# NEW JOBS — CLEANER AIR

## Employment Effects Under Planned Changes to the EPA's Air Pollution Rules

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PERI
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The **Political Economy Research Institute (PERI)** is an economic policy research organization affiliated with the University of Massachusetts, Amherst. PERI conducts academic research that is directly engaged with crucial economic policy issues. PERI has broad, and intersecting, areas of specialty: macroeconomics, financial markets and globalization; labor markets (especially low-wage work, both in the U.S. and globally); economic development (with a particular focus on Africa); the economics of peace; and environmental economics.

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# FOREWORD

The U.S. electric power sector is changing and modernizing in response to societal and market forces. Power companies face a business imperative to meet increasing pressures for cleaner, more efficient energy that will safeguard public health and protect the world's climate.

These forces are already transforming the industry. Significant capital investment has been flowing in recent years to cleaner technologies such as renewable energy, energy efficiency and natural gas-fired generation. Investment to clean up and modernize the nation's existing fossil fuel generation fleet has already begun to contribute to a cleaner energy future.

New air pollution rules expected this year from the U.S. Environmental Protection Agency will further accelerate these trends. And – as this new Ceres report shows - they will have a major added benefit: significant job creation.

Meeting new standards that limit sulfur dioxide, nitrogen oxides, mercury and other pollutants will create, in the report's own words, "a wide array of skilled construction and professional jobs" – from the electricians, plumbers, laborers and engineers who will build and retrofit power plants all across the eastern U.S., to operation and maintenance (O&M) employees who will keep the modernized facilities running.

The report finds that investments driven by the EPA's two new air quality rules will create nearly 1.5 million jobs, or nearly 300,000 jobs a year on average over the next five years – and at a critical moment for a struggling economy. The end product will be an upgraded, cleaner American industry, along with good paying jobs and better health for the nation's most vulnerable citizens.

For this report, researchers at the University of Massachusetts' Political Economy Research Institute carefully gauged the job impacts of pending and proposed EPA rules, using independent models and conservative assumptions. Its findings are especially good news for the many states, such as Ohio, Michigan, Pennsylvania, Virginia and Missouri, that are most dependent on traditional fossil fuel energy and most worried about traditional industrial jobs losses.

America's status as one of history's great economic powerhouses has long depended on our willingness and ability to reinvest and innovate when changing times tell us it's time to retool. We've seen throughout our history that clean technology investments – whether to clean our rivers, improve our air quality or compete in the emerging low-carbon global economy – have long-term benefits that far outweigh the upfront costs.

Since 1970, investments to comply with the Clean Air Act have provided $4 to $8 in economic benefits for every $1 spent on compliance, according to the nonpartisan Office of Management and Budget. Since the passage of the Clean Air Act Amendments in 1990, U.S. average electricity rates (real) have remained flat even as electric utilities have invested hundreds of billions of dollars to cut their air pollution emissions. During the

same period, America's overall GDP increased by 60 percent in inflation-adjusted terms. The bottom line: clean air is a worthwhile investment.

Significant change is often unsettling, never without short-term costs and some dislocation. But failing to change, especially now, offers much grimmer prospects. We are entering – in fact have already entered – a great global industrial and economic realignment toward clean energy. The greatest benefits, for both today's families and future generations, will flow to those who anticipate these changes, and take proactive steps to respond.

For our electric power sector and the workers tied to it, this report outlines why this path makes sense.

Mindy S. Lubber
President of Ceres

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# EXECUTIVE SUMMARY

Clean air safeguards have benefitted the United States tremendously. Enacted in 1970, and amended in 1990, the Clean Air Act ("CAA") has delivered cleaner air, better public health, new jobs and an impressive return on investment—providing $4 to $8 in benefits for every $1 spent on compliance.[1]

History has proven that clean air and strong economic growth are mutually reinforcing. Since 1990, the CAA has reduced emissions of the most common air pollutants 41 percent while Gross Domestic Product increased 64 percent.[2] Clean air regulations have also spurred important technological innovations, such as catalytic converters, that helped make the United States a world leader in exporting environmental control technologies.

This study, prepared by the University of Massachusetts' Political Economy Research Institute (PERI), demonstrates how new air pollution rules proposed for the electric power sector by the Environmental Protection Agency ("EPA") will provide long-term economic benefits across much of the United States in the form of highly skilled, well paying jobs through infrastructure investment in the nation's generation fleet. Significantly, many of these jobs will be created over the next five years as the United States recovers from its severe economic downturn.

Focusing on 36 states[3] in the eastern half of the United States, this report evaluates the employment impacts of the electric sector's transformation to a cleaner, modern fleet through investment in pollution controls and new generation capacity and through retirement of older, less efficient generating facilities. In particular, we assess the impacts from two CAA regulations expected to be issued in 2011: the Clean Air Transport Rule ("Transport Rule") governing sulfur dioxide ($SO_2$) and nitrogen oxide (NOx) emissions from targeted states in the eastern half of the U.S.; and the National Emissions Standards for Hazardous Air Pollutants for Utility Boilers ("Utility MACT") rule which will, for the first time, set federal limits for hazardous air pollutants such as mercury, lead, dioxin, and arsenic. Although our analysis considers only employment-related impacts under the new air regulations, the reality is these new standards will yield numerous other concrete economic benefits, including better public health from cleaner air, increased competitiveness from developing innovative technologies and mitigation of climate change. Moreover, increased employment during this critical five year period will also benefit severely stressed state budgets through increased payroll taxes and reduced unemployment benefit costs.

1. Office of Management and Budget (OMB). Informing Regulatory Decisions: 2003 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities. Office of Information and Regulatory Affairs, Office of Management and Budget, Washington DC. 2003.
2. U.S. Environmental Protection Agency, Our Nation's Air - Status and Trends through 2008, February 2010.
3. As depicted on the map in Figure 2, the Eastern Interconnection also includes the District of Columbia and small portions of Wyoming, Montana, New Mexico, and Texas. A small portion of South Dakota is within the Western Interconnection.

To estimate the job impacts, this study used a forecast of future pollution control installations, construction of new generation capacity, and coal plant retirements from a December 2010 study prepared by two researchers at Charles River Associates ("CRA").[4] Applying stringent EPA compliance requirements, including an assumption that the Utility MACT rule will require pollution controls on all coal-fired power plants by 2015, that study projected that between 2010 and 2015 the power sector will invest almost $200 billion on capital improvements, including almost $94 billion on pollution controls and over $100 billion on about 68,000 megawatts of new generation capacity. Constructing such new capacity and installing pollution controls will create a wide array of skilled, high-paying jobs, including engineers, project managers, electricians, boilermakers, pipefitters, millwrights and iron workers.

## Key findings:

- As detailed in Table ES.1 below, between 2010 and 2015, **these capital investments in pollution controls and new generation will create an estimated 1.46 million jobs or about 291,577 year-round jobs on average for each of those five years.**

**Table ES.1. Aggregate Employment Estimates from Capital Improvements: Construction, Installation, and Professional Jobs (between 2010 and 2015)**

| | DIRECT | DIRECT + INDIRECT |
|---|---|---|
| Pollution controls | **325,305** | **683,734** |
| New generation capacity | **312,617** | **774,151** |
| TOTAL | **637,922** | **1,457,885** |

***Note: All values reported in "job-years". One job-year equals one year of full-time employment.***

- As described in Table ES.2, transforming to a cleaner, modern fleet through retirement of older, less efficient plants, installation of pollution controls and construction of new capacity **will result in a net gain of over 4,254 operation and maintenance (O&M) jobs across the Eastern Interconnection**. Distribution of these O&M jobs will vary from state-to-state, depending on where coal plants are retired (O&M job reduction) and where new generation capacity is installed (O&M job gains).

4. "A Reliability Assessment of EPA's Proposed Transport Rule and Forthcoming Utility MACT", Shavel and Gibbs, CRA, December 16, 2010.

**Table ES.2. Employment Estimates of Net O&M Jobs Associated with Capital Improvements and Retirement of Coal Generation**

| | DIRECT | DIRECT + INDIRECT |
|---|---|---|
| Pollution controls | **7,170** | **14,077** |
| New generation capacity | **4,106** | **8,061** |
| Retirement of coal generation | **(9,109)** | **(17,884)** |
| NET TOTAL | **2,167** | **4,254** |

- Over the five years, investments in pollution controls and new generation capacity will create significant numbers of new jobs in each of the states within the Eastern Interconnection, more than offsetting any job reductions from projected coal plant closures.
  - The largest estimated job gains are in Illinois, (122,695), Virginia, (123,014), Tennessee, (113,138), North Carolina (76,966) and Ohio (76,240).[5]
  - In states with net O&M job reductions, projected gains in capital improvement jobs will provide enough work to fully offset the O&M job reductions.
  - The construction of pollution controls will create a significant, near-term increase in new jobs. O&M job reductions are likely to occur later in the period.

5. All values reported in "job-years". One job-year equals one year of full-time employment.

# I. INTRODUCTION

The CAA and its 1990 amendments have significantly reduced power sector air pollution. In 2011, EPA plans to implement regulations that will further reduce targeted emissions. Last July, the EPA proposed the Transport Rule to introduce new standards governing $SO_2$ and $NO_x$ emissions from 31 states and the District of Columbia, emissions that hinder the ability of downwind states to comply with national ambient air quality standards. In addition, EPA is required under court order to issue final Utility MACT regulations to limit electric generators' hazardous air pollutant emissions, including, for example, mercury, arsenic, chromium, nickel, lead, and hydrochloric acid.

**Merrimack Station**

**The Merrimack Station, New Hampshire's largest coal-fired power plant, constructed a scrubber to control $SO_2$ and mercury emissions. According to PSNH, the owner of the facility, the project provided more than 300 construction jobs for the three-year construction period.**

*Source: PSNH*

Focusing on the Eastern and Midwestern regions of the U.S., this study evaluates the employment impacts between 2010 and 2015 of these proposed and planned changes to EPA air regulations resulting from the power sector's investment in pollution controls and new generation, and from retirement of existing coal generation. For the purposes of this analysis, the study assumes stringent compliance requirements, including an assumption that the Utility MACT rule will require scrubbers and advanced particulate controls on all coal units by 2015.[6]

6. According to a study by Dr. Ira Shavel and Mr. Barclay Gibbs of Charles River Associates, "[o]thers...believe that MACT compliance may allow lower cost and relatively inexpensive dry scrubbing options using sorbents to capture acid gases and metals (e.g., trona with activated carbon injection)." A Reliability Assessment of EPA's Proposed Transport Rule and Forthcoming Utility MACT, Shavel and Gibbs, CRA, December 16, 2010, at p. 9.

**Deer Creek Station**

**Basin Electric began construction on the Deer Creek power plant, a 300-megawatt natural gas combined-cycle generation facility in South Dakota, in July 2010. The project will require about 350 workers at the peak of construction and 70 gas pipeline construction workers. The power plant is scheduled for commercial operation in June 2012 and will have about 30 full-time employees.**

*Source: Basin Electric*

The modeling projections focus on the years between 2010 and 2015, as that is the period during which companies will prepare to comply with the Utility MACT and Transport rules. For purposes of this analysis, we therefore assume the expenditures are spread over these years, and limit the employment effects from these capital investments to that period.

As detailed further in Appendix B, to estimate the employment impacts associated with the projected capital spending and coal plant retirements in the 36 states analyzed, we use the IMPLAN 3.0 input-output model, which is based on data from the U.S. Commerce Department's Bureau of Economic Analysis that has been finely disaggregated by sector and state.[7] Capital investments in pollution controls and new generation capacity and coal plant retirements[8] affect employment not only in the power generation sector, but also in sectors linked to electric generation, such as engineering services, coal, natural gas, metal fabrication, construction and business services. Based on the relationships between different economic sectors in the production of goods and services, the input-output model estimates the effects on employment resulting from an increase in spending on the products and services of a given industry. For example, the model estimates the number of jobs directly created in the design, engineering, and construction industries for each $1 million spent on pollution control retrofits and the construction of new generation capacity. As we explain below, the

7. The data used to construct the IMPLAN 3.0 model is based on 2008 figures – the most up-to-date picture of the sectoral relationships in the U.S. economy currently available.

8. Notably, not all the capital investments or coal plant retirements result directly from the new EPA air regulations, as reduced electricity demand, lower sustained fuel prices resulting from recent discoveries of abundant, domestic natural gas supplies, and state renewable energy programs also influence investment and retirement decisions.

model can also estimate the jobs indirectly created in other industries through that same $1 million in spending—for example, in industries such as steel components and hardware manufacturing.

**Mercer Station Pollution Control Retrofits**

**The Mercer station and Hudson station coal plants in New Jersey recently completed the installation of air pollution control systems. More than 1,600 construction workers were on the Mercer and Hudson facility job sites at the peak of construction.**

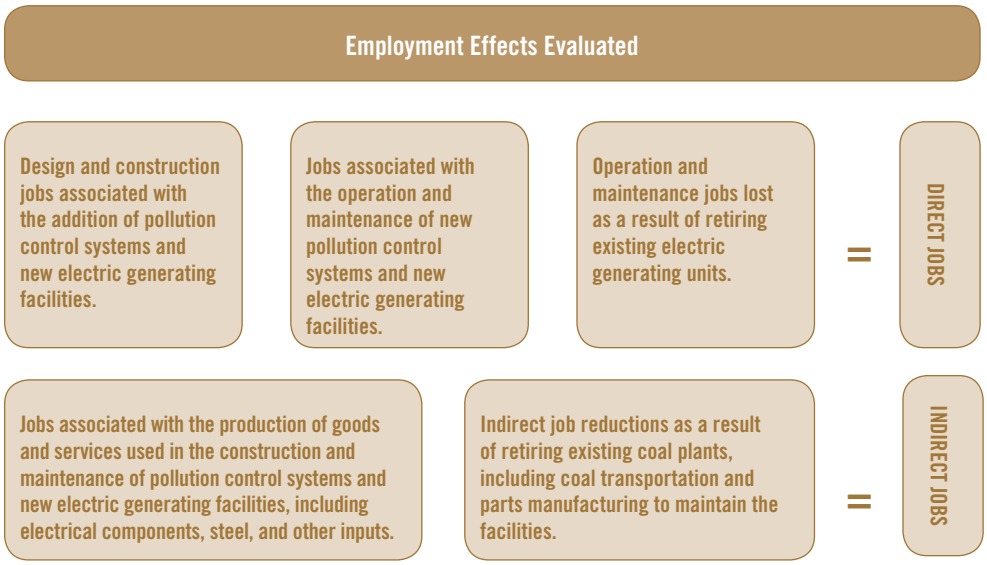
*Source: PSEG Corporation*

As described in Figure 1 below, our employment estimates include both direct and indirect job creation. First, it examines employment directly generated by capital investments in pollution controls and new generation capacity. Here the focus is on a wide array of skilled jobs associated with designing, procuring and installing pollution controls, and building new generation, including engineers, project managers, electricians, boilermakers, pipefitters, millwrights, iron-workers and security personnel.[9] As

9. For a more detailed discussion of occupational and skills requirements, see the National Commission on Energy Policy report, Task Force on America's Future Energy Jobs, available at www.bipartisanpolicy .org/sites/default/files/NCEP%20Task%20Force%20on%20America's%20Future%20Energy%20Jobs%20-%20Final%20Report.pdf.

these jobs are directly linked to these investment expenditures, they are created and maintained throughout the five year investment period. The direct effect represents jobs created by spending in the respective sector. For example, building new capacity involves expenditures to construct and install that capacity, including payments to new employees. Firms that install the new capacity will also have to purchase goods and services from other sectors, which in turn will create jobs in those other sectors: this "second round" of employment creation constitutes the indirect job effect.

**Figure 1. Scope of Employment Analysis**




*Note: The income associated with both direct and indirect employment will stimulate spending on goods and services that will result in additional job creation. These induced effects are not explicitly considered in this analysis.*

We do not explicitly consider a third source of job creation: "induced" jobs. Induced jobs are those created when individuals spend the money they earn from the direct and indirect employment. The size of the induced effects varies for a number of reasons, but will correlate with the number of direct and indirect jobs.[10] As this study calculates only the direct and indirect job impacts and excludes induced jobs, it provides a conservative estimate of the total employment impact.

10. Induced employment refers to the jobs generated when individuals in the direct and indirect jobs spend their income on goods and services. The size of the induced effects vary depending on the state of the economy. For example, if already employed individuals move from one job to another, the induced effects will be smaller (and could even be zero if there is no change in income). But if unemployed individuals move into the newly created jobs, as would be more likely given our current high unemployment rate, induced effects would likely be large.

**Merrimack Station**

**The scrubber retrofit at PSNH's Merrimack Station includes a concrete stack that stands at more than 445 feet. Concrete for the stack was delivered around-the-clock by the Redimix Company based in New Hampshire. By mid-July, when the shell of the stack was completed, a rotating shift of six Redimix drivers had delivered an estimated 1,060 cubic yards of concrete.**

*Source: PSNH*


The study also calculates estimated net changes in O&M jobs which, unlike construction and installation and related professional jobs, exist as long as the plants continue to generate electricity or the pollution control systems continue to operate. We project that although retiring older, less efficient capacity will lead to some O&M job reduction, installing pollution controls and building new generation will lead to a net increase in O&M jobs.

Estimating the employment impacts under EPA's air pollution regulations requires forecasts of future pollution control installations, new power plant construction and coal plant retirements. The forecasts used in this report are based on a detailed CRA modeling assessment entitled, "A Reliability Assessment of EPA's Proposed Transport Rule and Forthcoming Utility MACT," published in December 2010 by Dr. Ira Shavel and Mr. Barclay Gibbs of Charles River Associates (the "CRA Study").[11] The CRA Study used CRA's North American Electricity and Environment Model (NEEM) to estimate coal unit retirements, new capacity additions, and pollution control retrofits, taking into account the operating characteristics of existing capacity and the capital and operating costs of potential new capacity. As highlighted in Table 1 below, the CRA Study's predicted coal plant retirements are consistent with other similar assessments.

The CRA Study limited its analysis to the Eastern Interconnection where most of the nation's coal-fired generating capacity is located and where most of the capital investment associated with EPA's air pollution regulations is expected to occur. The Eastern Interconnection, one of four major power grids in the U.S. and Canada, comprises about 36 states (in part or whole) and the District of Columbia as shown in the map in Figure 2 below, accounts for much of the transmission system east of the Continental Divide[12] and contains approximately 73 percent of U.S. electricity generation. Moreover, as the Transport Rule only applies to states in the Eastern U.S., the estimated power sector changes projected below are concentrated in that part of the country.

11. Available at http://www.crai.com/Publications/listingdetails.aspx?id=13473

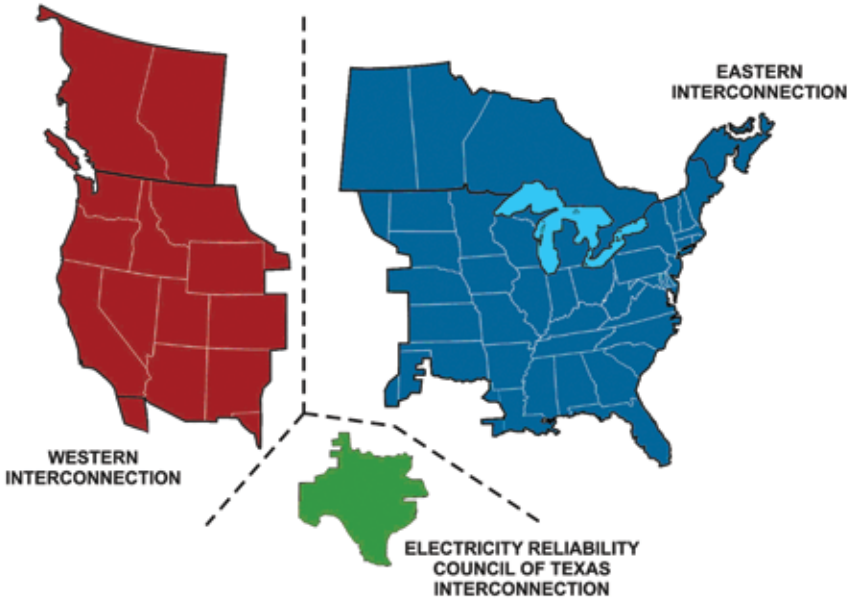
12. One notable exception is Texas, the majority of which is linked into a separate interconnected system.

### Table 1. Recent Projections of Coal Plant Retirements and Power Industry Investment

| | Author, Date | Projected Retirements | Notes |
|---|---|---|---|
| A Reliability Assessment of EPA's Proposed Transport Rule and Forthcoming Utility MACT | Shavel and Gibbs, Charles River Associates, December 2010 | 35 GW of coal plant retirements by 2015 (Eastern Interconnection) | Models utility MACT and Transport Rule |
| Potential Coal Plant Retirements Under Emerging Environmental Regulations | The Brattle Group, December 2010 | 28-39 GW of coal retirements by 2020 (Eastern Interconnection) | Models utility MACT and Transport Rule (scrubbers and SCR mandate) |
| Integrated Energy Outlook | ICF Consulting, January 2011 | 60 GW of coal plant retirements by 2018 (nationwide figure) | Models utility MACT, Transport Rule, coal ash, and cooling water regulations |

The CRA Study assumed stringent requirements to comply with the forthcoming Utility MACT regulations and proposed Transport Rule, including an assumption that by 2015 the Utility MACT rule will require scrubbers, activated carbon injection, and advanced particulate controls on all coal units. Furthermore, the CRA Study provided plant-level estimates of pollution control retrofits and retirements which could then be evaluated under the IMPLAN model.

### Figure 2. The Eastern Interconnection and Other North American Electric System Interconnections



# II. EASTERN INTERCONNECTION EMPLOYMENT IMPACTS UNDER PLANNED EPA RULES

This report calculates estimated employment effects in the Eastern Interconnection in two broad categories: (1) construction, installation and professional jobs from capital investment in pollution controls and new generation capacity; and (2) net O&M jobs directly and indirectly associated with those capital improvements and O&M job reductions from retiring older, less efficient coal capacity.

## Capital Improvements Spending on Pollution Controls and New Generation Capacity

The CRA Study projects that between 2010 and 2015 the electricity power sector will spend an estimated $196 billion on capital improvements under EPA's new utility MACT and Transport rules: $93.6 billion on pollution controls and $102.4 billion on about 68,000 megawatts of new generation capacity. Expenditures on pollution controls are assumed to include four technologies: (1) activated carbon injection ("ACI") to control mercury emissions; (2) activated carbon injection with fabric filters ("ACI+") to control mercury and other hazardous air pollutant emissions; (3) flue gas desulfurization ("FGD") or "scrubbers" to control $SO_2$ and hazardous air pollutant emissions; and (4) selective catalytic reduction ("SCR") to control $NO_x$ emissions.

**Jeffrey Energy Center**

**The Jeffrey Energy Center, the largest coal-fired power plant in Kansas, upgraded the scrubbers at the facility to achieve greater than 95 percent $SO_2$ control. The project started in 2007 and was completed in 2009. The project required over 1,300 tons of structural steel and more than 850 construction workers were on-site at the peak of construction.**

*Source: Westar*

Using the widely endorsed and proven IMPLAN 3.0 input-output model, we estimate the direct and indirect employment effects of substantial pollution control expenditures and resulting job impacts. In addition to investments in pollution controls, we also estimate the employment impacts of investment in new generation capacity involving nine different technologies: (1) advanced coal technologies; (2) integrated gasification combined cycle, ("IGCC") (coal); (3) combined cycle (natural gas); (4) combustion turbine (natural gas); (5) nuclear; (6) municipal waste/landfill gas; (7) biomass; (8) solar (photovoltaic); and (9) wind.

As with pollution controls, the design and construction of new generation capacity requires substantial expenditures for a variety of goods and services. Our employment estimates consider how these expenditures vary by technology. For example, landfill gas capacity involves expenditures on turbines, air and gas compressors, pipes and pipefitting, iron and steel milling, environmental control machinery, and construction services.

The capital investments will generate direct and indirect jobs in a range of sectors involving skilled and professional occupations. Direct jobs would include, for example, new non-residential construction, metal fabrication, and engineering. Indirect jobs would include steel manufacturing, catalyst system manufacturing, control system manufacturing, and transportation services.

Table 2 presents estimates of the aggregate jobs created over five years through investments on capital improvements and new capacity. Between 2010 and 2015, the almost $94 billion of investment in pollution controls would generate an estimated 325,305 direct jobs and an estimated 683,734 direct and indirect jobs. The $102.4 billion of investment in new generation would create a total of 312,617 direct jobs and 774,151 direct and indirect jobs. Taken together, projected investments in capital improvements under the new EPA regulations would create an estimated 1,457,885 jobs over the next five years, or over 290,000 full-time jobs on average per year over the five year period.

**Table 2. Aggregate Employment Estimates from Capital Improvements: Construction, Installation, and Professional Jobs (between 2010 and 2015)**

| | DIRECT | DIRECT + INDIRECT |
|---|---|---|
| Pollution controls | **325,305** | **683,734** |
| New generation capacity | **312,617** | **774,151** |
| TOTAL | **637,922** | **1,457,885** |

***Note: All values reported as "job-years". One job-year equals one year full-time employment.***

To reflect the reality that construction, installation and professional jobs will be realized over the period during which the investments occur, the 1,457,885 figure represents total jobs created over the five year period, with each job-year representing a single job that lasts one year.[13] If all the expenditures were to happen in a single year,

13. The characteristics of the jobs – in terms of benefits, hours of work, and wages – would reflect the current composition of jobs in the industries impacted by the construction and installation expenditures.

1,457,885 jobs would be created that year. However, a more realistic assumption would be that the pollution control and new generation expenditures would be spread out over time. For purposes of illustration, assuming that 10 percent of the expenditures will occur in the first year, 15 percent in the second year, and 25 percent in each of the three subsequent years, the job creation in three peak years would be 25 percent of 1,457,885, or 364,471 jobs per year.

## O&M Jobs

In addition to jobs associated with the design, construction and installation of pollution controls and new generation, the model also projects more permanent O&M jobs. Pollution controls, for example, need workers to maintain systems and handle waste. Similarly, power plants require workers to operate and maintain their equipment. We estimate the O&M jobs associated with these capital investments above by first estimating the O&M costs associated with the capital investment and then use the input-output framework to estimate the employment impacts.

In the case of older, less efficient existing capacity, much of which is already challenged by sustained low natural gas prices and reduced demand, companies may choose to retire existing capacity rather than installing pollution control systems, causing some O&M job reductions.[14] The CRA Study projects 35 gigawatts of coal plant retirements by 2015 in the Eastern Interconnection. To estimate the direct employment impact of predicted retirements, we did not use the input-output framework, but instead used detailed finance and operation data which the Federal Energy Regulatory Commission ("FERC") requires utilities to submit annually. Current employment levels from the FERC forms were matched to retired plants whenever possible. For retired plants with no matched employment data, we used state averages of employment per MW derived from plants in the same state with such employment data. We did, however, apply the input-output model to estimate indirect job losses from capacity retirements.

Table 3 shows the net Eastern Interconnection O&M employment impacts. Pollution control investments would create 7,170 O&M direct jobs and the new capacity investments would create 4,106 direct O&M jobs, offset by a reduction of 9,109 direct O&M jobs through capacity retirements, for a net gain of 2,167 direct O&M jobs. Combining both direct and indirect jobs results in a net gain of 4,254 jobs for the states analyzed.

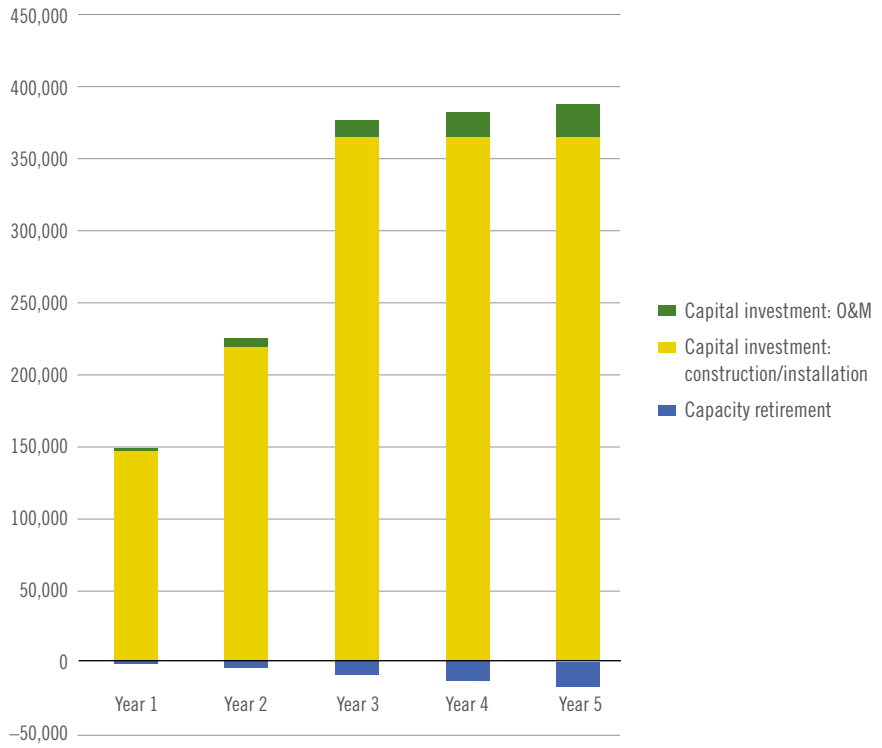
14. Some retirements may also generate short-lived gains in employment through necessary expenditures to shut down a facility (e.g. demolition, waste removal, etc). Also, companies may redeploy workers to other plants or offer early retirement opportunities. We do not, however, consider these possibilities.

### Table 3. Estimates of Net O&M Jobs Associated with Capital Improvements and Retirement of Capacity

| | DIRECT | DIRECT + INDIRECT |
|---|---|---|
| Pollution controls | **7,170** | **14,077** |
| New generation capacity | **4,106** | **8,061** |
| Retirement of existing capacity | **(9,109)** | **(17,884)** |
| NET TOTAL | **2,167** | **4,254** |

Figure 2 summarizes Eastern Interconnection direct and indirect employment effects in the three main categories of job creation and reductions: (1) construction, installation and professional jobs created through new capital investment, (2) O&M jobs created through new capital investment, and (3) job reductions due to capacity retirements. Again, we assume that 10 percent of the adjustments under the new EPA standards will occur in the first year, 15 percent in the second year, and 25 percent in each of the three subsequent years. Clearly, construction, installation and professional jobs dominate the picture. However, more O&M jobs are created as power companies adapt to the new standards.

### Figure 3. Estimates of Direct and Indirect Employment Effects Over Time (between 2010 and 2015)



# III. STATE-LEVEL ANALYSIS OF EMPLOYMENT IMPACTS

Using job impact estimates from projected pollution controls and new generation investments and capacity retirements, we also calculated state-level impacts for the states in the Eastern Interconnection.

## State-level Spending on Pollution Controls and New Generation

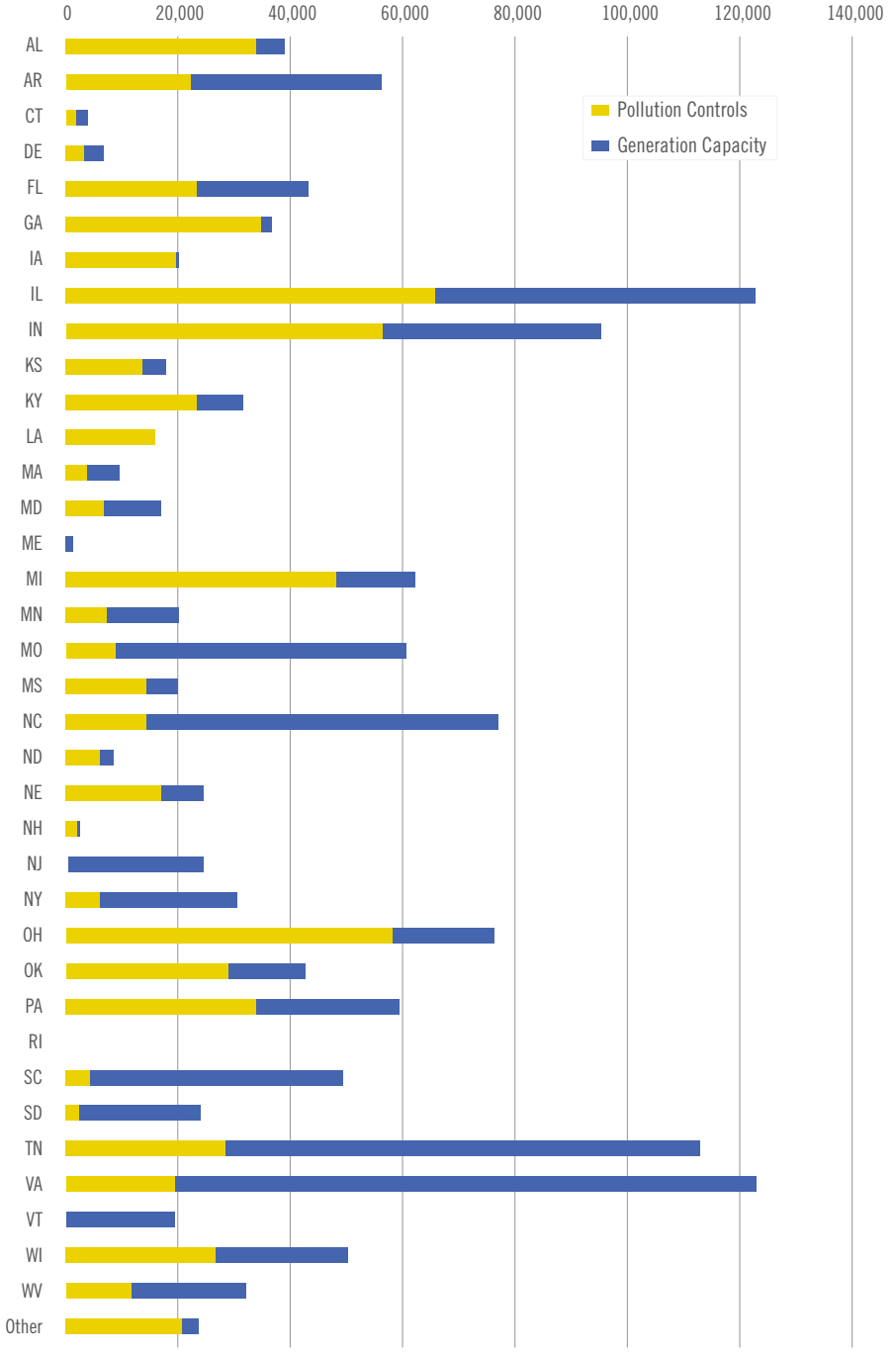
Table A1 in the appendix summarizes state-level capital improvements in terms of: (1) total spending on pollution controls; (2) total increase in energy capacity expressed as megawatts; and (3) capital expenditures needed to increase capacity by the relevant number of megawatts.

To estimate state-specific employment impacts, we used the same methodology as with the Eastern Interconnection analysis except that we relied on individual state input-output models. Figure 4 below shows estimated direct and indirect jobs created through both the pollution control and new generation investments detailed in Table A1. (Table A2 in the appendix summarizes the data used in Figure 4.) Not surprisingly, the number of jobs created tracks closely with the estimated spending. For example, Illinois, which has the highest projected spending on pollution controls over the five year investment period, has the greatest number of related jobs: 65,600 direct and indirect jobs. Similarly, Virginia with the highest projected investment in new capacity, experiences the largest number of related jobs: 103,365 direct and indirect jobs.

## State-level Estimates of O&M Jobs from Capital Improvements

Table A3 in the appendix presents state-level estimates of the O&M jobs associated with the capital investments detailed in Table A1. Permanent O&M jobs increase with the amount of the capital investments and vary with the composition of technologies utilized. Although states with zero spending gain no O&M jobs, most states gain substantial numbers of such jobs. For example, Ohio gains over 1,100 O&M jobs (direct and indirect) from pollution control investments, and Virginia gains over 920 O&M jobs (direct and indirect) from new capacity investments.

## Figure 4. Estimated Construction, Installation, and Other Professional Jobs Gains from Investment in Capital Improvements




Note: All values reported in "job-years". One job-year equals one year of full-time employment.

## Table 4. Summary of Direct and Indirect State-Level Job Impacts from Capital Improvements and Coal Plant Retirements

| | Capital Improvements | | Retirements |
|---|---|---|---|
| | Construction, Installation, & Professional Job Gains over 5 years (in job years) | O&M Job Gains | O&M Job Reductions |
| AL | 38,755 | 764 | (1,184) |
| AR | 56,110 | 690 | 0 |
| CT | 3,858 | 41 | 0 |
| DE | 6,542 | 114 | (219) |
| FL | 43,106 | 699 | (970) |
| GA | 36,465 | 584 | (1,700) |
| IA | 19,899 | 386 | (475) |
| IL | 122,695 | 1,429 | (549) |
| IN | 95,193 | 1,413 | (563) |
| KS | 17,812 | 342 | (179) |
| KY | 31,477 | 875 | (982) |
| LA | 15,842 | 297 | (145) |
| MA | 9,545 | 66 | (157) |
| MD | 16,922 | 226 | (180) |
| ME | 1,279 | 19 | 0 |
| MI | 62,346 | 987 | (1,124) |
| MN | 20,141 | 309 | (542) |
| MO | 60,512 | 1,727 | (271) |
| MS | 19,803 | 360 | (183) |
| NC | 76,966 | 973 | (1,014) |
| ND | 8,207 | 193 | (58) |
| NE | 24,331 | 208 | (217) |
| NH | 2,420 | 40 | (155) |
| NJ | 24,255 | 316 | (123) |
| NY | 30,496 | 303 | (187) |
| OH | 76,240 | 1,365 | (1,772) |
| OK | 42,651 | 623 | 0 |
| PA | 59,243 | 794 | (1,272) |
| RI | 359 | 323 | 0 |
| SC | 49,311 | 757 | (968) |
| SD | 23,909 | 379 | 0 |
| TN | 113,138 | 1,379 | (869) |
| VA | 123,014 | 1,225 | (369) |
| VT | 19,107 | 197 | 0 |
| WI | 50,233 | 784 | (874) |
| WV | 32,253 | 675 | (583) |
| Other | 23,453 | 277 | (2) |
| TOTAL | 1,457,885 | 22,138 | (17,884) |

*Note: Employment estimates taken from Tables A2, A3, and A4.*

## State-level Estimates of Job Reductions from Retirements

Using FERC data for direct job reductions and state specific input-output models for indirect job losses, Table A4 in the appendix presents state-level estimates of job reductions from coal plant retirements. Notably, the CRA Study's projected coal plant retirements are only partly attributable to stricter EPA regulations. According to the CRA Study, substantial retirements are also driven by reduced demand and low priced, abundant natural gas.[15]

Furthermore, the estimated job reductions in Table A4 will be offset by gains in construction, installation, and professional jobs and O&M jobs due to capital investments in pollution controls and new generation capacity. As such, it is important to examine the net change in employment from all of these sources. To reflect the total impact of capital investments and coal plant retirements between 2010 and 2015, Table 4 provides a comprehensive side-by-side comparison using the estimated gains in construction, installation and professional jobs from Table A2, O&M job gains from capital improvements from Table A3 and job reductions due to coal plant retirements from Table A4.

Significantly, when considering both direct and indirect effects and all sources of job creation and job reductions, all of the states show a net gain in employment over the analysis period.

15. "However, given the recent discoveries of abundant, domestic natural gas supplies, a competing fuel for electric generation, as well as reduced electricity demand, coal plant owners may elect to retire some existing plants rather than investing the capital necessary to install pollution controls," *A Reliability Assessment of EPA's Proposed Transport Rule and Forthcoming Utility MACT*, Shavel and Gibbs, CRA, December 16, 2010, at p. 3.

## CONCLUSION

After evaluating the employment impacts of the electric power sector's transformation to a cleaner, modern fleet, we conclude that the installation of air pollution controls and construction of new generation under the proposed and planned EPA air rules will lead to a net job gain in the Eastern Interconnection states.

The installation, design and construction of pollution controls and additional generation capacity will create the greatest number of new jobs. Although some O&M jobs will be lost because of projected coal plant retirements, these losses will be offset by new O&M jobs from pollution control and new generation capacity investments, resulting in net job gains across all the states studied.

Notably as well, this report only considered the net employment impacts from capital investments in pollution controls and new generation and from coal plant retirements. When evaluating the overall impact of new EPA air regulations, one must also recognize that the positive job impacts detailed in this study do not provide the entire picture, as the air regulations will also provide substantial economic benefits from cleaner air, improved public health and increased competitiveness through innovative technologies.

# APPENDIX A

## Table A1. Pollution Controls and New Generation Capacity Investments from the CRA Study

| State | Pollution Controls | Additional Installed Capacity (MW) | Investment in New Capacity |
|---|---|---|---|
| AL | $4.1 billion | 766 | $691 million |
| AR | $2.4 billion | 1,472 | $4.2 billion |
| CT | $229 million | 220 | $381 million |
| DE | $414 million | 585 | $687 million |
| FL | $2.7 billion | 1,793 | $2.3 billion |
| GA | $4.3 billion | 89 | $228 million |
| IA | $2.5 billion | 17 | $46 million |
| IL | $7.6 billion | 2,946 | $7.3 billion |
| IN | $7.2 billion | 2,613 | $4.8 billion |
| KS | $1.8 billion | 225 | $539 million |
| KY | $3.8 billion | 898 | $1.1 billion |
| LA | $2.1 billion | — | — |
| MA | $504 million | 108 | $653 million |
| MD | $1.0 billion | 2,558 | $3.3 billion |
| ME | — | 86 | $201 million |
| MI | $6.3 billion | 1,033 | $1.7 billion |
| MN | $1.1 billion | 652 | $1.4 billion |
| MO | $6.6 billion | 4,103 | $6.8 billion |
| MS | $1.5 billion | 773 | $754 million |
| NC | $2.0 billion | 6,488 | $7.9 billion |
| ND | $1.1 billion | 175 | $454 million |
| NE | $2.2 billion | 403 | $1.0 billion |
| NH | $266 million | 20 | $57 million |
| NJ | $51 million | 3,100 | $3.8 billion |
| NY | $944 million | 1,826 | $3.5 billion |
| OH | $7.1 billion | 1,792 | $2.2 billion |
| OK | $3.5 billion | 993 | $1.6 billion |
| PA | $4.7 billion | 2,321 | $3.3 billion |
| RI | — | 20 | $57 million |
| SC | $695 million | 5,554 | $5.8 billion |
| SD | $269 million | 3,083 | $3.0 billion |
| TN | $3.6 billion | 4,868 | $9.9 billion |
| VA | $2.6 billion | 12,531 | $13.8 billion |
| VT | — | 1,359 | $3.0 billion |
| WI | $3.4 billion | 1,285 | $2.9 billion |
| WV | $2.6 billion | 960 | $2.7 billion |
| Other | $2.6 billion | 333 | $403 million |
| TOTAL | $93.6 billion | 68,047 | $102.4 billion |

## Table A2. Estimated Construction, Installation, and Other Professional Job Gains from Investment in Capital Improvements

| | Pollution Controls | | Generation Capacity | | Total |
|---|---|---|---|---|---|
| State | Direct | Direct + Indirect | Direct | Direct + Indirect | Direct + Indirect |
| AL | 16,298 | 33,495 | 1,955 | 5,260 | 38,755 |
| AR | 11,334 | 22,409 | 14,325 | 33,701 | 56,110 |
| CT | 799 | 1,617 | 844 | 2,240 | 3,858 |
| DE | 1,649 | 3,191 | 1,626 | 3,350 | 6,542 |
| FL | 9,856 | 23,271 | 6,552 | 19,834 | 43,106 |
| GA | 15,642 | 34,836 | 503 | 1,629 | 36,465 |
| IA | 10,282 | 19,602 | 112 | 297 | 19,899 |
| IL | 30,594 | 65,600 | 21,928 | 57,096 | 122,695 |
| IN | 27,763 | 56,648 | 15,788 | 38,545 | 95,193 |
| KS | 7,067 | 13,706 | 1,720 | 4,106 | 17,812 |
| KY | 11,892 | 23,222 | 3,155 | 8,255 | 31,477 |
| LA | 8,004 | 15,842 | 0 | 0 | 15,842 |
| MA | 1,735 | 3,678 | 2,445 | 5,867 | 9,545 |
| MD | 3,236 | 6,967 | 4,797 | 9,955 | 16,922 |
| ME | 0 | 0 | 570 | 1,279 | 1,279 |
| MI | 21,534 | 48,097 | 5,425 | 14,249 | 62,346 |
| MN | 3,557 | 7,590 | 5,067 | 12,551 | 20,141 |
| MO | 4,237 | 8,902 | 20,668 | 51,610 | 60,512 |
| MS | 7,514 | 14,202 | 2,323 | 5,601 | 19,803 |
| NC | 6,485 | 14,275 | 24,689 | 62,691 | 76,966 |
| ND | 3,190 | 5,971 | 1,073 | 2,237 | 8,207 |
| NE | 8,261 | 16,968 | 3,196 | 7,363 | 24,331 |
| NH | 1,031 | 2,068 | 122 | 352 | 2,420 |
| NJ | 134 | 308 | 9,157 | 23,946 | 24,255 |
| NY | 2,960 | 6,155 | 9,998 | 24,341 | 30,496 |
| OH | 26,299 | 58,175 | 6,407 | 18,065 | 76,240 |
| OK | 14,380 | 28,898 | 5,709 | 13,753 | 42,651 |
| PA | 15,157 | 33,833 | 9,096 | 25,411 | 59,243 |
| RI | 0 | 0 | 118 | 359 | 359 |
| SC | 2,038 | 4,421 | 17,625 | 44,889 | 49,311 |
| SD | 1,247 | 2,382 | 9,060 | 21,527 | 23,909 |
| TN | 13,455 | 28,445 | 35,956 | 84,693 | 113,138 |
| VA | 9,450 | 19,648 | 41,835 | 103,365 | 123,014 |
| VT | 0 | 0 | 9,323 | 19,107 | 19,107 |
| WI | 12,555 | 26,801 | 8,837 | 23,431 | 50,233 |
| WV | 6,455 | 11,746 | 9,692 | 20,507 | 32,253 |
| Other | 9,214 | 20,764 | 919 | 2,688 | 23,453 |
| TOTAL | 325,305 | 683,734 | 312,617 | 774,151 | 1,457,885 |

Note: All values reported in "job-years". One job-year equals one year of full-time employment.

## Table A3. Estimated Operating and Maintenance Job Gains from Investments in Capital Improvements

| | Pollution Controls | | Generation Capacity | | Total |
|---|---|---|---|---|---|
| State | Direct | Direct + Indirect | Direct | Direct + Indirect | Direct + Indirect |
| AL | 359 | 684 | 42 | 80 | 764 |
| AR | 229 | 417 | 150 | 273 | 690 |
| CT | 11 | 24 | 8 | 17 | 41 |
| DE | 34 | 60 | 30 | 54 | 114 |
| FL | 202 | 461 | 105 | 238 | 699 |
| GA | 274 | 563 | 10 | 20 | 584 |
| IA | 212 | 381 | 3 | 5 | 386 |
| IL | 481 | 1,007 | 202 | 422 | 1,429 |
| IN | 564 | 1,060 | 188 | 352 | 1,413 |
| KS | 160 | 289 | 30 | 53 | 342 |
| KY | 398 | 738 | 74 | 137 | 875 |
| LA | 146 | 297 | 0 | 0 | 297 |
| MA | 28 | 59 | 4 | 8 | 66 |
| MD | 31 | 81 | 55 | 145 | 226 |
| ME | 0 | 0 | 10 | 19 | 19 |
| MI | 405 | 850 | 65 | 137 | 987 |
| MN | 89 | 172 | 71 | 137 | 309 |
| MO | 615 | 1,157 | 304 | 570 | 1,727 |
| MS | 155 | 273 | 50 | 87 | 360 |
| NC | 162 | 306 | 355 | 667 | 973 |
| ND | 89 | 162 | 17 | 31 | 193 |
| NE | 60 | 171 | 13 | 37 | 208 |
| NH | 18 | 35 | 2 | 5 | 40 |
| NJ | 50 | 105 | 102 | 212 | 316 |
| NY | 58 | 114 | 97 | 188 | 303 |
| OH | 599 | 1,161 | 106 | 204 | 1,365 |
| OK | 241 | 489 | 66 | 134 | 623 |
| PA | 255 | 571 | 100 | 223 | 794 |
| RI | 0 | 0 | 132 | 323 | 323 |
| SC | 68 | 124 | 352 | 634 | 757 |
| SD | 24 | 44 | 184 | 336 | 379 |
| TN | 350 | 634 | 412 | 745 | 1,379 |
| VA | 136 | 297 | 428 | 928 | 1,225 |
| VT | 0 | 0 | 101 | 197 | 197 |
| WI | 302 | 560 | 121 | 224 | 784 |
| WV | 275 | 485 | 108 | 190 | 675 |
| Other | 89 | 248 | 12 | 30 | 277 |
| TOTAL | 7,170 | 14,077 | 4,106 | 8,061 | 22,138 |

## Table A4. Estimated Job Reductions from Coal Plant Retirements

| State | Capacity (MW) Retired | Job Reductions | |
|---|---|---|---|
| | | Direct | Direct + Indirect |
| AL | 2,197 | 623 | 1,184 |
| AR | 0 | 0 | 0 |
| CT | 0 | 0 | 0 |
| DE | 447 | 123 | 219 |
| FL | 1,583 | 427 | 970 |
| GA | 3,018 | 831 | 1,700 |
| IA | 1,066 | 265 | 475 |
| IL | 901 | 263 | 549 |
| IN | 1,440 | 300 | 563 |
| KS | 287 | 99 | 179 |
| KY | 1,917 | 531 | 982 |
| LA | 259 | 71 | 145 |
| MA | 271 | 75 | 157 |
| MD | 250 | 69 | 180 |
| ME | 0 | 0 | 0 |
| MI | 1,926 | 537 | 1,124 |
| MN | 1,040 | 282 | 542 |
| MO | 479 | 144 | 271 |
| MS | 378 | 104 | 183 |
| NC | 3,009 | 540 | 1,014 |
| ND | 116 | 32 | 58 |
| NE | 276 | 76 | 217 |
| NH | 208 | 80 | 155 |
| NJ | 216 | 59 | 123 |
| NY | 348 | 96 | 187 |
| OH | 3,851 | 917 | 1,772 |
| OK | 0 | 0 | 0 |
| PA | 2,070 | 570 | 1,272 |
| RI | 0 | 0 | 0 |
| SC | 2,003 | 537 | 968 |
| SD | 0 | 0 | 0 |
| TN | 1,746 | 481 | 869 |
| VA | 683 | 170 | 369 |
| VT | 0 | 0 | 0 |
| WI | 1,437 | 474 | 874 |
| WV | 1,606 | 331 | 583 |
| Other | 2 | 1 | 2 |
| TOTAL | 35,029 | 9,109 | 17,884 |

# APPENDIX B

## Methodology and Assumptions

### a. Response of the Electric Sector to Proposed and Planned EPA Air Regulations

The December 2010 CRA Study developed forecasts of the electricity generation sector's responses to EPA's proposed and planned air regulations. For these forecasts, CRA researchers used a model of the energy sector, the North American Electricity and Environment Model (NEEM), to predict changes in capacity and investment expenditures[16]. We used the modeled responses to estimate employment impacts. The specific responses include: (1) expenditures on pollution control technologies (ACI, ACI+, FGD, and SCR), (2) additions to generating capacity involving nine technologies: advanced coal, IGCC, combined cycle, combustion turbine, nuclear, municipal waste, biomass, solar PV, and wind, and (3) coal plant retirements.

The CRA Study included information on pollution controls, new generation capacity and coal plant retirements was provided at the plant level. We aggregated this information to state-level and Eastern Interconnection-wide estimates of retirements and investment in pollution controls and new generation capacity.

### b. Linking Expenditures on Pollution Controls and Generation Capacity Additions to Sectors in the Input-Output Model

Jim Staudt of Andover Technology Partners, provided details of the precise categories of expenditures associated with each of the four pollution control technologies. Dr. Staudt is President of Andover Technology Partners and a nationally recognized expert on air pollution control, with a Ph.D in Engineering from the Massachusetts Institute of Technology. These expenditure breakdowns were linked to PERI's IMPLAN 3.0 input-output model to generate employment multipliers. Select examples of the types of expenditures/activities used to generate the employment estimates include:

ACI and ACI+: equipment (e.g. sorbent injector and disposal systems), engineering services, duct work, and electrical installation services.

FGD scrubbers: water treatment systems, chimney construction, fans & ductwork, engineering services, contractor services.

SCR: reactor housing construction and installation, ammonia handling systems, ductwork & fans, engineering services.

We matched each of these spending areas with an industrial sector in the input-output model. backing out some retrofits that were known to have been completed in 2010.

16. "Appendix B: Modeling and Methodology," *A Reliability Assessment of EPA's Proposed Transport Rule and Forthcoming Utility MACT*, Shavel and Gibbs, CRA, December 16, 2010, at p. 35-37.

We then combined individual spending categories into a single aggregate category for each of the four technologies (ACI, ACI+, FGD, and SCR), using individual expenditure shares as weights. We then generated employment estimates associated with expenditures on each of the four pollution control technologies using the input-output model.

We estimated employment creation from expenditures on generation capacity for each of the nine technologies using a similar procedure. Activities involved in the installation of new generation capacity are identified from industry sources. These activities are then matched with the relevant sectors in the input-output model to produce employment multipliers.

The sum of the indirect employment effects across the Eastern interconnection states based on the state-level input-output models will fall short of the aggregate estimates presented in Table 1, which are based on a national input-output model. The reason for the discrepancy is that indirect effects will be lower at the state level than at the Eastern Interconnection level. For example, based on the CRA Study's estimate, Ohio is expected to spend about $7.1 billion on pollution control technologies. However, firms installing these capital improvements may purchase goods and services from other states. These indirect purchases will create jobs in other states—not Ohio. In contrast, the aggregate estimates include all indirect effects from all the states combined. The state-level input-output models produce estimates of employment effects in one state only. They do not allow us to allocate the indirect effects that occur outside the state to other specific states (e.g., we do not know how much of the spending by Ohio's construction industry is on inputs from Missouri, for instance).

To account for this discrepancy, we allocate the difference between the total employment estimates (direct and indirect) from the national input-output model and the sum of the state-level estimates according to each state's share of the aggregate employment effects across all states.

### d. Estimating operating and maintenance expenditures associated with capital investments.

Estimates of O&M expenditures associated with investments in pollution controls are based on estimates compiled by Industrial Economics, Inc. of Cambridge, MA, for FGD scrubbers used in electric generation applications. The O&M estimates are derived from the EPA's Coal Utility Environmental Cost (CUE Cost) spreadsheet. The cost estimates produced by Industrial Economics include a 30 percent premium for administrative employment. To restrict the analysis to O&M jobs, we do not include this premium in the employment estimates, in order to restrict the analysis to O&M jobs. O&M expenditures total an estimated 6.6 cents for each dollar invested in FGD technologies. We assume that this same ratio of O&M costs to investment applies to the other pollution control technologies: ACI, ACI+, and SCR. We then estimate total O&M expenditures from the total dollar value of investments in pollution controls. The input-output model generates employment estimates based on these expenditures.

Estimates of O&M expenditures linked to new generation capacity are based on O&M expenditures used by the U.S. Energy Information Administration (EIA). Fixed and

variable O&M costs associated with each of the nine technologies are taken from the EIA publication, *Assumptions to the 2010 Annual Energy Outlook* (Table 8.2). For purposes of estimating O&M employment, O&M costs per kilowatt of installed capacity are computed assuming peak summer capacity. The O&M cost per KW can then be used to calculate total O&M expenditures, in response to changes in emissions regulations, associated with the predicted state-level and Eastern Interconnection investments in new generation capacity.

### e. Estimates of direct employment reductions from coal plant retirements

Current employment levels were obtained from FERC forms for some of these retired plants. FERC employment numbers are matched to retired plants whenever possible. For retired plants with no matched employment data, we used state averages of employment per MW derived from plants in the same state that do have such employment data. For states with planned retirements and no employment data whatsoever, national averages of employment per MW are used.

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