

An Economic Assessment of Net Employment Impacts from Regulating Coal Combustion Residuals



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Electricity is an integral part of the U.S. economy, with nearly 50-percent of the nation’s electricity produced from coal. Coal-based generation powers U.S. homes, industries, and manufacturing. The byproducts of coal combustion—coal combustion residuals (CCRs)—are used as a material input in the infrastructure that supports U.S. commerce, including roadways, bridges, and buildings. CCRs are recycled into materials used to construct homes, such as wallboard, cement, and roofing shingles.

The regulation of CCRs as proposed by EPA would impact the economics of coal power plants, the beneficial use industries that manufacture products from CCRs, electricity customers, and consumers of products made from CCRs. Changes to CCR handling, management, and disposal practices to comply with the proposed regulation would present new costs and impact the financial viability of some generating units. Increases in operating costs and the premature retirement of some coal-based generating units would lead to increased electricity prices and job impacts. Regulation that reduces the amount of CCRs beneficially used would cause job losses in industries that use CCRs, while industries associated with CCR handling and waste management would experience increased demand and add jobs.

This report presents an overview of EPA’s proposed regulation of CCRs and the impact of the proposed regulatory options on jobs. The analysis assesses the net job impacts in the electric generating industry, industries that recycle CCRs, industries that supply services and equipment to the electric generating industry, and industries that use electricity.

Key findings include:

- The Subtitle C regulation of CCRs would lead to a total of 183,900 to 316,000 job losses nationwide.
- The Subtitle D regulation would result in 39,000 to 64,700 job losses nationwide.

This report was prepared for Utility Solid Waste Activities Group (USWAG) by Veritas Economic Consulting.

Front Cover Photos (from left to right):

Concrete being laid down for a roadway. Using fly ash in concrete improves its “workability, reduces segregation, bleeding, heat evolution and permeability, inhibits alkali-aggregate reaction, and enhances sulfate resistance” (USDOT 2011).

Pittsburgh lit up at night. Coal-based generation provides almost half the electricity produced in the United States (EIA 2011).

The Freedom Tower in New York City will use Class C fly ash in its foundation, core and support columns, and slabs, totaling more than 240,000 yards of concrete with mix designs of 40-percent fly ash (ACAA 2008).

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Executive Summary

The regulation of coal combustion residuals (CCRs) as proposed by EPA would impact the economics of coal power plants, industries that recycle CCRs into products, electricity customers, and consumers that use products made from CCRs. Compliance with CCR regulation would present new costs and impact the financial viability of some coal-based generating units. Premature generating unit retirements and increased electricity prices would lead to regional employment impacts. The proposed CCR regulation would restrict the use of CCRs in some applications, which would cause economic impacts to beneficial use industries. Stigma and liability concerns associated with Subtitle C regulation may further impede recycling efforts, causing additional job losses in industries that use CCRs. In other sectors such as waste management and process equipment manufacturing, increased revenues would result in job additions.

This study quantitatively evaluates the net employment impacts associated with the regulatory options proposed by EPA—regulation under Subtitle C or Subtitle D of the Resource Conservation and Recovery Act (RCRA).¹ The geographic variation in the distribution of coal power plants would produce regional variation in electricity price impacts and job impacts. Thus, this analysis examined regional employment impacts due to premature generating unit retirements, electricity price increases, job losses in industries that use CCRs, impacts to sectors that supply goods and services to the electric power industry, and increases in employment in sectors related to CCR handling and disposal.

Table 1 summarizes the results of the analysis. As Table 1 shows, Subtitle C, the most stringent option imposing the highest compliance costs, would result in a loss of 183,900 to 316,000 jobs throughout the country. Comparatively, EPA’s proposed Subtitle D regulation would result in 39,000 to 64,700 job losses. As Figure 1 shows, the Midwest region is expected to experience the largest number of job losses.

Table 1: Summary of Job Impacts from the Proposed Regulatory Options

Proposed Regulatory Option	Description	Cost to Industry 3% Discount Rate Over 20 Years	Estimated Job Losses
Subtitle C	CCRs destined for disposal are regulated from the point of generation to the point of final disposition; surface impoundments are completely phased out; in-plant engineering retrofits are required to meet RCRA hazardous waste standards; landfills must meet siting and design criteria	\$78.92 billion to \$110.00 billion	183,900 to 316,000
Subtitle D	National liner, siting, and stability criteria for impoundments and landfills; surface impoundments must retrofit to meet liner and siting requirements or close	\$22.77 billion to \$34.66 billion	39,000 to 64,700

Sources: *Cost Analysis of Proposed National Regulation of Coal Combustion Residuals from the Electric Generating Industry* (EPRI 2010) Veritas estimates of Subtitle D rule follow methodology presented in EPRI (2010)

¹ EPA has also proposed a modification to the Subtitle D rule, which would allow surface impoundments to continue to operate until the end of their useful life if the impoundments meet requirements that include groundwater monitoring and dam integrity standards. Job impacts associated with this option were not evaluated.

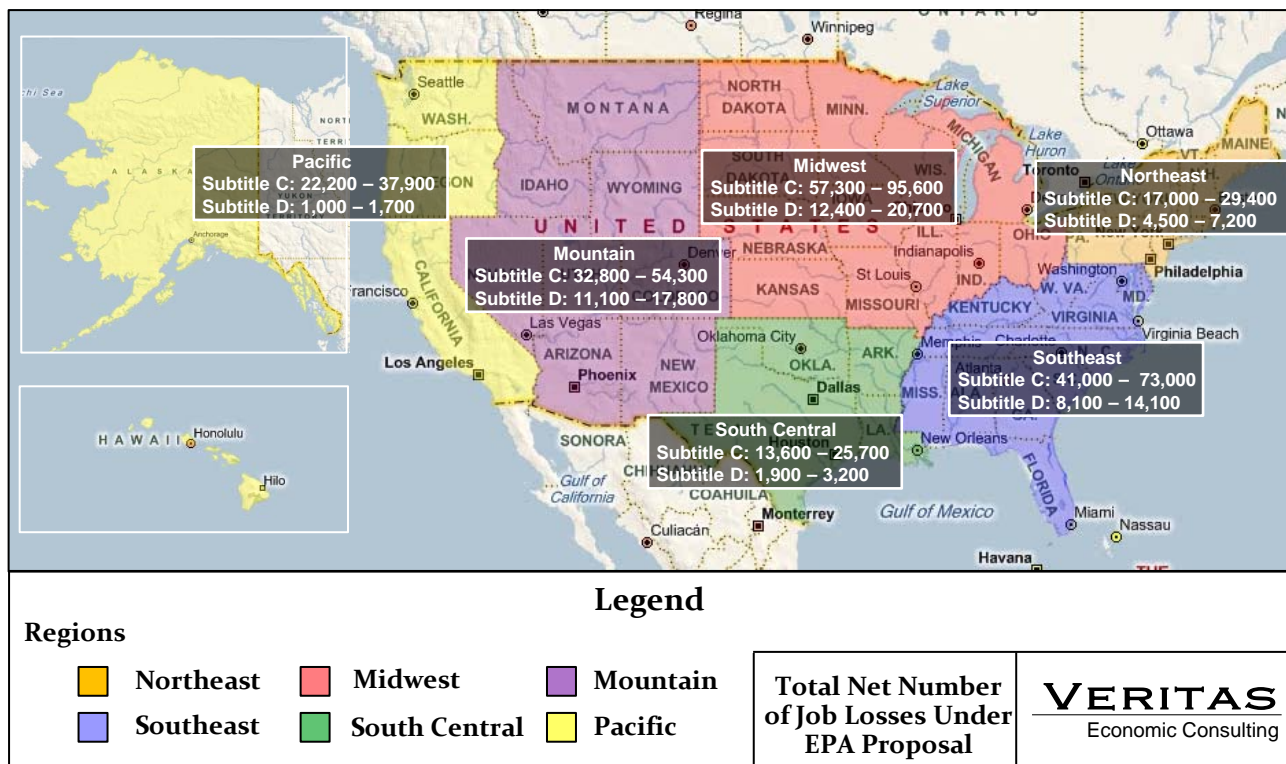


Figure 1: The Midwest would have the highest number of job losses from Subtitle C regulation (57,300 to 95,600 jobs). These estimates include impacts from unit retirements, electricity price increases, losses in the beneficial use industry, gains in waste management and CCR handling equipment manufacturing, and indirect and induced impacts in other industries.

To evaluate the impact of CCR regulations on jobs, this study estimates:

- The financial impacts of compliance costs on coal-based generating units using the Environmental Policy Simulation Model (EPSM) to identify units that are expected to prematurely retire as a result of the regulation and the changes in electricity prices resulting from increased costs for units that continue to operate.
- Job losses in the electric generating sector associated with unit retirements using plant-level employment data and job gains associated with replacement gas-based generation.
- Job losses expected to occur as a result of increases in electricity prices by assessing regional electricity price increases.
- Job gains in sectors associated with CCR handling and disposal by applying increased revenues from compliance expenditures to the relevant industries, including commercial waste management, material handling equipment manufacturers, and engineering and management consulting.
- Job losses in the beneficial use sector for two scenarios: elimination of unencapsulated uses of CCRs due to direct regulation and reduction of encapsulated uses due to liability issues or stigma effects. Changes in production costs for beneficial use industries associated with replacing CCRs with other materials are estimated and the corresponding reduction in demand is calculated based on industry-specific characterizations.
- The total net job impacts from the proposed regulation by estimating the indirect and induced employment impacts using an input-output model to evaluate the economic relationships between industry sectors.

CCR Regulation Would Affect Sectors Throughout the U.S. Economy

Nationally, 47% of electricity is generated from coal (EIA 2011). Coal provides baseload electricity generation, powering U.S. manufacturing, industry, businesses, and homes. The byproducts of coal combustion include fly ash, bottom ash, boiler slag, and synthetic gypsum—collectively called coal combustion residuals (CCRs). CCRs are used as a material input to several industries, including concrete production, building products, and road construction. CCRs have been recycled into a wide variety of products and applications, with over 55 million tons of CCRs beneficially used in 2009 (ACAA 2011). The proposed regulation of CCRs would impact not just the electric generating industry, but also electricity customers; industries that market, use, or manufacture products using CCRs; and consumers of those products.

The proposed CCR regulation would impose new costs on the management and disposal of CCRs, causing some generating units to prematurely retire. Some compliance costs would be passed on to electricity customers through higher electricity rates, which would add to the costs of industries and lead to job losses in other sectors. Figure 2 illustrates the economic linkages between coal power plants and the major industries that would be affected by the regulation. Regulation that affects the recycling of CCRs could cause these industries (shown in green) to find substitute materials, which can be more expensive. This would cause costs and prices to rise, reducing demand in each sector. Industries associated with waste management and CCR handling (shown in blue) may experience increases in economic activity associated with the regulation.

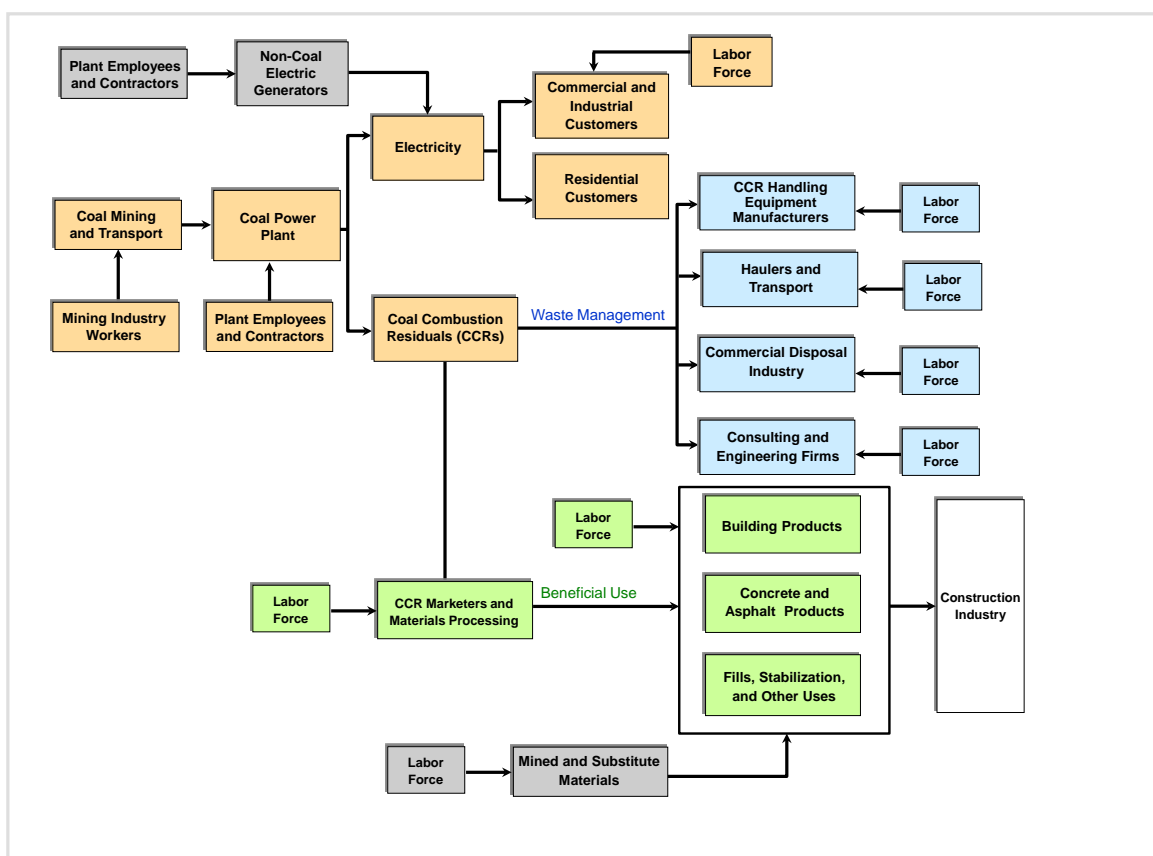


Figure 2: Unit retirements, changes in electricity prices, changes in the amount of CCRs recycled, and increased expenditures on CCR management would cause economic impacts throughout the economy.

Evaluating the impact that CCR regulation would have on jobs requires characterizing the economy under two separate conditions:

- The baseline or “without regulation” condition of the electric generating industry
- The direct costs of the regulation, and the economic responses to the regulation within the regulated industry and in affected industries.

This “without” and “with” regulation approach is central to all regulatory and economic impact analyses.

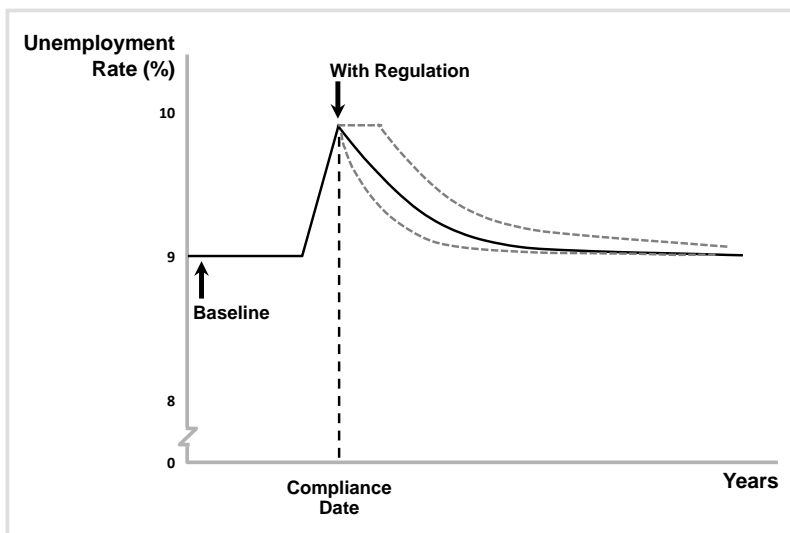
HIGHLIGHTS

- In the U.S., 47% of the electricity generated is derived from coal.
- In 2009, over 41% of CCRs were recycled into products used in construction, such as concrete, bricks, wallboard, and roofing shingles.
- Bridges, roadways, and large infrastructure projects utilize large amounts of CCRs.

Sources: EIA Electric Power Monthly (2011)
 ACAA 2009 Production & Use Survey (2011)
 American Coal Council *Economic Assessment* (2010)

The evaluation of these two economic conditions produces a number of potential metrics, including generating unit shutdowns, electricity price changes, and jobs impacts. Figure 3 illustrates this process with respect to unemployment. Because the costs of compliance could exceed the expected stream of future revenue for some units, they would prematurely retire. As a result, unemployment rates would increase, as shown in Figure 3. Because CCRs are currently used as inputs to manufacturing and construction industries, the regulation may cause those industries to switch to higher-cost substitute materials, which would lead to higher costs for their products. Industries that are not able to pass those costs on to consumers may be forced to decrease production and may also have to decrease their work force, leading to further job losses.

Over time, the difference in the unemployment rate under the “with regulation” and “without regulation” scenarios may decrease as unemployed workers find new employment in the affected community or relocate to other areas for employment. The regulation’s corresponding impact is the difference in what the unemployment would be without regulation, illustrated as the Baseline in Figure 3, and what the unemployment rate is estimated to be with regulation, illustrated by the band between the dotted lines. The band in Figure 3 reflects that current and future economic conditions can affect how quickly the unemployment rate rebounds to baseline levels. When unemployment is high and jobs are scarce, it takes displaced workers longer to find new employment. Currently the U.S. unemployment rate is 9% (U.S. Bureau of Labor Statistics 2011b).



- ### Uses of CCRs
- Roads and bridges
 - Buildings
 - Wallboard
 - Concrete masonry blocks
 - Portland cement
 - Roofing tiles/shingles
 - Surface coatings of asphalt
 - Road base
 - Mine reclamation
 - Paints, coatings, and adhesives
 - Soil stabilization
 - Embankments
 - Fills (flowable, structural)
 - Snow and ice control for roadways

Figure 3: As a result of electric generating units retiring prematurely, unemployment rates increase.

Regulatory Specification Would Significantly Affect Costs

EPA has co-proposed two regulatory options for disposal of coal combustion residuals (CCRs) generated by electric utilities (75 *Fed. Reg.* 35127–35264):

- Listing CCRs destined for disposal as a special listed waste under Subtitle C of the Resource Conservation and Recovery Act (RCRA)
- Regulating CCRs under Subtitle D of RCRA by issuing national criteria for CCR disposal including minimum liner and siting criteria.

The Subtitle C and Subtitle D regulatory approaches proposed by EPA require the closure of surface impoundments that do not meet minimum design and performance standards. However, the Subtitle C option has additional substantive requirements and restrictions. Table 2 summarizes the requirements of each option. The costs of the regulatory options proposed by EPA are summarized in Table 3. These are the estimated costs to the electric generating industry and do not reflect the cost to the beneficial use industry or individuals who will experience employment dislocations with these options. The potential net employment impacts of EPA’s proposed regulation is the subject of this report.

Table 2: Overview of Requirements by Proposed Option

Proposal Requirements	Subtitle C	Subtitle D
New landfills must meet minimum liner, siting, and performance criteria	✓	✓
Existing landfills must meet groundwater monitoring requirements	✓	✓
Surface impoundments must remove solids and retrofit to meet liner and siting criteria or close	✓	✓
Land disposal restrictions and treatment standards for wastewater and nonwastewater CCRs	✓	
Complete phase out of surface impoundments	✓	
Engineering retrofits for secondary containment and structural requirements for boilers, tanks, dewatering bins, buildings, and conveyance equipment	✓	
Tank-based wastewater treatment systems	✓	
RCRA Facility Investigation	✓	
Financial assurance	✓	under consideration using CERCLA authority
Closure of legacy impoundments to RCRA C standards	✓	
Disposal of CCRs in Subtitle C landfill	✓	

Subtitle C Regulatory Option

EPA would list CCRs destined for disposal as a “special waste” under RCRA Subtitle C—the federal program to manage hazardous wastes. The Subtitle C proposal would reverse the Bevill exemption for CCRs destined for disposal, regulating CCRs “from the point of their generation to the point of their final disposition, including during and after closure of any disposal unit” (75 Fed. Reg. 35133). The requirements of RCRA Subtitle C include siting and liner criteria, land disposal restrictions, groundwater monitoring, dust control, financial assurance, generator permits, secondary containment for tanks, and structural requirements for CCR storage handling and equipment. The “combined requirements under subtitle C would effectively phase-out all wet handling of CCRs and prohibit the disposal of CCRs in surface impoundments” (75 Fed. Reg. 35157).

Surface impoundments would be required to cease receiving CCRs within five years and close within seven years. Subtitle C regulation would also require the closure of legacy impoundments to RCRA C standards, the cost of which has not been assessed, but could be significant. Because CCRs would be regulated from their point of generation under Subtitle C, coal power plants would require retrofits and engineering modifications to “upstream” CCR handling and storage equipment and buildings. The cost estimates in Table 3 reflect these plant engineering upgrades and conversions required to meet Subtitle C requirements. These estimates also include increased disposal costs due to the additional landfill siting restrictions under Subtitle C. These upstream compliance costs and increased disposal costs due to siting restrictions have not been estimated by EPA nor included in the Regulatory Impact Analysis for the proposed rule (Santojanni 2011).

Subtitle D Regulatory Option

The Subtitle D option proposed by EPA would establish national criteria for impoundments and landfills including liner requirements, siting restrictions, stability criteria, groundwater monitoring, and closure and post-closure requirements. Existing impoundments would be required to remove solids and retrofit with a composite liner or cease receiving CCRs within five years and close within 210 days after ceasing the receipt of CCRs (75 Fed. Reg. 35128, 35252-53).

HIGHLIGHTS

- The cost of the Subtitle C rule is \$78.9 billion to \$110.0 billion.
- By comparison, the Subtitle D rule is expected to cost \$22.8 billion to \$34.7 billion.
- Under Subtitle C, CCRs would be regulated from the “point of generation,” requiring retrofits and upgrades to upstream CCR handling and storage equipment.
- Some power plants would be unable to meet Subtitle C landfill siting criteria, sending approximately 15 million to 20 million tons of CCRs to commercial hazardous landfills each year.

Sources: EPRI’s *Cost Analysis of Proposed National Regulation of Coal Combustion Residuals from the Electric Generating Industry* (2010)
Veritas estimates of Subtitle D rule follow methodology presented in EPRI (2010)

Table 3: Summary of Costs by Proposed Regulatory Option

EPA Regulatory Option	Cost to Industry 3% Discount Rate Over 20 Years (\$ billions)	Source
Subtitle C	\$78.9 – \$110.0	EPRI (2010)
Subtitle D	\$22.8 – \$34.7	Estimated in Current Study

Impacts Should Be Assessed on a Regional Basis

The abundance of coal-based electric generation in the United States indicates that CCR regulation could have significant financial impacts on the electricity generation sector overall. Coal-based generating plants are not evenly distributed across the U.S., but are geographically concentrated. In some states, over 80 percent of electricity generated is from coal, including Indiana, Kentucky, Missouri, Utah, West Virginia, and Wyoming (EIA 2011). Figure 4 shows the percentage of electric generation from coal for each state. CCR regulation would affect the financial outlook for coal units within each of these states.

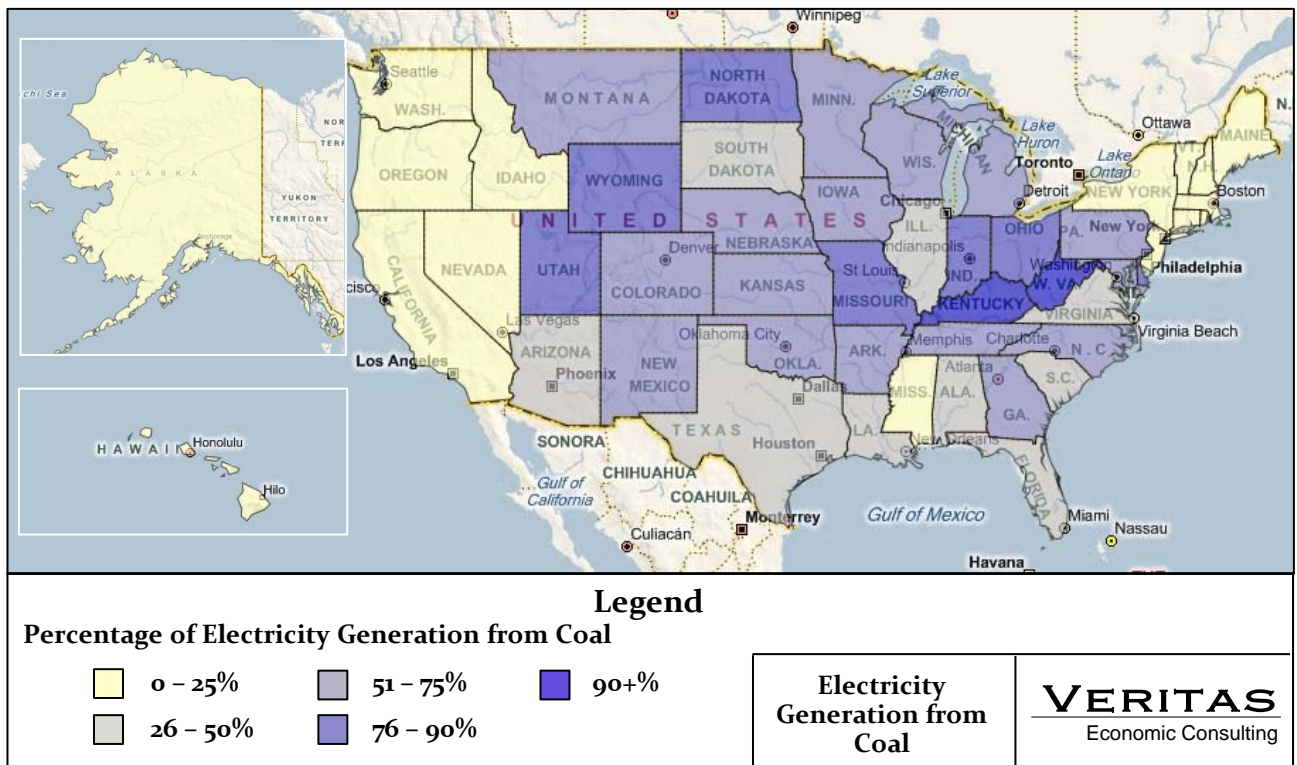


Figure 4: The national average percentage of electricity generation from coal is 47%. West Virginia has the highest percentage of generation from coal (96%). States fully or partially in MISO have an average of 65% electricity generation from coal (EIA 2011).

The location of the generating facilities subject to CCR regulation is shown in Figure 5 along with the Independent System Operator (ISO), Regional Transmission Organization (RTO), or North American Electric Reliability Corporation (NERC) region in which each facility participates. ISOs and RTOs coordinate, control, and monitor the operation of the electrical power system, with some acting as a marketplace for wholesale power. The implication of this geographic distribution is that the employment impacts of CCR regulation would be unequally distributed throughout the U.S. Depending on the technical characteristics and financial situation of each unit, some owners may decide to repower or prematurely retire the generating unit, while others might convert their ash handling and disposal systems and continue to operate in the post-regulation market. These economic decisions are influenced by the potential to recover some of the increased costs of production through higher prices for electricity.

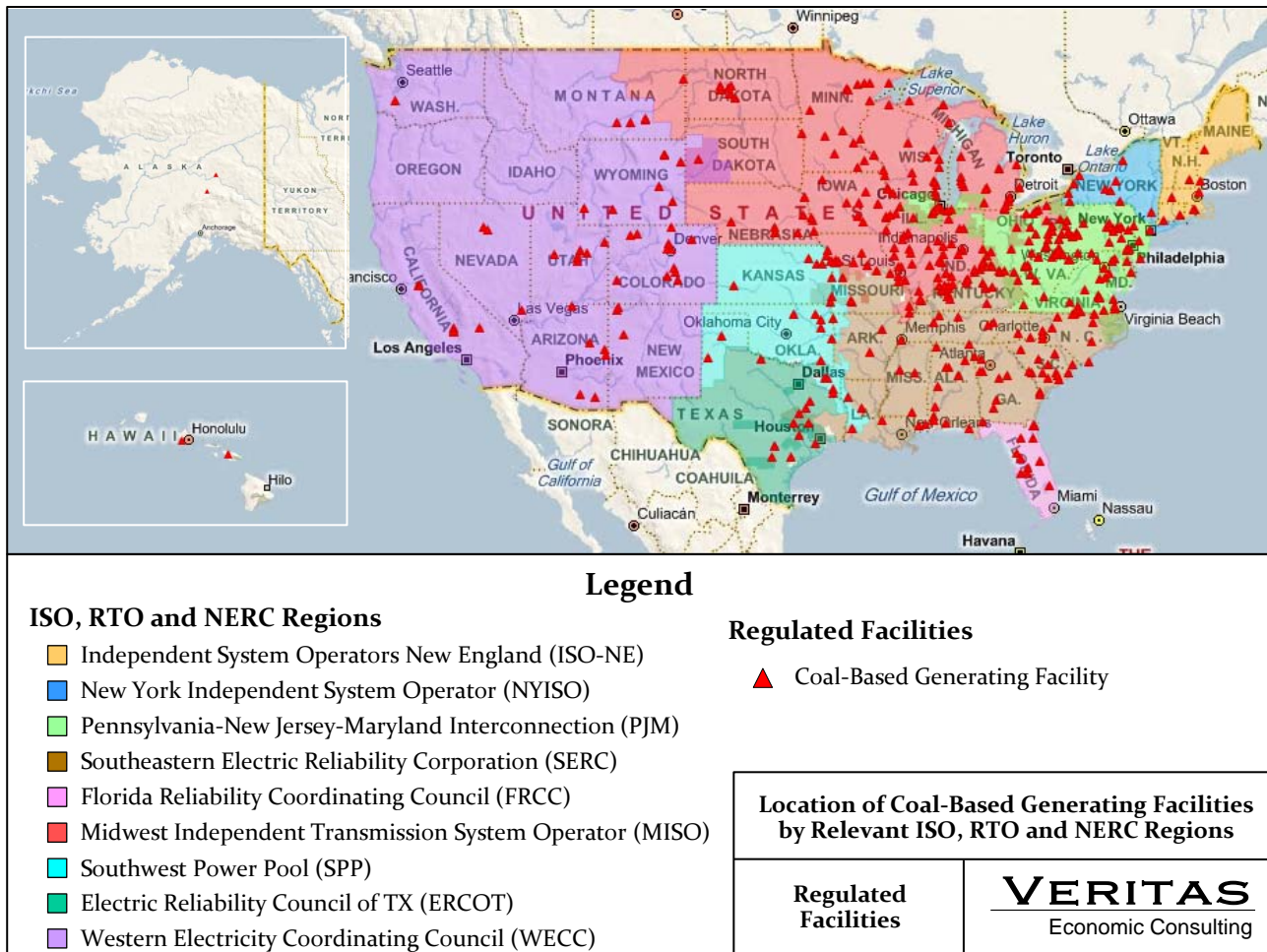


Figure 5: The analysis includes each generating facility subject to the regulation and its location by ISO, RTO, and NERC region.

While regulated utilities may be able to recover costs through rate cases, independent power producers would have to generate the funds from their financial systems. If the owner decides not to convert, the owner’s financial system would be affected by the forgone cost and revenue streams from the unit’s premature retirement.

These decisions occur in the context of economic markets. Economic markets for electricity arise within the interconnected systems of generators and wires that link producers and consumers. The electric transmission system consists of the power lines, towers, and equipment needed to safely and reliably move high-voltage power over long distances from disparate power generation sources to regional distribution systems that serve load centers. This system allows electricity generators to be spatially distant from load. Important economic features of these systems result from impracticalities of large-scale electricity storage and the location-specific nature of electricity generation, load, and delivery. Combined with temporal variation in load, these features lead to time- and location-specific electricity costs. Because units subject to CCR regulation are connected to different transmission systems, price impacts are expected to be location specific. Impacts to prices are expected to depend upon the type of units expected to close. Closures of baseload units would tend to drive up electricity costs in all time periods. Closures of load-following units would tend to primarily impact peak prices, whereas closures of units that rarely run might impact electricity prices very little.

Evaluating Job Impacts—Overview of Methodology

The CCR regulation as proposed by EPA would cause job losses in some sectors and job gains in others. As a first and commonly employed estimation, industries that experience demand reductions are expected to eliminate jobs; industries that would experience increases in revenues are expected to create jobs. These effects extend throughout the economy through direct, indirect, and induced job impacts:

- Direct impacts occur in the industry that is regulated—job losses due to unit retirements, and electricity price increases. Because CCR regulation would reduce recycling of CCRs, we also include the direct impacts of job losses in the beneficial use industries.
- Indirect impacts are changes in supplying industries as they respond to changes in directly affected industries. Indirect impacts would include job losses in the coal mining industry due to reduced demand for coal, as well as job increases in the waste management industry and CCR handling equipment manufacturing due to increases in demand for services.
- Induced job impacts reflect changes in local spending that result from job impacts in the directly and indirectly affected industry sectors.

Figure 6 presents a simplified illustration of how direct job losses from premature generating unit retirements would cause indirect and induced job losses. Generating unit retirements and increased electricity prices are estimated using EPSM, a dispatch simulation model that evaluates regional changes in electricity prices as a result of changes in production costs due to regulation (Veritas 2011). EPSM incorporates the technical characteristics of all thermal generating units including heat rate, capacity, and fuel type. Baseline electricity price and generation projections are consistent with external forecasts from ISOs and RTOs. The model has been used to support regulatory submittals (Mirant Canal 2009) and analyze the impacts of environmental policies for the Electric Power Research Institute (INL 2010). Estimated unit closures from EPSM for other environmental regulations have been consistent with similar studies (NERC 2010).

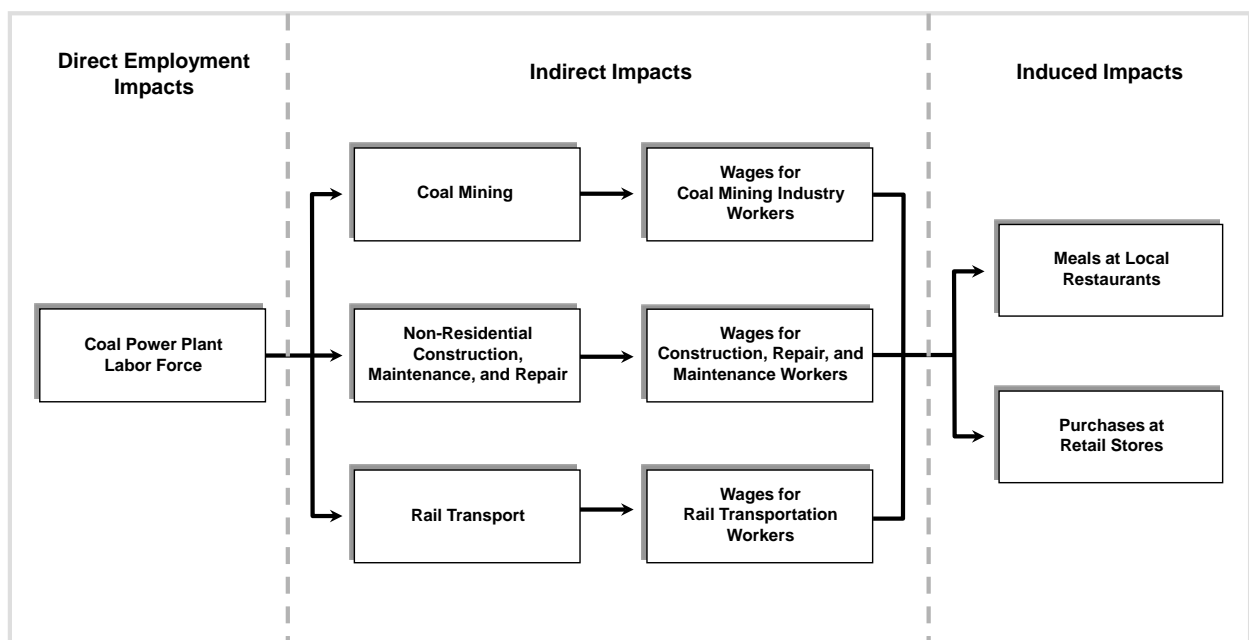


Figure 6: Job losses in the regulated industry produce indirect impacts in supplier industries and induced job losses in the affected community. Job losses in the beneficial use industry would also produce indirect and induced impacts.

To estimate the indirect and induced effects, the analysis uses an economic technique called input/output (I/O) analysis. To develop and conduct the I/O analysis, we used the IMPLAN program, which is designed to estimate indirect and induced employment impacts (MIG, Inc. 2009). IMPLAN contains detailed input-output information on more than 500 economic sectors at the national level, and has been used by state and federal government agencies for the analysis of employment impacts.

HIGHLIGHTS

- Generating unit retirements and electricity price increases are estimated with the Environmental Policy Simulation Model.
- Indirect and induced job impacts are estimated using IMPLAN.

Sources: Veritas' Environmental Policy Simulation Model (EPSM) (2011). See www.veritaseconomics.com/Working%20Papers/EPSM_20101.pdf for more details.
MIG, Inc.'s IMPLAN (2009)

To develop the national job impacts estimate, we evaluate the net employment impacts that might occur from the regulation at a detailed resolution for the Midwest ISO region (MISO) illustrated in Figure 7. Generating unit retirements and replacement generation in other regions are estimated using baseline net present values (output from EPSM) compared with unit-level compliance costs for each regulatory option developed according to the methodology presented in EPRI (2010). Using the relationship between total compliance costs and electricity price increases in MISO, we extrapolate job impacts to other ISO regions. The extrapolation is based on regional market structures and size, and the magnitude of compliance costs for each region. IMPLAN is used to identify the relationship between unit retirements and indirect and induced job impacts in two states: Minnesota and Illinois. We then extrapolate those impacts to the remainder of the U.S. by using state-level economic activity in the directly affected industries.

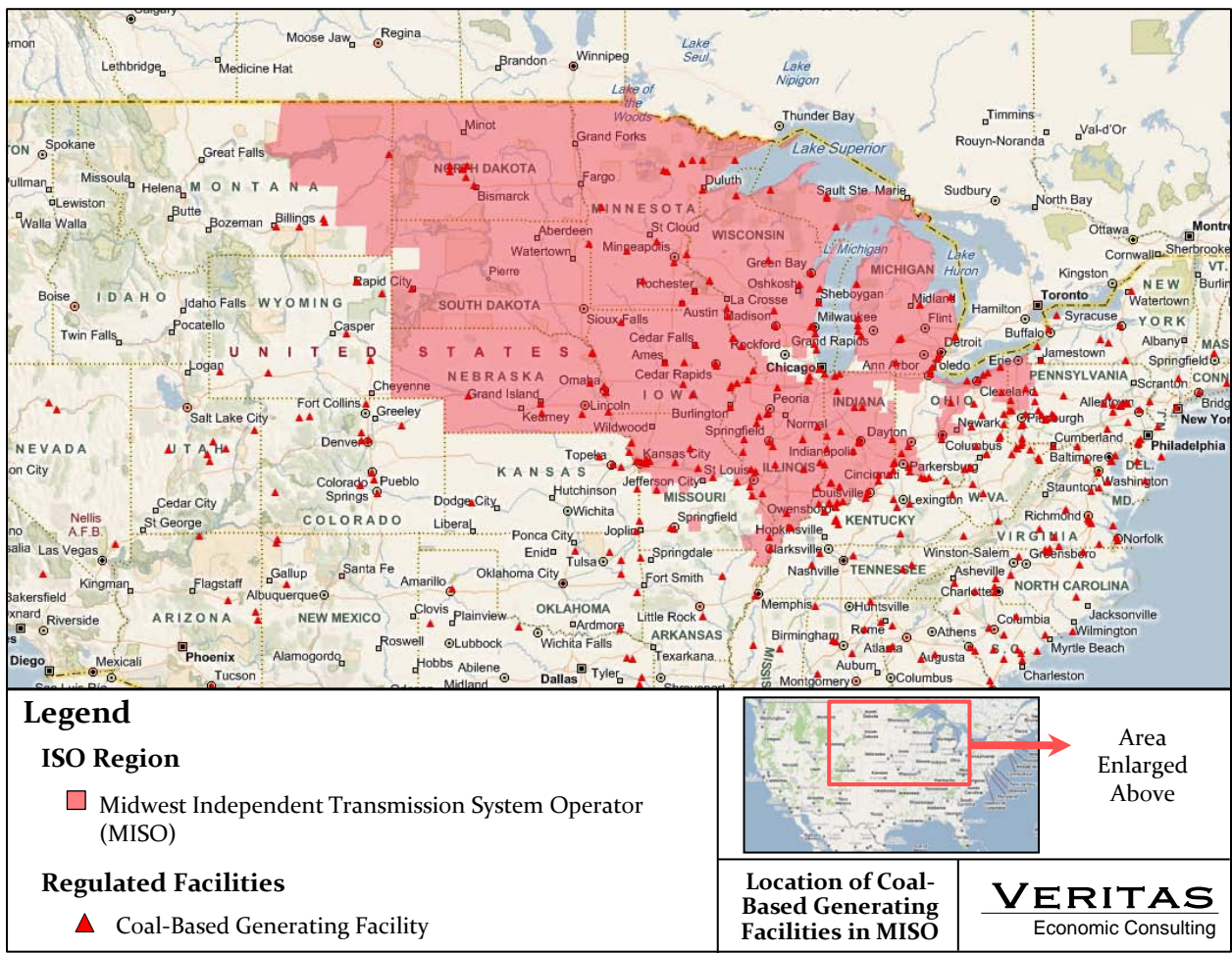


Figure 7: An electricity market model for MISO projects unit retirements and electricity price increases for the proposed regulatory options. MISO fully or partially covers 13 states.

Job Impacts from Changes in the Electric Generating Industry

Regulation of CCRs would result in new compliance costs for the coal-based electric generating industry. The financial impact of these costs on individual generating units would depend on the current economic status of the unit which is a function of its annual generation, the efficiency and age of the unit, and the electricity market in which the unit operates. The net present value of coal units under the Subtitle C and Subtitle D regulatory scenarios was used to identify which units would prematurely retire. The “with regulation” simulation was conducted for MISO using EPSM to assess the effects of increased electricity prices on unit net present values.

These estimates were extrapolated nationally by comparing the estimated stream of revenues for each unit with compliance costs. The corresponding job losses from unit shutdowns are estimated using the employment statistics for each of the retired units from regulatory report filings (FERC 2011; USDA Rural Development 2011). Job gains associated with replacement gas-based generation are similarly estimated. Because a gas-based generating unit requires less employees than a coal-based generating unit, the result is a net loss of jobs in the electric generating industry. In addition to these direct job impacts, the premature retirement of coal units and increased demand for waste management services would lead to corresponding employment impacts in related industries that provide services and supplies to coal power plants, and in the local community. Figure 8 presents the net job losses by geographic region due to these changes. As can be seen from Figure 8, some regions are more heavily impacted due to the concentration of industries that supply labor and other production inputs to the plant.

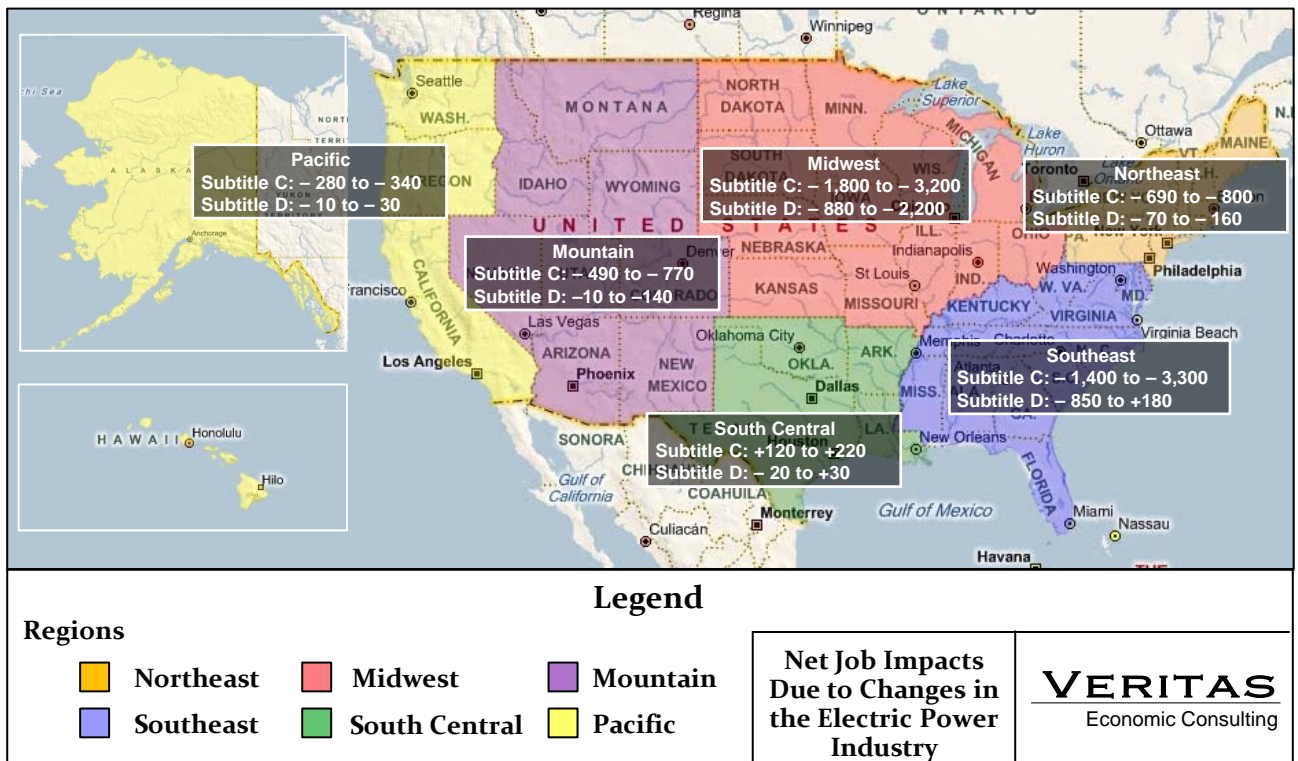


Figure 8: Changes in the electric generating industry including unit retirements and increased expenditures on CCR handling and disposal would lead to job impacts in other industries that supply goods and services to electric generating plants, as well as job impacts in the local economy.

HIGHLIGHTS

The net estimated job losses accounting for premature unit retirements and job gains for replacement gas-based generation are:

- Subtitle C: 6,300 to 7,600
- Subtitle D: 1,800 to 2,800

The total net job losses accounting for coal mining losses and employment increases in CCR handling and waste management industries are:

- Subtitle C: 4,400 to 7,900
- Subtitle D: 760 to 3,400

In addition to evaluating the indirect and induced job losses using IMPLAN, the analysis more thoroughly quantified the indirect effects of the regulation on the coal mining, waste management, and CCR handling and equipment manufacturing industries. Should coal units shut down or re-power using another fuel, coal mines could be affected by reduced demand. This decrease in demand is correlated to jobs based on labor statistics for coal mining (National Mining Association 2010). Coal power plants use most of the coal from U.S. mines (EIA 2009).

The indirect impacts to the waste management industry were estimated using predicted increases in revenue from commercial disposal of CCRs and current sales for the industry from census data (U.S. Census Bureau 2011a). Job impacts in industries related to CCR management, including process equipment manufacturing, are estimated by applying estimated capital expenditures on CCR handling equipment and plant retrofits to calculate employment increases.

Figure 9 summarizes the job impacts within each of these sectors as well as the three sectors that IMPLAN predicts would have the next largest job losses. As the figure shows, hazardous waste management and CCR handling industries would experience job gains, while coal mining and electric power generation would experience net job losses. The waste management sector would create more jobs to support the management of hazardous waste facilities to accommodate CCRs generated from coal plants that are predicted to use commercial landfills for disposal. The CCR handling and equipment manufacturing sector could add jobs to accommodate the increased demand for CCR storage and conveyance equipment, as well as engineering and management consulting support. As shown from Figure 9, fewer jobs are lost with Subtitle D regulation.



Figure 9: Due to changes in the electric power industry to comply with CCR regulation, other industries also experience employment impacts. Some industries such as waste management would add jobs, while other sectors such as coal mining would lose jobs due to reduced demand. The number labels in the graph reflect the Subtitle C job losses.

* The addition of jobs for replacement gas-based generation is shown for the electric power sector.

Job Losses Resulting from Electricity Price Increases

Environmental compliance costs have the potential to raise electricity rates as the costs of producing electricity increase. To better understand the potential price implications of CCR regulations, EPSM, an electricity market simulation model, was run for the Midwest Independent System Operator, Inc. (MISO). The model employs Baseline and With Regulation simulations as illustrated in Figures 10 and 11 below to identify price changes. Figure 10 represents a merit-order curve and market-clearing price under Baseline. In Figure 11, compliance requirements have been applied to the cost streams of regulated units and the model re-dispatched to create a With Regulation market simulation. As depicted in the figures, certain units are no longer profitable to operate and prematurely retire. Other units experience increased costs but continue to operate. As a result, overall system costs increase. This is reflected in the movement from the blue Baseline cost curve to the red With Regulation cost curve. In a competitive market such as MISO, the price implications of these increased costs are determined by the new competitive equilibrium, which occurs where the Demand and With Regulation Supply curves intersect.

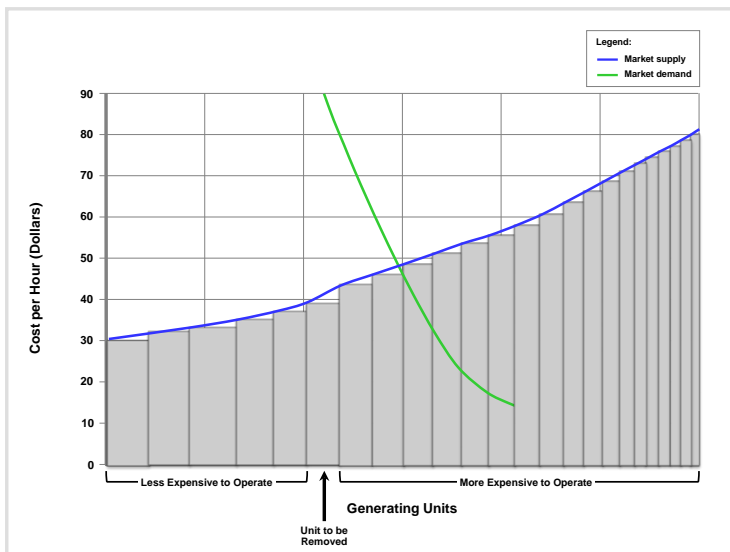


Figure 10: Baseline Electricity Supply Curve

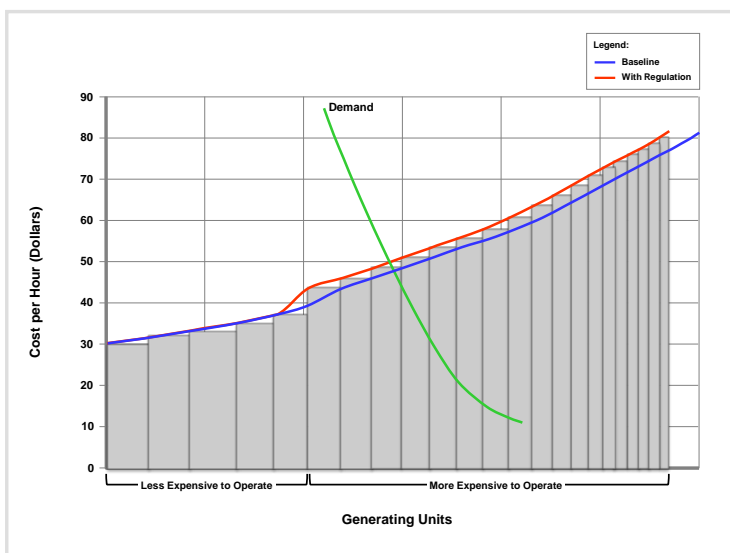


Figure 11: With Regulation Electricity Supply Curve

The results of this process project initial price increases of 1.9 percent in MISO for Subtitle C regulation. Price increases of 0.5 to 0.67 percent are projected for Subtitle D. In regions that operate as economic markets, the degree to which costs are borne by unit owners versus consumers would depend upon the types of units most affected as well as the market structure. Simulation modeling with re-dispatch was not conducted for the non-MISO generating units. The relationship between compliance costs, amount of coal-based generation and changes in electricity prices is system specific. To identify potential price increases in the remainder of the U.S., the relationship between compliance costs, electricity revenues, and price increases observed in MISO was extrapolated to other regions.

For this assessment of employment impacts, we judge that a 1% average increase in U.S. electricity rates is a reasonably likely outcome. Regional price impacts were predicted based on compliance costs relative to market size consistent with a 1% U.S. average price increase.

Changes in electricity prices can lead to economy-wide employment impacts through their effect on residential and business electricity consumers. Because of the nature of the demand for electricity, an initial outcome is that residential consumers would pay more for electricity. This leaves less disposable income available for other purposes, leading to a reduction in overall demand for all goods and services. For business electricity impacts, the commercial, industrial, and transportation sectors are all major users of electricity as an input to production. Electricity price increases would raise the costs of providing final goods and services in these sectors.

HIGHLIGHTS

- Subtitle C regulation would result in 163,700 to 261,900 jobs lost due to electricity price increases
- Subtitle D regulation would result in 38,300 to 61,300 job losses due to increases in electricity prices
- Electricity prices are projected to increase by 1.9% in MISO, and by an average of 1% overall. Some regions would be more impacted than others.

This leads to a reduction in the quantity demanded of affected industries' outputs, which impacts employment. Evidence of such effects has been studied by number of authors including Jaffe et al. (1995), Berman and Bui (2001), and Greenstone (2002). The most recent relevant study (Deschenes 2010) was conducted for the National Bureau of Economic Research and reports a relationship of a 0.16% to 0.10% reduction in employment for every 1% increase in electricity prices.

Based on this relationship, regional employment information, and calculated regional price increases, the job impacts depicted in Figure 12 were calculated. The results indicate a loss of 163,700 to 261,900 jobs nationally with Subtitle C regulation due solely to electricity price increases. Subtitle D regulation would result in 38,300 to 61,300 job losses, because electricity prices are not expected to increase as much as with Subtitle C regulation.

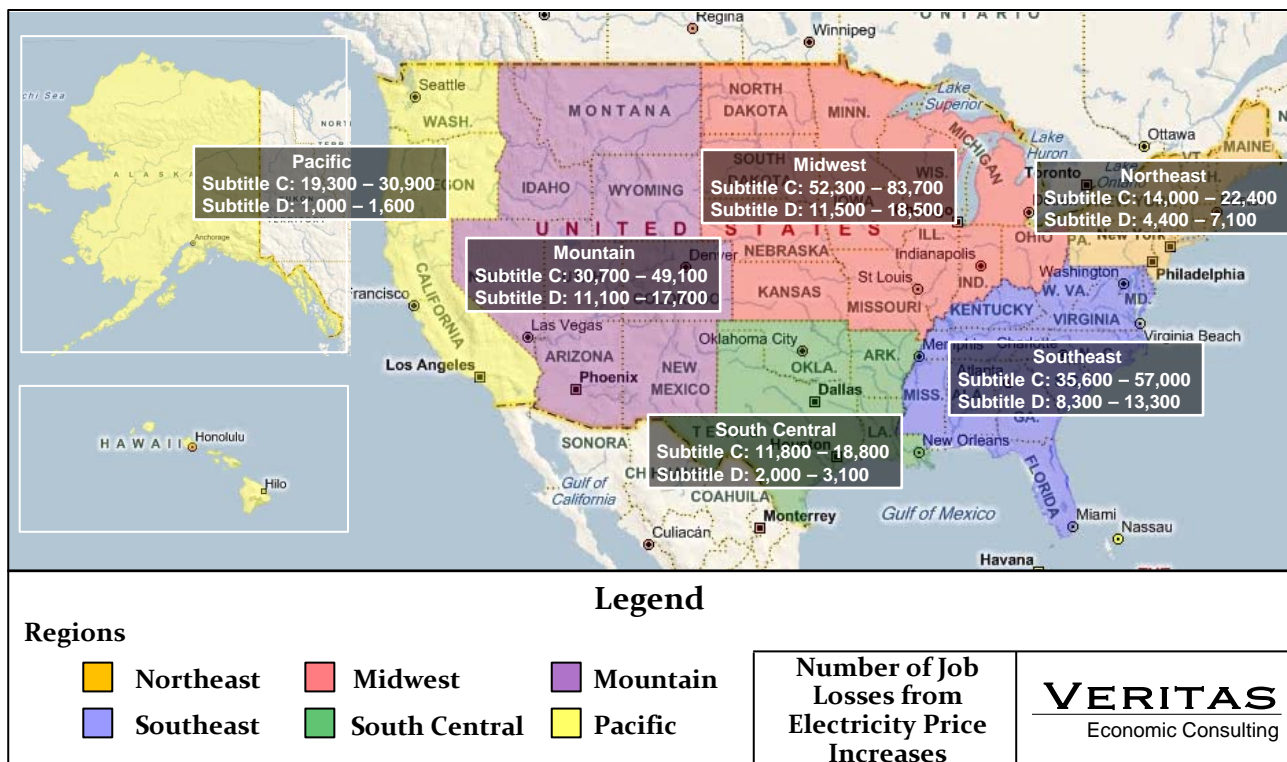


Figure 12: The regulation of CCRs as proposed by EPA would lead to increases in electricity prices. The Midwest region states are estimated to experience the most job losses. Nationally, 163,700 to 261,900 jobs would be at risk due to electricity price increases.

Job Losses in the Beneficial Use Industry

Coal combustion residuals contribute \$6–11 billion annually to the U.S. economy through revenues from sales for beneficial use, avoided cost of disposal, and savings from use as sustainable building materials (National Association of Manufacturers 2010). Among the principal industries depending on the beneficial use of CCRs are concrete and asphalt, wallboard and other building products, and road construction (American Coal Ash Association 2011; U.S. Bureau of Labor Statistics 2009, 2011a). CCR regulation could seriously impact these recycling efforts. EPA’s proposed rule explicitly considers certain “unencapsulated” uses as disposal, rather than beneficial use (75 *Fed. Reg.* 35155). These applications (such as structural fill) would be prohibited, since the regulation would require disposal in a landfill that meets the design and performance requirements of the rule.

Stakeholders have expressed concerns that liability and stigma would further impede recycling should CCRs be regulated under RCRA Subtitle C—the federal program to manage hazardous wastes (U.S. House of Representatives Committee on Oversight and Government Reform 2011). It is not clear whether consumers would continue to purchase products made with CCRs at the same rate and prices. Utilities and manufacturers that use CCRs may be unwilling to risk potential legal action over the sale and manufacturing of products made from CCRs. Regulatory commenting, recent congressional testimony, and industry surveys have provided specific examples of stigma and liability impacts even though a rule has not been finalized (Ward 2011; Stehly 2010; ACAA 2010; NRMCA 2011). Other studies have estimated the loss of 12,000 to 19,000 jobs in the construction industry due to environmental regulations including CCR regulation (Portland Cement Association 2011). The economic consequences of reduced recycling of CCRs were considered in this analysis.

JOBS IN CCR USE INDUSTRIES

Concrete Industry

Approximately 10.6 million tons of CCRs were used in concrete-related products during 2009. Those products provided employment for 240,100 manufacturing workers, 78,480 foundation, structure, and building exterior workers, and many of the 102,350 nonresidential building construction workers during 2010.

Wallboard Industry

Nearly 7.3 million tons of FGD gypsum were used in building products like wallboard during 2009. Those products provided employment for 13,800 manufacturing workers, 82,320 drywall and related installers, and 17,690 tapers during 2010.

Asphalt Products Industry

Asphalt products used in paving include recycled asphalt shingles, which are manufactured using as much as 60 percent fly ash. Asphalt products provided employment for 27,700 asphalt paving mixture/block and shingle manufacturing workers during 2008, and 99,280 roofers, 12,310 roofers’ helpers, and 51,830 paving, surfacing, and tamping equipment operators during 2010.

Road and Bridge Construction

Concrete- and asphalt-related products also provided employment for 75,290 highway, street, and bridge construction workers during 2010.

Sources: ACAA 2009 Production & Use Survey (2011)
U.S. Bureau of Labor Statistics “Occupational Employment Statistics” (2011a)
U.S. Bureau of Labor Statistics “2008 Detailed Industry Incidence Rates” (2009)

If industries are no longer able to use CCRs as an input to production they have two options:

1. Substitute another material input for CCRs
2. Close the manufacturing facility.

That decision requires consideration of the performance characteristics of the available substitutes, their delivered cost, and the cost of the facility modifications needed to use the substitute material in place of CCRs. Obviously, the closure of a manufacturing facility puts all the jobs at the facility at risk. However, if the facility finds it economic to remain open, its output could be reduced due to increased production costs from the use of substitute materials.

Materials that would replace CCRs are generally more expensive and the facilities may require modifications to use substitute materials. With higher costs and thus prices, demand could decrease and the need for employees would be reduced. Industries that manufacture comparable products without CCRs could experience higher commodity prices and may expand output, increasing employment at those locations.

Fly ash replaces 15 million tons of cement a year in its use in concrete (American Concrete Pipe Association 2010). While Portland cement sells at \$80 a ton, concrete quality fly ash sells for between \$0 and \$40 a ton (EPA 2008b). Removing CCRs from the supply chain could increase the price of concrete by an average of 10 percent (National Association of Homebuilders 2010). This cost increase would be reflected in increased housing costs because concrete foundation costs make up approximately 4.5 percent of typical new house construction costs. Other important building materials that use coal ash products include roofing shingles, paint, carpets and tiles, and asphalt. Together these comprise approximately 3 percent of typical new home construction costs. Using the increased costs for substitute materials, we estimate that housing costs would increase by 1% if CCRs are no longer used in building products. Specifying an elasticity of demand of 1.2 for the housing market, the residential construction industry would lose 7,000 jobs. Regional job losses were estimated using the number of housing starts for each state.

Similarly, non-residential building and transportation construction would be impacted by the increased costs of replacement materials for CCRs. Roads, bridges, and heavy construction utilize CCRs in structural fills, road base, cement, concrete, and asphalt products. The transportation construction industry contributes over \$120 billion annually to the U.S. economy (American Road and Transportation Builders Association 2011). Commercial and industrial construction spending totals over \$258 billion (U.S. Census Bureau 2011b). Many of the materials that would replace CCRs are similar in cost at current use rates, with Portland cement for concrete the exception. As higher cost materials are used to substitute for CCRs, production costs would increase. To estimate the employment impacts from Subtitle C regulation, the decrease in industry sales due to increased costs of replacement material were correlated to the number of jobs for each type of industry application using CCRs, such as concrete and structural fill (EPA 2008b; U.S. Bureau of Labor Statistics 2009). Non-residential building and transportation construction industries are estimated to lose 15,900 jobs due to increases in construction costs.

HIGHLIGHTS

Residential Construction

- Housing costs would increase by 1% due to Subtitle C regulation.
- The regulation would put 7,000 jobs in the residential construction industry at risk.

Non-Residential Building and Transportation Construction

- Subtitle C regulation would put nearly 16,000 jobs at risk in the non-residential building and transportation construction industries.

Impacts in Economically Disadvantaged Communities

This study evaluates how many jobs may be lost as a result of the proposed CCR regulation; however, it does not evaluate the characteristics of the individuals whose jobs are most likely to be affected nor the communities where impacts are likely to be highest. Low-income, minority, tribal, and other groups may be of particular concern. In January 2011, President Obama signed a new executive order (E.O. 13563) requiring regulatory review that takes into account competitiveness, job creation, and “distributive impacts” (76 *Fed. Reg.* 3821-3823).

The analysis conducted for this report has not been carried out at a fine-enough resolution to evaluate the varying impacts across subpopulations (e.g., lower-income workers) or different communities. However, variation in the geographic distribution of power plants subject to the regulation, the location of manufacturing facilities and coal mining, and differences in state and county-level unemployment and poverty rates suggest that the estimated job losses have the potential to more severely affect certain communities. Figure 13 presents U.S. Census statistics on state-level poverty rates throughout the United States. It also illustrates how much these levels vary by county within a specific geographic region (U.S. Census Bureau 2010). Job losses in these areas could exacerbate existing economic problems.

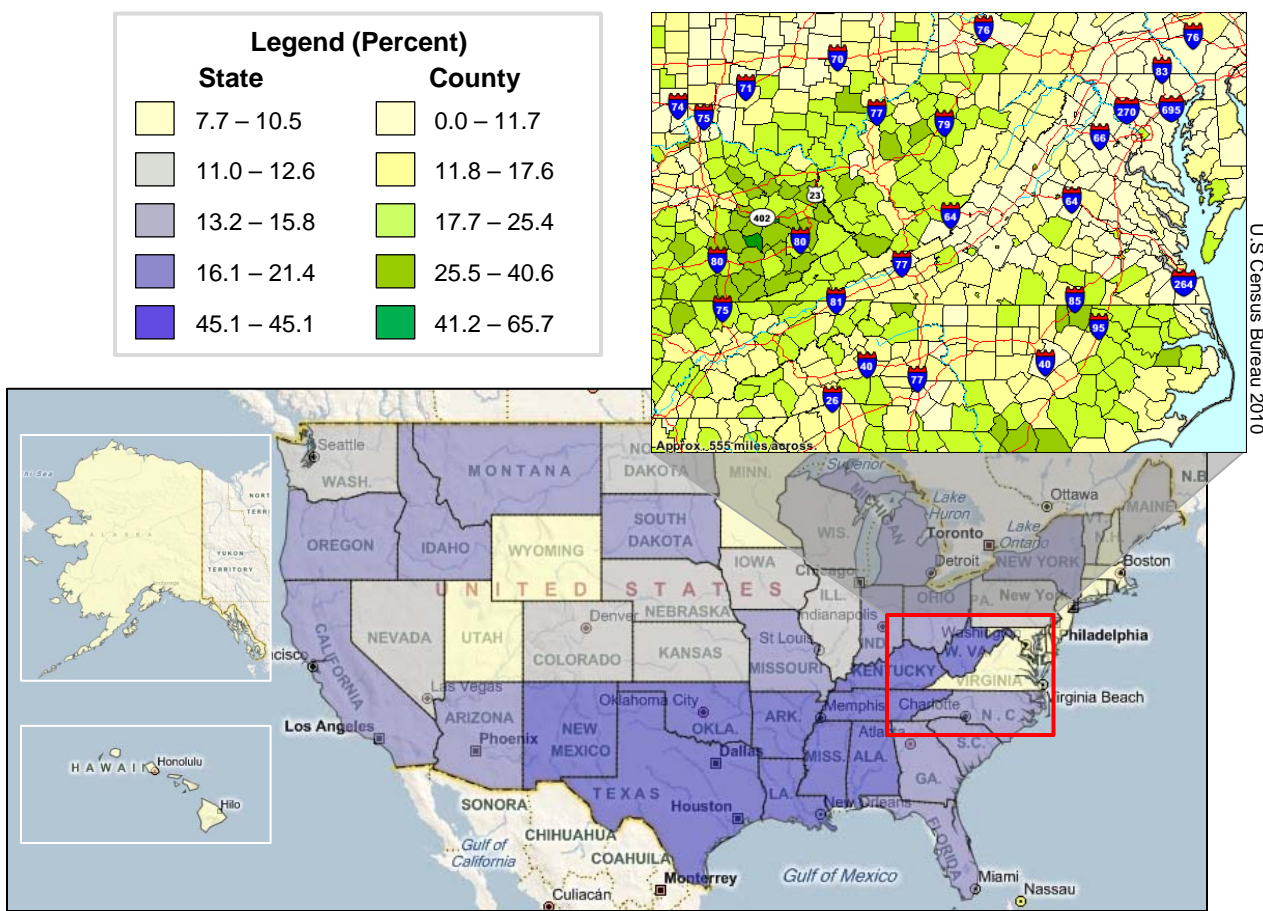


Figure 13: The percent of people living below poverty level shows wide variation by state and county. Communities with high poverty levels could be disproportionately affected by job losses.

Implications for Economic Competitiveness

Important considerations in the assessment of economic competitiveness mandated by Executive Order 13563 include the effect of multiple regulatory requirements and the potential for jobs to be off-shored due to decreased economic activity. Although a quantitative evaluation is beyond the scope of this study, the following discussion provides some context for these considerations with respect to multiple regulations and global competitiveness.

Impacts of Multiple Regulations

This study focused on the net job impacts of proposed CCR regulation. However, coal-based electricity generators currently face a suite of concurrent new or revised environmental regulations with overlapping compliance deadlines. Compliance and operating decisions would be made with consideration of compliance requirements of these other regulations affecting the coal-based generating industry, including national emission standards for hazardous air pollutants (NESHAP), the Transport Rule, greenhouse gas regulation, and 316(b) regulation of once-through cooling intake structures. The technological requirements to comply with one rule could affect the compliance strategy and costs for another regulation (Santoianni et al. 2011). The cumulative economic impacts of multiple regulations, from both an economic standpoint as well as a technological standpoint, could ultimately impact how many generating units shut down, the magnitude of increases in electricity costs, and the total number of jobs lost.

Impacts on Global Competitiveness

The proposed CCR rule would have impacts on economic competitiveness because of the effects on electricity prices nationally, and markets affected by international trade. For example, wallboard manufacturing in the U.S. has shifted from predominately mined gypsum (95% of all wallboard used mined gypsum as recently as 1995) to FGD gypsum. Currently, 45% of wallboard is manufactured from FGD gypsum. Between 1999 and 2008, new FGD gypsum wallboard plants were constructed and co-located with coal power plants, supporting 1,750 jobs. The average price of FGD gypsum is virtually identical to mined gypsum, not including transportation costs (Gardner and Hackett 2010; EPA 2008b; U.S. Geological Survey 2010).

Regulating CCRs under Subtitle C of RCRA would have implications for FGD gypsum and related industries. The implications of stigma and liability concerns are discussed in the beneficial use section. As a result of this occurring throughout the FGD gypsum wallboard supply chain, the 1,750 jobs in the FGD gypsum market are at risk because these wallboard manufacturing facilities cannot interchangeably use FGD gypsum and natural gypsum. The cheapest source of mined gypsum is Canadian imports, followed by rail shipping from western U.S. and Mexican mines. This means that under the current low demand for gypsum, jobs lost in the beneficial use sector are unlikely to be offset by jobs in the U.S. gypsum mining industry (Eagle Materials 2009; U.S. Bureau of Labor Statistics 2009; USG 2011). Further, increases in electricity prices could force manufacturing jobs to relocate to other countries. Trends from labor statistics for U.S. manufacturing compared with historical electricity prices suggest that as electricity prices increase, manufacturing jobs are lost.

Specifications and Uncertainties

This analysis provides a high-level evaluation of job impacts from EPA's proposed CCR regulatory options and is suggestive of the expected magnitude of losses that a thorough economic analysis would produce. This section presents a discussion of the implications associated with the analytical specifications used in the analysis and the major areas of uncertainties in the results.

Analysis Approach

This study utilized models of regional electricity markets and input-output modeling to assess job impacts. To fully characterize the technical opportunities for substitution in production and consumption, partial or general equilibrium modeling would be required. Partial equilibrium analysis uses microeconomic modeling (e.g., supply-demand models) for selected sectors in a production chain that are linked to produce a consistent set of prices and quantities throughout the modeled markets. General equilibrium analysis goes a step further. It captures the entire set of interrelationships in an economy. In both cases a disturbance such as new costs or product ban is introduced into the model (economy) and the model is used to compute the expected adjustments in other sectors and resources.

What is important to recognize is that when an entire product is eliminated through a ban or, as in this case, through the expected action of the market to the labeling of coal ash as "hazardous," then the job impacts can be significant if only in isolated industries and locations. This is because bans, broadly interpreted, may render entire manufacturing plants or business as unprofitable, exacerbating employment impacts in some communities. This analysis focuses on regional impacts because of the locational markets for electricity; however, the impacts in specific states and counties could be significant.

Implications of National Extrapolation

The analysis conducted for this report seeks to characterize the regulation's potential employment impacts in a manner that is as consistent with reality as possible. While the analysis characterized these impacts at a detailed, structural level for MISO and for Minnesota and Illinois, the scope did not allow for that complete characterization for the entire United States. Therefore, to develop the national employment impacts, the analysis extrapolates the results from the full-characterization to the remaining regions and states throughout the country.

The implication of this extrapolation is that the same level of detail for evaluating premature retirements and electricity price increases was not carried out for the remaining regions in the country nor in each of the states in the other regions. The effect that the extrapolation has on the national job loss estimates can be evaluated by using EPSM to estimate the premature retirements and corresponding price increases in the remaining NERC, ISO, and RTO regions throughout the country, developing state-specific direct job losses from both predicted premature retirements and price increases, and conducting state-specific input-output analyses to evaluate the corresponding indirect and induced effects from the direct job losses. As a result of the extrapolation, distributional impacts cannot be evaluated. To assess the impacts on particular socioeconomic groups or communities would require county-level identification of job losses from unit retirements, electricity prices, and losses in related supplier industries such as mining.

Assessment of Static Job Impacts

In principle, the impacts of a regulation may be shown on net to add or reduce the number of jobs in the economy. However, the aggregate level of employment over the long run is typically considered to be driven by demographics and macroeconomic phenomena. The job losses that may occur from a potential regulation can have impacts that are realized more immediately (static effects) and impacts that are longer-lived (dynamic effects). Static effects would accrue through initial rises in unemployment as a result of premature retirements, increased price increases, and job losses in the beneficial use industry. Dynamic effects relate to the duration of these effects. Specifically, over time, many of the unemployed workers may find other jobs either within their local community or in other communities. Because these outcomes would be influenced by a number of factors, including the age, skill, and industry of the employed workers, the dynamic case is more complex than the static.

For example, over time workers may make personal decisions regarding whether to move to a different location and/or transition into other areas of employment. Higher levels of unemployment could make these transitions harder for displaced workers. There is substantial variation in the natural rate of unemployment, and environmental regulations may add to or subtract from the cyclical levels in unemployment, especially in localized regions and industries. The analysis conducted here considers only the static case. However, combined with distributional impacts, dynamic job losses could be a significant consideration in the economic analysis of the proposed regulation.

Increases in Tipping Fees

Some coal power plants would be unable to site a Subtitle C landfill on-site due to numerous site-specific restrictions including fault area, seismic, floodplain, wetlands, and state statutes. Plants that are unable to construct a Subtitle C landfill would be forced to use commercial disposal. An analysis of site-specific restrictions on Subtitle C landfill siting indicates that between 14,970,000 and 20,550,000 tons of CCRs would be sent to commercial hazardous waste landfills each year (EPRI 2010) and is consistent with estimates developed by the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) (Zdanowicz 2011). This volume of waste would exceed the entire current capacity of the commercial hazardous waste market, estimated at 34,000,000 tons, within two years (Brown 2009; EPA 2008a; EPA 2010). As a result of this volume of CCRs being sent to commercial disposal, tipping fees at commercial facilities could increase. This would increase compliance costs for some coal power plants, as well as smaller industrial hazardous waste generators. The economic implications of increases in costs of disposal of hazardous waste generators has not been evaluated and would require supply-demand modeling. We evaluated the expected revenue and job creation due to this volume of CCRs entering the commercial disposal market, using current tipping fees for hazardous waste (EPRI 2010).

Other Potential Employment Impacts

The analysis does not include certain categories of potential employment impacts that might result from the regulation. For example, the analysis does not evaluate the employment impacts associated with CCR marketers. With reduced demand for CCRs, individuals and companies that specialize in assisting coal power plants to find markets for CCRs could experience job losses. The analysis also does not evaluate the potential employment impacts resulting from the construction of new capacity to replace retired units. A likely outcome for replacement power is that generation lost from older coal units would be replaced by increased output from load-following gas and coal units, which is the result modeled in this study. However, since the location of replacement generation is important for maintaining electric reliability, transmission-constrained dispatch modeling would be required to identify whether new capacity was required to replace retired units.

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Back Cover Photos (from left to right):
Hungry Horse Dam (MT) utilized 120,000 metric tons of fly ash in the concrete used in its construction (USDOT 2011).
Over 25 percent of the total cubic yards of concrete used in the construction of New Meadowlands Stadium (NJ) contained fly ash (EPA and New Meadowlands Stadium 2009).
The Washington D.C. area Metro system used more than 200,000 cubic yards of concrete containing fly ash in its construction (EcoSmart™ Foundation 2011).

