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IMPACTS OF THE ACID RAIN PROGRAM ON COAL INDUSTRY EMPLOYMENT

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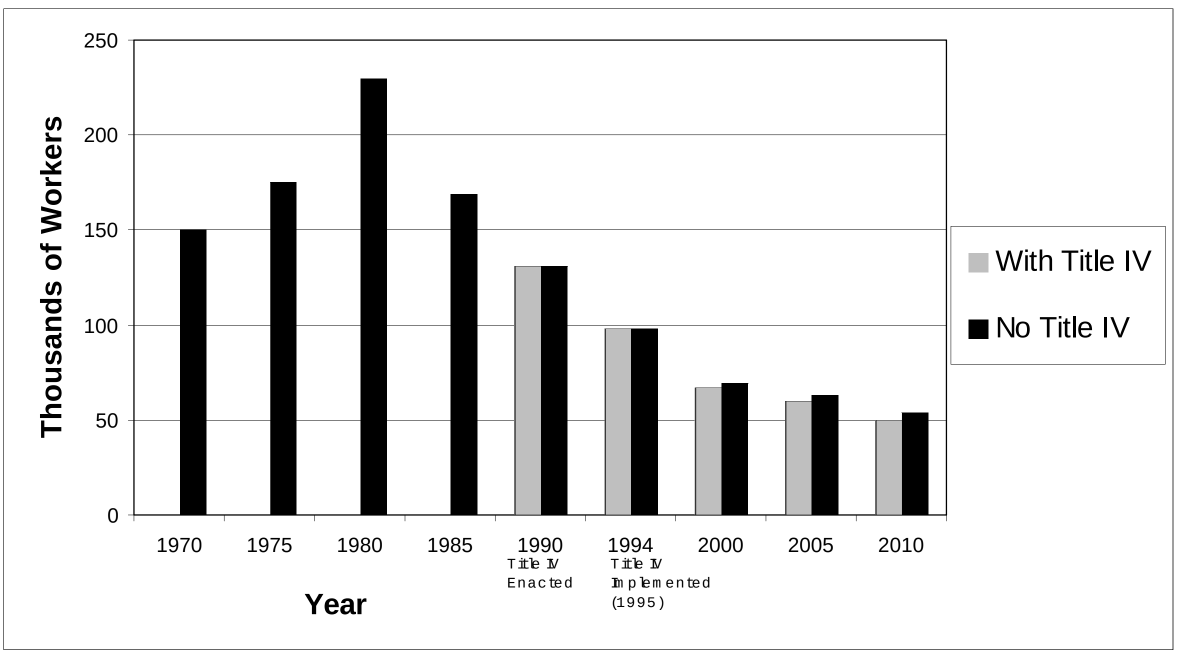
I. Executive Summary

This report addresses the impacts of the Acid Rain Program (created under Title IV of the Clean Air Act Amendments of 1990) on coal mining employment. It revisits the results of a study that was originally conducted in 1990, which compared the economic impacts of the acid rain provisions of several legislative scenarios being considered at the time. The earlier study projected that Title IV could have a substantial effect on coal mining employment. It predicted a gross loss of 13,000-16,000 coal miner job slots[1] by the year 2001 as a result of Title IV.

The current study revisits the original 1990 analysis and the differences in the results are quite substantial. The 2000 report projects that by the year 2010, Title IV of the Clean Air Act could result in a gross loss of approximately 7,700 job slots, or about half the loss projected by the 1990 study. The net loss would be only 4,100 coal miner job slots because 3,600 new job slots would be created. The extent to which Title IV affects coal mining employment, specifically job slots, is the focus of this paper.

These changes should be considered within the context of historical trends in coal mining employment. Employment for coal miners over the last 50 years peaked in 1978 at approximately 250,000 workers and has steadily declined in sub-

Exhibit 1: Job Slot Changes in the Mining Sector: Coal Mining Employment Changes With and Without The Acid Rain Program



Source: U.S. Department of Energy, Energy Information Administration (EIA) (2000). Energy Policy Act Transportation Rate Study: Final Report on Coal Transportation.

1 The measure of coal mining employment used in this report is "job slots," the sum of which is equal to the number of coal mining jobs or to the number of working coal miners in any one year. For details, see page 1.

sequent years. Even without Title IV, jobs for coal miners decreased as productivity improvements and other economic factors eroded the need for large numbers of miners. In 1990, the number of coal workers fell to 130,000. By 2010, approximately 50,000 coal miner jobs are projected to remain. Ninety-five percent of the decline (over 75,000 jobs) is expected to be due to productivity gains, and only five percent of the loss in jobs (4,100) is expected to be attributable to Title IV. These percentages are more dramatic compared to the peak of coal mining employment in 1978, where 98 percent of the projected job loss between 1978 and 2010 is related to productivity gains and only two percent of the net decrease in coal miner job slots is due to Title IV.

This analysis is complicated by changes in the demand for labor in the coal industry, resulting from factors unrelated to Title IV. Worker productivity improvements and the increasing share of production from strip mining due to increased substitutability of coal types have allowed the demand for coal to be satisfied with fewer workers. These differences in productivity are a result of the differences in mine types and the differences in the kinds of technologies used in each mine type. Regional shifts of coal production result in decreased labor requirements, or miner job slots.

Concerns over the effects of Title IV on coal employment stem from limits the Acid Rain Program places on the emissions of sulfur dioxide (SO_2), especially those emissions from the electric power industry. The Acid Rain Program limits the number of tons of SO_2 that are emitted to about half the number of tons plants would emit without Title IV's limits. To comply with the emissions limits mandated by Title IV, some utilities changed the type of coal that was used while others installed control technologies. The switch by utilities to lower-sulfur coals can reduce the demand for high-sulfur coal and the workers who mine it. The employment consequences of Title IV compliance decisions are derived largely from the fact that different regions of the country tend to have different levels of sulfur in their coals. Coal found west of the Mississippi, for example, is generally lower in sulfur than coal found in the Midwest or the Appalachians. Within the Appalachians, sulfur content varies; northern Appalachian coal tends to have a higher sulfur content than central or southern Appalachian coal. Likewise, the sulfur content of Midwestern coal also tends to vary somewhat but it is primarily high in sulfur. As plant operators switch among coals based on sulfur content (in addition to other characteristics such as heat and moisture content) in response to Title IV, they can increase or decrease the demand for the coal mined in different regions of the country. In turn, demand for miners in different regions can increase or decrease. These changes are further complicated by the fact that the labor required to produce a ton of coal differs across the regions. Thus, shifts to lower sulfur coal can, in some cases, reduce the net demand for miners, rather than simply shifting the locus of coal mined.

The results of this 2000 report show that the Acid Rain Program has had a limited impact on coal employment and that the program's future impacts on coal mining employment will be considerably lower than originally predicted.

II. Purpose and Background

This report reviews the impacts of the U.S. Environmental Protection Agency's (EPA) Acid Rain Program, established under Title IV of the 1990 Clean Air Act Amendments, on coal mining employment.[1] The estimated impacts are derived from modeling runs conducted in 1996 to estimate the costs of air regulations. By comparing coal demand by region for two model runs, only one of which took into account the SO_2 reductions required by Title IV, it was possible to calculate the broad regional shifts in coal production that could be attributed to Title IV. Productivity estimates for the eastern and western portions of the country were then used to translate these changes in coal demand into changes in coal industry employment.

The breakdown of coal supply into regions is not sufficiently detailed to capture all of the intraregional and intrastate shifts that may be caused by Title IV. Nonetheless, EPA considers the broad conclusions of the analysis to be sound. The report includes Title IV's impact on the number of miners' jobs and how those jobs shift between the eastern and western U.S. coal production regions.

Future employment impacts are expressed in terms of incremental changes in "job slots," which are defined as the number of workers needed to produce the industry's projected output of coal at projected productivity levels.[2] The analysis focuses on the extent to which Title IV results in fewer coal mining job slots, rather than on Title IV's impact on miners' employment. As mining productivity increases and demand for coal is steady, there will be fewer job slots but not necessarily miner lay-offs if these changes can be met through retirement or voluntary job changes. Because the demand for coal miners has been changing significantly as a result of factors unrelated to Title IV, one important component of this report is to document the extent to which coal miner job slots would be expected to decline in the absence of the Acid Rain Program--i.e., in the "baseline" scenario. Comparing incremental effects of EPA's program to this baseline reduction in job slots shows the incremental effects of Title IV.

"Jobs slots" is used in this report as a measure of employment and employment impacts, because it is identified with numbers of workers. Because productivity per hour varies from region to region, and labor hours per worker per year vary as well, concentrating on job slots can mask some of the effects of a change in demand. For instance, total labor hours by miners could rise, while job slots decline, if there were an increase in demand for western coal and a decrease in demand for eastern coal. The changes in job slots presented in this report could have been divided into changes caused by drops in coal demand, shifts to regions with higher hourly productivity, and shifts to regions with higher hours per work year; howev-

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1. This paper uses the EIA definition of coal employment, that "includes all employees engaged in production, preparation, processing, development, maintenance, repairs, shop or yard work at mining operation. It excludes office workers but includes mining operations management and all technical and engineering personnel." (EIA, 1995)

2. In any given year, the number of mining jobs, and the number of working coal miners, are expected to equal the number of "job slots." This term is used to avoid the impression that a miner loses his or her job whenever there is a reduction in the demand for mine labor, given that no miners need to lose their jobs if the rate of attrition matches the rate of reduction in demand. Other measures of employment demand use the total number of employees or the number of shifts completed by employees. However, as the length of shifts and number of hours worked per miner change over time, using these factors prevents consistent comparisons over time. Thus, the calculations in this report are based on a 2,060 hour work year in the East and a 2,536 hour work year in the West (For more detail, see Chapter III.C). Although the number of hours per slot could always change, it would be hard to predict what effects this might have on job slots. For example, if miners increase the number of hours worked per year by 5 percent but there is 4 percent less shifting of coal, the number of jobs in the East would still decline.

er, an analysis at this level of detail would be cumbersome and unlikely to add significantly to the outcomes presented in this report. Because the annual output per worker in the East and West differ by about a factor of four, while labor hours per year differ by only about 20 percent, it is clear that the annual productivity differences between East and West are due primarily to the differences in output per miner per hour. Furthermore, because the regional shifts in coal use are so much greater than the changes in total coal production, it is apparent that most of the changes in job slots are due to the interregional shifts.

Concerns over the effects of Title IV on coal employment stem from the limits the Acid Rain Program places on emissions of sulfur dioxide (SO_2) from utilities, which used almost 90 percent of the coal produced in 1996 (EIA, 1998). These limits reduce the demand for high-sulfur coal and the workers who mine it. Media reports have cited job losses in the thousands due to restrictions imposed by the Clean Air Act. *The New York Times*, for example, reported that coal mine employment in Illinois, Indiana, Ohio, Pennsylvania, western Kentucky, and northern West Virginia plunged more than 50 percent between 1990 and 1996. While the change in employment is attributed largely to automation, the Clean Air Act in general and the Acid Rain Program in particular are also blamed by the media, political groups, and mining interests for the loss of miners' jobs in the high-sulfur areas of the East (*New York Times*, 1996).

West Virginia and other states producing high-sulfur coal have been identified as suffering severe employment losses as a result of environmental policies, which include air regulations; however, policies that affect land use, waste disposal, and mining methods can also be important. Loss of mining employment has effects not only on the miners, but on other employees in the region, as these miners' demand for retail, entertainment, and related services declines with the loss of income. As recently as 1999, the Associated Press reported that "limits on sulfur pollution were imposed during the 1990s by the Clean Air Act, [subsequently] decimating the high-sulfur coalfields of northern West Virginia, western Pennsylvania, Ohio, Indiana and Illinois" (AP, 1999).

This report examines the validity of such employment loss claims. The Acid Rain Program was developed pursuant to a mandate contained in Title IV of the Clean Air Act as amended in 1990. Title IV sets two broad goals for EPA to reduce acid precipitation. First, SO_2 emissions are to be reduced by 10 million tons per year below the level in 1980. Second, NOx emissions are to be cut (in combination with regulations from other Titles of the Clean Air Act, including Title II, which affects mobile sources) by 2 million tons per year below the 1980 level. Almost all of Title IV's SO_2 and NOx reductions are to be made from coal-fired power plants operated by utilities.

Efforts to meet the NOx reduction goals are not expected to have any significant impacts on coal use or miners' employment. Most plants, through modifications to the power plant burners, can meet the moderate reductions in power plant NOx emissions required by the Title IV NOx program. Furthermore, the type of coal burned does not sufficiently affect either NOx emissions rates in the absence of combustion controls or their control efficiency. Thus, the NOx program does not discourage the use of any particular type of coal, and would have minimal effects on the total use of coal.

Title IV's SO_2 program, on the other hand, could potentially cause a significant increase in the costs for utilities that burn high sulfur coals. The program operates by distributing authorizations to emit SO_2, called allowances, to the owners of fossil fuel fired power plants that were in operation by 1995. To be permitted to emit SO_2, plant owners must hold allowances; for each ton emitted from a plant, the owner must surrender one allowance. Thus, the Act controls the number of tons that are emitted by limiting the number of allowances that are distributed. By distributing fewer allowances than the number of tons that plants would emit without Title IV's limits, the Act causes SO_2 emissions to go down. This reduction in SO_2 emissions, in turn, reduces the associated sulfates that occurs when SO_2 is transformed in the atmosphere and returns to earth as acid rain and dry acidic deposition. Sulfates are a form of fine particulate matter that adversely affects human health, visibility, the ecology of lakes and streams and the aesthetics and durability of bronze or marble structures and statues.

Though the Act controls the total number of allowances, it does not control which plants will emit SO_2. Instead, EPA lets the allowances that are distributed circulate freely among power plants through the market. Allowances may be sold by plants that are able to reduce emissions enough to be left with surplus allowances, and may be bought by plants that need more allowances than their allocation to cover their emissions. Utilities may also bank allowances for future use or sale. The flexibility introduced by the allowance market has important implications for coal use, in that it opens up many more compliance options for utilities. Rather than selecting only among control options that meet a particular emissions limit for each stack, plants can choose to switch to a lower sulfur coal, buy allowances, or use banked allowances. Utilities may also choose to install a scrubber that might be expensive to install and operate, but might allow a plant to over-control emissions.[3] If a plant's allowances exceed its emissions, the excess allowances may be sold or banked. The system also establishes a nationwide marginal price for SO_2 reductions, equal to the market price for allowances. The emissions reduction goal is derived from a statutory cap of 8.95 million tons of SO_2 emissions from utilities.

Title IV's SO_2 program is being implemented in two phases. In Phase I, which took effect in 1995, 263 of the largest boilers in the eastern United States with high emission rates received enough allowances for them to emit about 2.5 lbs. of SO_2 per mmBtu. In Phase II, which started in 2000, the rest of the fossil-fueled utility units serving generators larger than 25 MW have been brought into the system, and all units have been provided with allowances sufficient to emit at levels up to 1.2 lbs. of SO_2 per mmBtu (or less, if their existing permits required a lower limit). Thus, beginning in 2000, there is both an expansion in the number of utilities affected by the limit and a tightening of the aggregate SO_2 emission limit. Knowing that their plants would have fewer SO_2 allowances in 2000, many operators covered by Phase I over-controlled emissions and banked the excess allowances for use during the early years of Phase II. Because utilities have been over-controlling and banking excess allowances, the full impact of Title IV's SO_2 program on coal employment is not expected to be seen until about a decade into Phase II (by the year 2010). For this reason, this report concentrates on projections for the year 2010.

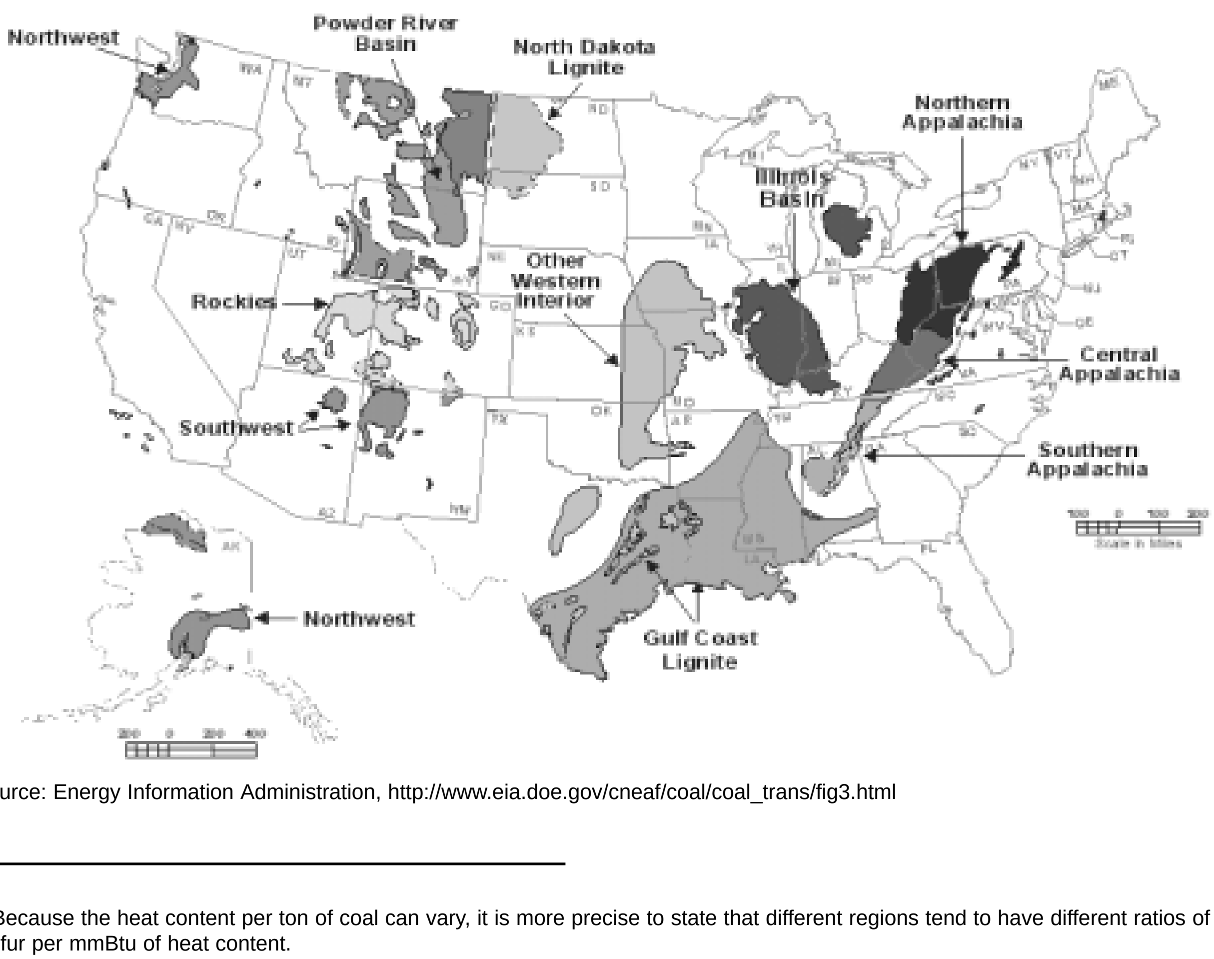
The combination of the SO_2 emission limits under Title IV and the flexibility of control strategies provided by the allowance system interact with the regional distribution of coal types to affect coal employment. Because of the allowance system, utilities are not obligated to change the type of coal they use or the way they use it—they can continue to use coal that is high in sulfur if they purchase enough allowances or choose to scrub. On the other hand, the allowance market provides a clear signal that the use of high sulfur coal has an additional cost. Therefore, power plant operators are given a market incentive to switch to a lower sulfur fuel or to install scrubbers in the stacks to reduce SO_2 emissions. If the choice is made to scrub, the plant might continue to use or even switch to a higher sulfur fuel, depending upon relative fuel prices, because the scrubber reduces SO_2 emissions from high sulfur coal. In Phase I of the program, 16 plants employing 27 boilers chose to scrub. Because sulfur removal rates were 90-95%, these few units accounted for

[3] This report is based on modeling that does not account for the SO_2 reduction potential provided by coal washing. In a study of SO_2 controls for China, coal washing was assumed to reduce SO_2 emissions from coal-fired generation by a third. In that it excludes a potentially cost-effective control measure, this report may overestimate the impacts of Title IV on coal industry employment (Liu and Spofford, 1994).

about half of the SO_2 reductions in Phase I (Ellerman et al., 2000).

The employment consequences of these compliance decisions are derived largely from the fact that different regions of the country tend to have different levels of sulfur in their coals.[4] Coal production regions as defined in this report are shown in Exhibits 1 and 2.[5] Coal found west of the Mississippi, for example, is generally lower in sulfur than coal found in the Midwest or the Appalachians. Within the Appalachians, sulfur content varies; northern Appalachian coal tends to be higher in sulfur than central or southern Appalachian coal. As plant operators switch among coals based on the coal's sulfur levels in response to Title IV, they can increase or decrease the demand for the coal output in different regions of the country. In turn, demand for miners in different regions can increase or decrease. These changes are complicated by the fact that different regions need more or fewer miners to produce a ton of coal. Coal miners' productivity is generally higher in some of the most important low-sulfur mining regions in the West than in most of the eastern high-sulfur mines because the coal in the West lies in thick layers close to the surface. Thus, shifts to lower sulfur coal can reduce the net demand for miners, rather than simply shifting the locus of coal mined.

Exhibit 1. Map of Coal-Producing Regions in the United States.



Source: Energy Information Administration, http://www.eia.doe.gov/cneaf/coal/coal_trans/fig3.html

[4] Because the heat content per ton of coal can vary, it is more precise to state that different regions tend to have different ratios of sulfur per mmBtu of heat content.

[5] The regions in Exhibit 1 show the breakdown used in IPM, which closely track the regions used by EIA.

Exhibit 2. Coal-Producing States By Region

Region		Coal Mined in 1992 (1,000 short tons and percent of total)	Sulfur Content
Eastern Region	**States in Eastern Sub-Region**		
Northern Appalachia	Maryland	3,341 (0%)	Primarily High Sulfur
	Ohio	30,403 (3%)	Primarily High Sulfur
	Pennsylvania	68,981 (7%)	Primarily High Sulfur
	Northern West Virginia	50,022 (5%)	Primarily High Sulfur
Central and Southern Appalachia	Alabama	25,796 (3%)	Primarily Low Sulfur
	Eastern Kentucky	119,382 (12%)	Primarily Low Sulfur
	Tennessee	3,476 (0%)	Primarily Low Sulfur
	Virginia	43,024 (4%)	Primarily Low Sulfur
	Southern West Virginia	112,142 (11%)	Primarily Low Sulfur
Midwest	Illinois	59,857 (6%)	Primarily High Sulfur
	Indiana	30,466 (3%)	Primarily High Sulfur
	Western Kentucky	42,686 (4%)	Primarily High Sulfur
Western Region		**Coal Mined in 1992**	**Sulfur Content**
Alaska		1,534 (0%)	Primarily Low Sulfur
Arizona		12,512 (1%)	Primarily Low Sulfur
Arkansas		58 (0%)	High and Low Sulfur
Colorado		19,226 (2%)	Primarily Low Sulfur
Iowa		289 (0%)	Primarily High Sulfur
Kansas		363 (0%)	Primarily High Sulfur
Louisiana		3,240 (0%)	High and Low Sulfur
Missouri		2,886 (0%)	Primarily High Sulfur
Montana		38,889 (4%)	Primarily Low Sulfur
New Mexico		24,549 (2%)	Primarily Low Sulfur
North Dakota		31,744 (3%)	Primarily Low Sulfur
Oklahoma		1,741 (0%)	Primarily High Sulfur
Texas		55,071 (6%)	High and Low Sulfur
Utah		21,339 (2%)	Primarily Low Sulfur
Washington		5,251 (1%)	Primarily Low Sulfur
Wyoming		190,172 (19%)	Primarily Low Sulfur

Source: Energy Information Administration, *Coal Industry Annual*, 1996. Table 1: Coal Production by State, 1987, 1992-1996, p.4.

Organization of the Report

Section III of this report outlines projected changes in coal use by utilities from a 1996 analysis and translates those demand changes into the expected number of job slot changes in 2010.[6] Section IV presents a discussion of those job slot changes relative to national coal employment trends, and Section V outlines limitations of the analysis. Appendix A provides a description of the 1996 Integrated Planning Model, which was used for the analysis; Appendix B shows the model projections of coal production under the baseline and Title IV for 2000, 2005, and 2010; Appendix C contains a comparison of results between the 1996 analysis and the analysis created for the 1990 Clean Air Act Amendments; Appendix D contains a comparison of results of modeling and analysis for 2000 based on the 1996 analysis and the 1992 analysis; Appendix E presents definitions of the acronyms and abbreviations used in the report; and Appendix F summarizes the peer review process that was undertaken for this report.

[6] IPM is a model that allows the calculation of coal and other energy input use, operating costs, emissions, and least-cost responses to emission limits for electric generating units in the United States. Appendix A contains a detailed description of the 1996 version of the Integrated Planning Model.

III. Projections of Changes in Labor Demand

A. Overview of Methodology

The projections of changes in labor demand as a result of Title IV are calculated using estimates of changes in coal use by utilities and regional mine labor productivity projections. The change in coal use by utilities is a model-derived output that is generated using a series of assumptions about the utility sector. The 1996 analysis (IPM96) was produced as part of a series of model runs conducted by ICF in support of EPA's Clean Air Power Initiative (CAPI) and the prospective analysis of the effects of the Clean Air Act (CAA) under Section 812 using a utility model called the Integrated Planning Model (IPM).[1] This study complements an earlier work for EPA using the same model. By comparing two of these model runs, one with Title IV's SO_2 program and one without the SO_2 program, changes in utilities' fuel choices were projected. Productivity of miners in 2010 is estimated using EIA data and IPM-projected productivity growth rates. These inputs can be translated into regional changes in the demand for miners. This section describes those calculations for the 1996 IPM analysis.

Over the past ten years, labor productivity growth in the mining sector has greatly exceeded the historic productivity growth rate in manufacturing. An analysis of the technology and management practices used in existing mines indicates that considerable opportunities still exist to improve productivity (ICF, 1996).

EPA's productivity growth assumptions for 2010 are based on an analysis of historic productivity by state, in union and non-union areas, and in surface and deep mines. Historic rates of improvement are projected to continue, but decline over time toward a more typical U.S. manufacturing labor productivity growth rate (2.5- 3.0 percent per year). This rate of improvement is applied to both existing and new mines (ICF, 1996).

The majority of this paper focuses on projections of coal use and employment in 2010 from the 1996 IPM analysis. Appendix C compares the 1992 analysis completed for EPA's Regulatory Impact Analysis (RIA) of the Acid Rain Implementation Regulations with the 1996 IPM analysis.

B. Changes in Coal Demand as Projected by the IPM96 Analysis

Changes in baseline coal use in favor of low-sulfur western coal can be expected to have an impact on coal use and coal mining employment. The regional changes in coal demand predicted by IPM for the year 2010 as a result of Title IV range from a loss of 58 million tons (or about 32 percent) in northern Appalachia to a gain of 63 million tons (or almost 11 percent) in the West from a baseline that excludes Title IV. Nationwide, consumption is expected to drop by 2 million tons in 2010 (which is about a fifth of one percent) as a result of Title IV's SO_2 requirements.[2] Exhibit 3 presents the baseline of utility coal use and the projected impact of Title IV on utility coal use in the year 2010. The analysis of coal use and

1 Both analyses are available on the internet. EPA's Clean Air Power Initiative, Oct. 1996. Obtained from http://www.epa.gov/capi/capifs3.html, September 1998.

2 Because tons of coal from different mines vary in their heat content, the percentage change in the use of energy from coal is not the same as the percentage change in tonnage used. Much of the coal produced in the West is subbituminous, which has a lower heat content than the bituminous coal mined in the East. Thus, a shift of coal production from the East to the West would be likely to reduce the use of coal measured on the basis of total energy content even if total tonnage did not change.

Exhibit 3. Baseline Utility Coal Use Projections in the Year 2010 (millions of tons)

Coal Supply Region	Baseline Utility Coal Use	Utility Coal Use with Title IV	Title IV Impact
East (Total of Eastern Sub-Regions)	**483**	**418**	**- 65**
Northern Appalachia	180	122	- 58
Central & Southern Appalachia	196	228	+ 32
Midwest	107	68	- 39
West	**575**	**638**	**+ 63**
Total US	**1,058**	**1,056**	**- 2**

Source: 1996 IPM runs. Totals do not sum due to rounding.

changes in job slot demands is conducted by region; refer to Exhibit 2 for a breakdown of the states in the eastern and western regions. Though the shift to western coal in response to Title IV is associated with a reduction in demand for coal produced in the East, it could have a mitigating effect on shifts in coal production within the East. Because of its low sulfur content, each ton of western coal that is used in place of an equivalent amount of high-sulfur eastern coal (from northern Appalachia or the Midwest) could eliminate the need to shift several tons of production from high-sulfur to medium-sulfur eastern coal. This issue, and interaction between transportation cost changes and baseline demand patterns, is discussed more fully in Appendix C.

C. Translation of Coal Demand into Labor Demand

As noted above, the difference in productivity between the eastern and western coal producing regions is primarily attributable to the difference in how the coal is mined. Given estimates of future coal production, regional miner productivity rates are necessary to develop projections of mine labor demand in future years. In 1994, the year in which the base case assumptions for the 1996 IPM analysis were developed, eastern coal miners produced an average of 3.28 tons of coal per hour while western miners produced 13.23 tons per hour (EIA, 2000c). Western miners also averaged more hours of work per year -- 2,536,[3] versus an average of 2,060 per year for eastern miners (EIA, 1995).[4]

These two factors imply that each million tons of coal mined per year in the East required 148 miners:

> 1,000,000 tons /(3.28 tons/hr * 2,060 hr/yr) or 148 miners,

while each million tons mined in the West required only 30 miners:

> 1,000,000 tons /(13.23 tons/hr * 2,536 hr/yr) or 30 miners.[5]

3 Hours-per-job estimates are from the *Coal Industry Annual* 1994, Energy Information Administration, October 1995, Table 1 (Production by region), Table 39 (Average number of miners by region), and Table 38 (Productivity). Production (tons) is first divided by the number of miners to obtain tons/worker. This result is then multiplied by hours/ton to obtain hours/worker.

4 This means that any given shift in coal production from eastern to western mines will tend to decrease the number of job slots because of higher productivity per unit of labor in the West and because the number of hours worked by a miner in the West is higher than the number of hours worked by a miner in the East.

5 Because of differences in heat contents among coals, a shift of a million tons from one region to another would not necessarily leave the total energy content of the coal constant. Shifting a given amount of coal, measured in terms of its heat content, from East to West might require an increase in the West that exceeded the reduction in the East, slightly changing the job shift estimates. In the modeling of the effects of Title IV, these differences in heat contents were accounted for.

Thus, shifting output from eastern to western coalfields will have employment impacts, even given constant production volumes. For example, a shift of 30 million tons of output from eastern to western coal-fields would require 148 * 30 or 4,400 fewer miners in the East, and only 30 * 30 or 900 more miners in the West, for a net reduction of 3,500 job slots.[6]

Exhibit 4 shows the productivity rates that were used in the 1996 IPM analysis.

Exhibit 4. Productivity Measures used in the Analysis[7] (tons per worker per hour and percentage growth per year)

Productivity Measure	**East**	**West**
1994 Base Productivity	3.28	13.23
Productivity Growth Rate: 1994-1999	*4.5 %*	*4.5 %*
2000 Productivity (calculated)	4.27	17.23
Productivity Growth Rate: 2000-2004	*4.0 %*	*4.0 %*
Productivity Growth Rate: 2005-2010	*3.5 %*	*3.5 %*
2010 Productivity (calculated)	6.14	24.77

Sources: U.S. Department of Energy, Energy Information Administration, *Coal Industry Annual* 1994 and ICF analysis.

The productivity increases for coal mining nationwide are incorporated into the IPM analysis using the base year 1994 and the values listed in Exhibit 4, above. Such changes in productivity would occur even in the absence of the Acid Rain Program. At these rates of productivity increase, output per hour in the East would reach 3.28 * 1.045(2000 - 1994) , or 4.27 tons per worker per hour in the year 2000 and 6.14 in 2010, while western output would reach 13.23 * 1.045(2000 - 1994), or 17.23 tons per hour in 2000 and 24.77 in 2010. This level of productivity represents an 87 percent increase over the productivity level in 1994 in both regions. Assuming no change in the number of hours of work per year in each region from the 1994 base case assumptions, these hourly productivity projections lead to estimates of 79 miners per million tons per year in the East, and 16 miners per million tons per year in the West. Using these values, the regional coal output changes shown in the third column of Exhibit 3 can be translated into the labor requirement changes shown in Exhibit 5.

Employment impacts of Title IV are reported in terms of net and gross changes. The net loss (4,100 miner job slots) is the nationwide change in jobs -- balancing losses in some regions with gains in others. Gross losses (7,700 miner job slots) are the total job slot losses in regions that show decreases in the need for coal miners.[8] As discussed above, these projections can be seen as indicating a fairly small decrease in net employment (of approximately 4,100 miner job slots in 2010, which is approximately eight percent of the baseline level of 54,000). At the same time, the figures suggest more substantial gross change in job slots in individual regions: a total of 7,700 fewer miners (18 percent of the baseline level of 43,400 miners in these regions) would be needed in northern Appalachia and the Midwest in the year 2010; 3,500 more miners (34 percent of the baseline level of 10,400 miners in these regions)

[6] Thus, one job slot is the equivalent of one miner-year of work, or 2,536 hours in the West and 2,060 hours of labor in the East.

[7] Actual growth rates could be sensitive to the demand shifts discussed in this report, especially if Title IV's effects on demand led to more closures or cutbacks at the less efficient mines in each region. Differential cutbacks could increase the effects of coal demand shifts (by increasing the number of job slots affected by each million ton shift), though this change might be offset in the long run as higher eastern productivity led to greater competitiveness.

[8] It should be noted that gross job loss within the mining industry does not fully capture all of the possible employment effects within mining regions. As a result of multiplier effects on regional economies, additional job losses outside of the industry are also possible.

would be needed in central and southern Appalachia and the West.

Another aspect of these measures of gross job changes that should be kept in mind is that intraregional shifts in coal demand (i.e., within northern Appalachia) may be even more important than the interregional shifts discussed above (i.e., between the East and West).[9] Though the northern Appalachian region is described as producing medium-to-high sulfur coal, for example, coals with a wide range of sulfur levels can be found in that region. Shifting from high-sulfur mines to low-sulfur mines within northern Appalachia would cut average sulfur levels, and result in gross miner labor demand reductions in the higher sulfur mines of the region, without registering as a net change in the region's output or miner labor demand. To some extent, these shifts in intraregional coal shipments mean that the measure of gross job slot changes presented in this analysis understate the changes (both positive and negative) in job slots that will result from Title IV. On the other hand, job slot shifts that occur within smaller geographical regions are not likely to be as disruptive as those that involve shifts in labor demand from the East to the West, because many of the same miners might be able to fill the job slots even after they have shifted.

[9] Coal switching within regions in Phase I of Title IV (1995-2000) was four times as important as coal switching between regions. (Ellerman et al., 1997).

IV. Demand Changes in Context

The preceding sections have shown that Title IV of the Clean Air Act will reduce the overall demand for miners in the coal industry and will also induce regional shifts in demand for miners, though neither of these changes is as great as had been projected when the CAAA were enacted in 1990. They also touched on concerns over effects of declining coal industry employment on local economies, and the linkage between these impacts and Title IV.

Before concluding that Title IV is or will be a major factor in these employment changes, however, it is important to place the projected effects of Title IV in context. This section presents data on the sharp decline in coal employment in the past, along with projections of future changes in employment expected even in the absence of Title IV. This baseline trend is then compared to the projected effects of Title IV itself, both for the nation as a whole and for regions that will be more heavily affected by Title IV due to the sulfur content of their coal resources. This comparison makes clear that it is the underlying trend toward higher miner productivity, not the effects of Title IV, that drives the long-term change in mining employment.

A. Historical Employment Levels and Trends

The level of demand for coal miners can be analyzed by looking separately at the total amount of coal produced and miner productivity. Higher coal production leads to increased miner demand, while higher miner productivity (output per miner per hour) reduces the mine labor required for a given quantity of coal.

From 1972 to 1990, annual coal production grew at an average rate of between three and four percent, almost doubling in that period to just over a billion tons in 1990. Since 1990, coal production has changed little. Thus, in the absence of significant changes in miner productivity, demand for coal miners would be near its peak.[1] Exhibit 6 shows annual coal production between 1972 and 1995.

Exhibit 6. Historical Trends in Annual Coal Production

Year	Annual Production (millions of short tons)
1972	602.5
1975	654.6
1980	829.7
1985	883.6
1990	1,029.1
1995	1,033.0

Source: Annual Energy Review. http://www.eia.doe.gov/emeu/aer/coal.html (EIA, 2000b).

Miners' productivity, however, did change dramatically over this period. After rising rapidly and steadily from 1949 through the late 1960s, miner productivity plunged by about a third through the 1970s. This drop in productivity resulted from a combination of labor unrest, aggressive implementation of mine safety regulations, and rapid entry of less experienced firms and miners in response to the oil shocks of the 1970s (Darmstadter, 1997).

Productivity (in terms of the hourly average tons of coal mined per miner) began climbing again at

[1] It should be noted that improvements in productivity have contributed to the increased use of coal over time. In the absence of these changes in miner productivity, current levels of coal usage would be lower.

the end of the 1970s and grew very rapidly through at least 1994: in contrast to the two-percent-per-year drop in miner productivity from 1970 to 1980, miner productivity rose by more than six percent annually from 1980 through 1994. Part of this rapid gain resulted from improvements and growing mechanization in both surface mining (prevalent in the West) and underground mining (common among mines in the eastern U.S.). Labor productivity at surface mines benefited from increases in the size of the excavating equipment (i.e., larger equipment can haul more coal per hour than smaller, more labor-intensive equipment). At the same time, underground mining shifted towards highly mechanized "longwall" techniques in which mining machines ate into a coal seam along a wall a thousand feet long or more, while the unsupported roof of the mine was allowed to collapse behind the equipment as it moved. Miners' productivity at both underground and surface mines also benefited from the increasing use of sophisticated computer control systems (Darmstadter, 1997).

Another factor leading to higher average productivity among miners was the closure of some of the smallest and least efficient mines. These mines had been opened in response to the oil shocks and a resulting spike in the price of coal in the mid 1970s (EIA 1998, p. 113). When coal prices declined, these mines were no longer profitable.

Aggregate miner productivity was also boosted by the rapid increase in the West's share of coal production starting in the early 1970s. Because miner productivity in the West is several times that of the rest of the U.S., the nation's average miner productivity increases as production shifts to the West. Western coal is transported to eastern utilities by rail. Aiding the penetration of western coal into eastern markets, including the increased use in the utility industry, has been a drop in rail rates of more than a third between 1979 and 1993 (Darmstadter, 1997). Moreover, ambient air quality standards for SO_2 favored low-sulfur coal (even before the promulgation of regulations under Title IV[2]).

Through the 1970s, the combination of increasing coal production and declining output per miner led to rapid increases in employment. Employment reached a peak in 1978 at about 250,000 workers. From that point, rapid increases in productivity outstripped the rate of growth in coal demand, and employment began to drop. By 1994, just before Title IV's SO_2 program went into effect, the number of coal workers had fallen below 100,000, a loss of about 150,000 miner jobs in less than 20 years.

B. National Title IV Employment Impacts in Context

By projecting coal demand and miner productivity into the future, it is possible to project future changes in demand for coal miners. Under assumptions that leave out the effects of Title IV, modest increases are projected in coal demand by utilities for both eastern and western coal through at least 2010. These estimates are presented in Appendix B, which also shows projections for total coal demand under simplifying assumptions that the ratio between utility demand and total demand is constant.[3] Over the same period, annual increases are projected in miner productivity of 4.5 percent until 2000, falling to 4.0 percent per year for the next five years, and then to 3.5 percent in 2005 and thereafter (EPA, 1996). Combining region-specific estimates of coal production for 2000, 2005, and 2010 with estimates of labor requirements per million tons of produc-

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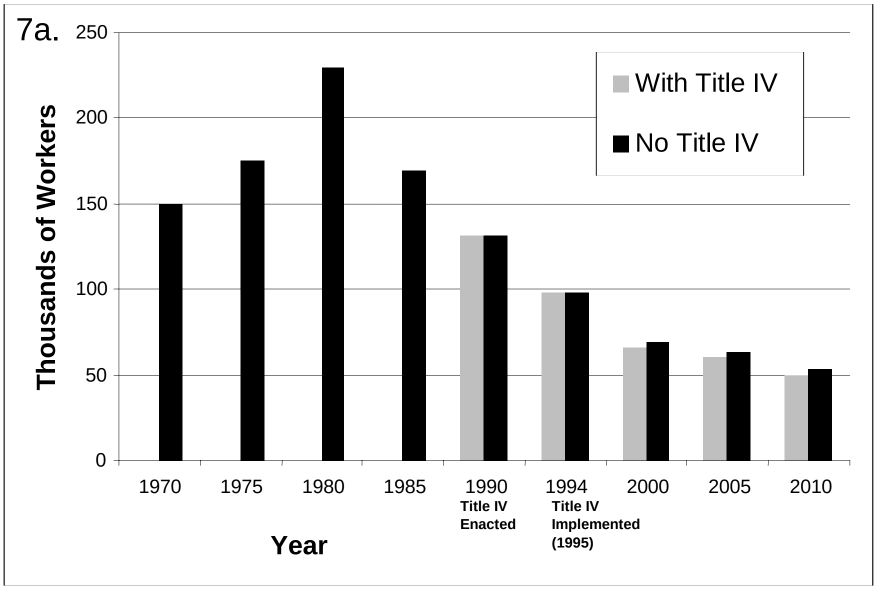
[2] The influence of air quality standards in existence before the Title IV regulations were promulgated may have been weakened by the nature of the SO_2 emissions rate targets, a large portion of which (perhaps over 90 percent), were non-binding. State Implementation Plans generally are not the binding mechanisms that drive reduction in SO_2 emissions and are only one way to meet local air quality standards (Burtraw, 2000).

[3] The numbers supporting these graphics are presented in Appendix B.

tion (calculated using projected increases in mining productivity from a 1994 baseline) yields projections of mining employment in the absence of Title IV. These projections are shown in Exhibit 7a. Exhibit 7b provides the data points shown in Exhibit 7a.

Exhibits 7a and b. Job Slot Changes in the Mining Sector: National Coal Mining Employment With and Without Title IV



Sources: 1) Data from the U.S. Department of Energy, Energy Information Administration, *Coal Industry Annual* 1994; 2) ICF analysis.

7b. Year	Thousands of miners	
	With Title IV	Without Title IV
1970	150	150
1975	175	175
1980	230	230
1985	169	169
1990	131	131
1994	98[4]	98
2000	67	69
2005	60	63
2010	50	54

Sources: 1) Data from the U.S. Department of Energy, Energy Information Administration, *Coal Industry Annual* 1994; 2) ICF analysis.

Exhibit 7a also shows projected coal mining employment if the effects of Title IV are taken into account. This projection, shown as the light-colored bar, was calculated based on the coal output projections shown in Appendix B under the heading "Projections Including Effects of Title IV," and identical productivity estimates. Exhibit 7a shows clearly that, although mining employment has fallen dramatically since its peak in the late 1970s, and is expected to continue falling, most of this drop has occurred and would continue to occur independently of Title IV. This same point is made in a different way in Exhibit 8. Exhibit 8 compares the cumulative loss in miners' job slots through 2010 from the 1978 peak and from 1990 (the year the CAAA was enacted) to the miners' job slot losses attributable to Title IV. As shown, the losses attributable to Title IV are small compared to the drop in miner job slots that was already underway and continues to occur due to increases in coal miner productivity.

C. Employment Changes in the Regions Most Affected by Title IV

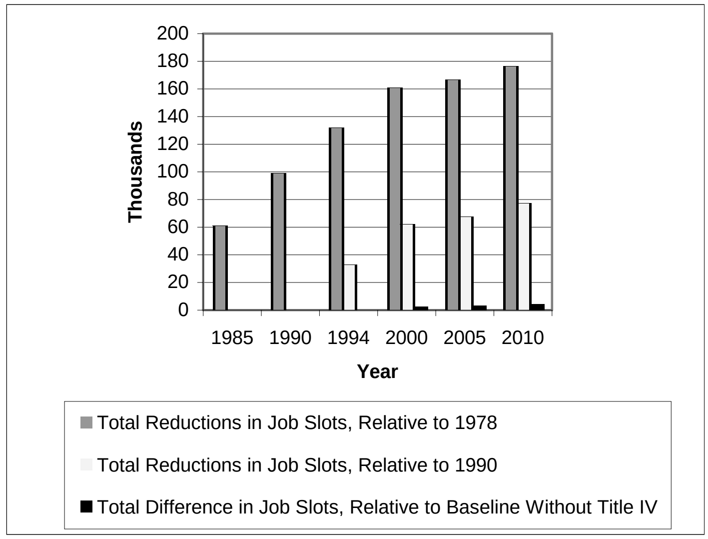
The preceding section concentrated on the effects of Title IV on total nationwide coal employment, netting out the reductions in miners' job slots in some regions with the gains in others. It is also useful to focus specifically on the regions that are projected to lose miner job slots as a result of Title IV, keeping in mind that there will be offsetting

4 There may have been some effect on employment in 1994, even before Title IV took effect, as a result of utilities anticipating the regulations. This possible effect was not modeled in EPA's analyses.

gains in job slots for miners in other regions.

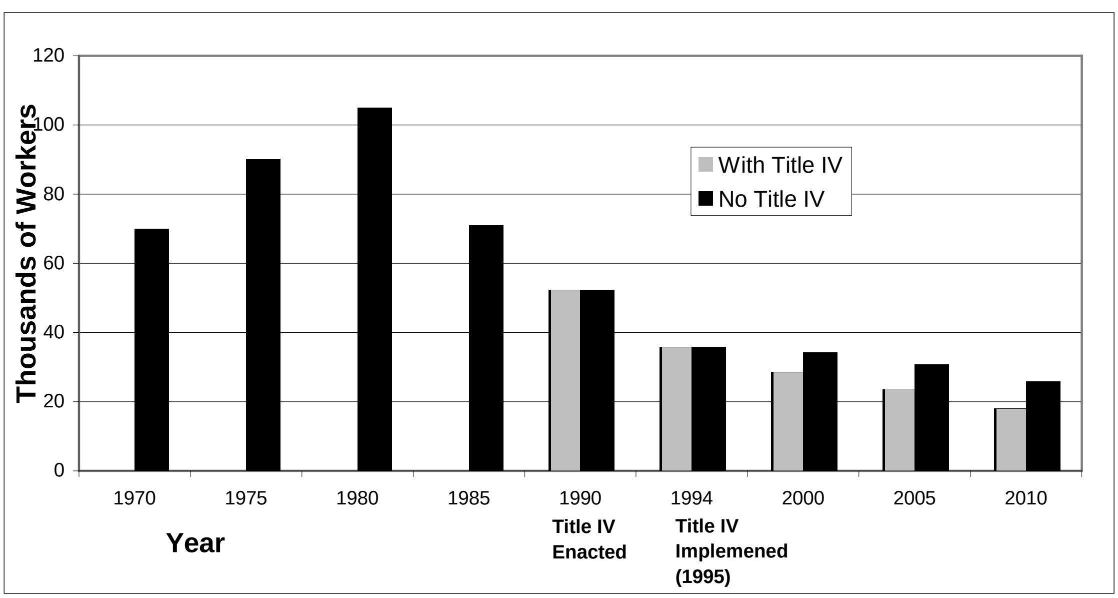
In addition to projected output by region and for the entire U.S., Exhibit 3 also shows total output and output changes in northern Appalachia and the Midwest. Coal employment in these two regions is expected to decline under Title IV because of the higher sulfur levels in their coal resources. To put these changes in the context of historical employment changes in these areas, Exhibit 9a shows total employment in these regions with and without Title IV. Exhibit 9b provides the data points shown in Exhibit 9a. Though the effects of Title IV are more evident in Exhibit 9a than in Exhibit 7a, which shows national mining job losses, it is again true that most of the lost job slots came before Title IV, and that mining employment is expected to continue to decline in these regions even if Title IV did not exist. Exhibit 10 displays the cumulative loss in miners' job slots through 2010 from the 1978 peak and from 1990 (the year the CAAA was enacted) to the miners' job slot losses attributable to Title IV. By the year 2010, the loss in job slots attributable to Title IV will represent only about ten percent of the reduction from the peak in 1978.

Exhibit 8. National Coal Mining Employment Losses With and Without Title IV



Sources: ICF analysis of and data from the U.S. Department of Energy, Energy Information Administration, *Coal Industry Annual* 1994.

Exhibit 9a. Coal Miners' Job Slots With and Without Title IV in Northern Appalachia and the Midwest



D. Programs to Assist Unemployed Coal Miners

Mine and other coal industry workers facing job losses attributable to the requirements of the Clean Air Act are eligible for grants from the Federal government for job training, educational, and relocation assistance. Operating between 1992 and 1993, the Clean Air Employment and Training Act (CAETA) was designed as a special appropriations through the U.S. Department of Labor to assist such workers. The program was discontinued after 1993, but the Department of Labor maintained the authority to provide grants through a discretionary fund in Part B of Title III of the Job Training Partnership Act, as amended by the 1990 CAAA in Title XI "Clean Air Employment Transition Assistance," (29 U.S.C. 1501).[5]

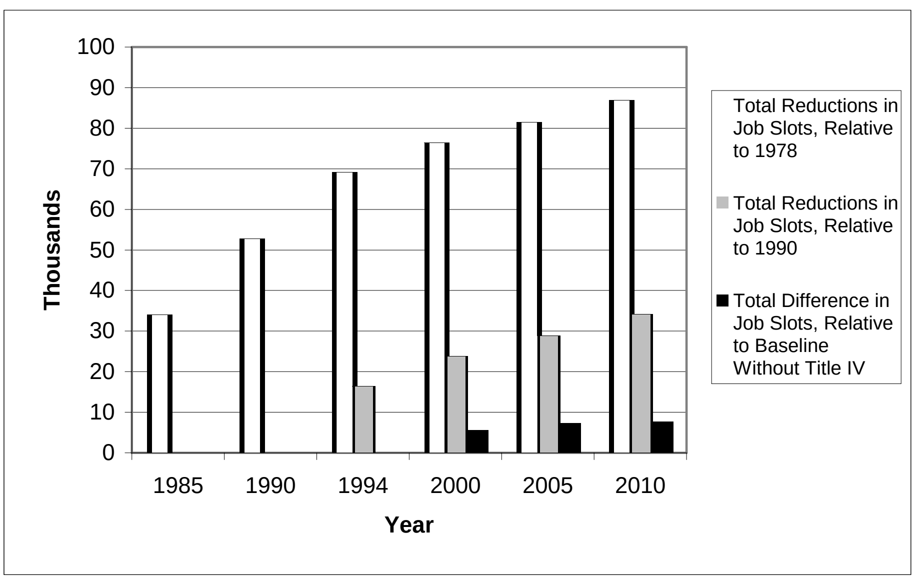
As of 1998, over $82 million was granted by the Federal government between 1992 and 1996 to coal mining companies, states, and the United Mine Workers Union for provision of job counseling, vocational and occupational training, needs related payments, and related services. Workers in eastern and midwestern States received the majority of grants and funding, with Illinois (12 grants, $32.5 million) and West Virginia (seven grants, $23.5 million), receiving the largest share of the assistance. The average grant served approximately 182 workers and provided nearly $2.4 million in dislocated worker services. Exhibit 11 shows, by State, the number and value of CAETA and Title III grants directed to dislocated coal miners between 1992 and 1996.

Exhibit 9b. Coal Miners' Job Slots With and Without Title IV in Northern Appalachia and the Midwest

Year	Thousands of miners	
	With Title IV	Without Title IV
1970	70	70
1975	90	90
1980	105	105
1985	71	71
1990	52.3	52.3
1994	35.8	35.8
2000	28.6	34
2005	23.5	31
2010	18.1	26

Sources: ICF analysis of and data from the U.S. Department of Energy, Energy Information Administration, *Coal Industry Annual* 1994.

Exhibit 10. Coal Miners' Job Slot Losses With and Without Title IV in Northern Appalachia and the Midwest



Sources: ICF analysis of and data from the U.S. Department of Energy, Energy Information Administration, *Coal Industry Annual* 1994.

5 During 1992 and 1993, almost $25 million was allocated through CAETA. An additional $58 million was awarded through the discretionary Title III program. Nearly $31 million was granted through Title III in 1995.

Exhibit 11. CAETA and Title III Grants: Distribution by State 1992-1996 Program Years

Location of Grantee(s)	Number of Grants Awarded	Number of Workers Served	Total Amount of Grants (Undiscounted)
Illinois	12	2,119	$ 32,508,695
West Virginia	7	1,258	$ 23,482,784
Indiana	1	682	$ 6,573,467
United Mine Workers Union	1	625	$ 2,000,000
Pennsylvania	1	543	$ 1,400,000
Ohio	8	495	$ 8,103,152
Kentucky	1	225	$ 5,249,890
Missouri	1	192	$ 1,000,000
Idaho	1	164	$ 485,027
Kansas	1	33	$ 900,000
Texas	1	30	$ 842,189
Total	**35**	**6,366**	**$ 82,545,204**

Source: Brian Deaton, US Department of Labor, February 27, 1998. Table titled "Projects Funded to Assist Dislocated Workers from Clean Air Amendments Impacts."

V. Limitations of the Analysis

The analyses conducted for this report incorporated a fine-grained representation of the behavior of a large number of industrial entities; it covers both a long period of time and a wide geographical area. As with any similar attempt to project the future in detail, it is subject to limitations and uncertainties. Thus, several factors could lead to cost and emission impacts above or below the reported impacts. Those factors are shown in Exhibit 12.[1]

Exhibit 12. Limitations of the Analysis

Limitation	Potential Influence on the Findings
This study is based on the results of two energy/economic models, IPM and CEUM, both of which necessarily make various simplifying assumptions. For example, these models assume that utilities act so as to minimize the total cost of producing a given quantity of electricity, setting aside other motives such as a desire to preserve local mining jobs. The models also assume risk neutrality and perfect foresight. This may affect job loss because, for example, utility planners might expect higher allowance prices than are actually seen, and over-invest in scrubbers, which use higher sulfur coal that would further limit job loss. Even with entirely correct information on the current population of generating units, however, the difficulty of predicting changes in that population (as well as in other factors) in the future would add uncertainty to the projections.	Decreased job loss
Pollution Control Costs and Performance - EPA used estimates of SO_2 scrubber costs and performance that reflect the current state of the art. However, technological progress stimulated by competition could lead to improvements in the performance and cost of pollution control technology in the future. These improvements could in turn lead to greater reliance on scrubbers relative to coal switching, and therefore to smaller changes in coal mining employment. For this reason, the Agency's estimates of future job impacts could be overstated.	Decreased job loss
The analyses used for this report relied on a database that consists of information on virtually every utility generator in the U.S. The Agency has assembled the best information on each boiler and generator that is publicly available. Inevitably, when working with information on such a large number of facilities, some units might not be represented correctly. Improvements to the database could lead to changes in estimated impacts.	Mixed effects on job loss
Though most of the attention given to the job impacts of Title IV relates to coal miners, Title IV positively affects employment in railroads and pollution control equipment manufacturing, installation, and operation. These secondary employment effects have not been examined in this analysis. It is important to note instances in which environmental programs will generate new jobs to offset jobs that are lost. The crux of the controversy over Title IV, however, appears to be centered on the gross number of mining jobs lost in high-sulfur coal mining regions, rather than on a measure of net jobs created. As no number of jobs created in the transportation or pollution control industries would have an effect on the gross reductions in labor demand due to coal miner job losses, no estimate of jobs created was produced for this report.	Decreased net job loss
Because coal-mining regions were the geographical unit of analysis, this report did not pick up potential shifts between states in these regions, or within individual states. This limitation probably has little effect on estimates of the net changes in labor demand, but might have resulted in underestimates of gross labor demand shifts.	Increased gross job loss
To ensure consistency with related analyses, the most recent model runs used for this report were conducted in 1996, and therefore did not use the most up-to-date projections of the growth in labor productivity, other regulatory initiatives, or fuel prices.	Mixed effects on job loss

1 In addition to those limitations discussed, it should also be noted that this analysis does not take into consideration non-utility use of coal, nor does it consider whether any difficulties might arise for displaced workers in finding new employment opportunities.

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Appendix A: Description of the 1996 Integrated Planning Model

This appendix discusses the use of the Integrated Planning Model (IPM) for the analysis, including assumptions about the baseline and about technologies for power generation and emission control.

A.1. Analytical Overview

The actions of electricity generators under a set of regulations were projected using IPM, which is a detailed computer model of the electric power industry. IPM is designed to find the most efficient (that is, the least-cost) way to satisfy the demand for electricity under a series of limitations or constraints. The constraints under which IPM "produces" electricity can include a limit on tons of SO_2 emissions, and it is by setting this constraint that the effects of Title IV can be modeled. Running IPM without a limit on tons of SO_2 emissions produces a picture of the baseline situation in which the Title IV is not in effect. A rerun of the IPM after adding a constraint that limits SO_2 emissions to a specified number of tons shows what the industry would do to comply with Title IV while keeping its costs as low as possible. More detail on how IPM operates is provided below and in Analyzing Electric Power Generation Under the CAAA, Office of Air and Radiation, U.S. Environmental Protection Agency, July 1996 (www.epa.gov/capi/IPM/update.htm).

IPM is an optimization model that uses a linear programming formulation to select investment options and to dispatch generating and load management resources to meet overall electricity demand and energy requirements. The model selects the investment options based on the cost and performance characteristics of the available options, forecasts of customer demands for electricity, and reliability criteria. System dispatch, which involves the determination of proper and most efficient use of the existing and new resources available to utilities and their customers, is determined using the resource mix, unit operating characteristics, and fuel and other costs. Unit and system operating constraints provide the system-specific reality to the model's simulations. The model has the capability of using forecasts of conditions, requirements, and option characteristics to make present decisions and is thus termed as dynamic. The model tries to represent the perspective of utility managers, regulatory personnel, and the investing public in reviewing important financial options for the utility industry and electricity consumers. The model's objective is to minimize the discounted sum of capital and operating costs over the full planning horizon.

IPM has been used for over ten years by electric utilities, trade associations, and government agencies both in the U.S. and abroad to address a wide range of electric power market issues. The applications have included capacity planning, environmental policy and compliance planning, wholesale price forecasting, and asset valuation. EPA has used IPM extensively for environmental policy and regulatory analysis. In particular, EPA has used IPM to analyze NOx emission policy and regulations as part of the Clean Air Power Initiative (CAPI) in 1996 and as a tool to analyze alternative trading and banking programs during the OTAG process in 1996 and 1997.

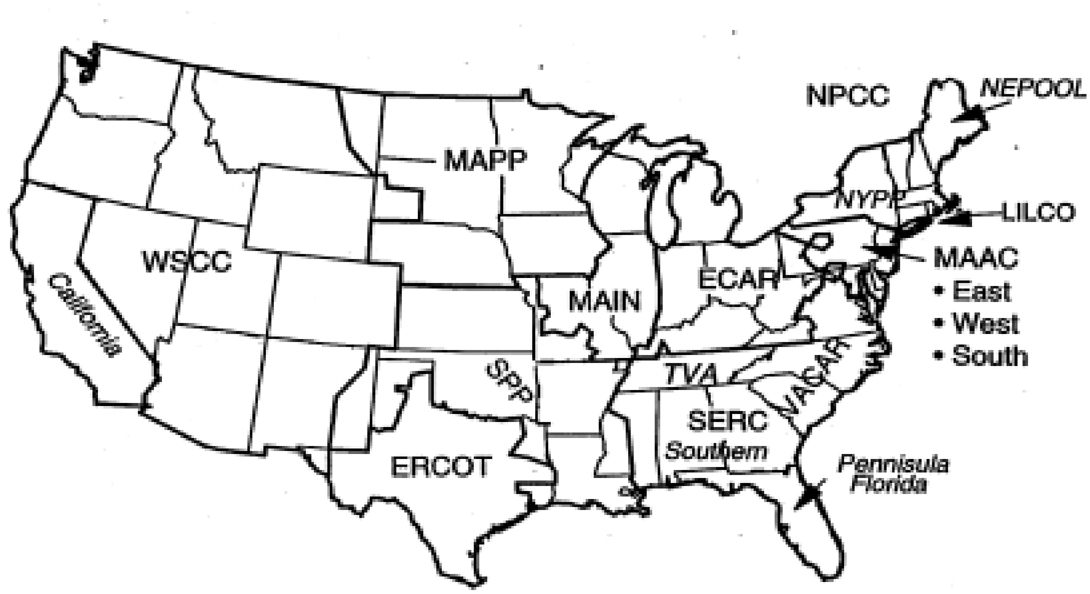
IPM has undergone extensive review and validation over this ten-year period. In April 1996, EPA requested participants in the CAPI process to comment on the Agency's new approach to forecasting electric power generation and selected air emissions. EPA received many helpful comments and made a series of changes in its methodology and assumptions based on CAPI participants' recommendations. Recently, IPM and EPA's modeling assumptions were reviewed as part of the OTAG process. Again, changes were made to the methodology and assumptions to accommodate participants' recommendations.

The version of IPM used by EPA represents the U.S. electric power market in 21 regions, as depicted in Exhibit A-1. These regions correspond in most cases to the regions and subregions used by the North American Electric Reliability Council (NERC). IPM models the electric demand, generation, transmission, and distribution within each region as well as the transmission grid that connects the regions.

cation of the model has focused heavily on understanding the future operations of coal-fired units, which will have the greatest air emissions among the fossil-fired units. The operation of other types of non-fossil fuel-fired generation capacity, including nuclear and renewables, are also simulated but at a higher degree of aggregation.

Working with these existing model plants and representations of alternative new power plant options, IPM determines the least-cost means for supplying electric demand while limiting air emissions to remain below specified policy limits. Multiple air emissions policies can be modeled simultaneously. For example, IPM is used in this

Exhibit A-1. Integrated Planning Model Regions in the Configuration Used by EPA



Source: ICF Consulting.

The model includes existing utility power plants as well as independent power producers and cogeneration facilities that sell firm capacity into the wholesale market. Data on the existing boiler and generator population, which consists of close to 8,000 records, are maintained in EPA's National Electric Energy Data System (NEEDS). In order to make the modeling more time and cost efficient, the individual boiler and generator data are aggregated into "model" plants. EPA's appli-

study to simulate compliance with existing CAAA Title IV SO_2 emission requirements. While determining the least-cost solution, IPM also determines the optimal compliance strategy for each model plant.

A wide range of compliance options are evaluated, including the following:

- ❖ Fuel Switching - For example, switching from high sulfur coal to low sulfur coal.

- ❖ Repowering - For example, repowering an existing coal plant to a gas combined-cycle plant.

- ❖ Pollution Control Retrofit - For example, installing selective catalytic reduction (SCR), selective non-catalytic reduction (SNCR), or gas reburn (to reduce NOx emissions), or flue gas desulfurization (to control SO_2 emissions).

- ❖ Economic Retirement - For example, retiring an oil or gas steam plant.

- ❖ Dispatch Adjustments - For example, running high NOx cyclone units less often, and low NOx combined-cycle plants more often.

IPM provides estimates of air emission changes, incremental electric power system costs, changes in fuel use, and other impacts for each air pollution policy analyzed.

The model is not limited in scope to facilities owned by electric utilities, but also includes independent power producers (IPP) that provide electricity to the power grid on a firm-contract basis, as well as IPP facilities larger than 25 MW that provide power on a non-firm basis.

IPM simultaneously models over an extended time period, and reports results for selected years. These analyses provide results for 2000, 2005, and 2010.

In applying IPM to analyze EPA emission policy, EPA has developed a set of data and assumptions that reflect the best available information on the electric market and operating factors. The relevant data and assumptions can be grouped into the following categories:

- ❖ Macro Energy and Economic Assumptions - These assumptions are related primarily to electricity demand projections, fuel prices, power plant availability, capacity factors, lifetimes, and heat rates. Heat rate data on individual coal plants are used in constructing the model plants. Also included in this category are discount rate and year dollar assumptions.

- ❖ Electric Technology Cost and Performance - These assumptions are related to electric technology cost and performance for existing and new plants, as well as for existing plant refurbishment and repowering.

- ❖ Pollution Control Performance and Costs - These assumptions primarily cover the performance and unit costs of pollution control technologies for NOx and SO_2.

Each of these sets of data and assumptions are briefly discussed below. More detail can be found in EPA's report entitled "Analyzing Electric Power Generation under the CAAA."

A.1.1 Macro Energy and Economic Assumptions

EPA made assumptions about major macro energy and economic factors, as shown in Exhibit A-2. See Appendix No. 2 of EPA's report "Analyzing Electric Power Generation under the CAAA" for details on most of the macro energy and economic factors.

A.1.2. Electric Energy Cost and Performance Assumptions

In order to simulate the electric power market under base case conditions, assumptions were made on the cost and performance of new power plants as well as for repowering existing power plants. These characterizations of new power plant costs and performances were used in IPM to determine the least cost means for meeting projected future electricity requirements subject to the base case emission restrictions and the SO_2 emission limits specified for the analysis.

Exhibit A-2. Key Baseline Assumptions for Electricity Generation

Factor	Assumption	Source/Comments
Discount Rate	6 percent	ICF estimate
Electricity Demand Growth Rate (% per Year)	1993-2000 = 1.8% 2001-2010 = 1.7% After 2010 = 1.3%	NERC and DRI estimates
Power Plant Lifetimes	Fossil Steam = 65 years if ≥ 50 MW = 45 years if < 50 MW Nuclear = 40 year license length	ICF estimate
U.S. Nuclear Capacity (GW)	1993 = 99 GW 2000 = 97 GW 2005 = 94 GW 2010 = 90 GW 2020 = 48 GW	ICF estimate based on current utility plan and assumed plant shutdowns; No new nuclear construction assumed
Nuclear Capacity Factors (%)	2000 = 75% 2005 = 74% 2010 = 73% 2020 = 74%	EIA estimate
U.S. Imported Crude Oil Prices (1995 $/BBL)	2000 = $20 2005 = $22 2010 = $24 2020 = $28	1996 EIA estimate, post 2010 extrapolation
Wellhead Natural Gas Price (1995$ per MMBtu)	2000 = $1.80 2005 = $1.92 2010 = $1.92	Model forecast of future gas prices in the Base Case
Fossil Steam Plant Availability (%)	1994 = 80% 2000 = 82% 2005/10/20 = 85%	ICF estimate based on historic trends
Coal Mining Productivity Increases (% per year)	1995-1999 = 4.5% 2000-2004 = 4.0% 2005-2009 = 3.5% 2010-2014 = 3.0% 2015-2025 = 2.5%	ICF estimate based on long run trends
Coal Transportation Rates (% change/year 2001-2010)	Current rail, truck, and barge costs, declining 2% per year	ICF estimate using unit cost information and FERC form 423 delivery data and long run trends

Sources: As noted in the right-hand column.

Power plant cost and performance assumptions were developed for the following new conventional and unconventional power plant types:

New Conventional Power Plants

- ❖ Conventional Pulverized Coal
- ❖ Advanced Coal (Integrated Gasification Combined Cycle - IGCC)
- ❖ Combined Cycle
- ❖ Combustion Turbine

New Renewable/Nontraditional Options

- ❖ Biomass IGCC
- ❖ Solar Photovoltaics
- ❖ Solar Thermal
- ❖ Geothermal
- ❖ Wind

In order to capture changes in technology over time, cost and performance projections were developed for 2000, 2005, and 2010. In general, the year 2000 estimates reflect current technology, the 2010 estimates reflect advancements in costs and performance, and the 2005 estimates represent midpoints between these values. The approach was adopted from work that the Energy Information Administration (EIA) did in support of the 1995 and 1996 Annual Energy Outlooks (AEO95 and AEO96). EIA had its approach peer-reviewed during its development.

In addition to the AEO, key data sources used to develop the cost and performance assumptions are as follows:

EPRI, TAG Technical Assessment Guide, Electricity Supply - 1993, EPRI TR-102276-V1R7, June 1993;

SERI, The Potential of Renewable Energy: An Interlaboratory White Paper, SERI/TP-260-3674, March 1990; and

TVA, Integrated Resource Plan Environmental Impact Statement, Volume Two,
Technical Documents, July 1995.

In addition to these assumptions on new power plants, EPA also developed assumptions on the cost and performance of repowering existing power plants. The following three types of repowering options were considered:

- ❖ Repowering Coal Steam to Integrated Gasification Combined-Cycle
- ❖ Repowering Coal Steam to Gas Combined-Cycle
- ❖ Repowering Oil/Gas Steam to Gas Combined-Cycle

The key sources of data for this section are the repowering studies conducted by Bechtel Corporation and the TVA Integrated Resource Plan EIS.

For more details on the assumptions made about the cost and performance of new power plants and repowering of existing power plants, see Appendix No. 3 of EPA's report, "Analyzing Electric Power Generation under the CAAA."

A.1.3. Pollution Control Performance and Cost Assumptions

Exhibit A-3 contains the scrubber cost assumptions used in the model. These assumptions were developed from a review of Phase I experience in the 1989 base case and 1992 SO_2 RIA, updated for 1995 dollars and to reflect a 95 percent SO_2 removal rate (consistent with actual planned performance for announced Phase I scrubbers). Actual costs will need to be adjusted upwards to

Exhibit A-3. Scrubber Cost Assumptions (1995$, excludes retrofit factor) (Based on estimates for medium sulfur coal (2%S))

Capital ($/kW)	172
Fixed O&M ($/kW/yr)	6.2
Variable O&M (mills/kWh)	1.0
Capacity Penalty (%)	2.1%
Energy Penalty (%)	2.1%
% Removal	95%

Source: U.S. Environmental Protection Agency (July 1996), Office of Air and Radiation, *Analyzing Electric Power Generation Under the CAAA*.

account for the difficulty of the retrofit. This report assumes a retrofit factor of 1.1 for large power plants. For plants with installations below 500 MW, these factors should be scaled by (500/x)0.6, where x is the MW size of the power plant.

For more details on the assumptions made about pollution control cost and performance see Appendix No. 5 of EPA's report, Analyzing Electric Power Generation under the CAAA.

A.2 References

Bechtel Power Corporation (February 1996), Cost Estimates for NOx Control Technologies Final Report.

Bechtel Power Corporation (June 1996), Draft technical study on the use of gas reburn to control NOx at coal-fired electric generating units.

Electric Power Research Institute (June 1993), TAG Technical Assessment Guide, Electricity Supply - 1993, EPRI TR-102276-V1R7.

SERI (March 1990), The Potential of Renewable Energy: An Interlaboratory White Paper, SERI/TP-260-3674.

Tennessee Valley Authority (July 1995), Integrated Resource Plan Environmental Impact Statement, Volume Two, Technical Documents.

U.S. Environmental Protection Agency (July 1996), Office of Air and Radiation, Analyzing Electric Power Generation Under the CAAA. For more about the Clean Air Act Amendments, visit the Clean Air Power Initiative (CAPI) main page at http://www.epa.gov/capi/capi.html.

Appendix B: Coal Use Projections With and Without Title IV

This appendix presents the projections of coal production by region made in the course of modeling the effects of Title IV. Under assumptions that do not include Title IV, only modest increases were projected in coal demand by utilities for both eastern and western coal through at least 2010. These estimates are presented in Exhibit B-1, which also shows projections for total coal demand under simplifying assumptions that the ratio between utility demand and total demand is constant. Exhibit B-2 shows the change in demand for coal from 1994 to 2000, 2005, and 2010. These demand estimates, along with projections of miner productivity, were used to project future changes in demand for coal miners.

Exhibit B-1. Coal Use by Utilities and Total Production With and Without Title IV (millions of tons per year)

	Baseline Demand Projections		Projections Including Effects of Title IV	
	Demand by Utilities	**Estimated Total Demand**	**Demand by Utilities**	**Estimated Total Demand**
Year	**2000**	**2000**	**2000**	**2000**
Region				
Northern Appalachia	170	194	139	159
Central & Southern Appalachia	164	187	188	214
Midwest	94	108	76	86
West	525	598	549	625
Total	953	1,086	952	1,084
Northern Appalachia + Midwest	265	301	215	245
Year	**2005**	**2005**	**2005**	**2005**
Region				
Northern Appalachia	183	208	133	152
Central & Southern Appalachia	180	205	212	242
Midwest	96	109	70	80
West	569	648	612	696
Total	1,028	1,171	1028	1,170
Northern Appalachia + Midwest	279	318	204	232
Year	**2010**	**2010**	**2010**	**2010**
Region				
Northern Appalachia	180	205	122	138
Central & Southern Appalachia	196	223	228	260
Midwest	107	122	68	78
West	574	654	637	725
Total	1,058	1,205	1055	1,202
Northern Appalachia + Midwest	287	327	190	216

Source: IPM 1996 runs.

Exhibit B-2. Coal Use Changes Due to Title IV

	Change (in millions of tons)		Percent Change	
	Demand by Utilities	**Estimated Total Demand**	**Demand by Utilities**	**Change in Utility Demand Due to Title IV**
Year	**2000**	**2000**	**2000**	**2000**
Region				
Northern Appalachia	-31	-35	-18.2%	-18.0%
Central & Southern Appalachia	24	27	14.6%	14.4%
Midwest	-18	-22	-19.1%	-20.4%
West	24	27	4.6%	4.5%
Total	-1	-2	-0.1%	-0.2%
Northern Appalachia + Midwest	-50	-56	-18.9%	-18.6%
Year	**2005**	**2005**	**2005**	**2005**
Region				
Northern Appalachia	-50	-56	-27.3%	-26.9%
Central & Southern Appalachia	32	37	17.8%	18.0%
Midwest	-26	-29	-27.1%	-26.6%
West	43	48	7.6%	7.4%
Total	0	-1	0.0%	-0.1%
Northern Appalachia + Midwest	-75	-86	-26.9%	-27.0%
Year	**2010**	**2010**	**2010**	**2010**
Region				
Northern Appalachia	-58	-67	-32.2%	-32.7%
Central & Southern Appalachia	32	37	16.3%	16.6%
Midwest	-39	-44	-36.4%	-36.1%
West	63	71	11.0%	10.9%
Total	-3	-3	-0.3%	-0.2%
Northern Appalachia + Midwest	-97	-111	-33.8%	-33.9%

Source: IPM 1996 runs

Appendix C: Differences Between 1990/1992 and 1996 Analyses

Several analyses have been conducted over the years bearing on the magnitude of the Title IV-induced shifts in coal and labor demand. Changes in the models and assumptions used to conduct these analyses have raised the issue of whether the earlier conclusions about labor market impacts have changed as well. This appendix discusses the changes in assumptions, and compares the projected coal and labor demand impacts of Title IV in the context of these changes. The assessment is complicated by several circumstances: many different analyses of the impacts of Title IV have been conducted; there are multiple factors affecting job impacts; projection timeframes differ from study to study; there are gaps in the data that are required to make consistent comparisons; and there are different ways to interpret the same results. Still, it is possible to infer that the more recent analyses take changes in the industry into account, and are thereby correct in predicting lower overall labor demand impacts.

This appendix is divided into four sections, covering the following: the analyses that are compared; industry changes since the 1992 analysis; differences in impacts on coal demand; and differences in impacts on labor demand.

C.1. Analyses Considered

This document examines comparisons of the impact in the year 2010 (and, to a lesser extent, 2000) of Title IV from two studies: ICF's analysis for the EPA's Regulatory Impact Analysis (RIA) of the Acid Rain Implementation Regulations; and ICF's Integrated Planning Model (IPM) runs for the Clean Air Power Initiative (CAPI) and Section 812 Prospective analyses (which are the focus of the body of this report). The analysis for the RIA was conducted in 1991 using the Coal and Electric Utilities Model (CEUM), with baseline assumptions prepared in 1989. Outputs of the model that are available include coal output by region with and without the SO_2 program, under two baseline scenarios: a low emissions growth case, and a high emissions growth case. As discussed in the body of this report, the CAPI/Section 812 analyses were conducted in 1996 using an improved and updated utility model called IPM. Available outputs include utility coal use by region, with and without the Title IV SO_2 program; the runs use a single set of baseline assumptions dating from 1996.[1]

Three related studies were examined, but the detailed comparisons made between the 1992 and 1996 studies were not also done for these studies. These related studies include the following: ICF's 1990 analysis of proposed acid rain programs, using CEUM and 1989 base case assumptions (which was a precursor to the 1992 ICF analysis used for the RIA); ICF's 1995 analysis of the Title IV SO_2 program using CEUM and 1993 base case assumptions; and a recent study conducted at MIT of the actual effects of Phase I of the SO_2 program against a backdrop of changes prior to the program's effective date. The 1990 analysis is important in that it explicitly calculated and presented coal industry employment changes associated with changes in coal supply. The regulatory regimes that it analyzed—competing Senate and House acid rain proposals—were similar to the final proposals analyzed in 1991 and presented in the 1992 Regulatory Impact Analysis. The 1995

[1] Though the 1998 version of IPM was run for the SIP call analysis (see http://www.epa.gov/ttn/rto/sip), those results were not used in this report because a no-Title IV case was not run using 1998 data. A comparison of the job slot impacts of Title IV requires a comparison of the model results with and without Title IV.

ICF analysis differed in that it used a single set of base case assumptions, which were closer to the "low" 1989 base case, and recognized the possibility of using subbituminous western coal from the Powder River Basin in eastern boilers designed to use bituminous coal. The MIT analysis employed a questionnaire, interviews with power plant operators, data on allowance prices, and actual use of coal and scrubbers in complying with Phase I of the Title IV SO_2 program. The review of actual data in the MIT analysis was used to estimate the actual cost of the program and help explain the utilities' responses to the program. These three analyses are referred to in the text for illustrative purposes.

C.2. Industry Changes Since the 1992 RIA

Of the numerous changes in the coal and electric utility industries that have occurred since the 1992 analysis was conducted, three are of particular importance to the question of employment impacts.[2] These three changes—coal mining productivity projections, the suitability of subbituminous coal for eastern boilers, and shipping cost reductions—are discussed in turn in the following sections.

Coal mining productivity. The trend toward improved coal-mine productivity appeared much stronger by 1996 than had been assumed in the analyses of the late 1980s and early 1990s. Exhibit C-1 compares the productivity growth rates that were used in the 1992 and 1996 analyses.

Labor productivity growth in the mining sector has greatly exceeded the historic productivity growth rate in manufacturing over the last ten years. An analysis of the technology and management practices used in existing mines indicates that considerable opportunities still exist to improve productivity.

EPA's future productivity growth assumptions are based on an analysis of historic productivity by state, in union and non-union areas, and in surface and deep mines. The historic rates of improvement are then projected to continue, but to decline toward a more typical U.S. manufacturing labor productivity growth rate (2.5 - 3.0 percent per year) over time. This rate of improvement is applied to both existing and new mines.

A review of 1985-94 average labor productivity growth in each region indicates that growth has been about 5.6 percent per year (SAB, 1997). Furthermore, this rate seems to be similar in all parts of the country, regardless of union membership or mine type. Rates vary from one year to the next, but, overall, no significant differences can be identified by mine type or union affiliation in the last ten years. Although the 1993 coal strike has affected the trend, the rate of improvement has been declining over time.

Exhibit C-1 shows that the hourly output that would have been predicted in the 1992 analysis for the year 2010 was considerably lower than in the 1996 analysis. The more recent projections, used in the 1996 analysis, set the rate of productivity growth for the years 1996 through 2000 at 4.5 percent per year, dropping to 4.0 percent and then 3.5 percent over the next ten years. This rate translates into substantially higher projected productivity for the year 2010. This gain in projected labor productivity might appear to favor western coal producers, whose projected output per worker has risen more than the output per worker at eastern mines (i.e., an increase from 2.0 percent in the 1992 analysis, to between 3.5 and 4.5 percent, instead of the smaller increase from 3.0 percent to between 3.5 and 4.5 percent for the East). Because labor is a much larger component of the cost of eastern coal than western coal, however, the unexpectedly large improvements in eastern productivity are actually more significant economically than the even larger percentage gains in western productivity. Thus, labor productivity

[2] An additional change resulting from restructuring since 1998 is that plants have changed from being EIA classified as traditional utilities to non-utilities. Because this analysis uses data from 1996, this issue does not affect the outcomes.

Exhibit C-1. Comparison of Productivity Measures used in the 1992 and 1996 Analyses (tons per worker per hour and percentage growth per year)

Productivity Measure	1992 Analysis		1996 Analysis	
	East	**West**	**East**	**West**
1989 Productivity (calculated)	2.50	10.07	NA	NA
1994 Base Productivity	3.28	13.23	3.28	13.23
2000 Productivity (calculated)	3.46	12.52	4.27	17.23
2010 Productivity (calculated)	4.65	15.27	6.14	24.77
Growth Rate to back calculate 1994 Rate to 1989 Rate for 1992 Analysis	*5.6 %*	*5.6 %*	*NA*	*NA*
Growth Rate: 1994-1999	*3 %*	*2 %*	*4.5 %*	*4.5 %*
Growth Rate: 2000-2004	*3 %*	*2 %*	*4.0 %*	*4.0 %*
Growth Rate: 2005-2010	*3 %*	*2 %*	*3.5 %*	*3.5 %*

Source: ICF analysis.

improvements might have tended to shift utilities toward the use of eastern coal to some degree.

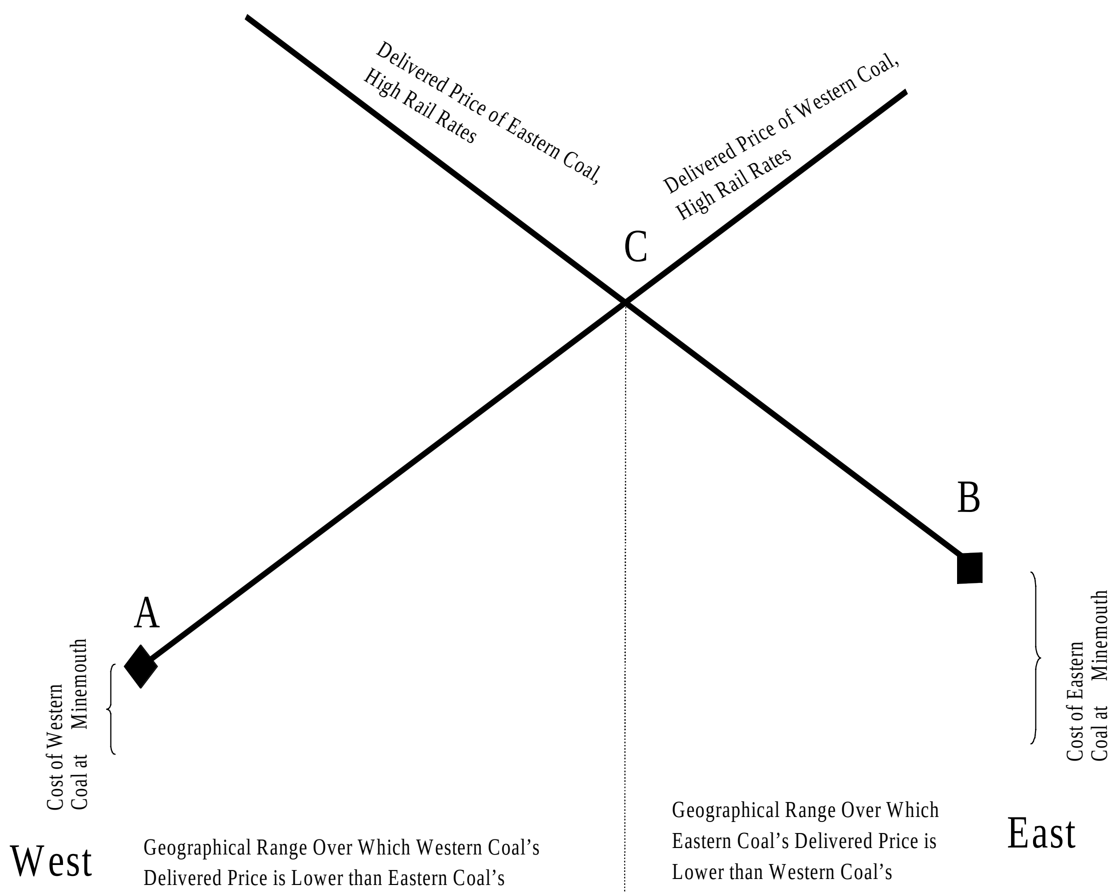
Substitutability of Coal. A second important change in assumptions is the recognition that subbituminous coal from the Powder River Basin in the West can be used in eastern boilers that were designed for bituminous coal. The ability to substitute Powder River Basin coal is important for two reasons: it is less expensive to mine than the eastern coal it can replace, and it is generally much lower in sulfur than eastern coal. Thus, it is potentially a very attractive fuel source both for economic reasons and for compliance with regulations requiring lower SO_2 emissions. In early analyses of the effects of Title IV, coal from the western Powder River Basin had been assumed to play a minor role in utilities' compliance strategies because of questions about the costs of transporting it to the East, and about its suitability for boilers designed for higher-heating-value/lower ash bituminous coal. The 1990 and 1992 analyses assumed that eastern bituminous boilers would not switch to western subbituminous coal, though the text mentioned that this kind of switch was potentially important. By 1993, the possibility of this type of coal switching was well established, though it was assumed that it would involve a significant capital cost (ICF, 1993). Coal purchasing patterns show the growth in the number of power plants that are switching to subbituminous coal, which primarily comes from western regions. For example, during a peak electricity usage month in 1999, approximately 136 of 244 coal burning power plants east of the Mississippi River, or 58 percent of the plants, purchased subbituminous coal. This compares with 110 of 263 plants, or 42 percent of plants, during the same month in 1993 (EIA, 1993 and 1999). The effects of this change in assumptions can be seen in the 1995 analyses of the effects of Title IV, which showed a significantly larger shift toward western coal at the expense of lower-sulfur central and southern Appalachian coal (ICF, 1995).

Assumptions about Transportation Costs. A third change over the past six years has been a very significant drop in the per-mile costs of shipping coal by rail. This decrease is attributed to several factors. Railroads were able to reduce costs in part because deregulation of the industry in 1980 allowed the industry to restructure itself by abandoning unprofitable lines and merging with other companies. Costs were further reduced through work force and equipment downsizing. Some of these cost savings were eventually passed on to customers. Utilities were also able to secure lower rates by increasing use of leased or utility-owned rail-cars, rather than railroad-owned cars.

While the cost to ship coal between the various supply-and-demand-regions fell overall, the differences were not always uniform. For example, between 1988 and 1993, the cost to ship a ton of coal from western supply regions to the east North Central region declined by 40 percent on average. At the same time, the rail costs to ship a ton of coal from eastern supply regions to the east North Central region declined only by about 25 to 30 percent. Because of this difference in the rates of cost decline, and the great distance from the western coal fields to the East, the cost to ship a ton of low-sulfur western coals to eastern markets has decreased relatively more than the cost to ship eastern coals to the eastern markets (EIA, 1995). This relative change in transportation costs has apparently outweighed, by a considerable degree, the advantages of increased labor productivity in the East, leaving a substantial net incentive to use western coals.

The effects of this increased cost-effectiveness are illustrated in Exhibit C-2. The diagram is a schematic picture of the interplay of mining and transportation costs in determining the relative sales of western and eastern coals. Costs are shown vertically, while space is shown horizontally. Western coal costs considerably less to mine, so point A (showing the cost of the western coal with no transportation cost) is lower than point B. Not all customers would necessary find western coal less expensive, however, because shipping it eastward is costly: each additional mile that it must be shipped toward the East raises its delivered cost, as shown by the line sloping upward to the right. (The slope of the line is related to the cost of shipping in cents per ton-mile.) Eastern coal must also be shipped if it is to compete for the business of coal users between the

Exhibit C-2. Schematic Explanation of Effects of Rail Transportation Rates on Coal Competition



Source: ICF analysis.

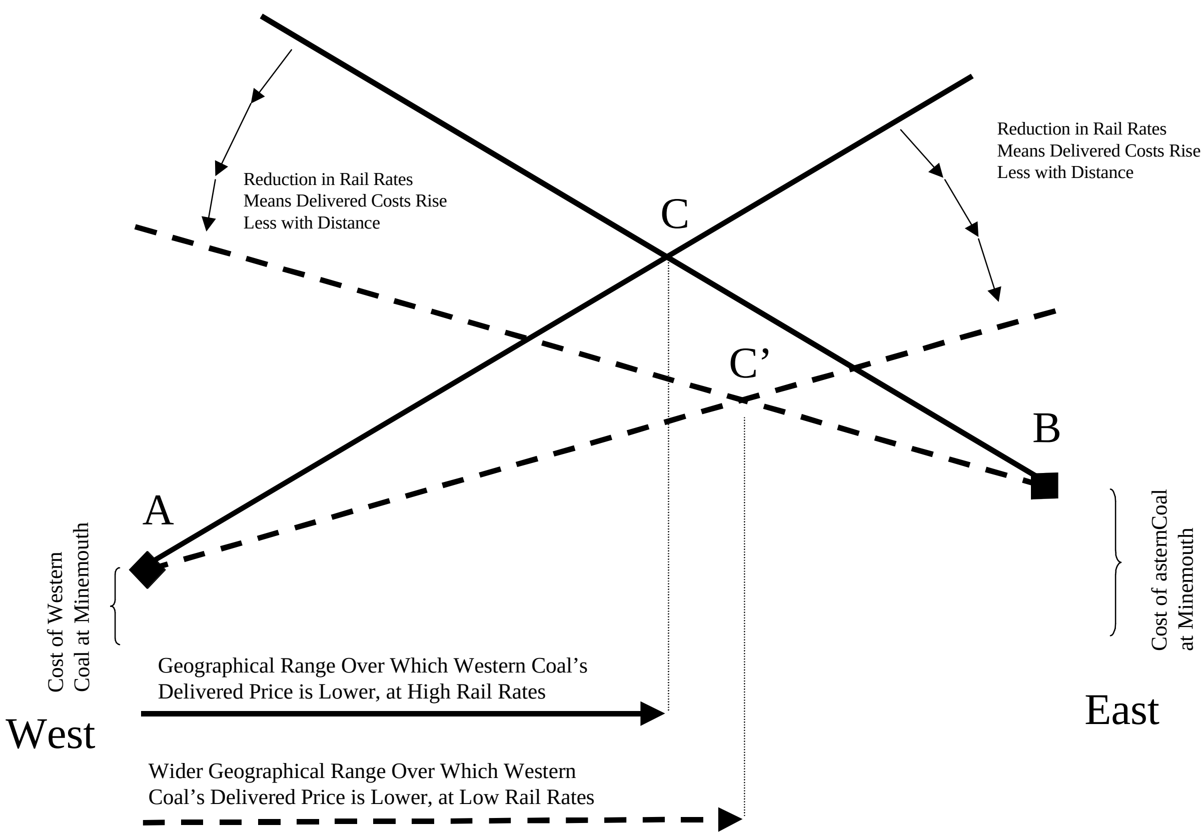
eastern and western coal-fields: the delivered cost of eastern coal is represented by the line sloping upward to the left.

At a certain point, the *delivered* costs of the two coals are equal (shown as point C). There, the delivered cost of the western coal at that point will be mostly transportation cost, while the delivered cost of the eastern coal will be more heavily based on mining cost. For all points east of this dividing line, eastern coal will have an economic advantage; for all points to the west, western coal will be less expensive.

A decline in the per-mile cost of transportation can be shown on the diagram as a flattening of the delivered-cost lines, as shown in Exhibit C-3: at a lower cost per ton-mile, each incremental distance adds less to the delivered cost than at the higher cost. As a result, the delivered-cost lines cross at a point further to the right (i.e., further to the East), and the dividing line between the area served by western and eastern coal regions moves as well. These diagrams illustrate the concept that, as the transportation costs hampering the spread of inexpensive western coal come down, the area of the country in which it is economically competitive expands.

The net increase in the attractiveness of using western coal, described above, would exist even in the absence of Title IV. In other words, coal users in the Midwest and East would find western coal relatively more cost-effective even if its lower sulfur content were of no importance. Therefore, part of the reduction in SO_2 emissions

Exhibit C-3. Schematic Explanation of Effects of Rail Transportation Rates on Coal Competition



Source: ICF analysis

required by Title IV would already be accomplished in the baseline.[3] Because Title IV's limits are specified in terms of a nationwide cap on emissions, the shift toward low-sulfur western coal in the baseline means that less incremental SO_2 reduction will be needed to meet the Title IV requirements. The MIT study of Phase I compliance strategies suggests that the shift to western coal for economic reasons cut baseline SO_2 emissions by 425,000 tons annually—a reduction that accounted for more than ten percent of the total emissions reductions under Phase I (Ellerman et al., 1997).

C.3. Comparisons of Coal Demand Projections

The baseline shift in coal use discussed above appears to have been captured by ICF's IPM model. This tentative conclusion is based on the fact that the baseline results from 1996 show a relative increase in the use of western coal and a drop in eastern coal use, compared to the 1992 results. Because of differences between IPM and the earlier CEUM, though, this conclusion is not certain. This section presents and discusses these results and the reason for the uncertainty in the conclusion.

Exhibit C-4 compares two different coal projections in the absence of Title IV: the 1992 RIA's projection of total coal production, and the 1996 analyses' projection of coal *use by utilities*.[4] Because these two projections differ (by the amount of coal exported or used by industry), it is not possible to show conclusively how projections of utility coal use differ between the 1992 and 1996 analyses. The sizes and directions of the differences between the two projections for eastern coals versus western coals, however, strongly suggest that the more recent analysis projects more western coal use by utilities.

As seen in Exhibit C-4, ICF's more recent analysis projects utility use of eastern coal in both 2000 and 2010 to be considerably below earlier projections of eastern coal production. These differences do not necessarily mean that projected utility use of eastern coal fell between 1992 and 1996, because the differences shown in the table could be explained by the quantity of coal taken by industry and exporters. The 1996 projection of utility use of western coal, however, is now higher than the 1992 projection of western coal production for the year 2000. Because utility use of western coal is only one component of total production, it must be true that the year 2000 projection of utility use of western coal was higher in 1996 than in 1992. A similar pattern is seen for the year 2010: the difference between 1992 and 1996 projections for western coal is much smaller than for eastern coal. The differences between the 1992 and 1996 projections for both 2000 and 2010 are easily explained by a shift from eastern to western coal by utilities. Nevertheless, it is true that these patterns could also have resulted from other shifts (e.g., changes in total utility demand and/or changes in exports or industrial use).

Exhibit C-5 compares Title IV's projected impacts on coal use for the year 2010 for the 1992 and 1996 analyses. The 1996 analysis predicts greater shifts between eastern and western coal than the 1992 analysis, and a much smaller shift from high-sulfur Midwestern coal to low-sulfur central

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3 It may well be that some of the changes in technology that induced the shift in favor of using more western coal were actually induced by the existence of Title IV and the development of the Acid Rain Program. For example, the prospect of a need for substantial cuts in utility SO_2 emissions could have given utilities an added incentive to develop ways to use low-cost, low-sulfur subbituminous coal in boilers originally designed for bituminous coal. To the extent that this is the case, the baseline discussed here would not be a true non-Title IV baseline, and the effects of Title IV presented in this report would be understated compared to their true values. No attempt was made to determine the extent to which the changes favoring the use of subbituminous coal were endogenous in this way, though if the attempt had been made, the results of the analysis might fall somewhere between those shown for the 1992 analysis and 1996 analysis.

4 Projections for the year 2000 are included in the table because their implications for baseline coal use are less ambiguous than are the projections for 2010.

Exhibit C-4. Baseline Coal Industry Output and Use Projections in the Years 2000 and 2010 (millions of tons per year)

	2000			2010		
Coal Supply Region	**1992 RIA (total production; high base case)**	**1996 Analysis (use by utilities)**	**Difference (1996 analysis minus 1992 RIA)**	**1992 RIA (total production; high base case)**	**1996 Analysis (use by utilities)**	**Difference (1996 analysis minus 1992 RIA)**
East	648	428	- 220	955	483	-472
Northern Appalachia	197	170	- 27	290	180	-110
Central & Southern Appalachia	302	164	- 138	359	196	-163
Midwest	149	94	- 55	306	107	-199
West	491	524	33	675	575	-100
Total	1,138	952	- 186	1,630	1,058	-572

Source: ICF analysis. Totals do not add due to rounding.

and southern Appalachian coal was projected in 1996 than in 1992.

A greater projected shift toward the West in the 1996 analysis might seem counterintuitive, given the expectation that more recent projections should take into account the greater baseline penetration of western coal due to lower rail rates and expanded opportunities for using subbituminous coal in the East. By reducing baseline sulfur emissions, this shift should reduce the need for further coal switching, and might have been expected to reduce net job slot losses.

From another perspective, however, the changes that led to a baseline increase in the use of western coal would also make it a more attractive option for the additional reductions in SO_2 emissions that will be needed in Phase II. Because the baseline shifts toward the use of low-sulfur western coal for economic reasons did not meet the goals of Title IV's Phase II program by themselves, there will still be a need for incremental sulfur reductions. The impacts of these incremental reductions will depend on the choices made by power plant operators from among their compliance options. If western coal is less expensive to

Exhibit C-5. Comparison of Projected Effects of Title IV on Coal Use in the Year 2010 (millions of tons per year)

Coal Producing Region	**1992 RIA Analysis, High Base Case**	**1996 Analysis**	**Difference (1996 Analysis minus 1992 RIA)**
East	- 35	- 65	-30
Northern Appalachia	- 41	- 58	-17
Central & Southern Appalachia	135	32	-103
Midwest	- 129	- 39	90
West	38	63	25
Total	3	- 2	-5

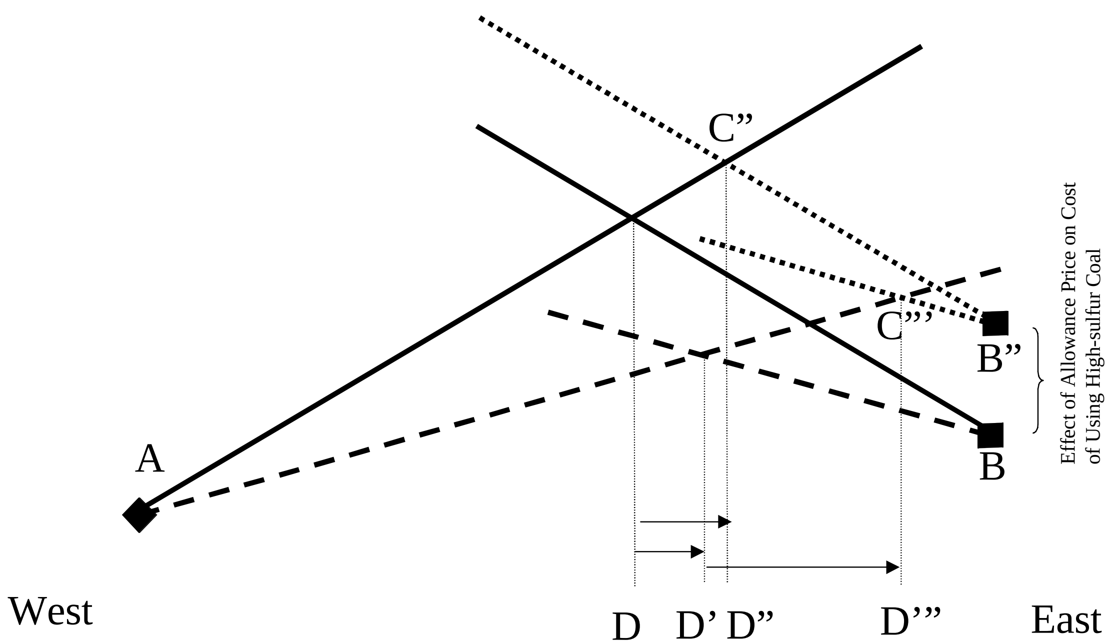
Source: 1992 SO_2 RIA, Appendix 4b, 1996 IPM runs. Totals do not add due to rounding.

ship than before and still has a substantial cost advantage, it might still be the best compliance choice for a large segment of the industry.[5] Thus, it would not be surprising to see greater shifts in job slots from eastern to western coal producing regions in a model in which western coal is more accessible. The only question would be whether the baseline shift to the West was large enough to preempt the need for further shifts in response to regulations.

This question can be addressed using the analytical framework presented in Exhibits C-2 and C-3. Exhibit C-6 shows the combined effects of (1) the need to purchase allowances on the cost of using high sulfur coal, and (2) the reduction in transportation costs in the baseline. The need to purchase additional allowances for every additional ton of high-sulfur coal is illustrated by the upward shift in the costs for the eastern coal. Minemouth cost B shifts upward to B" to show the true cost of using a ton of high-sulfur coal under Title IV. The delivered cost curves sloping upward to the left shift as well; the resulting curves are shown as dotted lines. If there had been no change in transportation costs, the breakeven point between western and eastern coal would be at D" (based on intersection point C"). Point D" is further to the East than the original breakeven point D, indicating that Title IV would cause western coal's market share to gain relative to eastern coal.

As discussed above, however, a change in transportation costs would cause part of the market share change to take place in the baseline. In Exhibit C-6, this baseline shift is shown as the distance from D to D'. It might seem, then, that instead of Title IV causing an incremental market share change from D to D", it would cause only the small shift from D' to D".

Exhibit C-6. Combined Effects of Transportation Rates and Allowance Price on Coal Competition



Source: ICF analysis.

5 In this simplified analysis, no distinction is made between the eastern and western coals in terms of heat content per ton. If the heat content per ton of lower sulfur western coal is lower than that of the coal it is replacing, this difference would have to be reflected by expressing the costs of purchasing and transporting the coals in terms of equivalent amounts of energy: point A would be somewhat higher, and the slopes of lines A-C" and A-C'" would be somewhat steeper. The main point of the graph would not be affected.

The effects of the transportation cost change, though, interact with the effects of allowance prices to cause an additional increase in the market share of western coal. With lower transportation costs, the effect of a given allowance price, and hence a given upward shift in the cost of using eastern high-sulfur coal (shown by the shift from B to B") would be to move the breakeven point from D' to D'"(based on intersection point C'"). This eastward shift in the zone in which western coal is competitive is potentially large enough to outweigh the baseline effect noted in the paragraph above. In other words, even though the transportation cost reduction led to a baseline shift in western coal's market share that reduced the incremental effects of Title IV, the net effect of Title IV on western coal use could still be greater with lower transportation costs. In the diagram, lower transportation costs would increase Title IV's net effect so long as the distance from D' to D'" exceeds the distance from D to D'.

The net effect of lower transportation costs on Title IV's impact on western coals depends on a number of factors. One crucial factor, not shown in Exhibit C-6, is the extent to which the baseline shift in western coal use causes allowance prices to be lower (than if the baseline shift had not occurred). As noted above, Exhibit C-6 was constructed as though allowance prices, and thus the shift from B to B", would be the same whether transportation costs were high or low. In fact, the baseline shift to greater use of western low-sulfur coal could reduce the price of allowances by reducing the need for incremental SO_2 reductions. Though it would be cumbersome to illustrate, lowering B" would shift D'" to the left, showing a smaller net effect of Title IV on western coal use. In the extreme, if the baseline increase in western coal due to transportation cost reductions (D to D') were large enough to accomplish all of Title IV's goals, the allowance price would drop to zero (because there would be no need for, and thus no value in, further SO_2 reductions). In that case, the effects of Title IV on western coal use would clearly be smaller as a result of the transportation cost change.

In actuality, emissions consequences of the baseline shift in coal use was apparently only a fraction of the required emission reduction in Phase I of Title IV and manifestly did not drive the allowance price to zero (Ellerman et al., 1997). It is, therefore, difficult to tell a priori whether transportation cost reductions increased or decreased the effects of Title IV on western coal use. It does not seem unreasonable that the CEUM and IPM modeling results suggest that the effects on western coal use increased.

Another consequence of the increasing attractiveness of western coal, both in the baseline and as a compliance strategy, is that it would definitely reduce the need for coal shifting within the East. In the earlier analysis, much of the needed reduction in sulfur had to come from shifts from high-sulfur eastern coal to lower-sulfur eastern coal. In part, these changes could come within a given region or state. To a substantial degree, however, they also came from interregional shifts within the East: particularly, from high sulfur coal in the Midwest region to medium or low sulfur coal in the central and southern Appalachian region. To the extent that the 1996 analysis projected greater shifts to western coal, it also projects a smaller need for shifts within the East. Furthermore, because the differences in sulfur levels between eastern coals is often not as great as between eastern and western coal, more total tons of coal must be shifted in order to cut SO_2 emissions by a given amount. Thus, because both the baseline and post-Title IV shifts toward western coal are very good substitutes for shifts between eastern coal regions, it is reasonable to expect that there are fewer tons of coal demand moving among the eastern regions in the 1996 analysis.

C.4. Changes in Employment Impact Projections

The different productivity and baseline assumptions used in the 1992 RIA and 1996 analysis result in somewhat different employment change projections. The 1992 RIA did not quantify the employment impacts of Title IV. It did, however, provide a qualitative assessment, stating that there would be both a small net decline in nationwide employment and significant shifts from one region to another. Corresponding to the coal mining changes shown in Exhibit C-5, the RIA projected decreased employment in northern Appalachia and the Midwest.[6]

Similarly, employment gains were projected for central and southern Appalachia and the West. These employment gains, however, were not expected to completely offset the employment losses in northern Appalachia and the Midwest.
The effects of projected coal switching shown in Exhibit C-5 on coal mining employment can be calculated using projected labor productivity. Understanding the impacts on employment, however, is complicated by the fact that projections of mining productivity have changed since the late 1980s and early 1990s. As discussed above, whereas the base cases prepared in 1989 (and used in the 1992 analyses) projected coal miner productivity increases of only two to three percent per year, the 1996 analysis recognizes that actual productivity has been rising twice as fast. Thus, the employment implications of changes in coal use projections from 1992 to 1996 depend on which productivity assumptions are used.[7]

To focus on the effects of differences in coal use projections, we first show the projected effects on employment holding the productivity assumptions constant from the 1992 to the 1996 analysis. Exhibit C-7 shows the incremental impacts of Title IV on coal labor requirements for the 1992 and 1996 analysis, using the labor productivity assumptions from the 1992 analysis (shown in the first two columns of Exhibit C-1). The projected job slot changes in Exhibit C-7 are based on the productivity factors of 4.65 tons per miner-hour in the East and 15.27 tons per miner-hour in the West. The differences in employment impact estimates between the 1992 and 1996 analyses result solely from differences in their projections of coal use.

Exhibit C-7. Labor Demand Comparisons for 2010 Using Constant Productivity Growth Assumptions (from the 1989 Base Cases) (numbers of job slots)

Coal Supply Region	1992 RIA (high base case)	1996 Analysis	Difference (1996 analysis minus 1992 RIA)
East	- 3,700	- 6,800	- 3,100
Northern Appalachia	- 4,300	- 6,100	- 1,800
Central & Southern Appalachia	+ 14,100	+ 3,300	- 10,800
Midwest	- 13,500	- 4,100	+ 9,400
West	+1,000	+ 1,600	600
Net* Change	- 2,700	- 5,200	- 2,600
Gross** Change (in regions with reduced demand)	- 17,800	- 10,100	+ 7,600

* Net is nationwide job slot change, netting the gains and losses in regions listed above.
** Gross is the total regional losses for those regions that have losses.

Source: ICF analysis. Totals do not add due to rounding.

6 Because it takes fewer workers to mine a given quantity of coal in the West than in the East, shifting coal production from the East to the West will add fewer workers in the West than it will subtract in the East.

7 As a concrete example, a drop in coal demand of 10 million tons will have twice the effect on labor demand if it took 200 workers to produce each million tons than if it only took 100 workers.

Applying the lower labor productivity growth rates used in the 1992 analysis to the coal demand impacts projected by both the 1992 and 1996 analyses, the 1992 analysis projected a 2,700 job-slot-loss in 2010, compared to the 1996 analysis's 5,200 job slots. However, from a difference perspective, the gross reductions in labor demand in the regions most affected by Title IV are considerably smaller (10,100 job slots vs. 17,800) according to the more recent analysis. This result occurs because the 1996 analysis projected less coal switching within the East than did the 1992 analysis.

Exhibit C-8 shows effects of combining the more recent coal demand estimates with newer labor productivity projections. The net effects of Title IV are projected to be greater by only about 2,700 job slots. Gross employment impacts of Title IV are now projected to be substantially smaller than previously projected. The 1992 RIA analysis projected (implicitly) that almost 18,000 job slots would be eliminated by 2010; now, projections using the 1996 analysis are that less than half that number—7,700—will be lost. This change in gross job slot losses results from a dramatic drop in projected job slot losses in the Midwest (from over 13,500 down to about 3,000). As discussed above, the increased shift to western coal was in place of shifts to eastern low-sulfur coal.

Exhibit C-8. Labor Demand Comparisons for 2010 Using Productivity Growth Assumptions from the 1989 Base Cases for the 1992 Analysis, and Productivity Growth Assumptions from the 1996 Base Case for the 1996 Analysis (numbers of job slots)

Coal Supply Region	1992 RIA (high-base case)	1996 Analysis	Difference (1996 analysis minus 1992 RIA)
East	-3,700	-5,100	-1,500
Northern Appalachia	-4,300	-4,600	-300
Central & Southern Appalachia	+14,100	+2,500	-11,600
Midwest	-13,500	-3,100	+10,400
West	+1,000	+1,000	0
Net* Change	-2,700	-4,100	-1,500
Gross** Change (in regions with reduced demand)	-17,800	-7,700	+10,100

* Net is nationwide job slot change, netting the gains and losses in regions listed above.
** Gross is the total regional losses for those regions that have losses.

Source: ICF analysis. Totals do not add due to rounding.

C.5. References

Ellerman, A. Denny, Schmalensee, Richard, Joskow, Paul L., Montero, Juan Pablo, and Bailey, Elizabeth M. (1997). Emissions Trading Under the U.S. Acid Rain Program: Evaluation of Compliance Costs and Allowance Market Performance. MIT Center for Energy and Environmental Policy Research, Cambridge, MA, October, 1997.

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Appendix D: Results of Modeling and Analysis for 2000

As noted in the body of this report, the analysis focuses on 2010 because the full effects of Title IV are not expected to be seen until about that year. For purposes of comparison to analyses that discuss Title IV's impacts in 2000, and to show how projections of coal and labor demands change over time, it may be useful to see projections for 2000 based on both the 1990/1992 analysis and the 1996 analysis. This appendix consists of four tables: Exhibits D-1 and D-3 show coal use and employment projections based on the 1996 IPM runs, and Exhibits D-2 and D-4 show similar projections based on the earlier 1990/1992 analysis.

Exhibit D-1. Projections of Coal Use by Utilities in the Year 2000. (using 1996 IPM runs) (millions of tons)

Coal Supply Region	Utility Coal Use in Baseline	Utility Coal Use with Title IV	Title IV Impact
East	428	403	-25
Northern Appalachia	170	139	-31
Central & Southern Appalachia	164	188	24
Midwest	94	76	-18
West	524	549	25
Total	952	952	0

Source: 1996 IPM runs. Totals do not sum due to rounding.

Tables D-1 and D-2 show generally comparable coal shifts from the East to the West, with very little net change in total tons of coal either produced or used by utilities. The more recent analysis, however, shows a much smaller shift within the East. In 1996, utilities were projected to increase their year 2000 use of central and southern Appalachian coal by 24 million tons, and to decrease their use of Midwest coal by 18 million tons. In 1990/1992, the equivalent figures were an increase of 62 million tons for central and southern Appalachian coal, and a drop of 64 million tons in the Midwest.

Exhibit D-2. Projections of Coal Industry Output in the Year 2000. (Using 1990/1992 model runs) (millions of tons)

Coal Supply Region	Coal Production in Baseline	Coal Production with Title IV	Title IV Impact
East	648	615	-33
Northern Appalachia	197	166	-31
Central & Southern Appalachia	302	364	62
Midwest	149	85	-64
West	491	521	30
Total	1,138	1,134	-4

Source: 1992 SO_2 RIA, Appendix 4b (high base case). Totals do not sum due to rounding.

These different projections of interregional coal shifts are reflected in the employment projections: Exhibit D-3 shows a much smaller shift of job slots between the Midwest and central and southern Appalachia than does Exhibit D-4. Largely as a result of this difference, Exhibit

D-3 shows a smaller gross and net reduction in job slots.[1] These patterns are similar to those seen in the analyses for the year 2010, with smaller shifts within the East leading to smaller gross job losses.

Exhibit D-4. Projected Effects of Title IV on Coal Industry Employment in the Year 2000.
(Using 1990/1992 model runs)

Coal Producing Region	Change in Job Slots
East	- 4,000
Northern Appalachia	- 3,700
Central & Southern Appalachia	7,400
Midwest	- 7,700
West	700
Net* Job Slot Change	- 3,200
Gross** Job Slot Change	- 11,400

* Net is nationwide job slot change, netting the gains and losses in regions listed above.
** Gross is the total regional losses for those regions that have losses.

Source: 1992 SO_2 RIA, Appendix 4b (high base case). Totals do not sum due to rounding.

Exhibit D-3. Projected Effects of Title IV on Coal Industry Employment in the Year 2000
(Using 1996 IPM runs)

Coal Producing Region	Change in Job Slots
East	- 2,800
Northern Appalachia	- 3,500
Central & Southern Appalachia	2,700
Midwest	- 2,000
West	600
Net* Job Slot Change	- 2,300
Gross** Job Slot Change	- 5,600

* Net is nationwide job slot change, netting the gains and losses in regions listed above.
** Gross is the total regional losses for those regions that have losses.

Source: ICF analysis, using 1996 IPM runs. Totals do not sum due to rounding.

[1] Here and elsewhere in this report, "gross job slot changes" are the sums of job slot reductions across all of the regions with losses, whereas "net job slot changes" are the sums of job slot reductions across all regions, net of job slot increases.

Appendix E: List of Acronyms and Definitions

1992 RIA: the Regulatory Impact Analysis developed for Title IV provisions in 1992

1996 Analysis: an analysis created in 1996 to estimate the coal production and employment impacts of the Title IV provisions of the Clean Air Act

The Act: The Clean Air Act (CAA)

CAA: Clean Air Act

CAPI: Clean Air Policy Initiative (http://www.epa.gov/capi/capi.html)

CEUM: The Coal Electric Utility Model, used to generate the coal projections for the 1992 RIA

EIA: Energy Information Administration

IPM96: 1996 version of the Integrated Planning Model

Job Slot: one job slot is the equivalent of one miner-year of work (2,536 hours in the West and 2,060 hours of labor in the East)

Low sulfur coal: The Energy Information Administration (EIA) "classifies coal, in terms of pounds of sulfur per million Btu as low (less than or equal to 0.60 pounds of sulfur), medium (between 0.61 and 1.67 pounds of sulfur), and high (greater than or equal to 1.68 pounds of sulfur). When coal is sampled, sulfur content is measured as a percent by weight of coal on an 'as received' or 'dry' (moisture-free) basis." (EIA, 2000a)

RIA: Regulatory Impact Analysis

Appendix F: Peer Review Process

EPA's draft report, "Impacts of Title IV of the Clean Air Act Amendments of 1990 on Coal Industry Employment," was subjected to external peer review during the spring, 2000. EPA uses peer review to uncover any technical problems or unresolved issues in a work product through the use of independent experts.[1] The peer review process is used to enhance the technical work product by providing a documented critical review by qualified individuals who are independent of those who performed the technical work. Because the draft report analyzes the potential impact of a major environmental program on an employment sector that has undergone significant reduction over time, the Agency wanted to be certain that the report's methodology, assumptions and conclusions received in-depth assessment.

EPA began the peer review process by inviting four eminent resource economists (Dallas Burtraw, A. Denny Ellerman, Richard Gordon, and Michael Rieber) to conduct the review. EPA asked for an overall evaluation of the report based on whether criteria such as the validity of the methodology, the appropriateness of the assumptions, and the soundness of the conclusions were satisfied. EPA also asked for more detailed responses to a series of questions, such as the consistency of the paper's conclusions with the reviewers' understanding of coal industry employment. Finally, the reviewers were invited to submit specific comments on the format and content of the paper, which the reviewers provided through line-by-line citations from the text.

To assure the integrity of the handling of reviewer comments, each reviewer was assigned a randomly selected number for use in submitting reviews. In addition to the questions described above, EPA asked the reviewers whether the report should be issued as a public document. Three reviewers responded that the report should be released with minor changes. One reviewer believed that the report should be released only after major revisions. EPA incorporated many of the comments and suggestions submitted by the reviewers into the report. Comments that would have required effort beyond the scope of the report or that would have required major structural revisions or new analyses were not accepted. EPA prepared a document that recorded all comments submitted by the peer reviewers and the Agency's responses. This document and all other materials prepared during the course of the peer review will be maintained.

Biographies of the Peer Reviewers:

Dr. Dallas Burtraw is a Senior Fellow at Resources for the Future and a lecturer at Johns Hopkins SAIS University. He specializes in environmental policy issues such as the effects of SO_2 trading, emissions reductions, and social costs. His research interests also include restructuring of the electric utility market, social costs of pollution, and the impacts of environmental regulation.

Dr. A. Denny Ellerman is an internationally recognized authority on coal economics and emissions trading. He is currently serving as the Executive Director of the Center for Energy and Environmental Policy Research at Massachusetts Institute of Technology. He lectures at the Sloan School of Management and has written numerous articles related to CO_2 trading and other market based compliance measures.

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[1] U.S. Environmental Protection Agency, Science Policy Council, *Peer Review Handbook*, EPA 100-B-98-00

Dr. Richard Gordon is a leading authority on the economics of the coal industry. He served as the Director of the Center for Energy and Mineral Policy Research at the Pennsylvania State University, Department of Mineral Economics. A small selection of works from his list of publications includes: U.S. Coal and the Electric Power Industry; Coal in the U.S. Energy Market: History and Prospects; "North American Free Trade: Another Challenge to Coal;" and "Energy, Exhaustion, Environmentalism, and Etatism."

Dr. Michael Rieber is an authority in mineral economics, and currently serves as a professor at the University of Arizona and as a visiting professor at the Western Australian School of Mines/Curtin University of Technology in Perth, Australia. He specializes in topics such as the markets for copper and mercury, and the economics of coal slurry pipelines. Dr. Rieber has also provided expert testimony before government agencies and consults for local governments, mining companies, and other organizations.