *Slow growth in demand*. The slow growth in electricity demand in recent years has seen expensive marginal generators (like coal plants) dispatched less often, further reducing their revenue and pushing them closer to retirement.[8]

[1] Commonwealth Economics, *Energy in Pennsylvania: Past, Present and Future* (2013), Exhibit 3-3, p 58.
[2] Commonwealth Economics, Exhibit 3-1, p 56.
[3] Commonwealth Economics, p 68.
[4] Joe Napsha, "FirstEnergy affirms plan to shutter 2 plants", Pittsburgh Tribune-Review, October 4 2013, http://triblive.com/news/westmoreland/4819037-74/plants-power-firstenergy#axzz2gklz4ClJ.
[5] Commonwealth Economics, Exhibit 2-1, p 34.
[6] Rory McIlmoil et al, *The Impact of Coal on the Pennsylvania State Budget* (2012), http://downstreamstrategies.com/documents/reports_publication/ds_penncoal_budget_final.pdf, p 16.
[7] Jeffrey Jones, "Implications of Accelerated Coal Plant Retirements", 2014 http://www.eia.gov/forecasts/aeo/section_issues.cfm#power_plant.
[8] EIA, "Projected retirements of coal-fired power plants" (July 31, 2012), http://www.eia.gov/todayinenergy/detail.cfm?id=15031.

- *Aging coal plant fleet*. Much of the retirements are concentrated in the Mid-Atlantic region, where the coal-fired plants tend to be older plants co-located next to large coal reserves at the time of their construction. These plants tend to be less efficient and more polluting, making them more vulnerable to more efficient gas plants and environmental regulations.[9]
- *Environmental regulations.* While not responsible for all of the changes in the industry, the introduction of the EPA's Mercury and Air Toxics Standard (MATS) and other similar cleanup requirements has pushed many of the older, less economic coal-fired plants "over the edge" by requiring them to make upgrades.
- *Competition from western coal.* The Appalachian coal mining industry faces stiff competition from coal in the Powder River and Illinois Basin. The spot price for Northern Appalachian coal averaged $63/ton in the week ending August 26th 2014, compared to $12/ton for Powder River basin and $44/ton for Illinois Basin coal.[10] This is driven largely by differences in labor productivity (higher in the West) and sulfur content (lower in the West).
- *Weak global demand.* The global market for coal has been soft in recent times, with European prices hitting a five-year low in September due to concerns about oversupply (a concern related to the increasing competitiveness of gas).[11] Coal imported from Colombia is now cheaper than Appalachian coal for power plants in the Eastern U.S., at around $75-82/ton compared to $79-86/ton. [12]

These trends appear set to continue for some time. The EIA's Annual Energy Outlook for 2014 projected that of the 310 GW of installed coal-fired capacity in 2012, 50 GW (or 16 percent) is projected to retire by 2020 in the Reference Case.[13] Natural gas is expected to surpass coal as the largest source of electricity generation nationally by 2035 in the Reference Case, but in the "Accelerated Retirements" Case that projects a higher cost for coal and a low cost for gas, it is expected to come as soon as 2019. [14] In the event of Low Electricity Demand, coal retirements are projected to be double the Reference case in the Reliability First Corporation (RFC) region which includes PA.[15] In the coal production sector, a gradual increase in national production is projected, but this is driven by coal from the Interior, and Appalachia sees a 14 percent decline in production.[16]

The closure of the Mitchell and Hatfield's Ferry plants by FirstEnergy is the biggest coal-fired plant retirement in recent history in Pennsylvania, and an example of the impacts that such closures can have on a community. The decision was announced on July 9th, 2013, without any prior warning from the company, and by December the plants were closed. The plants employed 380 workers (180 at Hatfield's Ferry and 200 at Mitchell) many of whom were members of the Utility Workers Union of America (UWUA). Some union members were offered other jobs with

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[9] EIA, "27 gigawatts of coal-fired capacity to retire over next five years" (July 2012), http://www.eia.gov/todayinenergy/detail.cfm?id=7290.
[10] Alison Cassady, *Complex Market Forces are Challenging Appalachian Coal Mining*, October 6 2014, https://www.americanprogress.org/issues/green/report/2014/10/06/98371/complex-market-forces-are-challenging-appalachian-coal-mining/, p 3.
[11] Alison Cassady, p 6.
[12] Alison Cassady, p 6.
[13] EIA, AEO 2014, p 69.
[14] EIA, AEO 2014, p 69.
[15] EIA, AEO 2014, p 83.
[16] EIA, AEO 2014, p 116.

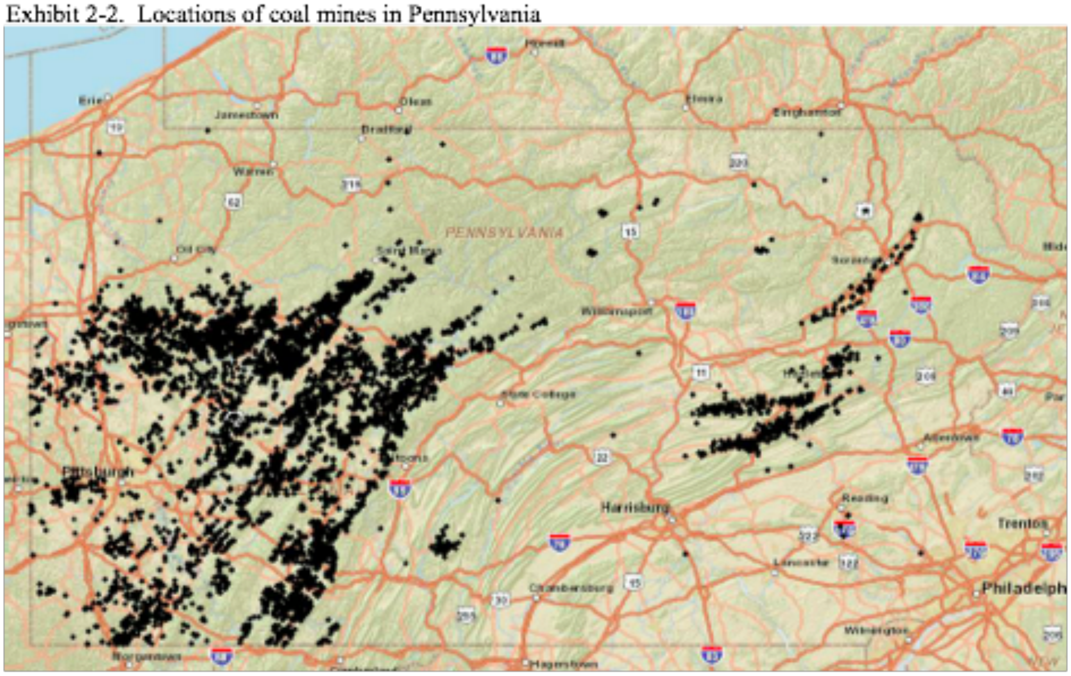
the company, but not all, and the jobs would require them to move out of state. What's more, the offer was conditional on the UWUA accepting the company's current contract proposal in the context of an ongoing contract negotiation.[17] The closure would also see county property tax revenue fall and rates rise for other ratepayers. In testimony to the state legislature, the FirstEnergy Generation President Jim Lash attributed the closure to depressed wholesale and retail energy markets, cheap and abundant natural gas, and environmental regulations.[18]

The flipside of this decline in coal in the southwest region is the boom in gas production. With over two-thirds of the state's landmass lying above the Marcellus shale formation, Pennsylvania has hosted much of the country's growth in "fracked" gas. Dry gas production in the state has increased from 198,925 MMcf in 2008 to 3,232,290 MMcf in 2013—a 1,363 percent increase.[19] This has led to a corresponding rise in employment, with direct employment in the oil and gas extraction industry rising by 15,114—a startling 259 percent—between 2007-2012.[20] In 2009, employment in oil and gas exceeded that in coal production in PA for the first time, marking a landmark in a state once defined by its coal industry. [21] This huge increase in gas production in the state begs the question—could the decline in coal production and employment be offset by a continued increase in gas production and employment in the southwest region?

[17] Joe Napsha, "FirstEnergy affirms plans to shutter 2 plants" *Pittsburgh Tribune-Review*, Oct 4 2013, http://triblive.com/news/westmoreland/4819037-74/plants-power-firstenergy#axzz2gklz4ClJ.
[18] Testimony of James Lash, President FirstEnergy Generation, Before the House Consumer Affairs Committee, October 3 2013, http://www.legis.state.pa.us/cfdocs/legis/tr/transcripts/2013_0177_0003_tstmny.pdf.
[19] Energy Information Administration, Natural Gas Gross Withdrawals and Production, http://www.eia.gov/dnav/ng/ng_prod_sum_dcu_spa_a.htm.
[20] .
[21] BLS, "The Marcellus Shale gas boom in Pennsylvania: employment and wage trends" (February 2014).

Appendix B - Coal Mines in Pennsylvania

Exhibit 2-2. Locations of coal mines in Pennsylvania



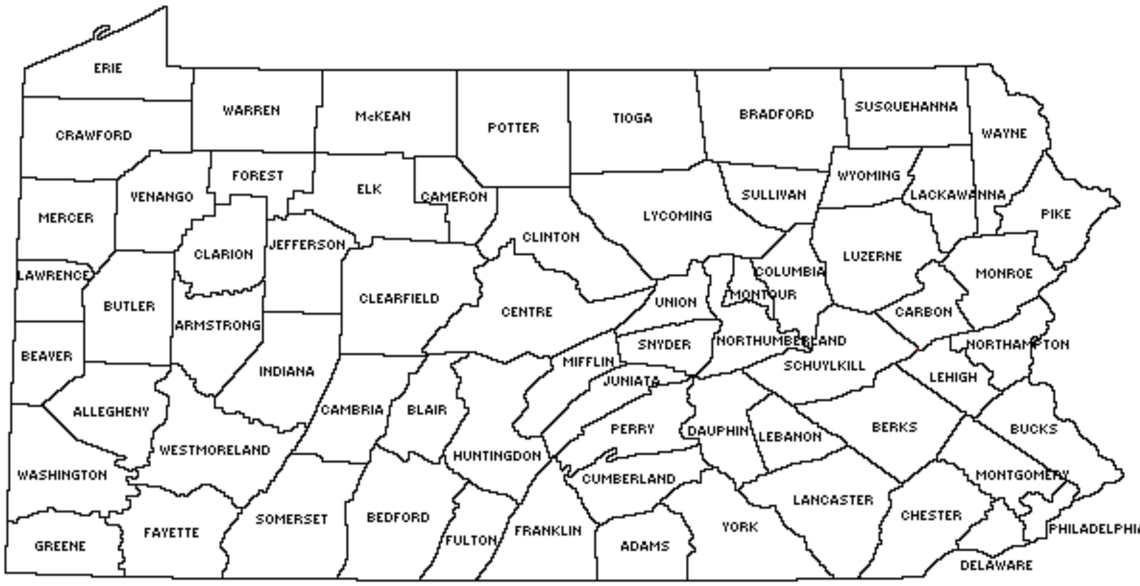
Source: Pennsylvania Spatial Data Access
Penn State Institutes of Energy and the Environment

Source: Commonwealth Economics, Energy in Pennsylvania: Past Present and Future (2010) p 35

Appendix C - Coal-fired Power Plants in Pennsylvania

Source: Energy Information Administration, http://www.eia.gov/state/?sid=PA.

Appendix D - Counties of Pennsylvania



Source: Pennsylvania Department of Transportation:
http://www.dot.state.pa.us/Internet/Bureaus/pdPlanRes.nsf/ctymap.gif.

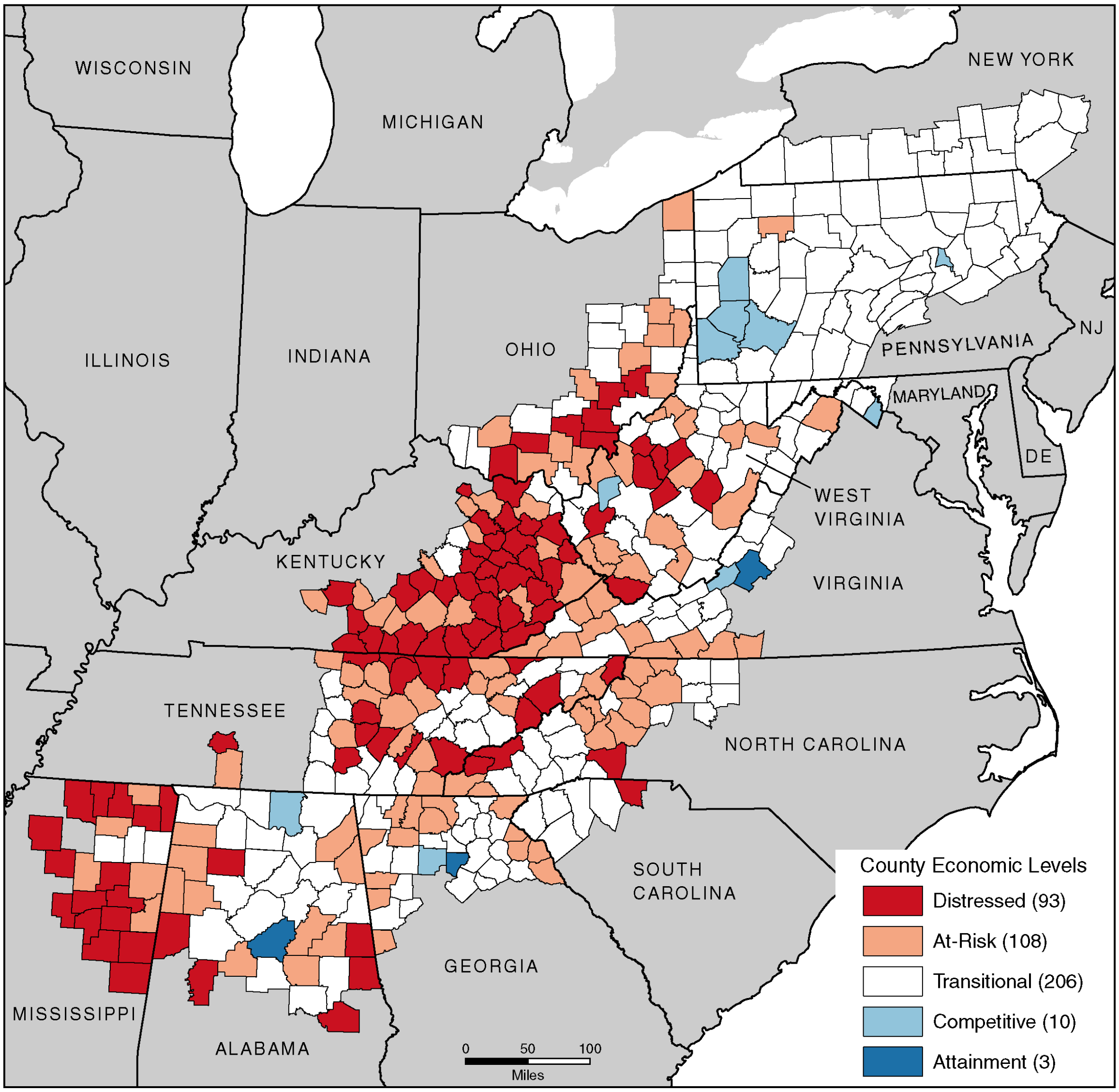
Appendix E - Profile of the Southwest Region

Source: Compiled by author from Census, BLS and PA Department of State data.

	Year	Source	Allegheny	Armstrong	Beaver	Butler	Cambria	Clearfield	Fayette	Greene	Indiana	Somerset	Washington	Westmore'd	Region	Pennsylvania
Population	2012	Census	1,229,912	68,367	170,274	185,084	141,541	81,494	135,668	38,088	88,143	77,115	208,451	363,233	2,787,370	12,764,475
Age																
<18	2013	Census	19.2%	19.7%	19.8%	21.1%	19.2%	19.1%	19.6%	19.3%	18.5%	18.6%	19.9%	19.0%	19.4%	19.2
>65	2013	Census	17.1%	19.7%	19.3%	16.5%	19.7%	18.6%	19.0%	16.6%	16.8%	19.9%	18.5%	20.1%	18.1%	17.1
Race																
White	2013	Census	81.3%	97.9%	91.2%	96.5%	94.0%	95.6%	93.3%	95.0%	95.1%	96.1%	94.2%	95.2%	89%	83.2%
Black	2013	Census	13.3%	0.9%	6.3%	1.2%	3.9%	2.8%	4.7%	3.4%	2.7%	2.7%	3.2%	2.5%	8%	11.5%
Latino	2013	Census	1.8%	0.7%	1.4%	1.3%	1.6%	2.7%	1.0%	1.3%	1.3%	1.3%	1.4%	1.0%	2%	6.3%
Education																
High School	2013	Census	92.90%	88.9%	91.0%	92.7%	88.8%	87.0%	85.4%	85.1%	87.8%	85.6%	90.4%	92.1%	91.2%	88.7%
Bachelors	2013	Census	35.90%	14.6%	21.9%	30.5%	18.3%	13.5%	14.0%	15.5%	21.9%	14.5%	25.6%	25.3%	28.1%	27.5%
Income ($2013)																
Per Capita	*09-13	Census	31,593	23,661	26,258	30,957	22,659	21,273	20,884	21,819	22,933	22,192	28,433	28,051	28,399	28,502
Median Household	*09-13	Census	51,366	45,241	49,217	58,230	41,730	41,030	39,115	44,388	43,997	43,597	53,693	50,763	49,716	52,548
Poverty Rate	*09-13	Census	12.9%	13.0%	12.2%	9.3%	14.9%	14.5%	18.4%	14.7%	17.7%	12.4%	10.5%	10.2%	12.7%	13.3%
People/square mile	2010	Census	1,676	106	392	233	209	71	173	67	108	72	243	355		283.9
Unemployment	2013	BLS	6.5%	8.0%	7.2%	6.3%	8.6%	8.4%	8.5%	6.4%	7.3%	9.0%	6.9%	6.9%	7.0%	7.4%
Political																
Obama Vote	2012	State Dept	56.7%	30.0%	46.0%	31.9%	40.1%	34.8%	45.3%	40.5%	39.8%	27.8%	42.6%	37.6%		52.1%
Wolf Vote	2014	State Dept	58.3%	38.5%	51.2%	36.0%	54.6%	46.5%	58.0%	56.2%	45.6%	42.2%	48.2%	42.5%		54.9%

Appendix F – County Economic Status in Appalachia, FY 2014

Source: Appalachia Regional Commission, http://www.arc.gov/research/MapsofAppalachia.asp?MAP_ID=71



Created by the Appalachian Regional Commission, March 2013
Data Sources:
Unemployment data: U.S. Bureau of Labor Statistics, LAUS, 2009–2011
Income data: U.S. Bureau of Economic Analysis, REIS, 2010
Poverty data: U.S. Census Bureau, American Community Survey, 2007–2011

Effective October 1, 2013
through September 30, 2014

Appendix G – Southwest Region — Capacity & Generation

Source: compiled by author from EIA data

Capacity & Generation Mix as of 2012

	Capacity (MW)	Cap'y (%)	Generation (MWh)	Gen'n (%)
Coal	12,277	71%	67,064,802	74%
Gas	2,199	13%	8,219,461	9%
Wind	656	4%	1,026,048	1%
Hydro	119	1%	446,902	0%
Solar	-	0%	-	0%
Biomass	5	0%	32,371	0%
Nuclear	1,806	10%	14,260,156	16%
Petroleum	157	1%	126,637	0%
Total	*17,218*	100%	*91,176,377*	100%

Capacity & Generation Mix as of 2012, factoring in now-retired power plants

	Capacity (MW)	Cap'y (%)	Generation (MWh)	Gen'n (%)
Coal	9,272	66%	54,799,545	69%
Gas	2,199	16%	8,219,461	10%
Wind	780	6%	1,026,048	1%
Hydro	119	1%	446,902	1%
Solar	-	0%	-	0%
Biomass	5	0%	32,371	0%
Nuclear	1,806	13%	14,260,156	18%
Petroleum	45	0%	126,637	0%
Total	14,100.60	100%	*78,911,120*	100%

Appendix H – Southwest Region — Sales & Prices

Bundled Electricity Sales by Utility (2012, EIA)

Utility	Type	Customers	Sales (MWh)	Revenues ($ 000)	Ave. Price (c/kWh)
Duquesne Light Co	IOU	357,389	3,753,214	511,435	13.6
Pennsylvania Power Co	IOU	117,460	1,619,347	156,487	9.7
West Penn Power Company	IOU	560,612	8,026,805	664,129	8.3
Central Electric Coop, Inc - (PA)	Coop	25,094	282,091	34,309	12.2
Pennsylvania Electric Co	IOU	431,429	4,517,589	551,408	12.2
United Electric Coop, Inc - (PA)	Coop	18,748	164,836	22,840	13.9
REA Energy Coop Inc	Coop	22,732	364,277	36,854	10.1
Somerset Rural Elec Coop, Inc	Coop	13,395	186,716	18,304	9.8
Bedford Rural Elec Coop, Inc	Coop	9,186	155,664	16,477	10.6
Region Total		*1,556,045*	*19,070,539*	*2,012,244*	*10.9*

Retail Electricity Statistics for Pennsylvania (2012, EIA)

State	Customers	Sales	Revenues	Ave Price
Pennsylvania Total	5,974,108	144,709,727	14,334,889	9.9
Pennsylvania (IOUs only)	3,930,303	46,320,959	5,588,092	12.1
Southwest (population proportion)	*1,304,562*	*66,725,000**	*3,130,300*	-

* Based on the IOU sales from the first table, compared with the population proportion of IOU sales we would expect for the southwest region, we find that sales in the southwest region are 1.89 times higher than for the state as a whole. This leads us to a proportionate estimate of 59,577,620 MWh. Expecting a higher proportion for industrial customers in the southwest region, we use the 66,725,000 MWh figure from Appendix K.

Appendix I – Southwest Region — Coal & Gas Production

Coal Production 2012

Source: EIA historical detailed coal production data 2012 (http://www.eia.gov/coal/data.cfm#production)

County	Production (short tons)	Ave Employees	Labor Hours
Allegheny	17,427	11	7,471
Armstrong	2,527,942	340	776,151
Beaver	231,756	24	50,172
Butler	233,318	47	101,050
Cambria	1,333,408	262	591,432
Clearfield	3,487,627	708	1,473,694
Fayette	105,633	52	79,047
Greene	25,673,405	3,294	7,478,105
Indiana	3,246,521	586	1,292,544
Somerset	4,224,587	1,249	2,601,304
Washington	10,085,113	792	1,886,139
Westmoreland	210,365	48	87,963
Region Total	*51,377,102*	*7,413*	*16,425,072*
State Total	*55,472,200*	*8,960*	*19,566,568*

Gas Production 2012

Source: compiled by author from EIA and USDA data

	Units	Source	2010	2011	2012	2013
Gross Withdrawals						
State	MMcf	EIA	572,902	1,310,592	2,256,696	3,259,042
Region	MMcf	USDA	247,824	490,225	*834,978*	*1,205,846*
Share			0.43	0.37	*0.37*	*0.37*
Dry Production						
State	MMcf	EIA	568,324	1,301,661	2,244,693	3,232,290
Region	MMcf	Calculated	*244,379*	*481,615*	*830,536*	*1,195,947*
Share			*0.43*	*0.37*	*0.37*	*0.37*

N.B. "EIA" refers to Pennsylvania Natural Gas Withdrawals and Production (http://www.eia.gov/dnav/ng/ng_prod_sum_dcu_spa_a.htm), "USDA" refers to USDA Economic Research Service County-level Oil and Gas Production in the US (http://www.ers.usda.gov/data-products/county-level-oil-and-gas-production-in-the-us.aspx).EIA and USDA figures on state gross withdrawals match each other to within less than 1 percent, so we consider them to be cross-applicable. Figures in italics have been calculated based on the proportionate share of state production attributable to the southwest region in 2011 (the most recent year in which data was available). Note, however, that this may no longer be accurate, due to the very large changes in gas production since 2011, which may not have been spread evenly.

Appendix J – Southwest Region — Energy Employment

Direct Employment in the Coal, Gas and Power Industry

Source: compiled by author from BLS and EIA data

Description	Year	Source	Pitts. MSA	Southwest	Pennsylvania	National
Population	2012	Census	2,360,989	2,787,370	12,764,475	314,112,078
Coal Mining	2012	EIA	1,884	7,697	8,927	89,838
Coal Mining	2012	BLS	1,814	-	8,619	85,925
Support for Coal Mining	2012	BLS	420	-	901	9168
Coal Industry Estimate	*2012*		*2,234*	*7,697*	*9,520*	*95,093*
Electric Power Industry	2012	BLS	3,549	-	15,724	393,366
Net Capacity (MW)	2012	EIA	-	17,217	45,406	-
Electric Power Estimate	*2012*		*3,549*	*5,962*	*15,724*	*393,366*
Oil & Gas Extraction	2012	BLS	1,985	-	4,783	181,473
Drilling Oil & Gas Wells	2012	BLS	499	-	4,086	92,340
Support for Oil & Gas	2012	BLS	-	-	11,476	282,447
Dry Production (MMcf)	2012	App H	-	830,536	2,244,693	-
Oil & Gas Estimate	*2012*		-	*7,528*	*20,345*	*556,260*

N.B. All figures are annual average employment unless otherwise indicated. A dash indicates a gap in the data. Employment estimates made in italics reflect inferences from the data.

Appendix K – BAU Case

BAU (Reference) Case						
Region		Type	2012	% share	2030	% share
RFC-W	Cap'y (MW)	Coal	71,683	55%	57,527	45%
		Gas	32,469	25%	47,937	37%
		Nuclear	17,683	14%	15,226	12%
		Wind	5,633	4%	5,633	4%
		Hydro	1,131	1%	1,495	1%
		Solar	60	0%	142	0%
		Biomass	312	0%	374	0%
		Petroleum	484	0%	324	0%
		Other	238	0%	238	0%
		Total	129,694	100%	128,895	100%
	Gen'n (000 GWh)	Coal	332,410	59%	378,303	58%
		Gas	61,271	11%	114,260	18%
		Nuclear	145,877	26%	122,721	19%
		Wind	12,869	2%	13,947	2%
		Hydro	3,608	1%	8,412	1%
		Solar	70	0%	167	0%
		Biomass	1,315	0%	11,790	2%
		Petroleum	2,505	0%	1,536	0%
		Other	348	0%	374	0%
		Total	560,273	100%	651,511	100%
Southwest	Cap'y (MW)	Coal	12,277	71%	9,272	54%
		Gas	2,199	13%	4,951	29%
		Nuclear	1,806	10%	1,806	11%
		Wind	656	4%	757	4%
		Hydro	119	1%	168	1%
		Solar	-	0%	11	0%
		Biomass	5	0%	13	0%
		Petroleum	157	1%	135	1%
		Other	-	0%	0	0%
		Total	17,218	100%	17,112	100%
	Gen'n (GWh)	Coal	67,065	74%	68,301	64%
		Gas	8,219	9%	19,324	18%
		Nuclear	14,260	16%	14,260	13%
		Wind	1,026	1%	1,184	1%
		Hydro	447	0%	1,086	1%
		Solar	-	0%	14	0%
		Biomass	32	0%	1,708	2%
		Petroleum	127	0%	306	0%
		Other	-	0%	-	0%
		Total	91,176	100%	106,024	100%
	Demand (Retail Sales) (GWh)		**2012**	**% of Gen**	**2030**	**% of Gen**
			66,725	73%	75,473	71%
	Prices (Ave Retail) (2012 c/kWh)		10.9		13.3	

N.B. All figures taken from the AEO 2014 are for the electric power sector (i.e. excluding end-use sectors). AEO 2014 capacity figures are provided in terms of "Oil and Natural Gas Steam", "Combined Cycle" and "Combustion Turbine/Diesel". We have treated "Oil & Natural Gas Steam" as "petroleum", and "CC" and "CT/D" as "gas" here. AEO 2014 figures imply very low capacity factor for gas (22 percent in 2012). This may be because the majority of gas plants in the southwest region are peaking plants, or it may indicate a glitch in our calculations of capacity by fuel type. AEO 2014 data also implies an impossibly high capacity factor for biomass. The implied capacity factor of *petroleum in the southwest region is lower than in the AEO case (~10 percent), which we attribute to mothballed but standby capacity in the southwest region as of 2012.*

Appendix L – Accelerated Retirements Case

Accelerated Retirements Case						
Region		**Type**	**2012**	**% share**	**2030**	**% share**
RFC-W	Cap'y (MW)	Coal	71,683	55%	43,478	34%
		Gas	32,469	25%	59,824	47%
		Nuclear	17,683	14%	15,226	12%
		Wind	5,633	4%	5,633	4%
		Hydro	1,131	1%	1,488	1.2%
		Solar	60	0%	142	0.1%
		Biomass	312	0%	374	0.3%
		Petroleum	484	0%	188	0.1%
		Other	238	0%	238	0.2%
		Total	129,694	100%	126,590	100%
	Gen'n (000 GWh)	Coal	332	71%	274	49%
		Gas	61	13%	212	35%
		Nuclear	146	10%	123	11%
		Wind	13	4%	14	4%
		Hydro	4	1%	8	1.0%
		Solar	0	0%	0	0.1%
		Biomass	1	0%	21	0.1%
		Petroleum	3	1%	1	0.4%
		Other	0	0%	0	0.0%
		Total	560	100%	654	100%
Southwest	Cap'y (MW)	Coal	12,277	71%	8,153	49%
		Gas	2,199	13%	5,881	35%
		Nuclear	1,806	10%	1,806	11%
		Wind	656	4%	713	4%
		Hydro	119	1%	167	1.0%
		Solar	-	0%	11	0.1%
		Biomass	5	0%	14	0.1%
		Petroleum	157	1%	61	0.4%
		Other	-	0%	-	0.0%
		Total	17,218	100%	16,806	100%
	Gen'n (GWh)	Coal	67,065	74%	57,755	54%
		Gas	8,219	9%	32,464	30%
		Nuclear	14,260	16%	14,260	13%
		Wind	1,026	1%	1,125	1.1%
		Hydro	447	0%	878	0.8%
		Solar	-	0%	14	0.0%
		Biomass	32	0%	86	0.1%
		Petroleum	127	0%	93	0.1%
		Other	-	0%	-	0.0%
		Total	91,176	100%	106,445	100%
	Demand (Retail Sales) (GWh)		**2012**	**% of Gen**	**2030**	**% of Gen**
			66,725	73%	74,140	70%
	Prices (Ave Retail) (2012 c/kWh)		10.9		13.9	

N.B. All figures taken from the AEO 2014 are for the electric power sector (i.e. excluding end-use sectors). As in Appendix J, AEO 2014 capacity figures are provided in terms of "Oil and Natural Gas Steam", "Combined Cycle" and "Combustion Turbine/Diesel", and we have treated "Oil & Natural Gas Steam" as "petroleum", and "CC" and "CT/D" as "gas" here. The implied capacity factor of hydro in this AEO 2014 case rises to around 63 percent, so we have assumed that the implied capacity factor in the southwest does not rise above 60 percent.

Appendix M – EPA Clean Power Plan Case

EPA Clean Power Plan Case						
Region		**Type**	**BAU 2030**	**% share**	**CPP 2030**	**% of BAU**
US	Cap'y (GW)	Coal	240	22%	195	81%
		Gas	459	42%	411	90%
		Nuclear	101	9%	100	99%
		Renewables	107	10%	117	109%
		Hydro	101	9%	101	100%
		Petroleum	82	7%	65	79%
		Other	5	0%	5	100%
		Total	*1,095*	*100%*	*994*	91%
	Gen'n (000 GWh)	Coal	1,668	37%	1,249	75%
		Gas	1,432	31%	1,346	94%
		Nuclear	797	17%	796	100%
		Renewables	350	8%	356	102%
		Hydro	280	6%	281	100%
		Petroleum	23	1%	10	43%
		Other	6	0%	16	267%
		Total	*4,557*	*100%*	*4,054*	89%
		Type	**BAU 2030**	**Share**	**CPP 2030**	**Share**
Southwest	Cap'y (MW)	Coal	9,272	54%	7,534	48%
		Gas	4,951	29%	4,433	29%
		Nuclear	1,806	11%	1,806	12%
		Wind	757	4%	1,265	8%
		Hydro	168	1.0%	335	2.2%
		Solar	11	0.1%	24	0.2%
		Biomass	13	0.1%	29	0.2%
		Petroleum	135	0.8%	107	0.7%
		Other	0.19	0.0%	0.19	0.0%
		Total	*17,112*	*100%*	*15,533*	*100%*
	Gen'n (GWh)	Coal	68,301	65%	53,104	57%
		Gas	19,324	18%	20,857	22%
		Nuclear	14,260	14%	14,260	15%
		Wind	1,184	1.1%	2,303	2.5%
		Hydro	1,086	1.0%	2,135	2.3%
		Solar	14	0.0%	33	0.0%
		Biomass	80	0.1%	185	0.2%
		Petroleum	306	0.3%	138	0.1%
		Other	-	0.0%	-	0.0%
		Total	104,555	100%	93,014	100%

Figures for 2030 for the Southwest Region were calculated based on the proportionate increase in capacity and generation nationally, and adjusted to match totals and provide reasonable implied capacity factors.

Appendix N – Beyond Case

Beyond Case						
Region		Type	BAU 2030	% share	CPP 2030	% of BAU
US	Cap'y (GW)	Coal	240	22%	195	81%
		Gas	459	42%	411	90%
		Nuclear	101	9%	100	99%
		Renewables	107	10%	117	109%
		Hydro	101	9%	101	100%
		Petroleum	82	7%	65	79%
		Other	5	0%	5	100%
		Total	*1,095*	*100%*	*994*	91%
	Gen'n (000 GWh)	Coal	1,668	37%	1,249	75%
		Gas	1,432	31%	1,346	94%
		Nuclear	797	17%	796	100%
		Renewables	350	8%	356	102%
		Hydro	280	6%	281	100%
		Petroleum	23	1%	10	43%
		Other	6	0%	16	267%
		Total	*4,557*	*100%*	*4,054*	89%
		Type	**BAU 2030**	**Share**	**CPP 2030**	**Share**
Southwest	Cap'y (MW)	Coal	8,153	49%	6,624	43%
		Gas	5,881	35%	5,266	35%
		Nuclear	1,806	11%	1,806	12%
		Wind	713	4%	1,122	7%
		Hydro	167	1.0%	334	2.2%
		Solar	11	0.1%	24	0.2%
		Biomass	14	0.1%	31	0.2%
		Petroleum	61	0.4%	48	0.3%
		Other	-	0.0%	-	0.0%
		Total	*16,806*	*100%*	*15,256*	*100%*
	Gen'n (GWh)	Coal	57,255	54%	42,873	45%
		Gas	32,464	30%	33,577	35%
		Nuclear	14,260	13%	14,260	15%
		Wind	1,125	1.1%	1,967	2.1%
		Hydro	878	0.8%	1,757	1.9%
		Solar	14	0.0%	32	0.0%
		Biomass	86	0.1%	190	0.2%
		Petroleum	93	0.1%	40	0.0%
		Other	-	0.0%	-	0.0%
		Total	*106,445*	*100%*	*94,696*	*100.0 %*

N.B. Capacity and Generation figures are taken from ____.
Figures for 2030 for the Southwest Region were calculated based on the proportionate increase in capacity and generation nationally, and adjusted to match totals and provide reasonable implied capacity factors.

Appendix O — EPA's Projected Job Impacts from proposal Clean Power Plan

Table 6-4. Engineering-Based[a] Changes in Labor Utilization, Regional Compliance Approach - (Number of Job-Years[b] of Employment in a Single Year)

Category	Option 1			Option 2		
Construction-related (One-time) Changes*						
	2017-2020	**2021-2025**	**2026-2030**	**2017-2020**	**2021-2025**	**2026-2030**
Heat Rate Improvement: Total	**32,900**	**0**	**0**	**33,900**	**0**	**n/a**
Boilermakers and General Construction	22,800	0	0	23,600	0	n/a
Engineering and Management	6,000	0	0	6,200	0	n/a
Equipment-related	2,900	0	0	3,000	0	n/a
Material-related	1,100	0	0	1,100	0	n/a
New Capacity Construction: Total	**24,700**	**-33,300**	**-37,000**	**14,700**	**-23,100**	**n/a**
Renewables	17,000	-4,700	-2,100	11,600	-3,100	n/a
Natural Gas	7,700	-28,600	-34,900	3,100	-20,000	n/a
Recurring Changes**						
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
Operation and Maintenance: Total	**-22,900**	**-23,800**	**-23,700**	**-15,300**	**-15,500**	**n/a**
Changes in Gas	2,300	-600	-3,400	1,000	-1,000	n/a
Retired Coal	-22,600	-20,800	-18,200	-14,600	-13,100	n/a
Retired Oil and Gas	-2,600	-2,400	-2,100	-1,700	-1,400	n/a
Fuel Extraction: Total	**-8,800**	**-14,900**	**-19,200**	**-6,600**	**-10,600**	**n/a**
Coal	-13,700	-17,000	-16,600	-10,900	-12,900	n/a
Natural Gas	4,900	2,100	-2,600	4,300	2,300	n/a
Supply-Side Employment Impacts - Quantified	**25,900**	**-72,000**	**-79,900**	**26,700**	**-49,200**	**n/a**

[a] Job-year estimates are derived from IPM investment and O&M cost estimates, as well as IPM fuel use estimates (tons coals or MMBtu gas).

[b] All job-year estimates on this are full-time equivalent (FTE) jobs. Job estimates in the Demand-Side energy efficiency section (below) include both full-time and part-time jobs.

*Construction-related job-year changes are one-time impacts, occurring during each year of the 2 to 4 year period during which construction and HRI installation activities occur. Figures in table are average job-years during each of the years in each range. Negative job-year estimates when additional generating capacity must be built in the base case, but is avoided in the Guideline implementation scenarios due to HRI or Demand-side energy efficiency programs.

Table 6-6. Estimated Demand-Side Energy Efficiency Employment Impacts For Option 1 and Option 2 for Both Regional and State Compliance Approaches

Source	Factor	Employment impact (jobs)*					
		Option 1			Option 2		
		2020	2025	2030	2020	2025	2030
BLS GGS additional jobs per additional million dollars	2.56	78,800	112,000	111,800	57,000	76,200	n/a

*Since these figures represent number of employees (full- or part-time) they should not be added to the full-time equivalent job-years reported in Table 6-5.

Source: EPA, *Regulatory Impact Analysis,* Table 6-4, p 6-26, Table 6-6, p 6-31, http://www2.epa.gov/sites/production/files/2014-06/documents/20140602ria-clean-power-plan.pdf.

Appendix P — JEDI Model Input Assumptions

Coal (release number C3.24.14)

Project Location	PENNSYLVANIA
Population	
Year Construction Starts	2015
Project Size - Nameplate Capacity (MW)	869
Capacity Factor (Percentage)	80%
Heat Rate (Btu per kWh)	9,370
Construction Period (Months)	55
Plant Construction Cost ($/kW)	$3,025
Cost of Fuel ($/mmbtu)	$4.94
Produced Locally (Percent)	80%
Fixed Operations and Maintenance Cost ($/kW)	$23.10
Variable Operations and Maintenance Cost ($/MWh)	$3.66
Money Value (Dollar Year)	2010

Gas (release number NG3.24.14)

Project Location	PENNSYLVANIA
Year Construction Starts	2015
Project Size - Nameplate Capacity (MW)	240
Capacity Factor (Percentage)	60%
Heat Rate (Btu per kWh)	7,000
Construction Period (Months)	36
Plant Construction Cost ($/KW)	$1,250
Cost of Fuel ($/mmbtu)	$4.47
Produced Locally (Percent)	80%
Fixed Operations and Maintenance Cost ($/kW)	$8.25
Variable O&M Cost ($/MWh)	$2.90
Money Value (Dollar Year)	2010

Solar PV (release number PV3.24.14)

Project Location	PENNSYLVANIA
Population (only required for County/Region analysis)	
Year of Construction or Installation	2015
System Application	Utility
Solar Cell/Module Material	Crystalline Silicon
System Tracking	Fixed Mount
Average System Size - DC Nameplate Capacity (kW)	1,000.00
Number of Systems Installed	11
Total Project Size - DC Nameplate Capacity (kW)	11,000.00
Base Installed System Cost ($/$kW_{DC}$)	$4,869
Annual Direct O&M Cost ($/kW)	$19.93
Money Value (Dollar Year)	2010

Conventional Hydro (release number CH3.24.14)

Project Location	Pennsylvania
Population (only required for County/Region analysis)	
Year of Construction/Installation	2015
Hydro Project Type	New Site
Project Installed New Capacity (MW)	62.8

Money Value (Dollar Year)	2015
Select Model Analysis Type (Simple/Advanced)	Simple

Wind (release number W10.13.14)

Project Descriptive Data	
Project Location	PENNSYLVANIA
Population (only required for County/Region analysis)	
Year of Construction	2015
Total Project Size - Nameplate Capacity (MW)	47
Number of Projects (included in Total Project Size)	1
Turbine Size (kW)	2,000
Number of Turbines	24
Installed Project Cost ($/kW)	$1,750
Operations and Maintenance Cost ($/kW)	$20.00
Money Value (Dollar Year)	2010

Appendix Q — BAU Case: Capacity Change Direct & Indirect Jobs

BAU Case - Direct & Indirect Jobs - Capacity Changes									
	Source	**Units**	**Coal**	**Gas**	**Wind**	**Solar**	**Hydro**	**Oil**	***Total***
Change	App J	MW	(3,005)	2,752	101	11	49	(22)	
Plant Size [a]	EIA	MW	869	240	47	1	63	15	
Number Built/Closed			(3.5)	11.5	2.2	11.0	0.8	(1.5)	
Direct per-plant									
Construction Onsite	JEDI	Jobs	3,224	282	51	99	692	282	
Cons. Services Onsite	JEDI	Jobs	1,199	-	2	154	193	-	
Cons. Supply Chain [b]	JEDI	Jobs	1,590	197	116	229	244	197	
Operating Onsite	JEDI	Jobs/year	125	12	4	2	3	12	
Operating Supply Chain [b]	JEDI	Jobs/year	1,249	169	3	1	8	169	
Direct total									
Construction Onsite		Jobs	-	3,229	110	1,089	540	-	*4,968*
Cons. Services Onsite		Jobs	-	-	4	1,689	151	-	*1,843*
Cons. Supply Chain [b]		Jobs	-	2,256	250	2,515	190	-	*5,211*
Operating Onsite		Jobs/year	(432)	137	9	24	2	(18)	*(260)*
Operating Supply Chain [b]		Jobs/year	(4,320)	1,935	6	8	6	(250)	*(2,364)*
Construction Period	JEDI	Years	1	1	1	1	4	4	
Operation (2015-2030)	AEO14	Years	12	10	12	12	7	14	
Construction Total									
Onsite Labor		*Job-Years*	-	3,229	114	2,778	2,762	-	*8,883*
Supply Chain [b]		*Job-Years*	-	2,256	250	2,515	762	-	*5,782*
Operating Total									
Onsite Labor		*Job-Years*	(5,188)	1,374	103	290	16	(248)	*(3,651)*
Supply Chain [b]		*Job-Years*	(51,835)	19,353	78	92	44	(3,493)	*(35,762)*

The jobs-per-plant figures come from JEDI model defaults, after the state and plant size were input. For the solar model we chose the "utility-scale" default, for the hydro model we chose the "new site" default, and for the oil model we used the natural gas model since it was simpler (and the total number of oil jobs is small). We have not provided figures for biomass, since a JEDI model for this type of plant is not available.

[a] *This is based on the average size of plants in the southwest region, taken from EIA data.*
[b] *Supply Chain job figures from JEDI should be treated with caution. They are likely overestimates, as they (a) do not account for the share of jobs located locally in the region and (b) are not the same as "indirect jobs".*
[c] *The indirect operating job figures should be treated with particular caution, since they include jobs involved in fuel production (i.e. coal mining and gas production), which we calculate separately in our report.*

Appendix R – Accelerated Retirements Case: Capacity Change Direct & Indirect Jobs

Accelerated Retirements Case - Direct & Indirect Jobs - Capacity Changes									
	Source	**Units**	**Coal**	**Gas**	**Wind**	**Solar**	**Hydro**	**Oil**	***Total***
Change	App J	MW	(4,124)	3,682	57	11	48	(96)	
Plant Size	EIA	MW	869	240	47	1	63	15	
Number Built/Closed			(4.7)	15.3	1.2	11.0	0.8	(6.4)	
Direct per-plant									
Construction Onsite	JEDI	Jobs	3,224	282	51	99	692	282	
Cons. Services Onsite	JEDI	Jobs	1,199	-	2	154	193	-	
Cons. Supply Chain	JEDI	Jobs	1,590	197	116	229	244	197	
Operating Onsite	JEDI	Jobs/year	125	12	4	2	3	12	
Op. Supply Chain	JEDI	Jobs/year	1,249	169	3	1	8	169	
Direct total									
Construction Onsite		Jobs	-	4,321	62	1,089	529	-	*6,000*
Cons. Services Onsite		Jobs	-	-	2	1,689	148	-	*1,838*
Cons. Supply Chain		Jobs	-	3,018	141	2,515	186	-	*5,860*
Operating Onsite		Jobs/year	(593)	184	5	24	2	(77)	*(378)*
Op. Supply Chain		Jobs/year	(5,928)	2,589	4	8	6	(1,089)	*(3,321)*
Construction Period	JEDI	Years	1	1	1	1	4	4	
Operation (2015-2030)	AEO14	Years	12	10	12	12	7	14	
Construction Total									

Onsite Labor	*Job-Years*	-	4,321	64	2,778	2,706	-	*9,868*
Supply Chain [b]	*Job-Years*	-	3,018	141	2,515	746	-	*6,420*
Operating Total								
Onsite Labor	*Job-Years*	(7,119)	1,839	58	290	16	(1,082)	*(5,999)*
Supply Chain [b]	*Job-Years*	(71,137)	25,893	44	92	43	(15,244)	*(60,310)*

See the notes to Appendix Q for more information on how these figures were reached and caveats that apply.

Appendix S – Clean Power Plan: Capacity Change Direct & Indirect Jobs

Clean Power Plan Case - Direct & Indirect Jobs - Capacity Changes									
	Source	**Units**	**Coal**	**Gas**	**Wind**	**Solar**	**Hydro**	**Oil**	***Total***
Change	App J	MW	(4,743)	2,234	609	24	216	(50)	
Plant Size	EIA	MW	869	240	47	1	63	15	
Number Built/Closed			(5.5)	9.3	13.0	24.0	3.4	(3.4)	
Direct per-plant									
Construction Onsite	JEDI	Jobs	3,224	282	51	99	692	282	
Cons. Services Onsite	JEDI	Jobs	1,199	-	2	154	193	-	
Cons. Supply Chain	JEDI	Jobs	1,590	197	116	229	244	197	
Operating Onsite	JEDI	Jobs/year	125	12	4	2	3	12	
Op. Supply Chain	JEDI	Jobs/year	1,249	169	3	1	8	169	
Direct total									
Construction Onsite		Jobs	-	2,621	662	2,376	2,380	-	*8,040*
Cons. Services Onsite		Jobs	-	-	26	3,684	664	-	*4,374*
Cons. Supply Chain		Jobs	-	1,831	1,506	5,486	839	-	*9,663*
Operating Onsite		Jobs/year	(682)	112	52	53	10	(40)	*(456)*
Op. Supply Chain		Jobs/year	(6,818)	1,571	39	17	28	(567)	*(5,164)*
Construction Period	JEDI	Years	1	1	1	1	4	4	
Operation (2015-2030)	AEO14	Years	12	10	12	12	7	14	
Construction Total									
Onsite Labor		*Job-Years*	-	2,621	688	6,060	12,176	-	*21,545*
Supply Chain [b]		*Job-Years*	-	1,831	1,506	5,486	3,357	-	*12,181*
Operating Total									
Onsite Labor		*Job-Years*	(8,188)	1,116	623	634	72	(564)	*(6,307)*
Supply Chain [b]		*Job-Years*	(81,815)	15,710	467	202	193	(7,940)	*(73,182)*

See the notes to Appendix Q for more information on how these figures were reached and caveats that apply.

Appendix T – Beyond Case: Capacity Change Direct & Indirect Jobs

Beyond Case - Direct & Indirect Jobs - Capacity Changes									
	Source	**Units**	**Coal**	**Gas**	**Wind**	**Solar**	**Hydro**	**Oil**	***Total***
Change	App J	MW	(5,653)	3,067	466	24	215	(109)	
Plant Size	EIA	MW	869	240	47	1	63	15	
Number Built/Closed			(6.5)	12.8	9.9	24.0	3.4	(7.3)	
Direct per-plant									
Construction Onsite	JEDI	Jobs	3,224	282	51	99	692	282	
Cons. Services Onsite	JEDI	Jobs	1,199	-	2	154	193	-	
Cons. Supply Chain	JEDI	Jobs	1,590	197	116	229	244	197	
Operating Onsite	JEDI	Jobs/year	125	12	4	2	3	12	
Op. Supply Chain	JEDI	Jobs/year	1,249	169	3	1	8	169	
Direct total									
Construction Onsite		Jobs	-	3,599	507	2,376	2,369	-	*8,851*
Cons. Services Onsite		Jobs	-	-	20	3,684	661	-	*4,365*
Cons. Supply Chain		Jobs	-	2,514	1,153	5,486	835	-	*9,988*
Operating Onsite		Jobs/year	(813)	153	40	53	10	(88)	*(557)*
Op. Supply Chain		Jobs/year	(8,126)	2,157	30	17	27	(1,236)	*(5,895)*
Construction Period	JEDI	Years	1	1	1	1	4	4	
Operation (2015-2030)	AEO14	Years	12	10	12	12	7	14	
Construction Total									
Onsite Labor		*Job-Years*	-	3,599	527	6,060	12,119	-	*22,305*
Supply Chain [b]		*Job-Years*	-	2,514	1,153	5,486	3,341	-	*12,495*
Operating Total									
Onsite Labor		*Job-Years*	(9,759)	1,531	477	634	72	(1,229)	*(8,274)*
Supply Chain [b]		*Job-Years*	(97,512)	21,568	358	202	192	(17,308)	*(92,501)*

See the notes to Appendix Q for more information on how these figures were reached and caveats that apply.

Appendix U – Beyond Case: HRI Upgrade Direct & Indirect Jobs

Beyond Case - HRI - Direct & Indirect Jobs						
Description	**Source**	**Units**	**Share**	**Central**	**Low**	**High**
Upgrades		MW	-	-	-	-
Cost	EPA	$000/MW	-	0	150	100
Boilermaking & Construction	EPA	$000/job	40%	78.5	78.5	78.5
Engineering and Management	EPA	$000/job	20%	141.0	141.0	141.0
Equipment Supply	EPA	$000/job	30%	458.0	458.0	458.0
Materials Supply	EPA	$000/job	10%	424.0	424.0	424.0
Boilermaking & Construction	EPA	Job-Years		2718	1087	4077
Engineering and Management	EPA	Job-Years		757	303	1135
Equipment Supply	EPA	Job-Years		349	140	524
Materials Supply	EPA	Job-Years		126	50	189
Total Direct		*Job-Years*		*3,475*	*1,390*	*5,212*
Total Indirect		*Job-Years*		*1,106*	*442*	*1,659*

Appendix V – Allocation of Power Plant Spending to Industries by NAICS Industry Codes

NAICS	Industry	Units	Coal	Gas	Wind	Solar	Hydro	LFG	Oil
	Capital Investment								
	Spending (Overnight Capital Costs)	mil 2010$	N/A					N/A	
230000	Construction	%	10%	7%	26%	30%	50%		7%
333611	Turbine and turbine generator set units manufacturing	%	15%	46%			15%		46%
327330	Concrete pipe, brick, and block manufacturing	%					10%		
541300	Architectural, engineering, and related services	%					10%		
335312	Motor and generator manufacturing	%					5%		
335313	Switchgear and switchboard apparatus manufacturing	%					3%		
335314	Relay and industrial control manufacturing	%					3%		
5416A0	Environmental and other technical consulting services	%							
33299C	Other fabricated metal manufacturing	%			12%				
32619A	Plastic Products Manufacturing	%			12%				
333613	Mechanical power transmission equipment manufacturing	%			3%	18%	5%		
334417	Electronic Connector Manufacturing	%			3%				
541700	Scientific research and development services	%			7%				
33329A	Other industrial machinery manufacturing	%	30%		37%				
332500	Hardware manufacturing	%				18%			
334419	Other electronic component manufacturing	%				18%			
541610	Management, scientific, and technical consulting services	%				18%			
333920	Material handling equipment manufacturing	%		18%					18%
33341A	Air purification and ventilation equipment manufacturing	%	5%	15%					15%
334513	Industrial process variable instruments manufacturing	%	10%	14%					14%
332410	Power boiler and heat exchanger manufacturing	%	30%						
	Total	%	100%	100%	100%	100%	100%	0%	100%

NAICS	Industry	Units	Coal	Gas	Wind	Solar	Hydro	LFG	Oil
	O & M (Fixed)								
	Spending (Fixed O&M Costs)	mil 2010$							
2211A0	Electric power generation, transmission, and distribution	%	100%	22%	25%	25%	80%		33%
811300	Commercial and industrial machinery and equipment repair and maintenance	%			50%	50%	10%		
5416A0	Environmental and other technical consulting services	%			25%	25%	10%		
212100	Coal mining	%							
21311A	Support activities for other mining	%							
211000	Oil and gas extraction	%							
213111	Drilling oil and gas wells	%							
213112	Support activities for oil and gas operations	%							
221200	Natural gas distribution	%		73%					
486000	Pipeline transportation	%		5%					67%
324110	Petroleum refineries	%							
	O & M (Fuel)								
	Spending (Variable Costs)	mil 2010$			N/A	N/A	N/A	N/A	
2211A0	Electric power generation, transmission, and distribution	%							
811300	Commercial and industrial machinery and equipment repair and maintenance	%							
5416A0	Environmental and other technical consulting services	%							
212100	Coal mining	%	82%						
21311A	Support activities for other mining	%	18%						
211000	Oil and gas extraction	%		64%					13%
213111	Drilling oil and gas wells	%		22%					4%
213112	Support activities for oil and gas operations	%		14%					3%
221200	Natural gas distribution	%							
486000	Pipeline transportation	%							80%
324110	Petroleum refineries	%							

NAICS	Industry	Units	Residential	Commercial	Industrial
	Energy Efficiency				
	Spending	mil 2010$			
230000	Construction	%	30.00%	30.00%	20.00%
335120	Lighting fixture manufacturing	%	10.50%	18.00%	
333414	Heating equipment (except warm air furnaces) manufacturing	%	21.00%	15.00%	10.00%
333415	Air conditioning, refrigeration, and warm air heating equipment manufacturing	%	21.00%	7.00%	10.00%
314110	Carpet and rug mills	%	1.59%	0.36%	
314120	Curtain and linen mills	%	1.59%	0.36%	
321910	Wood windows and doors and millwork	%	1.59%	0.36%	
327211	Flat glass manufacturing	%	1.59%	0.36%	
327215	Glass product manufacturing made of purchased glass	%	1.59%	0.36%	
326150	Urethane and other foam product (except polystyrene) manufacturing	%	1.59%	0.36%	
324122	Asphalt shingle and coating materials manufacturing	%	1.59%	0.36%	
325510	Paint and coating manufacturing	%	1.59%	0.36%	
32712A	Brick, tile, and other structural clay product manufacturing	%	1.59%	0.36%	
327215	Glass product manufacturing made of purchased glass	%	1.59%	0.36%	
327390	Other concrete product manufacturing	%	1.59%	0.36%	
335312	Motor and generator manufacturing	%		6.00%	
339940	Office supplies (except paper) manufacturing	%		2.00%	
334512	Automatic environmental control manufacturing	%		18.00%	
33341A	Air purification and ventilation equipment manufacturing	%			10.00%
33329A	Other industrial machinery manufacturing	%			10.00%
333611	Turbine and turbine generator set units manufacturing	%			10.00%
5416A0	Environmental and other technical consulting services	%			30.00%

Appendix W – Methodology for Calculating Spending Changes

Power Plant Changes

We used JEDI model release versions and input assumptions described in **Appendix P**. Based on the gross capacity changes set out in our electricity system scenarios from 2015-30, we then assumed that the least number of power plants would be built and retired to account for that capacity change. We also assumed construction/retirement dates and operating lives based on the Annual Energy Outlook and the EPA's RIA. Taking the project cost data from the JEDI model, we multiplied it by these capacity changes to reach spending figures as our model inputs.

Energy Efficiency

We only calculated energy efficiency spending and jobs for the Clean Power Plan and Beyond Cases, since estimates of EE savings and the cost of saved energy were readily available in the EPA RIA. To calculate the amount of energy efficiency MWh savings that would be made, we took the projected savings (as a percent of retail sales) from the EPA's GHG Abatement Measures Technical Support Document (TSD), and multiplied them by our projected retail sales for the southwest region (drawn from **Appendix K**) to reach a gross savings estimate attributable to EE.

We then multiplied these savings by the first-year cost of saved energy. In their TSD, the EPA used a cost of saved energy of $550/MWh (comprised of $275/MWh program costs, and $275/MWh participant costs, based on a 1:1 program-participant assumption) (TSD, p 5-52). However, the EPA acknowledged that this was a high figure and somewhat out of date being from 2009, compared to a more recent figure of $175/MWh ($350/MWh total costs) in a study from the Lawrence Berkeley National Labs (TSD, p 5-51). This is a big difference, and could significantly affect the results of our model. For the purposes of using a conservative spending (and therefore employment) figure, we used the lower figure of $330/MWh in our model. We assigned this 30 percent to residential, 30 percent to commercial and 40 percent to industrial efficiency for the purposes of allocating spending between industries as set out in **Appendix V**.

Appendix X — Comparison of Results of I-O and Engineering-Based Analysis

Comparison of Results of Engineering and I-O Methods (Job-Years)

	Engineering Onsite	Engineering Supply Chain	Input-Output Direct & Indirect*	Input-Output Direct & Indirect**
BAU				
Capital	8,883	5,782	27,290	27,290
O&M	(3,651)	(35,762)	(2,364)	(6,577)
ACCEL				
Capital	9,868	6,420	34,893	34,893
O&M	(5,999)	(60,310)	21,191	(9,295)
Clean Power Plan (change from BAU)				
Capital	21,545	12,181	36,073	36,073
O&M	(6,307)	(73,182)	(20,472)	(11,578)
Beyond Case (change from ACCEL)				
Capital	22,305	12,495	40,921	40,921
O&M	(8,274)	(92,501)	(21,176)	(13,939)
Total Direct Jobs in the Southwest Region (Source: Appendix J)				
	Coal Mining	*Electric Power*	*Oil & Gas Production*	
Jobs	7,697	5,962	7,528	
Job-Years (jobs * 15)	115,455	89,430	112,920	

**This reflects a different allocation of spending across industries to that in Appendix S, which applies the industry shares used by PERI in their 2014 analysis.*
*** This reflects our own adapted industry allocations, set out in Appendix S.*
**** These should be treated with caution, since they do not account for share of jobs in region*

As the summary table makes clear, the results of the I-O analysis is broadly consistent with our engineering-based analysis, so long as (a) we use the NAICS industry allocation adapted from PERI used in column 4 and set out in **Appendix V** (rather than directly applying PERI's shares), and (b) recognize that the job numbers from the engineering-based analysis are not counting "direct and indirect" jobs in the same way that our I-O model is, and (c) are also not counting jobs in the southwest region only in the same way that our I-O model is. The engineering numbers for the construction period are lower than those from the I-O model, but those for the O&M period are higher than those from the I-O model, suggesting that the comparison is not "apples to apples", but that the figures thereby reached can be considered useful as a numerical range, and that the modeling conducted in this report is best used for insights rather than for predictions.

Appendix Y – Change in Job-Years by Industry, Phase & Scenario

Direct & Indirect Job-Years in Major Industries, by Phase & Scenario

	Construction	Manufacturing	PS&T	MA&W	Mining	Utilities	Other
BAU							
Capital	3,004	15,241	1,656	2,951	102	110	4,227
O&M	(101)	(291)	(440)	(424)	(2,691)	(1,394)	(1,237)
Total	2,903	14,950	1,216	2,527	(2,589)	(1,285)	2,990
Accel							
Capital	3,537	19,770	2,052	3,858	128	141	5,406
O&M	(144)	(408)	(673)	(600)	(3,725)	(1,941)	(1,803)
Total	3,393	19,362	1,379	3,258	(3,597)	(1,800)	3,603
CPP							
Capital	16,007	43,377	9,266	8,049	382	336	14,093
O&M	(343)	(846)	(940)	(1,208)	(7,907)	(3,758)	(3,153)
Total	15,664	42,531	8,326	6,841	(7,525)	(3,422)	10,941
Beyond							
Capital	16,615	51,007	9,872	9,630	424	388	16,026
O&M	(420)	(1,060)	(1,431)	(1,538)	(9,760)	(4,754)	(4,270)
Total	16,195	49,947	8,441	8,093	(9,337)	(4,366)	11,756

Appendix Z — Job Characteristics in Selected Industries (National)

	Source	Years	Units	Mining NAICS 21	Utilities NAICS 22	Construction NAICS 23	Manufact'g NAICS 31-33	PS&T[a] NAICS 54	MA&W[b] NAICS 56	*Total*
Earnings										
Earnings	BLS	2012	ave hourly	29.22	34.23	25.93	23.92	35.95	18.14	
Hours	BLS	2012	ave weekly	44.2	41.9	38.7	40.7	36.8	34.8	
Union										
Coverage	BLS	2012	%	7.7	26.9	13.7	10.5	1.8	4.9	12.5
Membership	BLS	2012	%	7.2	24.7	13.2	9.6	1.2	4.3	11.3
Coverage	BLS	2012	thousands	72	226	850	1468	140	248	15,992
Membership	BLS	2012	thousands	66	207	820	1338	93	217	14,366
Female	BLS	2013	%	13.1	22.6	9.1	28.7	43.7	39.2	47
Race										
Black	BLS	2013	%	5.5	10.8	5.1	9.5	6.2	**14.2**	11.2
Latino	BLS	2013	%	**20.1**	10.2	**25.5**	15.7	8.2	**27.2**	15.6
Asian	BLS	2013	%	1.5	3.2	2.1	**6.8**	**9.7**	3.5	5.7
White/Other	BLS	2013	%	72.9	75.8	67.3	68	75.9	55.1	67.5
Full & Part Time										
<35 hours	BLS	2012	%	8%	16%*	18%	11%	20%**	20%**	25%
>35 hours	BLS	2012	%	92%	84%*	82%	89%	80%**	80%**	75%
<35 hours	BLS	2012	#	68	1060*	1338	1567	2780**	2780**	33852
>35 hours	BLS	2012	#	836	5607*	5897	12479	11264**	11264**	101383

** Figures are for broader "Transportation and Utilities" industry group. ** Figures are for broader "Professional and Business Services" industry group.*
[a] Professional, Scientific and Technical Services. [b] Management, Administration and Waste Services.

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[xxv] See Appendix G. To sense-check this, we compare the proportionate share of the state's customers to the number of customers of major utilities and cooperatives in the region, and find that they are roughly equal (1.31 million v 1.55 million). Because we would expect some of these utilities and coops' customers to be outside the region, we consider this reasonably equal.
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